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CLIMATE CHANGE AND SUSTAINABILITY: MEDITERRANEAN PERSPECTIVES

edited by

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HADI JAAFAR specialises in remote sensing applications in smart irrigation, water resources and food security. His research appears in a number of journals including Nature's Scientific Data, Remote Sensing of the Environment, Journal of Hydrology, Agricultural Water Management and Food Policy. Currently, Hadi is the principal investigator and leader of a Google.org-funded 3-year project that aims to apply artificial intelligence to estimate the precise water needs of agricultural fields using remote sensing. He is also the leader and the principal investigator of the ITSET project "Integrating time series ET mapping into an operational irrigation management framework", a two-year project funded by IHE-Delft and the government of the Netherlands that aims to develop a smart app for daily irrigation using remote sensing technologies. Hadi holds a Ph.D. in Irrigation Engineering from Utah State University and is currently an Associate Professor at the American University of Beirut.

List of Abbreviations

AU	African Union
BAU	Business-As-Usual
DDT	Di-dichlorodiphenyltrichloroethane
EFSD+	European Fund for Sustainable Development Plus
EIB	European Investment Bank
EPR	Extended Producer Responsibility
EU	European Union
FAO	Food and Agriculture Organisation (UN)
FIT4REUSE	Safe and sustainable solutions for the integrated use of non-conventional water resources in the Mediterranean agricultural sector
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GW	Gigawatt
HDPE	High-Density Polyethylene
IAI	Istituto Affari Internazionali
IELKA	Research Institute of Retail Consumer Goods
IFI	International Finance Institution
IPSF	International Platform on Sustainable Finance
IUCN	International Union for Conservation of Nature
LAS	League of Arab States
LDPE	Low-Density Polyethylene
MAECI	Ministry of Foreign Affairs and International Cooperation

MARPOL	International Convention for the Prevention of Pollution from Ships
MDG	Millennium Development Goal
MENA	Middle East and North Africa
MWI	Mismanaged Waste Index
NATO	North Atlantic Treaty Organisation
NDC	Nationally Determined Contribution
NDICI	Neighbourhood, Development and International Cooperation Instrument
NIMBY	Not-in-My-Backyard
OIC	Organisation for Islamic Cooperation
OSCE	Organization for Security and Cooperation in Europe
PET	Polyethylene Terephthalate
PP	Polypropylene
PVC	Polyvinyl Chloride
RES	Renewable Energy System
SDG	Sustainable Development Goal
TEN-E	Trans-European Energy Networks
UfM	Union for the Mediterranean
UN	United Nations
US	United States

Foreword

The current geological era is known to many as Anthropocene, from the Greek anthropos, "man". This expression, directly linked to the "anthropozoic era" referred to by the Italian geologist Antonio Stoppani (1824–1891) in 1873, aims to underline the way in which the terrestrial environment, in all its physical, chemical and biological characteristics, is shaped by the effects of human action.

The concept of Anthropocene, however, is not only partly inaccurate, but also unfair. A problem of human behaviour is no doubt present,[1] but this is linked to certain societies and economies, located in particular in Northern Europe, on the Atlantic coast of the United States and in Eastern China. Most of the rest of the world and its inhabitants bear little responsibility for the causes and dynamics related to Anthropocene, if not the fact of sharing its dramatic effects.

Consider the case of the United States, – inhabited by about 5 per cent of the world population – which produced, throughout the 20th century, about 30 per cent of global carbon dioxide emissions. These numbers are even more striking if China (7 per cent of dioxide emissions), India (2 per cent) and Europe (22 per cent) are included in the picture. The per capita emissions of India and China are still today "50–80 percent lower than the world averages",[2] and a country like Sri Lanka, whose life expectancy

[1] Jürgen Renn noted that "the present concentration of carbon dioxide has been reached at a rate at least ten, and possibly one hundred times faster than increases at any time during the previous 420,000 years". See Jürgen Renn, *The Evolution of Knowledge. Rethinking Science for the Anthropocene*, Princeton, Princeton University Press, 2020, p. 4.

[2] Eric Vanhaute, *World History. An Introduction*, London/New York, Routledge, 2013, p. 51.

is similar to that of the US (a year and a half of difference between the two countries), uses about 88 per cent less resources than the US and produces about 94 per cent less emissions on a per capita basis.

Although Anthropocene is a largely inaccurate concept, – and despite being considered as a "Eurocentric" and "unnecessary" intellectual posturing by a growing number of scholars[3] – ongoing debates surrounding this term are nonetheless igniting a number of positive effects. The most important is the reaffirmation of the centrality of human beings and their actions.

This volume, which is focused on a key area such as the Mediterranean basin and is produced within the framework of the New-Med project, provides timely elements to shed light on human action, climate change and sustainability in the Mediterranean area, as well as on the impact of covid-19 on these issues.

Each of these aspects will continue to play a central role in the near future, and the human dimension of the epochal changes that we are already witnessing will remain the key element at stake. Here it is enough to mention that the total population of Africa will grow from the current 1.2 billion to 2.5 billion by 2050, while the one in the MENA region is expected to double during the first half of this century (388 million in 2000, 724 million in 2050). This is why providing legal protection and opportunities – possibly using some of the billions of euro the EU has allocated to strengthen Europe's external borders – for "climate migrants", that is those (millions of people) who flee African and Middle Eastern countries because of the effects of climate change, is expected to remain a key component in the frame of the many structural solutions needed to tackle these challenges looking into the future.

Lorenzo Kamel
Rome, June 2021

[3] See, for instance, Kathleen D. Morrison, "Provincializing the Anthropocene: Eurocentrism in the Earth System", in Gunnel Cederlöf and Mahesh Rangarajan (eds), *At Nature's Edge. The Global Present and Long-term History*, New Delhi, Oxford University Press, 2018, ch. 1.

1.

Mediterranean Transitions: The Challenge of Sustainable Development

Andrea Dessì, Daniele Fattibene and Flavia Fusco

Six years since the adoption of the United Nations Agenda 2030, the world is not on track in meeting the vast majority of Sustainable Development Goals (SDGs). Subscribed to by all member states of the United Nations back in 2015, the Agenda 2030 builds on the legacy of the previous Millennium Development Goals (MDGs) and aims for an unprecedented transformation of our societies. Collectively, the SDGs provide a framework for eradicating poverty, eliminating inequalities and tackling climate change on the way to a sustainable, inclusive and just future for all.

States are required to meet a series of challenging performance indicators to achieve the SDGs. Yet, indicators and political declarations need to be coupled with clear commitments and effective investments to achieve and monitor progress. Even before the covid-19 outbreak, several countries were registering very low performance in areas such as food security and sustainable agricultural production (SDG 2), access to water (SDG 6), the development of more sustainable production and consumption models (SDG 12) or the fight against climate change (SDG 13).[1]

The pandemic has added further urgency to these objectives, underscoring the interdependency between human development and the envi-

[1] United Nations, *Sustainable Development Goals Progress Chart 2020*, July 2020, https://sdgs.un.org/node/26443.

ronment as well as the impact that unsustainable consumption and economic models are having on both. The profound and multidimensional impact of the pandemic on sustainable development has reached every corner of the world but has not impacted all states and societies alike. Vulnerable groups such as women, children, the elderly, internally displaced persons, migrants and informal workers have borne the brunt of the crisis, while struggling states and environmentally fragile ecosystems have been particularly exposed to its disruptive consequences.

Against this backdrop, the Mediterranean basin is understood to be particularly vulnerable to the interconnected challenges stemming from climate change and environmental degradation. Hit hard by the pandemic, states and societies across the Mediterranean have suffered considerable socio-economic repercussions due to restrictive measures put in place to combat the spread of the virus. Southern Mediterranean states, many of which were already struggling due to fraying social contracts, increased inequalities and mounting socio-economic grievances, have seen trade and tourism revenues contract, adding significant stress to their reform trajectories and efforts to put in place policies aimed at achieving sustainability while preparing for the impending energy transition and the effects of climate change.

The Mediterranean is indeed recognised as a climate change "hotspot" and growing research and attention has recently been directed towards assessing the medium- and long-term effects of such developments on states and societies across this region.[2] Clearly, only multilateral frameworks that are based on cooperative approaches and a degree of solidarity can hope to engender positive momentum towards addressing these issues. Yet, Mediterranean countries are at very different levels of economic and social development, with some being industrialised or ser-

[2] See for instance, Alexandre Tuel and Elfatih A.B. Eltahir, "Why Is the Mediterranean a Climate Change Hotspot?", in *Journal of Climate*, Vol. 33, No. 14 (2020), p. 5829-5843, https://doi.org/10.1175/JCLI-D-19-0910.1; Wolfgang Cramer, Joël Guiot and Katarzyna Marini (eds), *Climate and Environmental Change in the Mediterranean Basin. Current Situation and Risks for the Future. First Mediterranean Assessment Report*, Mediterranean Experts on Climate and Environmental Change (MedECC), November 2020, https://www.medecc.org/?p=3506.

vice-driven economies with low energy intensity and others grappling with poverty, unemployment, poor infrastructure and a lack of access to basic services, like reliable energy supply. These divergences complicate the task of conceiving a common energy and climate approach in the Mediterranean, and even formulating observations that can be applied to the region as a whole, let alone finding common solutions. Moreover, the lack of integration, particularly in the domain of trade and infrastructure connectivity across southern and eastern Mediterranean states, adds further challenges to efforts that aim to favour cooperative approaches to mitigate these challenges.[3]

It is no coincidence therefore that Mediterranean states are generally not on track for achieving the SDGs.[4] On the one hand, they seem to perform well for some indicators like poverty eradication (SDG 1), the promotion of good health and well-being (SDG 3) and quality education (SDG 4). On the other, alarming performances concern particularly biodiversity protection, including life below water (SDG 14) and life on land (SDG 15); social integration, including gender equality (SDG 5) and the fight against all forms on inequality (SDG 10); and the promotion of sustainable agriculture and diets (SDG 2).

Achieving sustainability in the Mediterranean basin is key to ensure thriving, resilient societies as well as more stable and secure states and social contracts. The region is indeed subject to several forms of vulnerability ranging from the political to the economic, social and environmental domains, with due differences across geographic areas. Recognised as the second most vulnerable region to climate change after the Arctic,[5]

[3] See for instance, Organisation for Economic Cooperation and Development (OECD), *Regional Integration in the Union for the Mediterranean. Progress Report*, Paris, OECD, May 2021, https://doi.org/10.1787/325884b3-en.

[4] Angelo Riccaboni et al. *Sustainable Development in the Mediterranean. Report 2020. Transformations to achieve the Sustainable Development Goals*, Siena, Sustainable Development Solutions Network Mediterranean (SDSN Mediterranean), 2020, http://hdl.handle.net/11365/1120952. Also see, UN Economic and Social Commission for Western Asia (UNESCWA), *Between Now and 2030: A Statistical Overview of Progress towards the Sustainable Development Goals in the Arab Region*, January 2021, https://www.unescwa.org/node/22638.

[5] See, Wolfgang Cramer, Joël Guiot and Katarzyna Marini (eds), *Climate and Environ-*

the Mediterranean basin is also one of the most water-challenged areas in the world, with high levels of water scarcity[6] as well as limited arable lands, most of which are heavily dependent on unpredictable rainfall.[7]

Climate change will further increase water stress and food insecurity in the Mediterranean, as declining precipitation and rising sea levels impact irrigated agriculture and lead to a general decrease in crop yields. Looking to the future, many countries will face more than 10–20 per cent precipitation reduction by 2050 coupled with an estimated increase of 1.5–5 degrees in temperature. Temperature increases in the Mediterranean region are already recognised as warming 20 per cent faster than the global average, and fresh water availability is predicted to decrease by 15 per cent over the next two decades, among the largest contractions in the world.[8] Rising sea levels, meanwhile, are expected to severely impact the population of the region, with half of the 20 global cities most exposed to this threat by 2050 located in the Mediterranean.[9]

Addressing sustainability is also essential to have a better understanding of the social, political, environmental and economic fragilities that exist in this region. When coupled with the multidimensional impacts of climate change, these may lead to new or renewed conflicts or social unrest as the recent history of the region attests. Resource scarcity, urbanisation and demographic growth are adding significant challenges to already strained governmental policies and finances. Meanwhile, persistent political divisions and the existence of a number of "frozen" and not too frozen conflicts – from Israel-Palestine to Western Sahara, Libya, Syria and the energy and water demarcation disputes in the Eastern Mediterranean – continue to represent formidable

mental Change in the Mediterranean Basin, cit.

[6] Marianne Milano et al., "Current State of Mediterranean Water Resources and Future Trends under Climatic and Anthropogenic Changes", in *Hydrological Sciences Journal*, Vol. 58, No. 3 (2013), p. 498-518, https://doi.org/10.1080/02626667.2013.774458.

[7] Food and Agriculture Organization (FAO) portal AQUASTAT, http://www.fao.org/aquastat/en.

[8] Wolfgang Cramer, Joël Guiot and Katarzyna Marini (eds), *Climate and Environmental Change in the Mediterranean Basin*, cit.

[9] Ibid.

challenges to region-wide multilateral approaches aimed at fostering sustainable development and cooperation. All countries across the area are in urgent need of identifying a common language that speaks to the local, national and regional dimensions of the multiple overlapping challenges at stake, working to develop holistic approaches that begin from a careful appreciation of pre-existing fragilities and the ways in which climate change can act as a threat multiplier in many of these contexts.

The above underscores the need for comprehensive, cooperative approaches to address sustainability-related challenges not only at a theoretical level, but most importantly in practical terms. The social, economic and environmental dimensions of sustainability need to be taken into account and collectively inform future endeavours aimed at fostering sustainable development in the Mediterranean region for the covid-19 recovery phase and beyond. It is undeniable that a region like the Mediterranean would greatly benefit from cooperation in tackling a number of pressing issues and that energy and climate take centre stage in these efforts. The energy transition is a challenge, but can also be transformed into an opportunity for economic development and enhanced south-south and north-south cooperation across the Mediterranean, potentially even becoming a means to de-escalate geopolitical tensions, such as those emerging in the Eastern Mediterranean. Hydrocarbon producers (e.g., Algeria, Egypt and Libya) will be particularly exposed to the challenge of green energy transitions, but such efforts – if adequately managed and linked to growing funding and support emanating from key international organisations – can help to place these states and societies on more sustainable trajectories of economic growth. Meanwhile, the emerging opportunities made available by renewable energy – and the growing emphasis on shortening supply lines and promoting a greener and more just recovery for the post-pandemic world – may provide new impetus for new forms of integration and cooperation across Mediterranean states.

It is against this backdrop that key international organisations, by no means limited to the United Nations and its specialised agencies, but also including regional organisations such as the European Union, the Organization for Security and Cooperation in Europe (OSCE), the Union for the Mediterranean (UfM), the African Union (AU), the League of Arab States

(LAS) and even the North Atlantic Treaty Organisation (NATO) and the Organisation for Islamic Cooperation (OIC) are all increasing their focus on climate change. Enhancing the interlinkages between the UN Agenda 2030 and the Paris Agreement, as well as regional and sub-regional efforts to tackle climate change, represents one key domain of such efforts. Meanwhile, the EU's Green Deal and the recently announced EU Agenda for the Mediterranean – which promises to provide new resources and support for states tackling the impact of the pandemic and the impending energy transitions[10] – can provide new frameworks for cooperative dialogue and investments on the road to creating a more sustainable, inclusive and just future for all.

It is with these thoughts in mind that the New-Med Research Network, a multi-year research, outreach and dissemination project run by the Rome-based Istituto Affari Internazionali (IAI) with the support of the Italian Ministry of Foreign Affairs and International Cooperation (MAECI), the OSCE Secretariat in Vienna and the Compagnia di San Paolo Foundation, has directed increased emphasis on investigating the interlinkages between climate change, state and societal resilience and security in the Mediterranean region.[11] The OSCE's growing emphasis on the implications of climate change for comprehensive security have helped spur the present research endeavour. The volume represents one component of a broader New-Med research agenda for 2021 and beyond, that specifically aims at shedding light on the different challenges faced by sustainability in this region, via the organisation of conferences, publications and webinars on the nexus between climate change, sustainability and human security across the Mediterranean. By promoting novel research into specific themes from non-Eurocentric perspectives, it is our hope that this volume can provide concrete inputs for ongoing policy discussions on the best means to relaunch effective forms of multilateral

[10] Council of the European Union, *Council Conclusions on a Renewed Partnership with the Southern Neighbourhood – A New Agenda for the Mediterranean* (7931/21), Brussels, 19 April 2021, https://data.consilium.europa.eu/doc/document/ST-7931-2021-INIT/en/pdf.

[11] For more information on the New-Med Research Network see the network's website: https://www.new-med.net.

cooperation across the Mediterranean region.

The volume is divided into five chapters, with each addressing a specific dimension of the relationship between climate change and sustainability in the Mediterranean. In chapter two, Marta Antonelli examines the water-food nexus in the Mediterranean, a region already suffering from severe water shortages and food insecurity and where per capita water availability has already declined by 20 per cent over the past two decades. The author argues that demographic processes, unbridled urbanisation as well as food import dependency ratios – which range from 44 per cent in Egypt to over 99 per cent in Lebanon – have exposed several states and societies to a number of shocks, which are likely to further increase in the near future due to the impact of climate change and environmental degradation. Antonelli proposes new approaches to agricultural and rural development policies in order to increase agricultural productivity and farmers' income, engage youth in farming via the adoption of new technologies, improve natural resource management and better promote the benefits of the highly sustainable and environmentally friendly "Mediterranean diet".

The third chapter by Hadi Jaafar focuses on the role of new technologies and digitalisation in helping to strengthen sustainable and more efficient food production across the Mediterranean. Many agricultural sectors (e.g., crop and livestock production, aquaculture, fisheries and forestry) require advanced and sustainable solutions to produce healthier food while protecting ecosystems. Examples include but are not limited to milking robots on dairy farms, greenhouses with fully automated climate control, automated irrigation systems on farms that irrigate based on real-time weather data and soil moisture sensors (i.e., machine-to-machine systems) and GPS-guided smart farm machinery, drones, satellite imagery use and automatic pest detection from imagery. Although synergies between and among farmers, organisations and institutions can help to promote a wider use of smart technologies, the author acknowledges that mainstreaming digital agriculture is still at an infant stage, particularly across southern Mediterranean states. More research and investments are therefore needed in order to enhance the visibility and positive carryon effects that an increased use of digital technologies can bring to agricultural production in the Mediterranean, while enhancing multilateral frameworks and public-private cooperation to promote best practices and cooperation in these domains.

In chapter four, Julien Boucher and Guillaume Billard address plastic pollution and waste management in the Mediterranean. The authors underline that the causes of these inputs are largely attributed to mismanaged waste, which can in turn be aggravated by environmental parameters such as rain, which transports waste to nearby watercourses. Despite the urgency of the problem, the authors recognise that research into plastic pollution is in its early days, with significant knowledge gaps in monitoring the actual quantities of plastic debris in the open oceans as well as the consequences on the wider food web and bio-accumulation in apex predators. Higher transparency on waste management performance is needed, while field data collection through remote sensing can represent a great asset, and help localise dumps and areas of high-intensity waste disposal. The authors propose a number of mitigation plans in the Mediterranean basin, looking for instance at plastic offsetting and extended producer responsibility (EPR) schemes. These policies can indeed encourage manufacturers and consumers to become more responsible for the waste they produce, while providing economic incentives to help producers who otherwise could not implement such measures.

The final chapter by Luca Franza addresses the issue of sustainable and clean transition in the Mediterranean. The creation of a sustainable, future-proof socio-economic development model which can only rest on a sustainable low-carbon energy mix is a key ingredient for regional stability. In this context, the European Green Deal and the covid-19 EU recovery packages may provide an opportunity for renewed cooperation. These programmes may help to tackle imbalances, obstacles or divergences across Mediterranean states, helping to promote multilateral energy cooperation. While breaking the cycle is not easy, the author argues that the transition towards sustainable energy will be essential to diversify the economy of North African oil and gas producers with more limited financial resources than wealthy Gulf nations. Against this backdrop, rather than purporting an "extractive" logic, EU-sponsored energy projects should have a strong local component and entail increased local energy use for industrial development, thereby helping to promote socio-economic sustainability.

References

Council of the European Union, *Council Conclusions on a Renewed Partnership with the Southern Neighbourhood – A New Agenda for the Mediterranean* (7931/21), Brussels, 19 April 2021, https://data.consilium.europa.eu/doc/document/ST-7931-2021-INIT/en/pdf

Wolfgang Cramer, Joël Guiot and Katarzyna Marini (eds), *Climate and Environmental Change in the Mediterranean Basin. Current Situation and Risks for the Future. First Mediterranean Assessment Report*, Mediterranean Experts on Climate and Environmental Change (MedECC), November 2020, https://www.medecc.org/?p=3506

Marianne Milano et al., "Current State of Mediterranean Water Resources and Future Trends under Climatic and Anthropogenic Changes", in *Hydrological Sciences Journal*, Vol. 58, No. 3 (2013), p. 498-518, https://doi.org/10.1080/02626667.2013.774458

Organisation for Economic Cooperation and Development (OECD), *Regional Integration in the Union for the Mediterranean. Progress Report*, Paris, OECD, May 2021, https://doi.org/10.1787/325884b3-en

Angelo Riccaboni et al. *Sustainable Development in the Mediterranean. Report 2020. Transformations to achieve the Sustainable Development Goals*, Siena, Sustainable Development Solutions Network Mediterranean (SDSN Mediterranean), 2020, http://hdl.handle.net/11365/1120952

Alexandre Tuel and Elfatih A.B. Eltahir, "Why Is the Mediterranean a Climate Change Hotspot?", in *Journal of Climate*, Vol. 33, No. 14 (2020), p. 5829-5843, https://doi.org/10.1175/JCLI-D-19-0910.1

United Nations, *Sustainable Development Goals Progress Chart 2020*, July 2020, https://sdgs.un.org/node/26443

UN Economic and Social Commission for Western Asia (UNESCWA), *Between Now and 2030: A Statistical Overview of Progress towards the Sustainable Development Goals in the Arab Region*, January 2021, https://www.unescwa.org/node/22638.

2.

The Water-Food Nexus in the Mediterranean Region: Prospects and Challenges for Sustainability

Marta Antonelli

2.1 The Mediterranean region's water challenges at a glance

The existence of humankind on Earth depends on water – a natural resource, a common good and a human right for all people in the world. Our most basic needs – drinking, eating – depend on access to safe and sufficient water resources. Over the past two decades, water availability per capita has declined by 20 per cent. While demand continues to rise, the water resource base is increasingly impaired, mismanaged and over-used. Today, about 1.2 billion people live in extremely water-scarce areas affected by water shortages – 520 millions of whom are rural, i.e., 15 per cent of the world rural population.[1] The confluence of increasing demand and shrinking supplies should prompt a sense of urgency to tackle these issues, as the global water crisis already threatens human and socio-economic development, water-related ecosystems and the ecosystem services they provide. Addressing water shortages and water scarcity is a prerequisite to achieve the 2030 Agenda for Sustainable Development and all 17 of the Sustainable Development Goals (SDGs), beyond SDG 6 that addresses the need to "ensure

[1] Food and Agriculture Organisation (FAO), *The State of Food and Agriculture 2020. Overcoming Water Challenges in Agriculture*, Rome, FAO, 2020, https://doi.org/10.4060/cb1447en.

access to water and sanitation for all".

Water has shaped the Mediterranean region's landscape, demography and development since the earliest times. Today, water is a rare resource and has already become a limiting factor for socio-economic development and a threat to human security in many countries of region. The Mediterranean basin comprises a broad variety of states, populations and cultures, encompassing three continents, i.e., the southern countries of Europe to the north, southwestern Asia to the east and the Maghreb region of North Africa to the south. The region is among the richest natural habitats in the world and is characterised by a large variety of ecosystems and species. Yet, clearly, differences in socio-economic development across the southern, eastern and northern areas are significant.[2]

The Mediterranean region is recognised as a climate change hotspot and one of the most water-challenged regions in the world,[3] with high degrees of water scarcity affecting the population.[4] The region holds about 1.2 per cent of the world's renewable water resources[5] and hosts about 7 per cent of the

[2] FAO and Plan Bleu, *State of Mediterranean Forests 2018*, Rome/Marseille, FAO/Plan Bleu, 2018, http://www.fao.org/documents/card/en/c/CA2081EN.

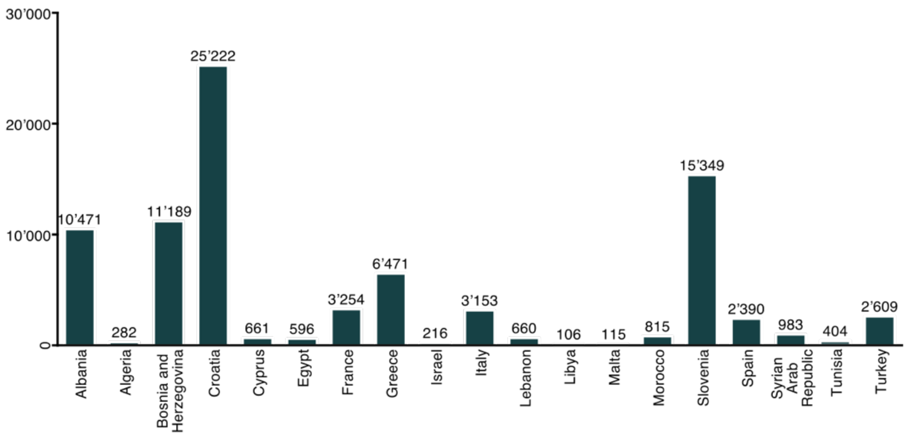
[3] Marcus Lindner et al., "Climate Change Impacts, Adaptive Capacity, and Vulnerability of European Forest Ecosystems", in *Forest Ecology and Management*, Vol. 259, No. 4 (February 2010), p. 698-709; Go-Un Kim, Kyong-Hwan Seo and Deliang Chen, "Climate Change over the Mediterranean and Current Destruction of Marine Ecosystem", in *Scientific Reports*, Vol. 9 (2019), Article 18813, https://doi.org/10.1038/s41598-019-55303-7; Alexandre Tuel and Elfatih A.B. Eltahir, "Why Is the Mediterranean a Climate Change Hotspot?", in *Journal of Climate*, Vol. 33, No. 14 (2020), p. 5829-5843, https://doi.org/10.1175/JCLI-D-19-0910.1; Wolfgang Cramer, Joël Guiot and Katarzyna Marini (eds), *Climate and Environmental Change in the Mediterranean Basin. Current Situation and Risks for the Future. First Mediterranean Assessment Report*, Mediterranean Experts on Climate and Environmental Change (MedECC), November 2020, https://www.medecc.org/?p=3506.

[4] Mesfin M. Mekonnen and Arjen Y. Hoekstra, "Four Billion People Facing Severe Water Scarcity", in *Science Advances*, Vol. 2, No. 2 (February 2016), Article e1500323, https://doi.org/10.1126/sciadv.1500323.

[5] Marianne Milano et al., "Current State of Mediterranean Water Resources and Future Trends under Climatic and Anthropogenic Changes", in *Hydrological Sciences Journal*, Vol. 58, No. 3 (2013), p. 498-518, https://doi.org/10.1080/02626667.2013.774458.

global population.[6] Water endowments are distributed very unevenly. Total renewable water resources per capita range from 25,000 m3 in Croatia to 106 m3 in Libya (Figure 1). Water deficit countries are mostly found in the southern and eastern Mediterranean basin. Jordan has long struggled with significant water scarcity,[7] while Cyprus, Egypt, Lebanon, Morocco and Syria are considered as *water poor*, as they have to cope with less than 1,000 m3 of water per capita per year. Algeria, Israel, Libya, Malta and Tunisia live with *water shortage* as they rely on less than 500 m3 of water per capita per year.[8] Additionally, seasonal water shortages are also observed, especially during summer when tourism peaks in coastal areas.

Figure 1 | Total renewable water resources per capita (m3/inhab/yr)



Source: Author's elaboration on FAO AQUASTAT.

[6] UN Environment Programme (UNEP) and Mediterranean Action Plan (MAP), "Socioeconomic Characteristics: Population and Development", in *2017 Mediterranean Quality Status Report*, February 2018, http://www.medqsr.org/node/233.

[7] See for instance, Jim Yoon et al., "A Coupled Human–Natural System Analysis of Freshwater Security under Climate and Population Change", in *PNAS*, Vol. 118, No. 14 (6 April 2021), Article e2020431118, https://doi.org/10.1073/pnas.2020431118.

[8] Data not available for Jordan and Palestine.

Currently, 44 out of 73 catchments (the area where water is collected by the natural landscape) in the Mediterranean region are under high to severe water stress, with hotspots in southern Spain, Tunisia, Libya, Syria, Lebanon, Jordan, Israel and Palestine. It has been estimated that climate change, coupled with business-as-usual water management policies, will leave all catchments in the Mediterranean under high to severe water stress by 2050, with the only exceptions being France and the Balkans. The result will be 34 million people under high water stress and 202 million under severe water stress. Climatic drivers are expected to reduce mean precipitation and groundwater availability, while increasing the frequency and duration of droughts, as well as increasing air temperatures.[9] This is likely to exacerbate freshwater scarcity, especially in arid and semi-arid catchments, and to intensify evapotranspiration conditions. The combination of climate change and population growth is likely to "expose a significant fraction of the world population to chronic or absolute water scarcity".[10] Climate change in the Mediterranean region is expected to increase irrigation water needs both for rainfed and irrigated agriculture, and to cause a general decrease in crop yields, such as maize, wheat and soybean.[11] The resulting implications range from a more intense competition between sectors (agriculture, industry, household) to possible implications in terms of food security and potential migratory flows as well as resource-based conflicts in the context of transboundary waters.

[9] Blanca E. Jiménez Cisneros and Taikan Oki (eds), "Freshwater Resources", in Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge/New York, Cambridge University Press, 2014, p. 229-269, https://www.ipcc.ch/report/ar5/wg2.

[10] Jacob Schewe et al., "Multimodel Assessment of Water Scarcity under Climate Change", in *PNAS*, Vol. 111, No. 9 (2014), p. 3245-3250 at p. 3249, https://doi.org/10.1073/pnas.1222460110.

[11] Luca Caporaso et al., "Drivers of Migration in the Trans-Mediterranean Region: The Likely Role of Climate Change and Resource Security in the Geopolitical Context", in Riccardo Valentini et al. (eds.), *Achieving the Sustainable Development Goals through Sustainable Food Systems*, Cham, Springer, 2019, p. 35-61.

Demographic processes, including population growth, unbridled urbanisation and socio-economic development, have acted as driving factors for increased water pressures in the Mediterranean region over the past decades. Population in the region grew from 281 million to 472 million between 1970 and 2010 and is expected to reach up to 572 million by 2030.[12] Demographic growth is higher in southern Mediterranean countries, e.g., Egypt and Algeria, where annual population growth rates stand at 2 per cent and 1.9 per cent respectively. While not particularly high in absolute terms, these rates remain relevant in the Mediterranean context, especially if compared with demographic trends in some countries of the northern shore such as a -0.2 per cent growth rate in Italy, 0.1 per cent in France and 0.6 per cent in Spain.[13]

To meet the requirements of a growing and increasingly urbanised population, the demand for water will increase, especially as a result of increasing food needs, but also due to additional water demands from other sectors. According to the Food and Agriculture Organisation (FAO), food production is projected to increase by 50 per cent between 2012 and 2050.[14] Rising incomes and urbanisation have been associated with a shift in dietary preferences towards higher consumption of animal-based products – which increase land requirements, energy, greenhouse gas emissions and water demand – as well as sugar, fats and oils, refined grains and processed foods.[15] Not only food production but also food consumption patterns are among the most important drivers of environmental impacts, in terms of greenhouse gas emissions, cropland use, biodiversity loss and water use.[16]

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[12] UNEP/MAP, "Socioeconomic Characteristics: Population and Development", cit.

[13] World Bank Data, *Population Growth (Annual %)*, 2019, https://data.worldbank.org/indicator/SP.POP.GROW.

[14] FAO, *The Future of Food and Agriculture – Trends and Challenges,* Rome, FAO, 2017, http://www.fao.org/3/a-i6583e.pdf.

[15] Corinna Hawkes, Jody Harris and Stuart Gillespie, "Changing Diets: Urbanization and the Nutrition Transition", in International Food Policy Research Institute (IFPRI), *2017 Global Food Policy Report*, Washington, IFPRI, 2017, p. 34-41, https://doi.org/10.2499/9780896292529_04.

[16] Walter Willet et al., "Food in the Anthropocene: The EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems", in *The Lancet Commissions*, Vol. 393, No.

Water and food are inherently connected as agriculture represents the biggest water user. At the global level, about 70 per cent of water withdrawal is for agricultural use, including food-related (directly and indirectly, e.g., the production of crops for animal feed) and non-food-related uses (e.g., textiles). In the Mediterranean countries considered in Figure 2, on average, agricultural water withdrawals stand at 52 per cent of total water withdrawals, while 19 per cent is for industry and 29 per cent for households. Importantly, the proportion of water devoted to agricultural use ranges from 75 per cent to almost 88 per cent of total water withdrawals in a number of water-challenged countries, such as Tunisia, Egypt, Libya, Syria and Morocco. Water is used by agriculture to satisfy crop water requirements, defined "as the depth (or amount) of water needed to meet the water loss through evapotranspiration" or, "the amount of water needed by the various crops to grow optimally".[17] Besides precipitation, additional water is often required to meet crop water requirements, by means of irrigation from superficial and groundwater sources. Irrigation water is critical to secure the livelihoods of rural populations in a number of Mediterranean water-poor countries, where a substantial proportion of the population is rural, e.g., Egypt (57 per cent), Syria (45 per cent), Morocco (37 per cent) and Tunisia (31 per cent).[18] Moreover, in some cases, rural population is still growing (+1.9 per cent per year in Egypt).[19]

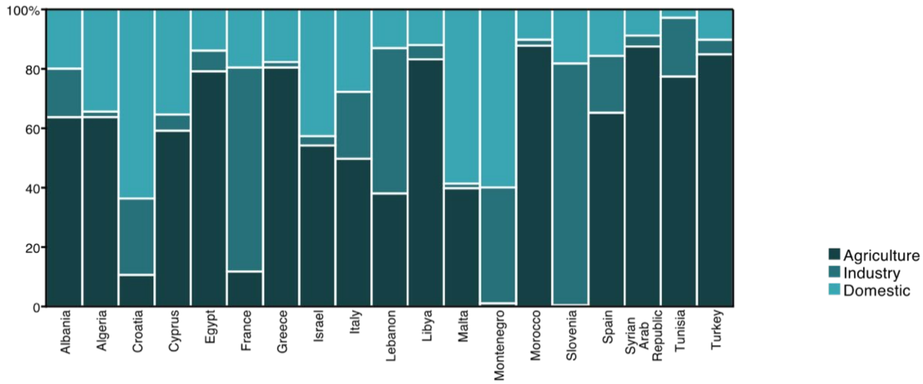
10170 (2 February 2019), p. 447-492.

[17] C. Brouwer and M. Heibloem, "Irrigation Water Needs", in *Irrigation Water Management Training Manuals*, No. 3, Rome, FAO, 1986, http://www.fao.org/3/s2022e/s2022e07.htm.

[18] World Bank Data, *Rural Population (% of Total Population)*, https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS.

[19] World Bank Data, *Rural Population Growth (Annual %)*, https://data.worldbank.org/indicator/SP.RUR.TOTL.ZG.

Figure 2 | Water use by sector in the Mediterranean countries



Source: Author's elaboration based on FAO AQUASTAT.

Future water prospects should also take into account the role of tourism, a major pillar of Mediterranean economies. Mediterranean basin countries are the world's leading destinations of international tourism, especially for France, Spain and Italy (representing 58 per cent of total arrivals in the region), as well as Greece and Turkey. Tourism accounted for 342 million arrivals and 30 per cent of total international arrivals globally in 2014, with an earning of 247 billion euro.[20] Water use from tourism is still relatively low, with peaks in the summer season and a spatial concentration in coastal areas and islands, often characterised by water deficits. However, with almost 500 million international tourist arrivals expected in 2030, the competition over water resources between sectors (agriculture, industry, household) will intensify.[21]

To sum up, the way Mediterranean societies allocate, use and manage water resources in agriculture today will determine the extent to which communities, and the ecosystems they depend upon, will continue to thrive and be able to nourish their population in the future. Long-dis-

[20] UN World Tourism Organization (UNWTO), "Tourism in the Mediterranean, 2015 edition", in *UNWTO Tourism Trends Snapshots*, February 2016, https://www.e-unwto.org/doi/book/10.18111/9789284416929

[21] UNEP/MAP, *2017 Mediterranean Quality Status Report*, cit.

tance water transfers by means of new infrastructures cannot respond to the need for water in the long term; and the use of unconventional water resources, such as desalination, is still very costly (currently only a few Mediterranean countries, such as Morocco, Israel and Spain use desalinated water in agriculture). Producing through the sustainable intensification of agriculture – i.e. "adopting practices along the entire value chain of the global food system that meet rising needs for nutritious and healthy food through practices that build social–ecological resilience and enhance natural capital within the safe operating space of the Earth system"[22] – is the way forward. Other important measures include reducing water losses, increasing efficiency of irrigation systems, shifting towards drought-tolerant crops and adopting deficit irrigation systems. According to one study, efficient irrigation systems can save to up to 35 per cent of agricultural water withdrawn in the region (about 223 km3 per year).[23]

Precision agriculture is among the most promising technologies that can pave the way for more sustainable agriculture by promoting natural resource stewardship and can also increase profits. It can be defined as an approach in which agricultural management is performed at the most effective place and time and at an appropriate intensity.[24] Through the use of artificial intelligence, sensors, the Internet of Things, robotics, blockchain and data, precision agriculture aims at increasing the quality and quantity of agricultural output while using less inputs – water, seeds, pesticides, fertilizers, etc. – thereby improving farm productivity and profitability, and reduc-

[22] Johan Röckstrom et al., "Sustainable Intensification of Agriculture for Human Prosperity and Global Sustainability", in *Ambio*, Vol. 46, No. 1 (February 2017), p. 4-17 at p. 7, https://doi.org/10.1007/s13280-016-0793-6.

[23] Marianela Fader et al., "Mediterranean Irrigation under Climate Change: More Efficient Irrigation Needed to Compensate for Increases in Irrigation Water Requirements", in *Hydrology and Earth System Sciences*, Vol. 20, No. 2 (2016), p. 953-973, https://doi.org/10.5194/hess-20-953-2016; Marianela Fader et al., "Modelling Mediterranean Agro-ecosystems by Including Agricultural Trees in the LPJmL Model", in *Geoscientific Model Development*, Vol. 8, No. 11 (2015), p. 3545-3561, https://doi.org/10.5194/gmd-8-3545-2015.

[24] Wouter H. Maes and Kathy Steppe, "Perspectives for Remote Sensing with Unmanned Aerial Vehicles in Precision Agriculture", in *Trends in Plant Science*, Vol. 24, No. 2 (February 2019), p. 152-164.

ing environmental impacts. For instance, precision agriculture tools can significantly reduce the use of those inputs that are responsible for greenhouse gas emissions; adopting drip irrigation systems can cut agricultural water use up to 60 per cent compared with sprinkler irrigation[25] (refer to chapter three in this volume for more on such practices and their potential benefits for sustainability).

Building on this premise, a number of projects in the Mediterranean are promoting solutions for more sustainable water management. For instance, FIT4REUSE (Safe and sustainable solutions for the integrated use of non-conventional water resources in the Mediterranean agricultural sector), a project involving actors from both north- and south-rim Mediterranean countries (Italy, Spain, France, Tunisia, Turkey and Israel), explores innovative, sustainable and safe water treatment technologies experimenting with reuse of treated wastewater and desalinated water in agriculture and for aquifer recharge. The project's broader ambition is indeed to develop further solutions to extend wastewater reuse to the overall basin.[26]

2.2 Food security, water security and virtual water trade

In 2009, the UN Committee on Food Security stated that "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life".[27] In the Mediterranean region, as well as in many areas of the world, food security is strictly interrelated with water security and agricultural commodity trade. Water is in fact a fundamental factor of production embedded in agricultural products. Consistently with international trade theory, commodity trade can be seen an implicit exchange in the factors of production, included water, i.e., as a virtual water trade. Food-water accounts for about 90 per cent of

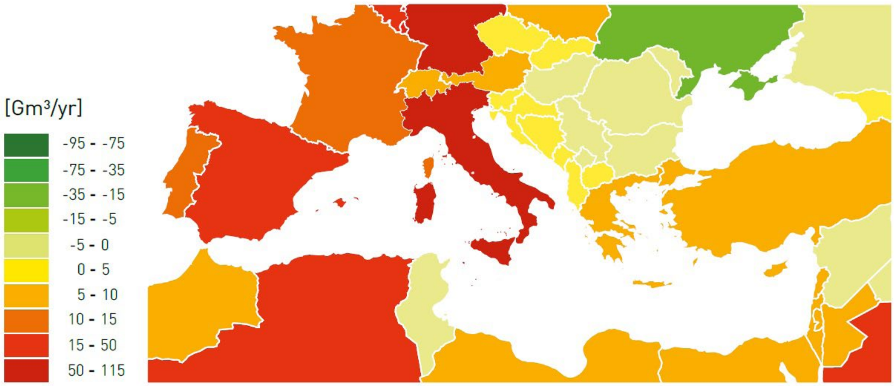
[25] Centre for European Policies Studies (CEPS) and Barilla Center for Food and Nutrition (BCFN), *Digitising Agrifood. Pathway and Challenges*, Parma, BCNF, November 2019, https://www.barillacfn.com/en/publications/digitising-agrifood.

[26] FIT4REUSE website: https://fit4reuse.org.

[27] FAO Committee on Food Security, *Reform of the Committee on World Food Security*, October 2009, p. 1, http://www.fao.org/documents/card/en/c/1d25dcd8-261c-5c88-9f47-fa586c5fdf96.

the water used consumptively by individuals, making clear why water and food security are closely interlinked.[28]

Figure 3 | Net virtual water imports in the Mediterranean region



Source: Marianela Fader and Carlo Giupponi (eds), "Water", in Wolfgang Cramer, Joël Guiot and Katarzyna Marini (eds), *Climate and Environmental Change in the Mediterranean Basin. Current Situation and Risks for the Future. First Mediterranean Assessment Report*, Mediterranean Experts on Climate and Environmental Change (MedECC), November 2020, p. 181-236 at p. 214, https://www.medecc.org/?p=3506.

Food security in a number of Mediterranean countries is highly dependent on virtual water trade. European countries are net virtual water importers (as imports exceed exports) from the rest of the world. Two northern Mediterranean countries (Italy and France) are among the five that account for 60 per cent of total virtual water imports (together with Germany, the Netherlands and Belgium).[29] Most Mediterranean countries are virtual water net importers (Figure 3) and much of the intra-regional virtual water trade occurs between the largest northern countries, namely, Spain, France and Italy.[30]

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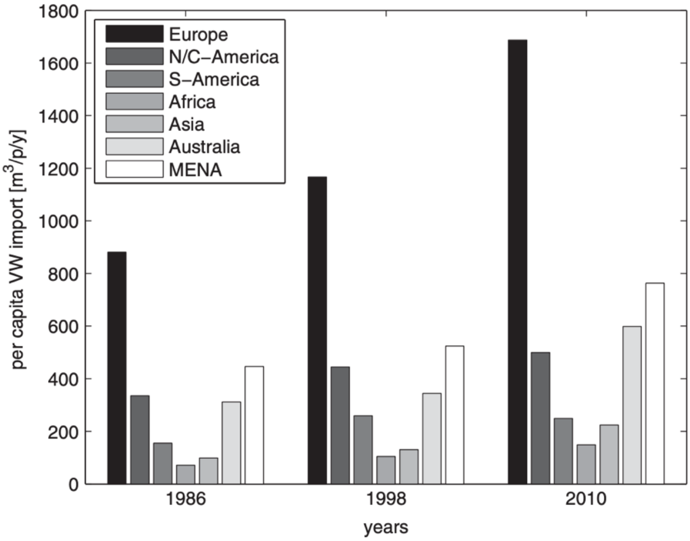
[28] J.A. (Tony) Allan, "Water and Food Security: Food-water and Food Supply Value Chains", in Marta Antonelli and Francesca Greco (eds), *The Water We Eat*, Cham, Springer, 2015, p. 17-34.

[29] Marta Antonelli, Stefania Tamea and Hong Yang, "Intra-EU Agricultural Trade, Virtual Water Flows and Policy Implications", in *Science of the Total Environment*, Vol. 587-588 (June 2017), p. 439-448.

[30] Roberto Roson and Martina Sartori, "Virtual Water Trade in the Mediterranean: Today and Tomorrow", in Marta Antonelli and Francesca Greco (eds), *The Water We Eat*, Cham, Springer, 2015, p. 159-174; Mesfin M. Mekonnen and Arjen Y. Hoekstra, "National

Against this backdrop, average virtual water imports in Europe and the Middle East and North Africa are the highest in the world and have been increasing over the past decade. According to the most recent data available, in 2010 imports were respectively 1,700 m3 cap-1 yr-1 and 601 m3 cap-1 yr-1 (Figure 4).

Figure 4 | Virtual water imports in different regions in the world



Source: Marta Antonelli and Stefania Tamea, "Food-Water Security and Virtual Water Trade in the Middle East and North Africa", in *International Journal of Water Resources Development*, Vol. 31, No. 3 (2015), p. 326-342 at p. 331.

Southern and eastern Mediterranean economies are highly dependent on food imports and especially cereals – both for human consumption and for feeding livestock – which make the largest contribution to the average per capita water footprint for consumption (27 per cent), followed by meat (22 per cent).[31] Import dependency ratios in the south Mediterranean

Water Footprint Accounts: The Green, Blue and Grey Water Footprint of Production and Consumption", in *Value of Water Research Report Series*, No. 50 (May 2011), https://waterfootprint.org/media/downloads/Report50-NationalWaterFootprints-Vol1_1.pdf; Marianela Fader and Carlo Giupponi (eds), "Water", cit.

[31] Arjen Y. Hoekstra and Mesfin M. Mekonnen, "The Water Footprint of Humanity",

range from 44 per cent in Egypt to over 99 per cent in Lebanon (Table 1). Dependency on food imports – and therefore virtual water trade – has exposed the Mediterranean economies to a number of shocks (including the covid-19 trade disruptions), in terms of import fluctuations and price volatility at the international, national and household levels. Moreover, as the 2007–2008 food price spikes demonstrated, food security is intertwined with social stability. Political upheavals and social unrest resulted in economic slowdowns (and vice versa), which in turn impacted the capacity to pay for food imports, with implications for long-term food security and sustainability. This is to say that, although reliance on food imports has supported food security in the region, it has also led to new unintended challenges linked to price volatility and exposure to import dependence, thus threatening long-term food security as well as potentially increasing threats to social stability and sustainability.

Although food self-sufficiency is not a feasible option for many economies in the region, there is room for improvement. In the medium and long run, food security strategies will require new approaches to agricultural and rural development policies in order to increase agricultural productivity and farmers' income, engage youth in farming, improve natural resource management and adapt to climate change conditions. For instance, the production, marketing and distribution of high value crops – such as olives and olive oil, and more generally fruits and vegetables – have large potential for improvement to benefit national economies, employment and food security outcomes.[32]

in *PNAS*, Vol. 109, No. 9 (28 February 2012), p. 3232-3237, https://doi.org/10.1073/pnas.1109936109.

[32] Aysen Tanyeri-Abur, "Food Security in the Southern Mediterranean/North Africa", in Antonella Vastola (ed.), *The Sustainability of Agro-Food and Natural Resource Systems in the Mediterranean Basin*, Cham, Springer, 2015, p. 3-14, https://doi.org/10.1007/978-3-319-16357-4_1.

Table 1 | Cereal import dependency ratio (2015–2017)

Albania	37.5
Algeria	76.1
Cyprus	91.7
Egypt	44.6
France	-107.1
Greece	25.8
Israel	89
Italy	33.4
Jordan	98
Lebanon	99.5
Malta	85.2
Montenegro	93.5
Morocco	54.2
Slovenia	28.4
Spain	38.7
Tunisia	71.1
Turkey	1

Note: The table is based on data availability. Palestine is not included due to the absence of available data.
Source: Author's elaboration based on FAOSTAT, *Cereal Import Dependency Ratio*.

As stated by the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), southern and eastern Mediterranean countries can address their food security issues, which have now been further exacerbated by the covid-19 pandemic, via five main actions: 1) ensuring water security to sustain inclusive economic growth; 2) establishing rural development policies and programmes; 3) prioritising the need to tackle food insecurity of marginalised and poor communities; 4) avoiding disruptions and promoting innovation in food supply chains; and 5) supporting agricultural production through technical and institutional innovation, as well as research.[33]

[33] Michel Petit et al., *The Covid-19 Pandemic: Threats on Food Security in the Mediterranean Region*, International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), July 2020, https://www.ciheam.org/?p=6830.

2.3 Reconnecting water and food through sustainable diets

Water and food security, environmental sustainability, health and dietary patterns are inextricably connected. Understanding how they influence one another is pivotal for the future of Mediterranean societies, economies and ecosystems. The two end points of the food system – namely, agricultural production and food consumption – have enormous impacts on human and planetary health, including water resources, and can thus work as powerful leverages to improve both.

The Mediterranean dietary model is based on the consumption of high amounts of olive oil and olives, fruits, vegetables, cereals (mostly unrefined), legumes and nuts, moderate amounts of fish and dairy products and low quantities of meat and meat products. It constitutes "a set of skills, knowledge, practices and traditions ranging from the landscape to the table, including the crops, harvesting, fishing, conservation, processing, preparation and, particularly, consumption of food".[34]

The Mediterranean diet has undergone a progressive evolution over the past 50 years, from being recognised as a dietary model for health and longevity, to representing a sustainable dietary pattern. Several studies across different countries have shown that a diet consistent with the Mediterranean dietary pattern is associated with a longer lifespan and a lower risk of non-communicable diseases (NCDs), such as cancer[35] and cardiovascular diseases.[36] This is consistent with a strong body of evidence documenting the impacts that dietary choices can have on NCDs, the main cause of death and disability at the global level according to an analysis on 195 countries

[34] Alexandre Meybeck et al. (eds), *Development of Voluntary Guidelines for the Sustainability of the Mediterranean Diet in the Mediterranean Region. Proceedings of a Technical Workshop*, Rome/Bari, FAO and CIHEAM, 2017, p. 137, http://www.fao.org/3/a-i7557e.pdf.

[35] Lukas Schwingshackl and Georg Hoffmann, "Adherence to Mediterranean Diet and Risk of Cancer: An Updated Systematic Review and Meta-Analysis of Observational Studies", in *Cancer Medicine*, Vol. 4, No. 12 (December 2015), p. 1933-1947, https://doi.org/10.1002/cam4.539.

[36] Esther Lopez-Garcia, et al., "The Mediterranean-Style Dietary Pattern and Mortality among Men and Women with Cardiovascular Disease", in *The American Journal of Clinical Nutrition*, Vol. 99, No. 1 (January 2014), p. 172-180, https://doi.org/10.3945/ajcn.113.068106.

between 1990 and 2017[37] as well as a recent review of meta-analyses.[38] Paradoxically, current dietary trends in the region show a general abandonment of the Mediterranean diet[39] with overweight, obesity and food-related chronic diseases coexisting[40] due to multifactorial influences including lifestyles changes, food globalisation as well as socio-cultural factors.

In 2010, the FAO cited the Mediterranean diet as an exemplary Sustainable Diet.[41] Since 2011, the FAO and CIHEAM-Bari have established the Mediterranean diet as a joint case study to be leveraged for more sustainable food production and consumption patterns in the region. As a mainly plant-based dietary pattern, the Mediterranean diet is associated with a reduction in diet-related greenhouse gas emissions.[42] Figure 5 shows the Mediterranean Double Pyramid, a diagram that demonstrates how adopting a healthy diet can also provide significant benefits for the environment, by reducing carbon footprints. The Health Pyramid (left) shows that cereals, preferably wholegrain, should be present in every meal, due to their higher fiber, vitamin and mineral content, together with seasonal vegetables and extra-virgin olive oil, a cornerstone of the Mediterranean diet and a fundamental product for the economy and environmental heritage. Fruit should

[37] Ashkan Afshin et al., "Health Effects of Dietary Risks in 195 Countries, 1990–2017: A Systematic Analysis for the Global Burden of Disease Study 2017", in *The Lancet*, Vol. 393, No. 10184 (11 May 2019), p. 1958-1972, https://doi.org/10.1016/S0140-6736(19)30041-8.

[38] Ahmad Jayedi et al., "Healthy and Unhealthy Dietary Patterns and the Risk of Chronic Disease: An Umbrella Review of Meta-Analyses of Prospective Cohort Studies", in *British Journal of Nutrition*, Vol. 124, No. 11 (14 December 2020), p. 1133-1144.

[39] Sandro Dernini and Elliott M. Berry, "Mediterranean Diet: From a Healthy Diet to a Sustainable Dietary Pattern", in *Frontiers in Nutrition*, Vol. 2 (May 2015), Article 15, https://doi.org/10.3389/fnut.2015.00015.

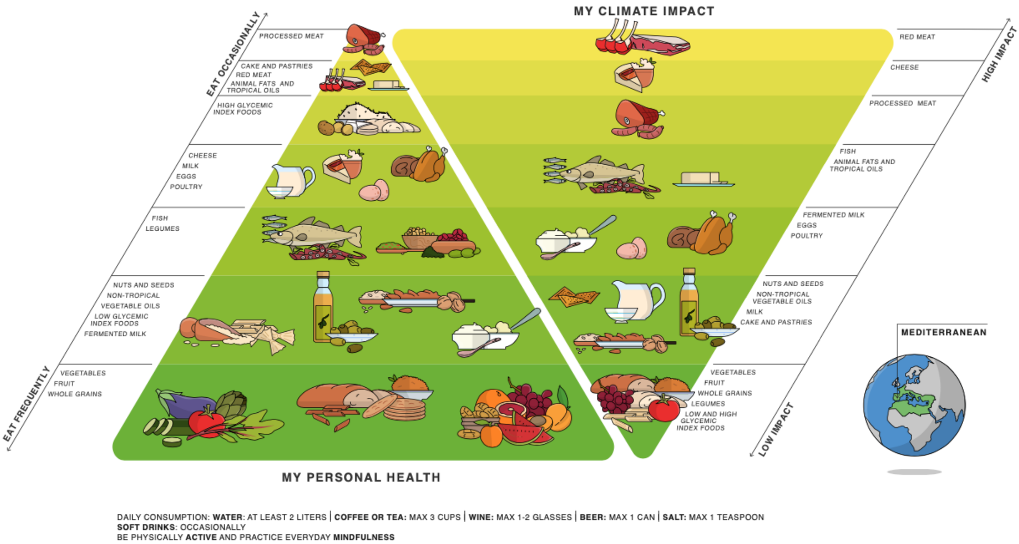
[40] Rekia Belahsen, "Nutrition Transition and Food Sustainability", in *Proceedings of the Nutrition Society*, Vol. 73, No. 3 (2014), p. 385-388, https://doi.org/10.1017/S0029665114000135.

[41] Barbara Burlingame and Sandro Dernini (eds), *Sustainable Diets and Biodiversity. Directions and Solutions for Policy, Research and Action*, Rome, FAO, 2012, http://www.fao.org/3/i3004e/i3004e00.htm.

[42] Marilena Vitale et al., "Recent Trends in Dietary Habits of the Italian Population: Potential Impact on Health and the Environment", in *Nutrients*, Vol. 13, No. 2 (2012), Article 476, https://doi.org/10.3390/nu13020476.

be considered as the primary form of dessert or snack. Legumes and fish are the main sources of protein, while poultry, eggs and dairy are consumed in moderation. The Climate Pyramid (right) shows that the production of animal-based products –especially red meat, followed by cheese, processed meat, fish, poultry, eggs and dairy products – makes the highest contribution to climate change, while plant-based products make the smallest.[43] Water footprints can also be reduced by adopting a Mediterranean dietary pattern.[44]

Figure 5 | The Mediterranean Double Pyramid



Source: BCFN and University Federico II of Naples, *A One Health Approach to Food*, cit., p. 38-39.

[43] Barilla Center for Food and Nutrition (BCFN) and University Federico II of Naples, *A One Health Approach to Food. The Double Pyramid Connecting Food Culture, Health and Climate*, Parma, BCFN, April 2021, https://www.barillacfn.com/en/publications/a-one-health-approach-to-food.

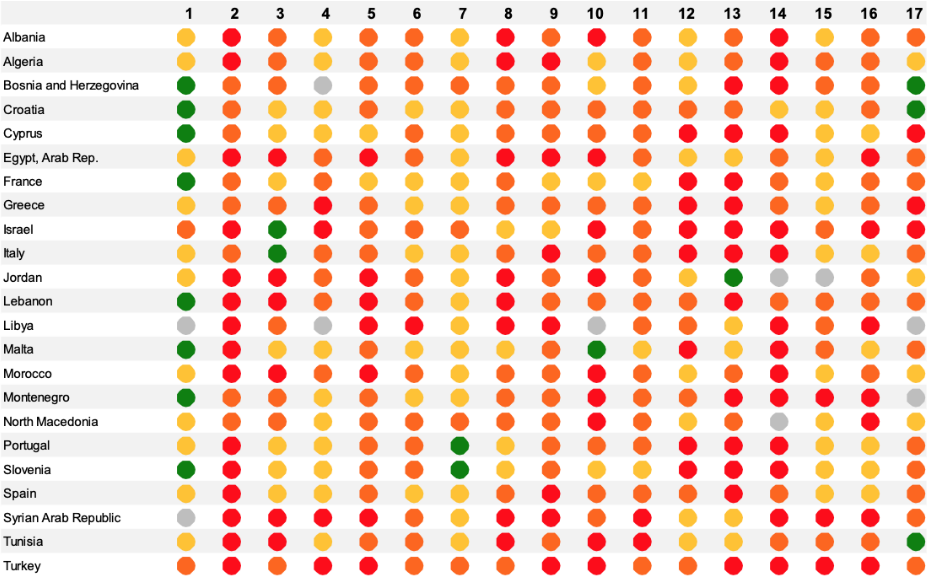
[44] David Tilman and Michael Clark, "Global Diets Link Environmental Sustainability and Human Health", in *Nature*, Vol. 515 (2014), p. 518-522.

Addressing water shortages and water scarcity is a prerequisite to achieve the 17 SDGs. Mediterranean countries are generally not on track on achieving the SDGs (Figure 6), with an average value of the SDG Index (71.6/100), which would locate the region around the 49th position in the global ranking. Alarming performances particularly concern biodiversity protection, including SDG 14 (life below water), SDG 15 (life on land); social integration, including SDG 5 (gender equality), SDG 10 (reduced inequality); and sustainable agriculture and diets, including SDG 2 (zero hunger) due to unsustainable agricultural practices as well as unhealthy diets. Compared to the rest of the world, Mediterranean countries perform better in socio-economic SDGs, such as SDG 1 (no poverty), SDG 3 (good health and well-being) and SDG 4 (quality education).[45] This calls for new approaches to food systems, as recognised by the Farm to Fork Strategy[46] which is an integral part of the European Green Deal to decarbonise the European Union by 2050. Launched in May 2020, the Farm to Fork Strategy is the first EU-wide policy that seeks to build fair, healthy, resilient and environmentally friendly food systems with a multidimensional and comprehensive approach that conceives food as a lever to boost lifestyles, health, the environment and the economy. More specifically, the strategy calls for reducing dependency on pesticides and antimicrobials, as well as excess fertilisation, increasing organic farming, improving animal welfare and reversing biodiversity loss; shifting diets to reduce non-communicable diseases; improving the incomes of primary producers and boosting competitiveness through food sustainability.

[45] Jeffrey D. Sachs et al., *Sustainable Development Report 2019. Mediterranean Countries Edition*, Siena, Sustainable Development Solutions Network Mediterranean (SDSN Mediterranean), 2019, https://www.sdsn-mediterranean.unisi.it/?p=1290.

[46] European Commission website: *Farm to Fork Strategy*, https://ec.europa.eu/food/farm2fork_en.

Figure 6 | SDG dashboard for Mediterranean countries



Legend: Green = on track or maintaining SDG achievement; Yellow = moderately improving; Orange = stagnating; Red = decreasing; Grey = information not available.
Source: Jeffrey D. Sachs et al., *Sustainable Development Report 2019*, cit., p. 19.[47]

2.4 Conclusion and policy recommendations

In 2005, the UNEP Mediterranean Strategy on Sustainable Development stated that

> agricultural and rural models, which are at the origins of Mediterranean identity, are under increasing threat from the predominance of imported consumption patterns. This trend is illustrated in particular by the decline of the Mediterranean dietary model despite the recognized positive effects on health. The prospective scenario for the expected impacts of trade liberalization, climate change and the lack of efficient rural policies offers a gloomy picture in some southern and eastern Mediterranean countries, with

[47] As explained in Sachs et al., the SDG dashboard focuses on the two worst indicators under each goal.

> the prospect of aggravated regional imbalances, deeper ecological degradation and persistent or accrued social instability.[48]

Even if made 16 years ago, this forecast still summarises the most pressing contemporary challenges faced by the Mediterranean food systems.

Addressing the inter-linkages between climate change, water scarcity and food will be the defining issue of the 21st century for the Mediterranean region, a climate change hotspot already characterised by water scarcity and shortage, with an increasingly urbanised population that is experiencing a nutrition transition with a shift in dietary preferences towards water-intensive food products. Unlocking the potential of food systems through more sustainable agricultural systems as well as through the promotion of sustainable and healthy diets, can lead to win-win solutions for people and the planet. This process fundamentally requires the uptake of more sustainable agricultural practices, a shift towards plant-based diets – consistent with the Mediterranean dietary model, recognised as an exemplary healthy and sustainable diet – as well as the reduction of food loss and food waste. Accelerating the transformation of food systems has the potential to catalyse progress in a number of SDGs, from SDG 2 (zero hunger) to SDG 12 (sustainable production and consumption) and SDG 13 (climate action) in the Mediterranean region.

Tackling the water-food nexus in the Mediterranean region will require strong political will, responsible institutions, effective governance and policy coherence to guarantee both water, food and nutrition security, while preserving ecosystems. A number of recommendations are provided below in an effort to pave the way towards more sustainable water and food systems in the Mediterranean context.

Developing a water risk assessment based on sound water accounting can inform integrated policies and interventions. Addressing water scarcity requires a common understanding of the status of water resources at the

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[48] UNEP/MAP, *Mediterranean Strategy for Sustainable Development. A Framework for Environmental Sustainability and Shared Prosperity*, approved by the Tenth Meeting of the Mediterranean Commission on Sustainable Development (MCSD), Athens, June 2005, p. 19, https://wedocs.unep.org/handle/20.500.11822/641.

Mediterranean level, as well as an assessment of future trends in supply (especially with regard to the impact of climate change), demand and accessibility, as well as virtual water trade. This is key to improving water resource management in agriculture and to attaining multiple SDGs. The project eGROUNDWATER (2020–2024) aims to fill this gap by focusing on developing enhanced information systems for groundwater assessment, modelling and sustainable participatory management, also through innovative data gathering techniques such as earth observation systems (drones, remote sensing), automatic sensors (soil moisture capacitance FDR, surface renewal), use of tools based on information and communication technologies (e.g., mobile apps) and the engagement of citizens and stakeholders in measurement collection (citizen science). The project involves partners from Morocco, Algeria, Portugal, Spain and France.[49]

Bridging science and innovation, especially by fostering cooperation between northern, eastern and southern Mediterranean countries. The Partnership on Research and Innovation in the Mediterranean Area (PRIMA) is a ten-year initiative (2018–2028), partly funded by the EU's research and innovation programme Horizon 2020, in order to develop solutions for sustainable management of water and agri-food systems in the Mediterranean basin, in particular favouring north-south cooperation among Mediterranean states. Since its inception, 129 projects (165 million euro) have been funded in southern Mediterranean countries, 31 of which (42 million euro) specifically target sustainable water resource management. The recently launched platform "PRIMA Observatory on Innovation" collects best practices in the Mediterranean countries focusing on farming systems, agri-food value chains and sustainable water management.[50] The project WATERMED 4.0 explores the water-food nexus by developing and applying an integrated decision support system based on the Internet of Things for managing the water cycle in agriculture and monitoring water demand, including measurement

[49] eGROUNDWATER website: https://egroundwater.com. The eGROUNDWATER project is part of the PRIMA programme supported by the European Union's Horizon 2020 research and innovation programme.

[50] PRIMA Observatory on Innovation website: https://primaobservatory.unisi.it/en/projects.

of economic, energy, social and governance factors that influence agricultural water use efficiency. The project involves partners from Spain, Algeria, Germany, Morocco and Turkey.[51]

Making the most of technology-based solutions to produce "more with less", promoting training and capacity building programmes and making finance available for their uptake. Precision agriculture, smart irrigation and e-agriculture can contribute to enhancing the resilience of food systems, while coping with the impact of global changes on agriculture and food security. There is a positive relationship between education and productivity in the agricultural sector. For instance, technological knowledge and skills – including the use of robots and processed data, notions of computer science, advanced machinery (auto-steered equipment, drones) and complex apps (RTK, Satellite imagery) – are key for the adoption of precision agriculture. The examples provided show that connectivity is an essential precondition to digitise the agriculture sector. Therefore, wide coverage and low cost of deployment and maintenance need to be ensured.

Fostering collaboration to establish a common vision for Mediterranean food systems, taking into account the common challenges that countries in the region face in terms of nutritional challenges, water scarcity and climate change. The Farm to Fork strategy, launched in May 2020 by the European Commission, is at the core of the European Green Deal and lays the groundwork for integrated and coordinated action across different areas and policies, to make EU food systems healthier, more sustainable, resilient and equitable.[52] To address the lack of a common vision around a Mediterranean food system, the Euro-Mediterranean Regional and Local Assembly (ARLEM) has recently suggested that the European Union and the Union for the Mediterranean should develop a macro-regional strategy for food security in the Mediterranean.[53]

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[51] Project WATERMED 4.0 website: https://www.watermed-project.eu.

[52] European Commission, *Farm to Fork Strategy*, cit.

[53] Agnès Rampal, *Draft Report on Agriculture and Food Security in the Context of Climate Change in the Mediterranean*, Euro-Mediterranean Regional and Local Assembly (ARLEM), 23 February 2021, https://knowledge4policy.ec.europa.eu/node/40846.

Strengthening the Mediterranean diet as a lever for human health and sustainability can contribute to achieving water, food and nutrition security, while revitalising social and cultural dimensions. Transdisciplinary research on the Mediterranean diet is needed to link nutrition, health, agriculture, food sciences, social sciences, economics and environmental science. The development of region-wide “voluntary guidelines for the sustainability of the Mediterranean diet and lifestyle” can also contribute to its revitalisation, as well as the inclusion of sustainability concerns in food-based dietary guidelines. Currently, there is no national dietary guideline in the Mediterranean that integrates the nutrition-environment dimensions.

Increase coordination and policy coherence across food, water, agriculture, health, energy and development. A number of the SDGs can be achieved only by recognising the interconnectedness between different sectors. For instance, SDG Target 6.4 on water use and scarcity (“By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity”) has a strong link to SDG Target 2.4 (“By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality”). Morocco, for example, is addressing the water-food-energy nexus through a new integrated governance approach being tried in an over-exploited aquifer in Berrechid Province, where the FAO is supporting the Water Basin Agency to strengthen trust and collaboration between different stakeholders to manage food and energy demand for water.[54]

Improve water governance between national, regional and local stakeholders to promote more sustainable water management in agriculture. Strengthening water governance as “the processes, actors and institutions in decision-making on water resources and delivery of water

[54] FAO, *The State of Food and Agriculture 2020*, cit., p. 90-93.

services, encompassing political, administrative, social and economic domains along with formal and informal systems and mechanisms”[55] is key for the region’s food and nutrition security. The recently funded MAGO project will test novel participatory processes for better water and innovation governance, with experiments in Tunisia, Spain, France and Lebanon. It is aimed at improving integrated water resource management, water use efficiency in agriculture, the use of alternative water resources and climate change adaptation through a novel participatory approach with end-users and stakeholders and a new online collaborative platform for researchers and entrepreneurs for delivering web applications.

Foster food security through actions at the national, regional and international level. As summarised by Tanyeri-Abur, interventions at the national level include: sustainable improvements in productivity (inputs, technology, extension); promotion of efficient supply chains (reduce waste, better logistics); targeted safety nets for the most vulnerable; better management of risks associated with high import dependency (food reserves, futures contacts); improvement in employment prospects in agriculture, particularly for the young. At the regional level: cooperation in policies affecting pricing of common resources; cooperation in harmonising trade policies; strengthening infrastructure in the region; improve market information systems and coordination of action to respond to world market volatility. At the international level: countering market volatility through new financing mechanisms.[56]

To conclude, food is one of the main human requirements and water availability is a prerequisite to nourish present as well as future generations. Water for food security in the Mediterranean is at stake and will require systemic thinking, sustainable agricultural practices, the reduction of food waste and the promotion of healthier and less water-intensive diets.

[55] Ibid., p. 87.

[56] Aysen Tanyeri-Abur, “Food Security in the Southern Mediterranean/North Africa”, cit., p. 13.

References

Ashkan Afshin et al., "Health Effects of Dietary Risks in 195 Countries, 1990–2017: A Systematic Analysis for the Global Burden of Disease Study 2017", in *The Lancet*, Vol. 393, No. 10184 (11 May 2019), p. 1958-1972, https://doi.org/10.1016/S0140-6736(19)30041-8

J.A. (Tony) Allan, "Water and Food Security: Food-water and Food Supply Value Chains", in Marta Antonelli and Francesca Greco (eds), *The Water We Eat*, Cham, Springer, 2015, p. 17-34

Marta Antonelli and Stefania Tamea, "Food-Water Security and Virtual Water Trade in the Middle East and North Africa", in *International Journal of Water Resources Development*, Vol. 31, No. 3 (2015), p. 326-342

Marta Antonelli, Stefania Tamea and Hong Yang, "Intra-EU Agricultural Trade, Virtual Water Flows and Policy Implications", in *Science of the Total Environment*, Vol. 587-588 (June 2017), p. 439-448

Barilla Center for Food and Nutrition (BCFN) and University Federico II of Naples, *A One Health Approach to Food. The Double Pyramid Connecting Food Culture, Health and Climate*, Parma, BCFN, April 2021, https://www.barillacfn.com/en/publications/a-one-health-approach-to-food

Rekia Belahsen, "Nutrition Transition and Food Sustainability", in *Proceedings of the Nutrition Society*, Vol. 73, No. 3 (2014), p. 385-388, https://doi.org/10.1017/S0029665114000135

C. Brouwer and M. Heibloem, "Irrigation Water Needs", in *Irrigation Water Management Training Manuals*, No. 3, Rome, FAO, 1986, http://www.fao.org/3/s2022e/s2022e07.htm

Barbara Burlingame and Sandro Dernini (eds), *Sustainable Diets and Biodiversity. Directions and Solutions for Policy, Research and Action*, Rome, FAO, 2012, http://www.fao.org/3/i3004e/i3004e00.htm

Luca Caporaso et al., "Drivers of Migration in the Trans-Mediterranean Region: The Likely Role of Climate Change and Resource Security in the Geopolitical Context", in Riccardo Valentini et al. (eds.), *Achieving the Sustainable Development Goals through Sustainable Food Systems*, Cham, Springer, 2019, p. 35-61

Centre for European Policies Studies (CEPS) and Barilla Center for Food and Nutrition (BCFN), *Digitising Agrifood. Pathway and Challenges*, Parma, BCNF, November 2019, https://www.barillacfn.com/en/publications/digitising-agrifood

Wolfgang Cramer, Joël Guiot and Katarzyna Marini (eds), *Climate and Environmental Change in the Mediterranean Basin. Current Situation and Risks for the Future. First Mediterranean Assessment Report*, Mediterranean Experts on Climate and Environmental Change (MedECC), November 2020, https://www.medecc.org/?p=3506

Sandro Dernini and Elliott M. Berry, "Mediterranean Diet: From a Healthy Diet to a Sustainable Dietary Pattern", in *Frontiers in Nutrition*, Vol. 2 (May 2015), Article 15, https://doi.org/10.3389/fnut.2015.00015

Economist Intelligence Unit (EIU) and Barilla Center for Food & Nutrition (BCFN), *Food Sustainability Index*, November 2018, https://foodsustainability.eiu.com

Eurostat, "MEDSTAT II: 'Water and Tourism' Pilot Study", in *Eurostat Methodologies and Working Papers*, 2009, https://europa.eu/!ffG4KJ

Marianela Fader and Carlo Giupponi (eds), "Water", in Wolfgang Cramer, Joël Guiot and Katarzyna Marini (eds), *Climate and Environmental Change in the Mediterranean Basin. Current Situation and Risks for the Future. First Mediterranean Assessment Report*, Mediterranean Experts on Climate and Environmental Change (MedECC), November 2020, p. 181-236, https://www.medecc.org/?p=3506

Marianela Fader et al., "Mediterranean Irrigation under Climate Change: More Efficient Irrigation Needed to Compensate for Increases in Irrigation Water Requirements", in *Hydrology and Earth System Sciences*, Vol. 20, No. 2 (2016), p. 953-973, https://doi.org/10.5194/hess-20-953-2016

Marianela Fader et al., "Modelling Mediterranean Agro-ecosystems by Including Agricultural Trees in the LPJmL Model", in *Geoscientific Model Development*, Vol. 8, No. 11 (2015), p. 3545-3561, https://doi.org/10.5194/gmd-8-3545-2015

Food and Agriculture Organisation (FAO), *The Future of Food and Agriculture – Trends and Challenges,* Rome, FAO, 2017, http://www.fao.org/3/a-i6583e.pdf

Food and Agriculture Organisation (FAO), *The State of Food and Agriculture 2020. Overcoming Water Challenges in Agriculture*, Rome, FAO, 2020, https://doi.org/10.4060/cb1447en

FAO Committee on Food Security, *Reform of the Committee on World Food Security*, October 2009, http://www.fao.org/documents/card/en/c/1d25dcd8-261c-5c88-9f47-fa586c5fdf96

FAO and Plan Bleu, *State of Mediterranean Forests 2018*, Rome/Marseille, FAO/Plan Bleu, 2018, http://www.fao.org/documents/card/en/c/CA2081EN

Corinna Hawkes, Jody Harris and Stuart Gillespie, "Changing Diets: Urbanization and the Nutrition Transition", in International Food Policy Research Institute (IFPRI), *2017 Global Food Policy Report*, Washington, IFPRI, 2017, p. 34-41, https://doi.org/10.2499/9780896292529_04

Arjen Y. Hoekstra and Mesfin M. Mekonnen, "The Water Footprint of Humanity", in *PNAS*, Vol. 109, No. 9 (28 February 2012), p. 3232-3237, https://doi.org/10.1073/pnas.1109936109

Ahmad Jayedi et al., "Healthy and Unhealthy Dietary Patterns and the Risk of Chronic Disease: An Umbrella Review of Meta-Analyses of Prospective Cohort Studies", in *British Journal of Nutrition*, Vol. 124, No. 11 (14 December 2020), p. 1133-1144

Blanca E. Jiménez Cisneros and Taikan Oki (eds), "Freshwater Resources", in Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge/New York, Cambridge University Press, 2014, p. 229-269, https://www.ipcc.ch/report/ar5/wg2

Go-Un Kim, Kyong-Hwan Seo and Deliang Chen, "Climate Change over the Mediterranean and Current Destruction of Marine Ecosystem", in *Scientific Reports*, Vol. 9 (2019), Article 18813, https://doi.org/10.1038/s41598-019-55303-7

Marcus Lindner et al., "Climate Change Impacts, Adaptive Capacity, and Vulnerability of European Forest Ecosystems", in *Forest Ecology and Management*, Vol. 259, No. 4 (February 2010), p. 698-709

Esther Lopez-Garcia, et al., "The Mediterranean-Style Dietary Pattern and Mortality among Men and Women with Cardiovascular Disease", in *The American Journal of Clinical Nutrition*, Vol. 99, No. 1 (January 2014), p. 172-180, https://doi.org/10.3945/ajcn.113.068106

Wouter H. Maes and Kathy Steppe, "Perspectives for Remote Sensing with Unmanned Aerial Vehicles in Precision Agriculture", in *Trends in Plant Science*, Vol. 24, No. 2 (February 2019), p. 152-164

Mesfin M. Mekonnen and Arjen Y. Hoekstra, "Four Billion People Facing Severe Water Scarcity", in *Science Advances*, Vol. 2, No. 2 (February 2016), Article e1500323, https://doi.org/10.1126/sciadv.1500323

Mesfin M. Mekonnen and Arjen Y. Hoekstra, "National Water Footprint Accounts: The Green, Blue and Grey Water Footprint of Production and Consumption", in *Value of Water Research Report Series*, No. 50 (May 2011), https://waterfootprint.org/media/downloads/Report50-NationalWaterFootprints-Vol1_1.pdf

Alexandre Meybeck et al. (eds), *Development of Voluntary Guidelines for the Sustainability of the Mediterranean Diet in the Mediterranean Region. Proceedings of a Technical Workshop*, Rome/Bari, FAO and CIHEAM, 2017, http://www.fao.org/3/a-i7557e.pdf

Marianne Milano et al., "Current State of Mediterranean Water Resources and Future Trends under Climatic and Anthropogenic Changes", in *Hydrological Sciences Journal*, Vol. 58, No. 3 (2013), p. 498-518, https://doi.org/10.1080/02626667.2013.774458

Michel Petit et al., *The Covid-19 Pandemic: Threats on Food Security in the Mediterranean Region*, International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), July 2020, https://www.ciheam.org/?p=6830

Agnès Rampal, *Draft Report on Agriculture and Food Security in the Context of Climate Change in the Mediterranean*, Euro-Mediterranean Regional and Local Assembly (ARLEM), 23 February 2021, https://knowledge4policy.ec.europa.eu/node/40846

Johan Röckstrom et al., "Sustainable Intensification of Agriculture for Human Prosperity and Global Sustainability", in *Ambio*, Vol. 46, No. 1 (February 2017), p. 4-17, https://doi.org/10.1007/s13280-016-0793-6

Roberto Roson and Martina Sartori, "Virtual Water Trade in the Mediterranean: Today and Tomorrow", in Marta Antonelli and Francesca Greco (eds), *The Water We Eat*, Cham, Springer, 2015, p. 159-174

Jeffrey D. Sachs et al., *Sustainable Development Report 2019. Mediterranean Countries Edition*, Siena, Sustainable Development Solutions Network Mediterranean (SDSN Mediterranean), 2019, https://www.sdsn-mediterranean.unisi.it/?p=1290

Jacob Schewe et al., "Multimodel Assessment of Water Scarcity under Climate Change", in *PNAS*, Vol. 111, No. 9 (2014), p. 3245-3250, https://doi.org/10.1073/pnas.1222460110

Lukas Schwingshackl and Georg Hoffmann, "Adherence to Mediterranean Diet and Risk of Cancer: An Updated Systematic Review and Meta-Analysis of Observational Studies", in *Cancer Medicine*, Vol. 4, No. 12 (December 2015), p. 1933-1947, https://doi.org/10.1002/cam4.539

Aysen Tanyeri-Abur, "Food Security in the Southern Mediterranean/North Africa", in Antonella Vastola (ed.), *The Sustainability of Agro-Food and Natural Resource Systems in the Mediterranean Basin*, Cham, Springer, 2015, p. 3-14, https://doi.org/10.1007/978-3-319-16357-4_1

David Tilman and Michael Clark, "Global Diets Link Environmental Sustainability and Human Health", in *Nature*, Vol. 515 (2014), p. 518-522

Alexandre Tuel and Elfatih A.B. Eltahir, "Why Is the Mediterranean a Climate Change Hotspot?", in *Journal of Climate*, Vol. 33, No. 14 (2020), p. 5829-5843, https://doi.org/10.1175/JCLI-D-19-0910.1

UN Environment Programme (UNEP) and Mediterranean Action Plan (MAP), *2017 Mediterranean Quality Status Report*, February 2018, https://www.medqsr.org

UNEP/MAP, *Mediterranean Strategy for Sustainable Development. A Framework for Environmental Sustainability and Shared Prosperity*, approved by the Tenth Meeting of the Mediterranean Commission on Sustainable Development (MCSD), Athens, June 2005, https://wedocs.unep.org/handle/20.500.11822/641

UN World Tourism Organization (UNWTO), "Tourism in the

Mediterranean, 2015 edition", in *UNWTO Tourism Trends Snapshots*, February 2016, https://www.e-unwto.org/doi/book/10.18111/9789284416929

Marilena Vitale et al., "Recent Trends in Dietary Habits of the Italian Population: Potential Impact on Health and the Environment", in *Nutrients*, Vol. 13, No. 2 (2012), Article 476, https://doi.org/10.3390/nu13020476

Walter Willet et al., "Food in the Anthropocene: The EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems", in *The Lancet Commissions*, Vol. 393, No. 10170 (2 February 2019), p. 447-492

Jim Yoon et al., "A Coupled Human–Natural System Analysis of Freshwater Security under Climate and Population Change", in *PNAS*, Vol. 118, No. 14 (6 April 2021), Article e2020431118, https://doi.org/10.1073/pnas.2020431118

3.

New Technologies, Digitalisation and Sustainable Agriculture in the Mediterranean: Challenges and Prospects

Hadi Jaafar

The impact of technology on the human condition dates back much further than anybody would imagine. Homo sapiens has existed for 100,000 years. Anthropological evidence shows that human beings were technological from the very beginning, using wood, stone and fire. We were technological because our life depended on it. And our life still depends on technology.

In the past century, it became evident that the green revolution[1] that peaked between the 1960s and 1980s did not result in reducing rural poverty and eradicating hunger.[2] In water-scarce regions such as the Near East and North Africa (NENA), the green revolution failed to halve hunger by 2015, as called for by the UN-promoted Millennium Development Goals.[3] The region is mostly characterised by limited arable lands

[1] "Green revolution" refers to the development of modern or high-yielding crop varieties for developing countries in the late 1950s. Robert E. Evenson and Douglas Gollin, "Assessing the Impact of the Green Revolution, 1960 to 2000", in *Science*, Vol. 300, No. 5620 (2 May 2003), p. 758-762.

[2] Miguel A. Altieri, *Agroecology. The Science of Sustainable Agriculture*, 2nd ed., Boca Raton, CRC Press, 1995.

[3] FAO, *The Near East and North Africa (NENA) Region Falls Short of Halving Hunger by*

(less than 20 per cent of total area in most countries), scarce water resources (less than 685 m3/capita/yr[4] on average) and semi-arid or arid climatic conditions. About 85 per cent of the total arable lands in the region are rainfed and climatic conditions are characterised by erratic and unpredictable rainfalls (Figure 1). Among southern Mediterranean states, average precipitation does not exceed 1,000 mm/year, well below the potential evaporation rate in the region, which is not the case for most northern Mediterranean states. Moreover, upwards of 60 per cent of the surface water resources in the region come from outside its boundaries.[5] Looking to the future, it is predicted that many countries will face a reduction in precipitation of more than 10–20 per cent by 2050 coupled with an estimated increase of 1.5–5 degrees in temperature.[6] The Food and Agriculture Organisation (FAO) estimates that by 2080 agricultural production will decrease by 40 per cent, with 5 per cent of the NENA population at risk of hunger.[7] So far, efforts aimed at increasing agricultural production in the region have not been promising.

Environmental degradation and climate change are exerting tremendous stress on natural resources needed for agriculture. High population growth rates, averaging over 2.2 per cent for the whole NENA region, and growing urbanisation are putting heavy pressure on natural resources while food demand is increasing. At the same time, the limited and fragile natural resource base and declining productivity constitute major constraints to the supply of food, making the region highly dependent on imports and highly vulnerable to hikes and volatility in international food prices and other externalities. Soils are degraded, groundwater in many aquifers is depleted and renewable surface waters are deteriorating in both quality and quantity. Finally, the already scant forest eco-systems (less than 3 per cent of the

2015, 3 June 2015, http://www.fao.org/neareast/news/view/en/c/289546. The Millennium Development Goals were subsequently replaced by the Sustainable Development Goals (SDGs) in 2015.

[4] World Bank website: *The Middle East and North Africa*, https://www.worldbank.org/en/region/mena.

[5] FAO portal: *AQUASTAT*, http://www.fao.org/aquastat.

[6] World Bank portal: *Climate Change Knowledge Portal*, https://climateknowledgeportal.worldbank.org.

[7] FAO, *The Future of Food and Agriculture. Trends and Challenges*, Rome, FAO, 2017, http://www.fao.org/3/i6583e/i6583e.pdf.

region) are threatened by unsustainable agricultural practices.

Traditional agricultural practices have to evolve to address many of these challenges. Precision agriculture, defined as "the application of modern information technologies to provide, process and analyse multisource data of high spatial and temporal resolution for decision making and operations in the management of crop production",[8] depends largely on digital agriculture, which is the use of digital information in agricultural practices and related decision making. One definition of digital agriculture is agriculture practices that employ new and advanced technologies within the value chain to improve food production. Practices such as watering through smart irrigation apps,[9] improving fertiliser applications based on localised needs as detected by sensors,[10] targeted spraying activities using drones[11] and harvesting mature crops with artificial intelligence–guided harvesters[12] are all aspects of digital agriculture that have a great potential in preserving natural resources, minimising environmental damage and optimising crop production.

Challenges exist, but so do opportunities. Adopting digital agricultural techniques in the Mediterranean region can directly contribute to the attainment of a number of Sustainable Development Goals (SDGs), in turn enhancing the sustainability of states and societies across the region. These include eradication of hunger and poverty (SDGs 1 and 2), an end to the loss of biodi-

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[8] National Research Council, *Precision Agriculture in the 21st Century. Geospatial and Information Technologies in Crop Management*, Washington, National Academies Press, 1997, https://doi.org/10.17226/5491.

[9] Hadi Jaafar and Samer A. Kharroubi, "Views, Practices and Knowledge of Farmers Regarding Smart Irrigation Apps: A National Cross-Sectional Study in Lebanon", in *Agricultural Water Management*, Vol. 248 (2021), Article 106759.

[10] Natalia Rogovska et al., "Development of Field Mobile Soil Nitrate Sensor Technology to Facilitate Precision Fertilizer Management", in *Precision Agriculture*, Vol. 20, No. 1 (February 2019), 40-55.

[11] Tanha Talaviya et al., "Implementation of Artificial Intelligence in Agriculture for Optimisation of Irrigation and Application of Pesticides and Herbicides", in *Artificial Intelligence in Agriculture*, Vol. 4 (2020), p. 58-73, https://doi.org/10.1016/j.aiia.2020.04.002.

[12] Albert James Brooks, *Development of a Grape Harvester Yield Monitoring System for Application in Precision Viticulture Systems*, Thesis, September 2009, https://hdl.handle.net/10214/20098.

versity (SDG 15), increasing water use efficiency (SDG 6), reducing emissions and building climate resilience (SDG 13), quality education (SDG 4) and support for sustainable consumption (SDG 12).

Figure 1 | Average rainfall precipitation in the Mediterranean (1980–2019)

Source: Chris C. Funk et al., "A Quasi-global Precipitation Time Series for Drought Monitoring", in *USGS Data Series*, No. 832 (2014), https://doi.org/10.3133/ds832. (CHRIPS[13])

3.1 Mediterranean agriculture and new technologies

Population growth and increasing demand for food have driven the agricultural sectors (e.g., crop and livestock production, aquaculture, fisheries and forestry) to require advanced and sustainable solutions to produce healthier food while protecting the ecosystem that nurtures our basic resources. The need for technology in agriculture stems from an understanding that current agri-food systems are insufficient to eradicate hunger and malnutrition. Applying digital solutions to agriculture can increase productivity while providing environmental and social benefits to surrounding ecosystems. Digital solutions can apply to management tasks on-farm as well as in the broader value chain and food system. Different sorts of data are used:

[13] Chris C. Funk et al., "A Quasi-global Precipitation Time Series for Drought Monitoring", in *USGS Data Series*, No. 832 (2014), https://doi.org/10.3133/ds832.

weather, consumption, energy use, prices and economic information.[14] Precision agriculture, smart farming, smart irrigation and e-agriculture all employ some sort of digital agriculture. Examples include but are not limited to milking robots on dairy farms, greenhouses with fully automated climate control, automated irrigation systems on farms that irrigate based on real-time weather data and soil moisture sensors (i.e., machine-to-machine systems) and GPS-guided smart farm machinery, drones, satellite imagery use and automatic pest detection from imagery.

The use of information technology to guide and connect stakeholders and also inform agribusinesses is a major component. Big data analytics, Internet of Things (IoT), cloud computing, artificial intelligence (AI), machine learning (ML) and mobile applications are gaining wide attention in this domain and are inseparable from the technologies described above. Most of the investment in precision agriculture techniques is led by research and development companies that are based in developed countries (for example, the US, Germany, Japan, Finland and France). Such expenditures have surged to 15.6 billion US dollars in 2014,[15] out of which 1 billion US dollars is in the areas of sensors, mapping and irrigation management.

The goal of digital agriculture is the production of more sustainable food with less external inputs and minimal environmental impacts while enhancing social welfare. This requires major shifts in the current practices of agricultural production (which depend largely on extensive use of fertilisers, pesticides, herbicides and often-imprecise irrigation).[16] This challenge is particularly relevant in the southern Mediterranean, where climate change, water scarcity, high rainfall variability, growing populations and many instances of political instability and conflict combine to add particular stress to production capabilities and sustainability.

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[14] Laurens Klerkx, Emma Jakku and Pierre Labarthe, "A Review of Social Science on Digital Agriculture, Smart Farming and Agriculture 4.0: New Contributions and a Future Research Agenda", in *NJAS-Wageningen Journal of Life Sciences*, Vol. 90-91 (2019), Article 100315, https://doi.org/10.1016/j.njas.2019.100315.

[15] Keith Fuglie, "The Growing Role of the Private Sector in Agricultural Research and Development World-Wide", in *Global Food Security*, Vol. 10 (September 2016), p. 29-38.

[16] Hadi Jaafar and Samer A. Kharroubi, "Views, Practices and Knowledge of Farmers Regarding Smart Irrigation Apps", cit.

Digital agriculture has gained worldwide acceptance as an effective approach to cope with challenges such as food insecurity, climate change, biodiversity decline and natural resource depletion. Many organisations have started to focus on and promote digital agriculture. FAO has led many efforts in this domain, also organising a regional conference for the NENA in March 2020.[17] Additionally, FAO established the "Digital Agriculture Forum 2020" aimed at fostering dialogue among various non-governmental agencies, universities and start-ups to help accelerate the digital transformation of agricultural food systems. The event fostered ongoing international dialogue on the issue and encouraged countries to develop new opportunities and cooperative frameworks in these domains. The World Bank stresses that the use of digital technologies will help to reduce costs, assist farmers in making well-informed decisions and improve access to information, knowledge and markets.[18]

Today, a consensus has developed among researchers, practitioners and civil society organisations (CSOs) engaged in agriculture and food systems that the current trends of food production, marketing and consumption are no longer sustainable as natural resources are being depleted and the livelihood of smallholder producers threatened. Indeed, migration, unemployment, food insecurity and malnutrition are on the rise, particularly in rural areas and among the most disadvantaged sections of the population in general. The extent of challenges varies significantly across Mediterranean states, but no country is immune to the threats of climate change, including in the domain of sustainable agriculture. Across the NENA, 52 million people presently suffer from chronic undernourishment.[19]

Hence, achieving food security and eradicating poverty will not be pos-

[17] FAO, *Digital Innovation for Promoting Agriculture 4.0 in the Near East and North Africa*, Regional Conference for the Near East, March 2020, http://www.fao.org/3/nd262en/nd262en.pdf.

[18] Robert Townsend et al., *Future of Food. Harnessing Digital Technologies to Improve Food System Outcomes*, Washington, World Bank, 2019, http://hdl.handle.net/10986/31565.

[19] UN News, *Around 52 Million in Near East, North Africa, Suffering Chronic Undernourishment, New UN Food Agency Report Reveals*, 8 May 2019, https://news.un.org/en/story/2019/05/1038111.

sible with current approaches to food production. Reaching SDGs 1 and 2 (ending poverty in all its forms everywhere and ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture), as well as SDG 6 (ensuring availability and sustainable management of water and sanitation for all) will require additional measures. The adoption of technology-based solutions to the agriculture value chain could be one way to mitigate the impacts of some of these problems.

3.2 Climate change and the challenge of sustainability in the Mediterranean

Many studies have demonstrated a clear correlation between climate change and rising temperatures on the one hand and decreased crop yields and the duration of growing seasons on the other. The rise in global surface temperature due to increased greenhouse gas (GHG) emissions is projected to increase from 1.4 to 5.8 degrees by 2080.[20] High temperatures, even if associated with no changes in rain precipitation, can still be expected to increase soil moisture evaporation and pose the risk of increased soil degradation and related effects.[21]

Moreover, climate change will affect water storage and blue water availability (surface water and groundwater),[22] hence affecting irrigated agriculture in the region. The expected rise in sea levels will increase salt-water intrusion into coastal aquifers. Farming systems will have to compete for more limited water resources. Soil water content will decrease, while runoff and erosion will also increase. Across the southern rim of the Mediterranean, increased temperatures and decreased precipitation are expected to gain further ground in the next 30 years or so.[23] Higher temperatures have

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[20] Valérie Masson-Delmotte et al. (eds), *Global Warming of 1.5 C. An IPCC Special Report on the Impacts of Global Warming…*, 2019, https://www.ipcc.ch/sr15.

[21] Martin Parry et al. (eds), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC*, Cambridge, Cambridge University Press, 2007, https://www.ipcc.ch/report/ar4/wg2.

[22] Mesfin M. Mekonnen and Arjen Y. Hoekstra, "The Green, Blue and Grey Water Footprint of Crops and Derived Crop Products", in *Hydrology and Earth System Sciences*, Vol. 15, No. 5 (May 2011), p. 1577-1600, https://doi.org/10.5194/hess-15-1577-2011.

[23] Chafik Abdallah and Hadi Jaafar, "Data Set on Current and Future Crop Suitability

already caused increased incidence of plant diseases, decreasing crop resilience to pests. Fungal diseases have also increased.[24]

The northern Mediterranean will also suffer from climate change.[25] Summers in central Spain and northern Greece for example will be 3–4 degrees hotter by 2080 on the basis of a medium emission scenario (RCP 4.5).[26] All the other countries in the northern and southern Mediterranean will witness 2–3 degrees increase in summer temperatures by 2080. The climate emergency in some areas of the Mediterranean is very alarming unless immediate actions are taken at national and regional level.

3.2.1 Water scarcity

Climate change clearly has a direct impact on the water sector. The world is facing severe challenges posed by high temperatures and limited water supplies, which are insufficient to meet increasing water demands. For years to come, stress on irrigated agriculture, pastoral systems, aquaculture and fisheries will increase. Groundwater aquifers within semi-arid parts of the region will eventually be depleted, and surface water will be decreasing in quality and quantity.[27] Fresh water resources in some parts of the southern Mediterranean region are expected to decrease by 50 per cent by 2050.[28] The NENA region is one of the most water scarce globally,

under the Representative Concentration Pathway (RCP) 8.5 Emission Scenario for the Major Crops in the Levant, Tigris-Euphrates, and Nile Basins", in *Data in Brief*, Vol. 22 (February 2019), p. 992-997, https://doi.org/10.1016/j.dib.2019.01.033.

[24] Sukumar Chakraborty and Adrian C. Newton, "Climate Change, Plant Diseases and Food Security: An Overview", in *Plant Pathology*, Vol. 60, No. 1 (February 2011), p. 2-14, https://doi.org/10.1111/j.1365-3059.2010.02411.x.

[25] Wolfgang Cramer et al., *Risks Associated to Climate and Environmental Changes in the Mediterranean Region*, Mediterranean Experts on Climate and Environmental Change (MedECC), 2019, https://www.medecc.org/?p=1807.

[26] World Bank Climate Change Knowledge Portal: *Spain: Climate Data Projections*, https://climateknowledgeportal.worldbank.org/country/spain/climate-data-projections; also for Greece.

[27] Refer to Chapter two in this volume for further analysis of the water-food nexus challenges in the Mediterranean region.

[28] FAO Regional Office for Near East and North Africa, *FAO Collaborates with Regional partners at Arab Water Forum to Find Solutions for NENA Region Water Scarcity*, 28 November 2017, http://www.fao.org/neareast/news/view/en/c/1070742.

with per capita freshwater supplies well below the water "poverty" line of 1,000 cubic meters per year.[29] The region is facing water stress on average more than 10 months/year. Irrigated agriculture remains the major user of water in the region, and it has doubled over the last 40 years (around 70 per cent of the region's water resources are used in agriculture; this percentage is more than 80 per cent in Morocco, Syria, Egypt and Turkey[30]). A detailed representation of the fresh water situation in the Mediterranean is presented in Table 1, demonstrating how ten countries of the southern Mediterranean are well below the water poverty line.

While the NENA region has historically relied on rain-fed farming and nomadism, water scarcity is challenging the sustainability of irrigated agro-ecosystems in all countries of the southern and eastern Mediterranean. The increased use of traditional irrigation practices and groundwater abstraction systems for agriculture have amplified the impact of climate change and water scarcity in the region. Originally meant to increase the resilience of farmers to climate variability in an arid environment, the introduction of irrigation systems has "fired back", adding to the water stress as local farmers shift to more intensive production systems with cheap water. Looking to the future, an increased use of advanced technologies is needed to improve economic water productivity in the NENA, particularly for the resilience of small farm holdings. A study showed that 70 per cent of all farms in NENA are less than 2 hectares large.[31] In comparison, the average plot size in Greece is 4.8 ha and in Italy is 8 ha.[32] In Spain, 51.6 per cent of the plots are less than 5 ha.[33] Small farmers thriving

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[29] FAO portal: *AQUASTAT*, http://www.fao.org/aquastat.

[30] Kina Stientje Harmanny and Žiga Malek, "Adaptations in Irrigated Agriculture in the Mediterranean Region: An Overview and Spatial Analysis of Implemented Strategies", in *Regional Environmental Change*, Vol. 19, No. 5 (2019), p. 1401-1416, https://doi.org/10.1007/s10113-019-01494-8.

[31] Sarah K. Lowder, Jacob Skoet and Terri Raney, "The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide", in *World Development*, Vol. 87 (November 2016), p. 16-29, https://doi.org/10.1016/j.worlddev.2015.10.041.

[32] Eurostat, *Agricultural Census in Italy*, 5 October 2018, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agricultural_census_in_Italy&direction=next&oldid=407510.

[33] European Commission, *Agriculture and Rural Development. Statistical Factsheet:*

on rain-fed agriculture are the most vulnerable to climate change given the lack of adequate resources for adaptation.

Table 1 | Fresh water withdrawals by sector in the Mediterranean as of 2017

Country	Agricultural use 10^9 m^3/yr	Industrial use 10^9 m^3/yr	Municipal use 10^9 m^3/yr	Renewable water resources per capita m^3/ inhabitant/year
Albania	0.905	0.2318	0.283	10471
Algeria	6.671	0.191	3.6	**281.9**
Bosnia and Herzegovina	No data	0.0718	0.3608	11189
Croatia	0.076	0.184	0.455	25222
Cyprus	0.184	0.017	0.11	**661.2**
Egypt	61.35	5.4	10.75	**596.2**
France	3.113	18.15	5.175	3254
Greece	9.041	0.2083	1.991	6471
Israel	1.249	0.072	0.983	**215.9**
Italy	17	7.7	9.488	3153
Lebanon*	1.6	0.27	0.826	**660.3**
Libya	4.85	0.28	0.7	**106.4**
Malta	0.0254	0.001	0.0374	**115.3**
Montenegro	0.0017	0.0628	0.0964	No data
Morocco	9.156	0.212	1.063	**815**
Slovenia	0.0039	0.758	0.1695	15349
Spain	20.36	5.966	4.89	2390
Syrian	14.67	0.6154	1.475	**982.8**
Tunisia	3.773	0.965	0.137	**403.6**
Turkey	50.05	2.898	6.016	2609

Note: * for Lebanon see Hadi Jaafar et al., "Refugees, Water Balance, and Water Stress: Lessons Learned from Lebanon", in *Ambio*, Vol. 49, No. 6 (June 2020), p. 1179-1193, https://doi.org/10.1007/s13280-019-01272-0.
Source: FAO AQUASTAT Database: http://www.fao.org/nr/water/aquastat/data/query/index.html.

Spain, June 2020, https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/agri-statistical-factsheet-es_en.pdf.

Global warming has also affected the northern Mediterranean. Yet, there is still limited evidence that rainfall patterns are changing, with the exception of Italy and Greece where a decreasing trend is detectable over the past 30 years if compared to the century average. Climate projections on the other hand indicate that Spain will witness an average decrease of 10 mm/month in all months by 2100,[34] while France will see a 15–20 mm drop in summer month rainfall. Most countries in the Mediterranean region have responded through adaptation strategies in several categories such as sustainable resource and water management as well as technological development, perhaps more so in the north than in the south.[35]

3.2.2 Impact of protracted crises due to conflicts

There is a direct relationship between conflicts and food insecurity. More than 50 per cent of all food-insecure people live in conflict-affected areas. Stress on natural resources is further aggravated in areas affected by protracted crises. Degradation of natural resources is reported in countries such as Turkey, Lebanon, Syria, Algeria, Tunisia and Morocco.[36] In Syria, early estimates for the damage caused to the agricultural sector were thought to exceed 1.8 billion US dollars in 2013 and have reached 17 billion US dollars at present. Syrian agricultural production dropped massively with the conflict,[37] with wheat, barley and cotton production showing vast decreases.[38] Refugees have also affected the farming systems. In Lebanon, the refugee crisis caused a massive and sudden increase in the population and has compounded the already existing

[34] World Bank Climate Change Knowledge Portal: *Spain: Climate Data Projections*, cit.

[35] Kina Stientje Harmanny and Žiga Malek, "Adaptations in Irrigated Agriculture in the Mediterranean Region", cit.

[36] UN-Spider Knowledge Portal: *Data Application of the Month: Land Degradation*, https://www.un-spider.org/node/12034.

[37] Hadi H. Jaafar et al., "Impact of the Syrian Conflict on Irrigated Agriculture in the Orontes Basin", in *International Journal of Water Resources Development*, Vol. 31, No. 3 (2015), p. 436-449.

[38] Hadi H. Jaafar and Farah A. Ahmad, "Crop Yield Prediction from Remotely Sensed Vegetation Indices and Primary Productivity in Arid and Semi-Arid Lands", in *International Journal of Remote Sensing*, Vol. 36, No. 18 (2015), p. 4570-4589.

water stress and degraded water quality especially in agricultural areas.[39] Protracted crises and conflicts in many southern countries such as Tunisia, Libya, Lebanon and Syria have in some cases continued to slow down the transition towards sustainable agri-food systems.

3.3 Can digital agriculture address challenges and gaps?

Since digital agriculture is a relatively new trend, there is still limited evidence on the benefits it can offer in alleviating hunger, reducing poverty, increasing food security and improving livelihoods, while protecting the environment and supporting sustainable ecosystems. However, several researchers as well as international organisations have highlighted the role that digital agriculture can play in addressing current and future challenges that agriculture faces in the Mediterranean.[40] Among them, digitising the agri-food sector can lead to positive spill-overs in terms of climate change adaptation, addressing water scarcity and boosting farmers' resilience through sustainable practices.

Digital agricultural practices can positively contribute to climate change mitigation. More specifically, climate-smart agriculture can help curb GHG emissions by reducing the energy requirements for irrigation, spraying and other farming and post-harvest activities. A pilot study on smart irrigation in Cyprus for example demonstrated a 22 per cent reduction in total irrigation needs.[41] Digital agriculture can improve the mitigation of climate change impacts by enhancing natural ecosystems. For example, when target spraying of pesticides and

[39] Hadi Jaafar et al., "Refugees, Water Balance, and Water Stress", cit.; Issmat I. Kassem and Hadi Jaafar, "The Potential Impact of Water Quality on the Spread and Control of COVID-19 in Syrian Refugee Camps in Lebanon", in *Water International*, Vol. 45, No. 5 (2020), p. 423-429, https://doi.org/10.1080/02508060.2020.1780042.

[40] Zhaoyu Zhai et al., "Decision Support Systems for Agriculture 4.0: Survey and Challenges", in *Computers and Electronics in Agriculture*, Vol. 170 (March 2020), Article 105256, https://doi.org/10.1016/j.compag.2020.105256; Ilaria Zambon et al., "Revolution 4.0: Industry vs. Agriculture in a Future Development for SMEs", in *Processes*, Vol. 7, No. 1 (2019), Article 36, https://doi.org/10.3390/pr7010036.

[41] Nikos Kalatzis, Nikolaos Marianos and Fotis Chatzipapadopoulos, *IoT and Data Interoperability in Agriculture: A Case Study on the Gaiasense TM Smart Farming Solution*, Paper presented at the 2019 Global IoT Summit (GIoTS), 17-21 June 2019.

herbicides is applied, the reduced environmental damage can provide for more suitable habitats for wild plants and animals, supporting genetic diversity and pollination.[42]

Digital agriculture could address challenges linked to water scarcity in different ways. Climate change mitigation and the eradication of hunger cannot be achieved without sustainable water management,[43] a key objective of digital agriculture. Irrigating crops based on an improved knowledge of crop water requirements, soil moisture and crop growth stage (all of which could be assessed more precisely with techniques such as the IoT, remote sensing, weather data systems and data from field sensors fed into mobile and web apps), will have a positive effect on blue water resources. It will reduce diversions from rivers and minimise pumping from groundwater resources. Many regions in the Mediterranean are experiencing drops in green water (water stored in the soil within the root zone of plants) availability due to more frequent droughts[44] (for example the Levant is experiencing the worst drought in 900 years; droughts are also occurring in the Egyptian Nile Basin as well as in Sardinia and Greece).[45] Green water is necessary to sustain the multiple ecosystem goods and services on which agriculture heavily depends. A reduction in blue water diversions will lead to improved environmental flows downstream and will result in a better management of green water. Regulating and reducing water applications in arid regions facilitates farming in abandoned and degraded areas. It improves economic crop water productivity, allow-

[42] Theocharis Moysiadis et al., "Use of IoT Technologies for Irrigation and Plant Protection: The Case for Cypriot Fruits and Vegetables", in Dionysis Bochtis et al. (eds), *Bio-Economy and Agri-production. Concepts and Evidence*, London, Academic Press, 2021, p. 175-194.

[43] FAO, *Regional Overview of Food Insecurity: Near East and North Africa. Strengthening Regional Collaboration to Build Resilience for Food Security and Nutrition*, Cairo, FAO, 2015, http://www.fao.org/3/i4644e/i4644e.pdf.

[44] Tommaso Caloiero et al., "Drought Analysis in Europe and in the Mediterranean Basin Using the Standardized Precipitation Index", in *Water*, Vol. 10, No. 8 (August 2018), Article 1043, https://doi.org/10.3390/w10081043.

[45] Ellen Gray, "NASA Finds Drought in Eastern Mediterranean Worst of Past 900 Years", in *NASA Articles*, 1 March 2016, https://www.nasa.gov/feature/goddard/2016/nasa-finds-drought-in-eastern-mediterranean-worst-of-past-900-years.

ing an increase in green water, aquifer recharge and protection from erosion. To reach the transformative ambition of the SDGs requires scaling up, which will help in water and energy conservation, crop yield improvements, and at the same time mitigate climate change impacts and reduce environmental degradation.

Digital agriculture helps mitigate the effects of rural-urban mobility by enhancing the resilience of smallholders. Market facilitation improvements – such as ensuring that a wide range of suppliers of equipment exist in the market, devising new methods of providing information on digital agriculture to farmers, or designing news strategies to promote sensor devices – may help promote digital agriculture by improving socioeconomic development, ecosystem functions and services. Moreover, digital agriculture can motivate and attract young people to engage in agriculture. Taking into account the decreasing interest among youth, an inclusion of technology in today's agricultural practices will bring different disciplines together and increase interest and collaboration in these fields, helping to prepare youth – the farmers of the future – to engage in agriculture. An example is the WATERMEDYIN project, entitled "Youth and Innovation for Sustainable Use of Water and Marine Resources in the Mediterranean", a regional initiative, sponsored by the Italian Agency for Development Cooperation (AICS) and executed by the Mediterranean Agronomic Institute (CIHEAM) office in Bari.[46] The project is implemented in Lebanon, Palestine and Tunisia. Another example, is the Station-F accelerator programme in France, which provides support for many start-ups in the Mediterranean region.[47]

3.4 Digital agriculture in the Mediterranean: Research and best practices

There are several success stories for digital agriculture in the Mediterranean, although a majority of these have been implemented in northern Mediterranean states. In Europe, the European Platform

[46] WATERMEDYIN project website: *WATERMEDYIN*, https://www.watermedyin.net/?p=2088.

[47] STATION F website: *Startup Programs*, https://stationf.co/programs.

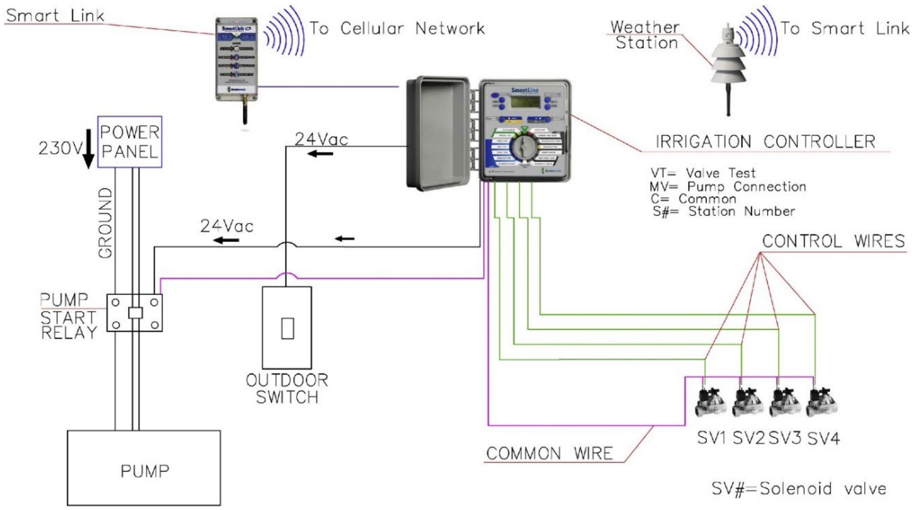
of national initiatives was launched in March 2017 and included several north Mediterranean countries such as Spain, France and Italy with the aim to coordinate national initiatives on the digitalisation of manufacturing sectors by harnessing the power of sensors and computations.[48] The IoT and information and communications technology are key dimensions of digital transformation technologies that have been introduced early in the 21st century. However, digital agriculture applications in the southern Mediterranean remain limited in scale. Nevertheless, researchers are putting forward many technologies and practices that could be adopted by the agricultural sector.

In Lebanon, during the past years there have been several research and outreach initiatives aimed at promoting the use of one aspect of digital agriculture: smart irrigation. Researchers at the department of Agriculture at the American University of Beirut (AUB) developed and showcased an automated irrigation system to produce *Origanum syriacum*, an edible and medicinal herb of high commercial value.[49] The system relies on input from a weather station to calculate crop water requirements and can be operated via a mobile app. The application can access the irrigation controller through the Global System for Mobile Communications (GSM) network, and the controller communicates wirelessly with the field weather station to fetch irrigation amounts. It will then automatically operate a pump and a set of solenoid valves to irrigate as required. The result was a significant decrease in farm visits and improved water productivity, signalling good potential for applications on other crops (Figure 2).

[48] Giorgia Bucci, Deborah Bentivoglio and Adele Finco, "Precision Agriculture as a Driver for Sustainable Farming Systems: State of Art in Literature and Research", in *Calitatea/Quality – Access to Success*, Vol. 19, Supplement No. 1 (March 2018), p. 114-121.

[49] Hadi Jaafar et al., "Determining Water Requirements of Biblical Hyssop Using an ET-Based Drip Irrigation System", in *Agricultural Water Management*, Vol. 180, Part A (2017), p. 107-117.

Figure 2 | Smart irrigation system developed at AUB, Lebanon



Source: Hadi Jaafar et al., "Determining Water Requirements of Biblical Hyssop Using an ET-Based Drip Irrigation System", cit.

Yet, there is little evidence that such techniques can be adopted on a commercial scale in the country, particularly due to several factors such as the required technical skills for installation, operation and management, and other ancillary limitations such as the lack of reliable power supply and the extra cost of required equipment and mobile subscriptions. Mobile subscriptions can be 250 US dollars/yr, controllers ~ 200 US dollars and solenoid valves are five times the cost of manual valves.

More studies are thus needed to justify the additional investment in all of the above especially for small-holder farmers. In 2018, the IHE-Delft Partnership Programme for Water and Development funded the ITSET project, initially targeting Lebanon's Bekaa valley and aimed at developing an operational irrigation framework and an application that helps farmers irrigate their crops precisely and that aids water managers in monitoring water use in agriculture.[50] Later in 2019, and as part

[50] IHE Delft website: *DUPC2: IHE Delft Partnership Programme for Water and Develop-*

of their call for global applications in artificial intelligence, Google.org and Tides Foundation granted researchers at AUB 1 million US dollars to develop a mobile app for irrigation that could be used anywhere in the world, with machine learning as a key component. Together, the two projects contributed to the development of the world's first mobile application for determining water requirements in agriculture.[51] The app, called AgSAT, relies on big data integration from remote sensing and satellite imagery, and is currently used in several countries across the Mediterranean region and beyond (for example, France, Morocco, Sudan, Saudi Arabia and the United Arab Emirates).

Other techniques are applied in North African countries. In Tunisia, several start-ups focusing on digital agriculture have been launched in the past five years. One example is a drone-based initiative managed by the Tunisian national society for plant protection called SONAPROV. The initiative seeks to develop an intelligent programme based on the training of drone remote pilots and the transfer of technology via a pilot project aimed to study and develop the agricultural sector in Sidi Bouzid, in central Tunisia. It resulted in the signing of two partnership agreements with the African Development Bank and the South Korean Busan Techno Park.[52] Finally, I-FARMING also provides an example of north-south collaboration where the start-up was supported by an accelerator programme in France known as Station-F. When prototyped, the smart irrigation solution helped reduce water and energy consumption on a farm by 20 per cent.[53]

In northern Mediterranean countries, digital agriculture is more widespread. For example, 4 per cent of French farmers use software-based variable rate input applications for their fields. By 2017,

ment, https://www.un-ihe.org/node/176769.

[51] IHE Delft, *AgSAT: An Application for Saving Water and Energy and Enhancing Food Production*, 17 December 2020, https://www.un-ihe.org/node/1252715.

[52] Sabrine Ahmed, "Interview avec Chokri Chabchoub", in *La Presse*, 21 May 2020, https://lapresse.tn/62589.

[53] Mathieu Galtier, "Start-up de la semaine: iFarming, future licorne tunisienne de l'irrigation en temps réel?", in *Jeune Afrique*, 21 December 2017, https://www.jeuneafrique.com/501309/economie.

remote sensing was already used on 10,000 km2 of farmland in France (85 per cent from satellite imagery and 15 per cent from drones and aircraft). Robots are also used in vineyards and for milking cows.[54] In Spain, researchers developed a computer vision system to automate the detection and localisation of fruits in a tomato crop in a typical Mediterranean greenhouse.[55] The system identifies and locates ripe tomatoes and can be used for any tomato-harvesting robot. Others developed a decision support tool (PLATEM PA) that applies real-time decisions from data such as variable rate irrigation, and selected parameters from field and weather conditions.[56] Furthermore, Italy has many advancements in digital agriculture. Researchers developed the "AgriLogger", a sensor that functions with a drone which collects and transmits weather data in remote areas not served by mobile coverage.[57] Yet, an analysis conducted in Greece on robotics in agriculture shows that such systems are still not mature for development.[58] Finally, in Cyprus, there have been projects over the last decade that showcased the use of the IoT as well as remote sensing application in agriculture. Future-Intelligence[59] is a technology for irrigation and pest management that was applied on cash-crops and that has been shown via pilot studies to improve water and pesticide use. Robotics are also in use to spray vineyards.[60]

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[54] Abdul Salam and Usman Raza, *Signals in the Soil*, Cham, Springer, 2020, p. 357-378.

[55] Marta Benavides et al., "Automatic Tomato and Peduncle Location System Based on Computer Vision for Use in Robotized Harvesting", in *Applied Sciences*, Vol. 10, No. 17 (2020), Aricle 5887, https://doi.org/10.3390/app10175887.

[56] Carlos Cambra Baseca et al., "A Smart Decision System for Digital Farming", in *Agronomy*, Vol. 9, No. 5 (2019), Article 216, https://doi.org/10.3390/agronomy9050216.

[57] Mohamed Idbella et al., "Agrilogger: A New Wireless Sensor for Monitoring Agrometeorological Data in Areas Lacking Communication Networks", in *Sensors*, Vol. 20, No. 6 (2020), Article 1589, https://doi.org/10.3390/s20061589.

[58] Naoum Tsolakis, Dimitrios Bechtsis and Dionysis Bochtis, "AgROS: A Robot Operating System Based Emulation Tool for Agricultural Robotics", in *Agronomy*, Vol. 9, No. 7 (2019), Article 403, https://doi.org/10.3390/agronomy9070403.

[59] Theocharis Moysiadis et al., "Use of IoT Technologies for Irrigation and Plant Protection", cit.

[60] George Adamides et al., "HRI Usability Evaluation of Interaction Modes for a Teleoperated Agricultural Robotic Sprayer", in *Applied Ergonomics*, Vol. 62 (July 2017), p. 237-246.

Considerable research has been conducted in the region on many digital agriculture practices. The Partnership for Research and Innovation in the Mediterranean, a joint programme co-financed by the European Commission and participating countries on food systems and water resources for the development of inclusive, sustainable and healthy Euro-Mediterranean societies, has been funding tens of projects in areas related to agriculture and innovation.[61]

3.5 Regional and multilateral collaboration

Collaboration is a condition for digital agriculture to succeed, and participatory planning is a useful approach to effective implementation of its principles and practices. Experiments and demonstrations conducted at the field, farm and landscape level need to involve multidisciplinary expertise from academia, the private sector and public authorities. Setting wider institutional and funding support for digital agriculture to foster a transdisciplinary, participatory and action-oriented approach is a crucial opportunity. Synergies between and among farmers, organisations and institutions can help to promote a wider use of smart technologies. Agricultural extension agents need to be trained for the purpose of applying and teaching digital skills to farmers and stakeholders along the value chain. Collaborative frameworks are important for success as they bring together institutions, research, land users and other actors, particularly when these span both northern and southern Mediterranean countries. Besides, international frameworks are fundamental for guiding promotion of digital agriculture.

However, mainstreaming digital agriculture in agricultural development policies and programmes is still at an infant stage in the southern Mediterranean region. Socio-economic and environment-related policy interventions are crucial for raising farmer awareness on up-to-date digital practices. Accordingly, policies that enhance farmers' access to credit, market and financial services could be developed. Additionally, in water-scarce areas, policies to limit non-beneficial water use to protect ground-

[61] PRIMA website: https://prima-med.org.

water might encourage farmers to resort to precision irrigation. Even in NENA countries where biodiversity, environment protection and ecosystem preservation policies exist, these are not clearly linked to digital agriculture and agricultural policies.

Governments require support at the local, national and some at the regional level for guiding transition processes in digital agriculture and for developing policies that help this transition. Transitions require innovations in policies and legal frameworks for rural institutions and partnerships, and adequate investments throughout the production, processing, marketing and consumption stages to achieve sustainability and equity throughout the entire food and agricultural system. Support can be sought from agencies that have thoroughly analysed the practicality of adopting digital agriculture in the region, such the World Bank and the International Fund for Agricultural Development.

There are still many barriers that may delay technological development. A major challenge is the cost of equipment. For example, the cost of a drone with a multispectral and thermal sensor to assess vegetation health can exceed 20,000 US dollars. Thus, the feasibility of migrating toward equipment-intensive agriculture needs to be carefully studied. The capital, operation and maintenance costs of digital agricultural practices might make production unprofitable in small-scale farming. Another barrier is difficulty in operation of some technologies. In Lebanon, for example, to import, own and operate an agricultural drone, one would need to acquire special permission from the intelligence agencies, obtain a license from the civil aviation authority and notify and coordinate with the defence forces each time the drone needs to be flown. It is also impossible to fly drones over some agricultural areas such as the south region. There are further maintenance difficulties that include issues with sensor network deployment and standardisation, and system architecture challenges. Moreover, adequate IT infrastructure must be available, which is also a challenge in developing countries as coverage in southern Mediterranean farming areas is still low. Finally, farmers and agriculture professionals will need to acquire new skills to manage these systems. Approaches need to consider factors related to infrastructure, law, knowledge, privacy, data security and data ownership. The public and private sectors will face new challenges in terms of capacity building around these new technologies.

3.6 Conclusion and policy recommendations

Given that digital agriculture provides benefits for productivity, food security, economic growth, water security and climate change mitigation, stakeholders from different countries of the northern and southern Mediterranean should come together for a mainstreaming of digital agriculture and the sharing of best practices. It is important to continue to research the extent and scale at which digital agriculture in the Mediterranean can contribute to self-reliance in food production, and how this can support human well-being and over what time period. Ultimately, more research is needed to understand how the challenges and benefits of digital agriculture outlooks can be assessed in terms of its applications for food supply, the environment, human health and food safety.

Based on the above analysis, several recommendations for enabling digital agriculture in the region can be presented. One of these recommendations is mainstreaming digital agriculture into agricultural policies and practices, and adopting participatory approaches in the formulation of policies for digital agriculture.

The inclusion of all relevant stakeholders is crucial to provide grounded and widely accepted policy recommendations. Options to consider when implementing digital agriculture policies include:

I. Involving farmers, CSOs and NGOs in developing policies that support digital agriculture penetration and mainstreaming.
II. Incentivising partnerships between the private sector, farmers, CSOs and national and local public authorities.
III. Establishing steering committees for digital agriculture at the country level by creating new laws and legislation that facilitate, encourage and sometimes mandate certain digital practices for the agricultural sector.
IV. Soliciting financial investments from governmental and international organisations to support increased uses and adoption of digital agriculture techniques and materials.

Second, there is a need to build capacity through intensive knowledge, mentorship, management and extension services targeting consumers, producers, stakeholders and decision makers. Specific recommendations regarding this matter include the use of scientific information in agricultural practices; for example, incentives for farmers who use mobile applications that provide data on irrigation requirements in near real time, such as AgSAT.

Third, promoting awareness within various groups through media campaigns and consultative sessions on the added value of digital agriculture will be essential to encourage adoption. In particular, this can be achieved by:

I. Encouraging investment and extension services targeted at small-scale producers.
II. Enhancing smart applications of herbicides and pesticides.
III. Incentivising the automation of irrigation systems by providing discounts and free training on the necessary grey/blue water footprint technology of agricultural and food systems along the full value chain.
IV. Sharing successful lessons and experiences, including farmer-to-farmer knowledge exchanges.
V. Supporting research programmes and targeted innovation on climate change mitigation.

Finally, scaling up digital agriculture remains a challenge in the Mediterranean region. Building awareness with various groups such as women, youth and citizens will provide added value and promote digital agriculture as a necessary, even vital practice for the future of agriculture in the Mediterranean. In this respect, it is particularly important to engage youth – the farmers of the future – throughout these processes. The adaptation of academia and education programmes is essential to create the necessary skills to operate, maintain and develop the technology and allow countries to adopt digital agriculture in their national agendas and thereby enhance the sustainability of states and societies across the Mediterranean region as a whole.

References

Chafik Abdallah and Hadi Jaafar, "Data Set on Current and Future Crop Suitability under the Representative Concentration Pathway (RCP) 8.5 Emission Scenario for the Major Crops in the Levant, Tigris-Euphrates, and Nile Basins", in *Data in Brief*, Vol. 22 (February 2019), p. 992-997, https://doi.org/10.1016/j.dib.2019.01.033

George Adamides et al., "HRI Usability Evaluation of Interaction Modes for a Teleoperated Agricultural Robotic Sprayer", in *Applied Ergonomics*, Vol. 62 (July 2017), p. 237-246

Sabrine Ahmed, "Interview avec Chokri Chabchoub", in *La Presse*, 21 May 2020, https://lapresse.tn/62589

Nadje Al-Ali, *The Relationship between Migration within and from the Middle East and North Africa and Pro-Poor Policies*, Institute of Arab & Islamic Studies-University of Exeter, July 2004, https://core.ac.uk/reader/2788042

Miguel A. Altieri, *Agroecology. The Science of Sustainable Agriculture*, 2nd ed., Boca Raton, CRC Press, 1995

Marta Benavides et al., "Automatic Tomato and Peduncle Location System Based on Computer Vision for Use in Robotized Harvesting", in *Applied Sciences*, Vol. 10, No. 17 (2020), Aricle 5887, https://doi.org/10.3390/app10175887

Albert James Brooks, *Development of a Grape Harvester Yield Monitoring System for Application in Precision Viticulture Systems*, Thesis, September 2009, https://hdl.handle.net/10214/20098

Giorgia Bucci, Deborah Bentivoglio and Adele Finco, "Precision Agriculture as a Driver for Sustainable Farming Systems: State of Art in Literature and Research", in *Calitatea/Quality – Access to Success*, Vol. 19, Supplement No. 1 (March 2018), p. 114-121

Tommaso Caloiero et al., "Drought Analysis in Europe and in the Mediterranean Basin Using the Standardized Precipitation Index", in *Water*, Vol. 10, No. 8 (August 2018), Article 1043, https://doi.org/10.3390/w10081043

Carlos Cambra Baseca et al., "A Smart Decision System for Digital Farming", in *Agronomy*, Vol. 9, No. 5 (2019), Article 216, https://doi.org/10.3390/agronomy9050216

Sukumar Chakraborty and Adrian C. Newton, "Climate Change, Plant Diseases and Food Security: An Overview", in *Plant Pathology*, Vol. 60, No. 1 (February 2011), p. 2-14, https://doi.org/10.1111/j.1365-3059.2010.02411.x

Wolfgang Cramer et al., *Risks Associated to Climate and Environmental Changes in the Mediterranean Region*, Mediterranean Experts on Climate and Environmental Change (MedECC), 2019, https://www.medecc.org/?p=1807

European Commission, *Agriculture and Rural Development. Statistical Factsheet: Spain*, June 2020, https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/agri-statistical-factsheet-es_en.pdf

Eurostat, *Agricultural Census in Italy*, 5 October 2018, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agricultural_census_in_Italy&direction=next&oldid=407510

Robert E. Evenson and Douglas Gollin, "Assessing the Impact of the Green Revolution, 1960 to 2000", in *Science*, Vol. 300, No. 5620 (2 May 2003), p. 758-762

FAO, *Digital Innovation for Promoting Agriculture 4.0 in the Near East and North Africa*, Regional Conference for the Near East, March 2020, http://www.fao.org/3/nd262en/nd262en.pdf

FAO, *The Future of Food and Agriculture. Trends and Challenges*, Rome, FAO, 2017, http://www.fao.org/3/i6583e/i6583e.pdf

FAO, *The Near East and North Africa (NENA) Region Falls Short of Halving Hunger by 2015*, 3 June 2015, http://www.fao.org/neareast/news/view/en/c/289546

FAO, *Regional Overview of Food Insecurity: Near East and North Africa. Strengthening Regional Collaboration to Build Resilience for Food Security and Nutrition*, Cairo, FAO, 2015, http://www.fao.org/3/i4644e/i4644e.pdf

FAO Regional Office for Near East and North Africa, *FAO Collaborates with Regional partners at Arab Water Forum to Find Solutions for NENA Region Water Scarcity*, 28 November 2017, http://www.fao.org/neareast/news/view/en/c/1070742

Keith Fuglie, "The Growing Role of the Private Sector in Agricultural Research and Development World-Wide", in *Global Food Security*, Vol. 10 (September 2016), p. 29-38

Chris C. Funk et al., “A Quasi-global Precipitation Time Series for Drought Monitoring”, in *USGS Data Series*, No. 832 (2014), https://doi.org/10.3133/ds832

Mathieu Galtier, “Start-up de la semaine: iFarming, future licorne tunisienne de l’irrigation en temps réel?”, in *Jeune Afrique*, 21 December 2017, https://www.jeuneafrique.com/501309/economie

Ellen Gray, “NASA Finds Drought in Eastern Mediterranean Worst of Past 900 Years”, in *NASA Articles*, 1 March 2016, https://www.nasa.gov/feature/goddard/2016/nasa-finds-drought-in-eastern-mediterranean-worst-of-past-900-years

Kina Stientje Harmanny and Žiga Malek, “Adaptations in Irrigated Agriculture in the Mediterranean Region: An Overview and Spatial Analysis of Implemented Strategies”, in *Regional Environmental Change*, Vol. 19, No. 5 (2019), p. 1401-1416, https://doi.org/10.1007/s10113-019-01494-8

Mohamed Idbella et al., “Agrilogger: A New Wireless Sensor for Monitoring Agrometeorological Data in Areas Lacking Communication Networks”, in *Sensors*, Vol. 20, No. 6 (2020), Article 1589, https://doi.org/10.3390/s20061589

IHE Delft, *AgSAT: An Application for Saving Water and Energy and Enhancing Food Production*, 17 December 2020, https://www.un-ihe.org/node/1252715

Hadi H. Jaafar and Farah A. Ahmad, “Crop Yield Prediction from Remotely Sensed Vegetation Indices and Primary Productivity in Arid and Semi-Arid Lands”, in *International Journal of Remote Sensing*, Vol. 36, No. 18 (2015), p. 4570-4589

Hadi Jaafar and Samer A. Kharroubi, “Views, Practices and Knowledge of Farmers Regarding Smart Irrigation Apps: A National Cross-Sectional Study in Lebanon”, in *Agricultural Water Management*, Vol. 248 (2021), Article 106759

Hadi Jaafar et al., “Determining Water Requirements of Biblical Hyssop Using an ET-Based Drip Irrigation System”, in *Agricultural Water Management*, Vol. 180, Part A (2017), p. 107-117

Hadi H. Jaafar et al., “Impact of the Syrian Conflict on Irrigated Agriculture in the Orontes Basin”, in *International Journal of Water*

Resources Development, Vol. 31, No. 3 (2015), p. 436-449

Nikos Kalatzis, Nikolaos Marianos and Fotis Chatzipapadopoulos, *IoT and Data Interoperability in Agriculture: A Case Study on the Gaiasense TM Smart Farming Solution*, Paper presented at the 2019 Global IoT Summit (GIoTS), 17-21 June 2019

Issmat I. Kassem and Hadi Jaafar, "The Potential Impact of Water Quality on the Spread and Control of COVID-19 in Syrian Refugee Camps in Lebanon", in *Water International*, Vol. 45, No. 5 (2020), p. 423-429, https://doi.org/10.1080/02508060.2020.1780042

Laurens Klerkx, Emma Jakku and Pierre Labarthe, "A Review of Social Science on Digital Agriculture, Smart Farming and Agriculture 4.0: New Contributions and a Future Research Agenda", in *NJAS-Wageningen Journal of Life Sciences*, Vol. 90-91 (2019), Article 100315, https://doi.org/10.1016/j.njas.2019.100315

Sarah K. Lowder, Jacob Skoet and Terri Raney, "The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide", in *World Development*, Vol. 87 (November 2016), p. 16-29, https://doi.org/10.1016/j.worlddev.2015.10.041

Valérie Masson-Delmotte et al. (eds), *Global Warming of 1.5 C. An IPCC Special Report on the Impacts of Global Warming...*, 2019, https://www.ipcc.ch/sr15

Mesfin M. Mekonnen and Arjen Y. Hoekstra, "The Green, Blue and Grey Water Footprint of Crops and Derived Crop Products", in *Hydrology and Earth System Sciences*, Vol. 15, No. 5 (May 2011), p. 1577-1600, https://doi.org/10.5194/hess-15-1577-2011

Theocharis Moysiadis et al., "Use of IoT Technologies for Irrigation and Plant Protection: The Case for Cypriot Fruits and Vegetables", in Dionysis Bochtis et al. (eds), *Bio-Economy and Agri-production. Concepts and Evidence*, London, Academic Press, 2021, p. 175-194

National Research Council, *Precision Agriculture in the 21st Century. Geospatial and Information Technologies in Crop Management*, Washington, National Academies Press, 1997, https://doi.org/10.17226/5491

Martin Parry et al. (eds), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assess-*

ment Report of the IPCC, Cambridge, Cambridge University Press, 2007, https://www.ipcc.ch/report/ar4/wg2

Natalia Rogovska et al., "Development of Field Mobile Soil Nitrate Sensor Technology to Facilitate Precision Fertilizer Management", in *Precision Agriculture*, Vol. 20, No. 1 (February 2019), 40-55

Abdul Salam and Usman Raza, *Signals in the Soil*, Cham, Springer, 2020, p. 357-378

Tanha Talaviya et al., "Implementation of Artificial Intelligence in Agriculture for Optimisation of Irrigation and Application of Pesticides and Herbicides", in *Artificial Intelligence in Agriculture*, Vol. 4 (2020), p. 58-73, https://doi.org/10.1016/j.aiia.2020.04.002

Robert Townsend et al., *Future of Food. Harnessing Digital Technologies to Improve Food System Outcomes*, Washington, World Bank, 2019, http://hdl.handle.net/10986/31565

Naoum Tsolakis, Dimitrios Bechtsis and Dionysis Bochtis, "AgROS: A Robot Operating System Based Emulation Tool for Agricultural Robotics", in *Agronomy*, Vol. 9, No. 7 (2019), Article 403, https://doi.org/10.3390/agronomy9070403

UN News, *Around 52 Million in Near East, North Africa, Suffering Chronic Undernourishment, New UN Food Agency Report Reveals*, 8 May 2019, https://news.un.org/en/story/2019/05/1038111

Ilaria Zambon et al., "Revolution 4.0: Industry vs. Agriculture in a Future Development for SMEs", in *Processes*, Vol. 7, No. 1 (2019), Article 36, https://doi.org/10.3390/pr7010036

Zhaoyu Zhai et al., "Decision Support Systems for Agriculture 4.0: Survey and Challenges", in *Computers and Electronics in Agriculture*, Vol. 170 (March 2020), Article 105256, https://doi.org/10.1016/j.compag.2020.105256.

4.

Recycling and Plastic Waste Management in the Mediterranean

Guillaume Billard and Julien Boucher

Plastic pollution in the world's oceans is a tangible threat. Many factors are responsible for the transfer of litter, of which a fraction is plastic, into the marine environment. These factors vary in time and space, but ultimately lead seas and oceans to be the final repositories of anthropogenic waste.[1] Out of global yearly plastic production (368 million tonnes in 2019), an estimated 3 per cent flows into the oceans, with projections varying between a low of 1.1–2.4 million tonnes to a high of 12 million tonnes per year.[2] If current commitments stay unchanged, global inputs could reach 80 million tonnes by 2040.[3]

Unlike the open oceans, the Mediterranean is a semi-enclosed sea bordered by a number of countries facing significant effects of human pressure, from high population growth rates to urbanisation and intensive maritime traffic, among others. Plastic pollution issues have in fact

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[1] Patricia Villarrubia-Gómez, Sarah E. Cornell and Joan Fabres, "Marine Plastic Pollution as a Planetary Boundary Threat – The Drifting Piece in the Sustainability Puzzle", in *Marine Policy*, Vol. 96 (October 2018), p. 213-220, https://doi.org/10.1016/j.marpol.2017.11.035.

[2] Julien Boucher et al., *The Marine Plastic Footprint*, Gland, IUCN, 2020, https://doi.org/10.2305/IUCN.CH.2020.01.en.

[3] PEW Charitable Trusts and SystemIQ, *Breaking the Plastic Wave. A Comprehensive Assessment of Pathways Towards Stopping Ocean Plastic Pollution*, 2020, https://www.pewtrusts.org/-/media/assets/2020/10/breakingtheplasticwave_mainreport.pdf.

steadily increased in the Mediterranean since the 1980s,[4] with annual quantities entering this environment now estimated between 220,000 and 570,000 tonnes per year.[5]

This plastic leakage is heterogeneous as specific entry points emit far more litter than others. Among them, the Nile river basin in Egypt, the Italian Po and the French Rhône rivers, as well as major coastal cities, are the main sources of marine litter in the Mediterranean Sea. Once in the marine environment, plastic debris become pervasive, as its presence is found on the sea surface and the seafloor, as well as on coastlines and in organisms living in these environments. Direct, multidimensional impacts arise, through collisions with ships, ingestion by marine species and visible pollution decreasing the perceived attractiveness of coastal areas. Against this backdrop, there has been a wake-up call from international organisations, non-governmental organisations and the broader public to address the question of plastic pollution in the environment. This issue is also specifically addressed by the Sustainable Development Goals (SDGs) (SDG 14, "life below water", in particular), in the European Union's Marine Strategy Framework Directive[6] and by many other policies, including bans and recycling incentives discussed below.

The analysis will discuss the extent, causes, impacts and challenges of the Mediterranean's marine plastic pollution. It will assess existing policy provisions and mitigating strategies adopted across Mediterranean states and outline a number of policy recommendations directed at relevant decision-makers from both shores of the Mediterranean.

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[4] Robert J. Morris, "Plastic Debris in the Surface Waters of the South Atlantic", in *Marine Pollution Bulletin*, Vol. 11, No. 6 (June 1980), p. 164-166.

[5] Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, Gland, IUCN, 2020, https://portals.iucn.org/library/node/49124; Dalberg Advisors and WWF Mediterranean Marine Initiative, *Stop the Flood of Plastic. How Mediterranean Countries Can Save Their Sea*, World Wide Fund for Nature (WWF), 2019, https://awsassets.panda.org/downloads/a4_plastics_reg_low.pdf.

[6] European Commission website: *Our Oceans, Seas and Coasts*, https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm.

4.1 Mapping pollution: Estimated stock, annual inputs and hotspots

Anthropogenic marine litter is mainly generated on land (approximately 80 per cent) and reaches the marine environment in a variety of ways, whilst the remaining fraction is directly generated at sea.[7] The advantages of utilising plastics are well known: their light weight, durability and cheapness have made them ubiquitous in everyday life since the 1950s. However, such advantages have quickly turned into drawbacks considering the mismatch between plastic inputs on the market and waste management capacity, which is critical to prevent leakage into the environment. As waste is generated, it quickly builds up in bins and containers, and needs to be properly collected to be effectively sorted, recycled and dealt with. If waste collection capacity is weak or missing, the possibility of waste transfer to the open environment is even higher. Once collected, waste can still be mismanaged, usually when low-value plastics are illegally dumped or burnt, or when directed to landfills to be buried.

In focussing on the Mediterranean region, we distinguish between “sanitary” and “non-sanitary” landfills. The latter are generally poorly maintained or have a low level of engineering standards that lead waste to be uncovered or prone to mobilisation via wind or rain. In some cases, the market-based design and production of plastic products worldwide is incompatible with the local waste management systems into which these products are introduced after use.[8] This can be attributable to the higher level of technology required to recycle a product (e.g., chemical recycling), an area where there is a clear mismatch between northern and southern shore countries across the Mediterranean. Without efficient waste management strategies and a reform of existing production and packaging modalities as well as consumer habits, this can lead to extensive pollution. Plastic products thus can enter the environment and accumulate, invading coastal and marine systems through riverine transport or wind.

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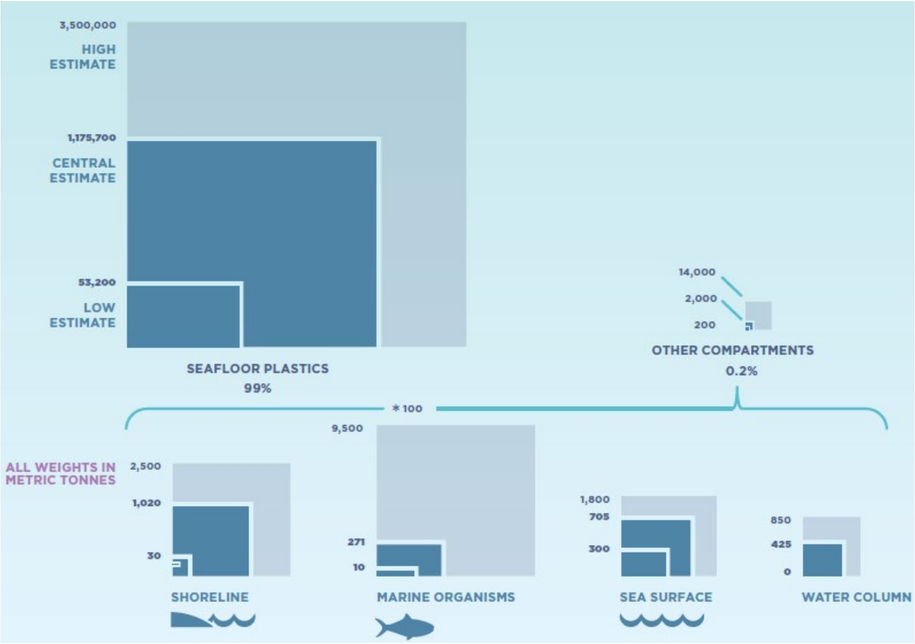
[7] Jenna R. Jambeck et al., “Plastic Waste Inputs from Land into the Ocean”, in *Science*, Vol. 347, No. 6223 (13 February 2015), p. 768-771.

[8] PEW Charitable Trusts and SystemIQ, *Breaking the Plastic Wave*, cit.

Unfortunately, the Mediterranean is no exception to these trends and is indeed considered one of the most polluted seas in the world.[9] Yet, quantifying plastic pollution in the Mediterranean Sea is not an easy task. Sources on the actual amount of plastic present in the basin differ widely. Estimates range from 705 to 1,455 and even 3,000 tonnes for the entire sea surface and more than 1,175,000 tonnes estimated for the seafloor with concentrations varying geographically.

Figure 1 | Stock of plastic debris inside the different compartments of the Mediterranean ecosystem



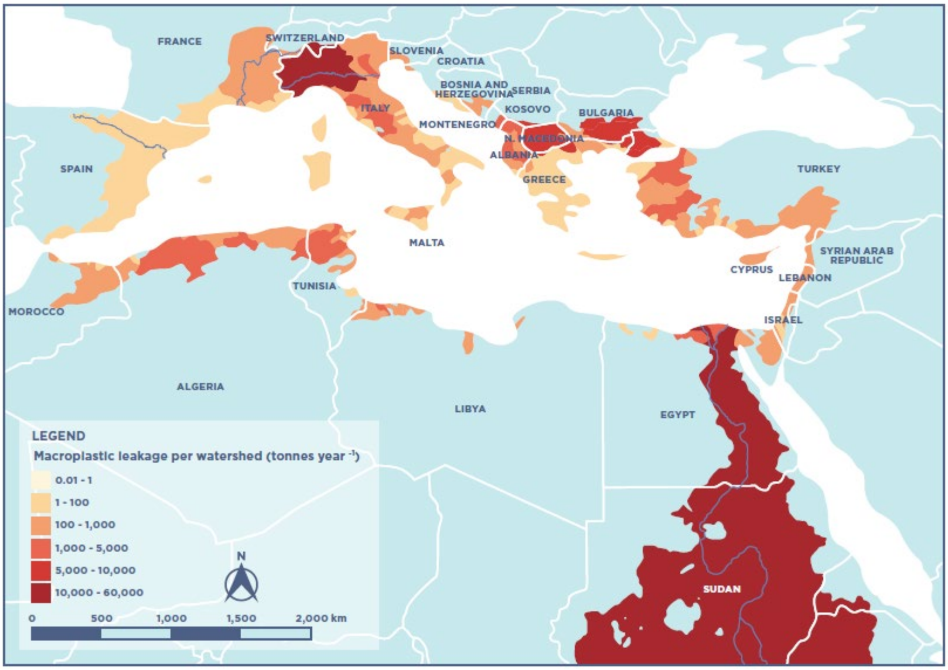
Source: Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit., p. 11. Courtesy of the International Union for Conservation of Nature (IUCN).

[9] Giuseppe Suaria et al., "The Mediterranean Plastic Soup: Synthetic Polymers in Mediterranean Surface Waters", in *Scientific Reports*, Vol. 6 (2016), Article 37551, https://doi.org/10.1038/srep37551.

Plastic debris is also found in other compartments of the marine environment, such as coastlines, ingested by marine fauna and yo-yoing inside the water column, floating between the surface and the seafloor at different depths. Therefore, more than 1,600 tonnes may be potentially added to estimated stocks outlined above.

In addition to the stock, a number of models have been developed to estimate the annual flux (or leakage) of plastic waste into the Mediterranean. In total, the Mediterranean Sea is presumed to receive more than 200,000 tonnes of plastic (either micro- or macro-plastics) every year, with an overwhelming proportion of 92 per cent being macro-plastics. Each Mediterranean country, however, does not contribute equally to the leakage.

Figure 2 | Contribution of watersheds in the leakage of plastic waste



Source: Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit., p. 27. Courtesy of IUCN.

The main countries contributing to this pollution are Egypt (74,000 tonnes per year), Italy (34,000 tonnes per year) and Turkey (24,000 tonnes per year).[10] The causes of these inputs are largely attributed to mismanaged waste, a category that includes, for example, uncollected waste and scarcity of sanitary landfills. Waste mismanagement can in turn be aggravated by environmental parameters such as rain, which can transport waste to nearby watercourses. This is what happens in the case of the Nile river, which is alone responsible for the leakage of 55,000 tonnes per year.[11] Therefore, a number of plastic pollution hotspots have emerged in the Mediterranean in correspondence with river basins (e.g., the River Po or River Rhône), but also in densely populated areas close to the shore and cities where waste is ineffectively managed (e.g., Tripoli or Tirana). If the way in which plastic litter is being exported to sea is somewhat complex, human activities are directly responsible for the transfer of such material to the environment. This is particularly true for Mediterranean countries where intensive agriculture is predominant, as debris from greenhouses, for example, have been found in the stomachs of sperm whales near the Strait of Gibraltar.[12]

The combination of high population, proximity to shore or rivers and high volumes of mismanaged waste, together with littering and accidental spillage, are therefore the main drivers of plastic flux into the Mediterranean Sea. It must be noted that all Mediterranean countries have different leakage points, as island states do not leak the same way as inland countries with large river basins for example. This flux in turn interacts with the marine life and human activities, creating a myriad of disruptive impacts for each ecosystem it reaches.

4.2 Impacts on biodiversity, economy, human health and sustainability

The most infamous effect of plastic pollution is its impact on flora and fauna. These widely documented impacts are multi-faceted and affect both terrestrial and marine organisms. Sea birds for example are some

[10] Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit., p. 28.

[11] Ibid.

[12] Renaud de Stephanis et al., "As Main Meal for Sperm Whales: Plastics Debris", in *Marine Pollution Bulletin*, Vol. 69, No. 1-2 (April 2013), p. 206-214.

of the first documented species interacting with plastic litter, mainly through ingestion, causing decreased gut capacity which can lead to starvation and ultimately death.[13] There is also evidence that plastic debris is passed from adults to juveniles in the feeding process during nestling period,[14] with a reported 66 per cent contamination rate for nine species of seabirds.[15] Other reported impacts on biodiversity include entanglement in mainly macro-sized debris (e.g., fishing nets) commonly referred to as *ghost fishing*; hypoxia (oxygen depletion) that occurs when large debris accumulates on the seafloor; and the dispersion of alien species attached to debris, from one ecological niche to another in the marine environment.[16]

Moreover, plastic waste at sea interacts with human activities and can lead to major economic drawbacks. This is particularly true for coastal communities highly dependent on tourism, and indeed these states tend to direct substantial amounts of money to cleaning campaigns. Pollution can lead to a dramatic decrease in tourism affluence, with serious socio-economic repercussions for local communities.[17] It is estimated that economic losses from plastic pollution in the Mediterranean Sea reached 641 million euro in 2018.[18]

The current situation in the Mediterranean – a region already suffering from severe socio-economic turmoil and fragilities, particularly in the South – should serve as a wake-up call for policymakers and businesses across the region. Economic damages include vessel downtime to

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[13] Marina Codina-García et al., “Plastic Debris in Mediterranean Seabirds”, in *Marine Pollution Bulletin*, Vol. 77, No. 1-2 (15 December 2013), p. 220-226.

[14] Peter G. Ryan, “Intraspecific Variation in Plastic Ingestion by Seabirds and the Flux of Plastic Through Seabird Populations”, in *The Condor*, Vol. 90, No. 2 (May 1988), p. 446-452.

[15] Renaud de Stephanis et al., “As Main Meal for Sperm Whales: Plastics Debris”, cit.

[16] Murray R. Gregory, “Environmental Implications of Plastic Debris in Marine Settings – Entanglement, Ingestion, Smothering, Hangers-on, Hitch-Hiking and Alien Invasions”, in *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol. 364, No. 1526 (27 July 2009), p. 2013-2025.

[17] Christopher G. Leggett et al., *Assessing the Economic Benefits of Reductions in Marine Debris: A Pilot Study of Beach Recreation in Orange County, California*, Cambridge, Industrial Economics, Incorporated, July 2014, https://marinedebris.noaa.gov/node/357.

[18] Dalberg Advisors and WWF Mediterranean Marine Initiative, *Stop the Flood of Plastic*, cit.

repair affected propellers, as well as loss of investments due to pervasive pollution, including from declining tourism. Yet, the influx of tourists coming to the Mediterranean region (approximately 200 million people prior to covid-19 pandemic) is responsible for a 40 per cent increase of marine litter in the summer period, due to the heavy reliance on single-use plastics, and the impossibility for local authorities to manage the subsequent waste generated as a result of high frequentation.[19]

Drifting and floating plastic debris has a tendency for adsorption (adhesion of molecules to a surface) meaning that in the open environment, they can take on toxins such as di-dichlorodiphenyltrichloroethane (DDT) or other pollutants identified as carcinogenic agents.[20] Moreover, their own chemical composition makes them potential threats if ingested, as they are generally produced from crude oil with many additives such as flame-retardants or plasticisers. Hence, plastic waste can have a huge impact on human and animal health. As fish and invertebrates ingest debris either passively or actively (filter feeding/mistaken for prey), this can lead to a direct transfer to humans through the food chain.[21] This transfer is even more significant and dangerous when the entire organism is consumed as in the case of mussels. The long-term impacts of micro-plastics in the human food system are however difficult to assert and require further research.[22]

Furthermore, marine litter can lead to adverse and durable effects on

[19] Eva Alessi and Giuseppe Di Carlo, *Out of the Plastic Trap: Saving the Mediterranean from Plastic Pollution*, WWF, June 2018, https://awsassets.panda.org/downloads/a4_plastics_med_web_08june_new.pdf.

[20] Lorena M. Rios, Charles Moore and Patrick R. Jones, "Persistent Organic Pollutants Carried by Synthetic Polymers in the Ocean Environment", in *Marine Pollution Bulletin*, Vol. 54, No. 8 (August 2007), p. 1230-1237.

[21] Juan Bellas et al., "Ingestion of Microplastics by Demersal Fish from the Spanish Atlantic and Mediterranean Coasts", in *Marine Pollution Bulletin*, No. 109, No. 1 (15 August 2016), p. 55-60; Nikoletta Digka et al., "Microplastics in Mussels and Fish from the Northern Ionian Sea", in *Marine Pollution Bulletin*, No. 135 (October 2018), p. 30-40.

[22] Luís Gabriel A. Barboza et al., "Microplastics in Wild Fish from North East Atlantic Ocean and Its Potential for Causing Neurotoxic Effects, Lipid Oxidative Damage, and Human Health Risks Associated with Ingestion Exposure", in *Science of the Total Environment*, No. 717 (May 2020), Article 134625, https://doi.org/10.1016/j.scitotenv.2019.134625.

the sustainable use of marine resources. The presence of marine plastics is also a threat to human food security (impacting marine food sources) and the sustainable use of the oceans, which all are addressed by the UN Agenda 2030 and the SDGs. Ecosystem services are also at risk. Defined as "the contributions of ecosystems to benefits used in economic and other human activity",[23] such services – which include for instance beaches – were valued at 49.7 trillion US dollars per year back in 2011.[24]

The presence of marine litter alone could decrease marine ecosystem service value by up to 5 per cent.[25] This is especially true for fisheries and aquaculture, as seafood is the principal source of animal protein in the world. Moreover, damage due to physical interactions of plastic with sea life (commercially important fish species for example) can reduce the efficiency and productivity of these activities.[26]

Finally, plastic waste in the sea also generates important costs for natural capital, which can be defined as "the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people".[27] In other words, natural capital refers to a chain, a process of services which in turn produce for example clean water or fertile soils. When it comes to sourcing plastic materials, or managing their end-of-life cycle, decisions on where to make that happen geographically can have important effects on natural capital.

[23] UN System of Environmental Economic Accounting (SEEA) website: *Introduction to SEEA Ecosystem Accounting*, https://seea.un.org/node/2622.

[24] Robert Costanza et al. "Changes in the Global Value of Ecosystem Services", in *Global Environmental Change*, No. 26 (May 2014), p. 152-558.

[25] Nicola J. Beaumont et al., "Global Ecological, Social and Economic Impacts of Marine Plastic", in *Marine Pollution Bulletin*, No. 142 (May 2019), p. 189-195, https://doi.org/10.1016/j.marpolbul.2019.03.022.

[26] John Mouat, Rebeca Lopez Lozano and Hannah Bateson, *Economic Impacts of Marine Litter*, KIMO International, September 2010, http://www.kimointernational.org/wp/wp-content/uploads/2017/09/KIMO_Economic-Impacts-of-Marine-Litter.pdf.

[27] Natural Capital Coalition, *Natural Capital Protocol*, 2016, p. 2, https://capitalscoalition.org/?p=24809.

4.3 Causes, challenges and knowledge gaps of plastic waste in the Mediterranean

Although waste produced in high-income countries is generally well managed and disposed of, some countries of the Mediterranean (Spain, France and Italy for example), and particularly private sector entities, find it more economically advantageous to send their excess waste to other regions of the world,[28] also via illegal channels.

This occurs, for instance, when domestic recycling facilities are unable to manage internally produced waste. China has a long history of foreign waste imports, and before the 2017 import ban, it imported 55 per cent of the world's plastic waste.[29] Following the ban, the country experienced a significant decrease in waste imports (-88 per cent), which shifted the direction of foreign trash flows towards South East Asia. Thailand for example experienced a 640 per cent increase in plastic imports from January to June 2018. Although this seems beneficial for both parties (exporters and importers), disposing of waste in those countries (which are usually dependent on such flows to generate income) takes a toll on local natural capital.[30] This also generates an informal recycling industry where safety protocols are largely absent, which can be detrimental to both the workforce and the surrounding environment (city streams for example).

Far from being an alarming phenomenon limited to Asia, waste trafficking also occurs between the two shores of the Mediterranean. Recently, such fluxes have been reported between Italy and Tunisia, raising awareness on the abuses committed in the waste trade.[31] In this

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[28] Zongguo Wen et al., "China's Plastic Import Ban Increases Prospects of Environmental Impact Mitigation of Plastic Waste Trade Flow Worldwide", in *Nature Communications*, Vol. 12 (2021), Article 425, https://doi.org/10.1038/s41467-020-20741-9.

[29] Ibid.

[30] Julie Raynaud, *Valuing Plastic. The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry*, UN Environment Programme (UNEP), 2014, https://wedocs.unep.org/handle/20.500.11822/9238.

[31] Simon Speakman Cordall, "Tunisia Minister Sacked and Arrested in Scandal over Illegal Waste from Italy", in *The Guardian*, 24 December 2020, https://www.theguardian.com/p/fptaa.

case, a cost-avoidance scheme motivated by lower disposal fees in Tunisia, led municipal waste to be exported from Italy to Tunisia, where a local company planned to dispose of the material while capitalising on the recovery of recyclables and lightning disposal costs for the Italian party. However, such exports are prohibited under the European Waste Shipment Regulation as they are only limited to countries in the European Free Trade Association, and prohibited by the Bamako Convention (of which Tunisia is a member) as municipal waste is considered as hazardous. Another consequence of the China ban on waste imports is the re-routing of waste flows to Mediterranean countries such as Turkey (estimated to host 37 per cent of EU's waste[32]). A country already struggling to manage its own waste, illegal imports are also a way to generate income at the expense of the environment and local livelihoods.

In order to reduce the trans-border shipment of waste, 187 countries have ratified the Basel Convention of the United Nations, where plastic waste has been added to the category of hazardous waste to regulate this circulation.[33] However, the United States, one of the world's main exporter of waste, is absent from the treaty and this hampers global efforts to tackle this dramatic phenomenon.

Despite growing awareness of the magnitude of the problem, plastic pollution research is in its early stages. Since the beginnings of such research in the early 1970s, studies have mainly examined the interactions of plastics with marine fauna (entanglement, ingestion).[34] Knowledge gaps are still present, regarding uncertainties in the distribution of plastic debris inside the water column. Field measurements on the sea surface usually report far lower quantities than those brought forward by models.[35]

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[32] Eurostat, *Turkey: Main Destination for EU's Waste*, 16 April 2020, https://europa.eu/!rD78jp.

[33] Chao Wang et al., "Structure of the Global Plastic Waste Trade Network and the Impact of China's Import Ban", in *Resources, Conservation and Recycling*, Vol. 153 (February 2020), Article 104591.

[34] Edward J. Carpenter et al., "Polystyrene Spherules in Coastal Waters", in *Science* Vol. 178, No. 4062 (17 November 1972), p. 749-750.

[35] Richard C. Thompson et al., "Lost at Sea: Where Is All the Plastic?", in *Science*, Vol.

On a larger scale, the general circulation of debris in the open oceans – as well as the consequences on the wider food web and bio-accumulation in apex predators – still requires further research. Traditionally, research on the Mediterranean Sea's plastic pollution has been focused on stock estimations and impacts (the so-called "bottom-up" approach), overlooking its root causes. This approach can be equated with the example of a hydropower dam failure: instead of investigating the structural flaws which led to the failure of the dam, studies focus on the consequences caused by the release of the impounded water downstream. In the case of plastics in the Mediterranean, the structural flaws would be waste management and sanitation across countries.

Among the root causes of worldwide plastic pollution, in both terrestrial and marine habitats, is the mismanagement of waste. Depending on its point of generation, categories include municipal, commercial, industrial, agricultural, and construction and demolition waste,[36] which usually is either inadequately disposed of in uncontrolled facilities, or is just dumped.[37]

A hierarchy exists in plastic polymers and the degree of recyclability the polymer can offer. Such high-value plastics typically include polyethylene terephthalate (PET) or high-density polyethylene (HDPE) on the one hand, while low-value plastics include polypropylene (PP) or low-density polyethylene (LDPE) on the other, mainly used for single-use applications such as plastic bags. When it comes to dumping waste into landfills, around 80 per cent of the bulk is composed of low-residual-value plastics, whereas the remaining fraction has a high residual value. In this context, it is estimated that 100 per cent of the low-value plastics disposed of in non-sanitary landfills will leak into the environment, while 90 per cent per cent of high-value plastic will be collected by waste pickers.[38]

304, No. 5672 (7 May 2004), p. 838.

[36] David K.A. Barnes et al., "Accumulation and Fragmentation of Plastic Debris in Global Environments", in *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol. 364, No. 1526 (27 July 2009), p. 1985-1998.

[37] Jenna R. Jambeck et al., "Plastic Waste Inputs from Land into the Ocean", cit.

[38] McKinsey Center for Business and Environment and Ocean Conservancy, *Stem-*

This low-value plastic waste can in turn be mobilised by wind and rainwater, leading to transfer into the marine environment through waterways.[39] This mainly concerns macro-sized waste, e.g., single-use packaging, containers and bottles, but also PVC pipes from the construction sector for example.[40]

A myriad of applications can be found depending on the level of separation the waste has undergone, and composition will change as recyclables are removed.[41] Transfer of waste into the sewage system can also participate in the leakage of macro-waste when rain levels exceed sewage treatment facility handling capacities.[42] The percentage of waste that is mismanaged in a country can be conceptualised via a mismanaged waste index (MWI). The MWI calculates this by dividing the mismanaged waste in the country by the total waste produced in that country.[43]

An International Union for Conservation of Nature (IUCN) study conducted across Mediterranean countries in 2020 (which include hydrological basins that are connected to this sea) reveals that the average MWI stands at 67 per cent. Additionally, the study shows that countries with high MWI are usually responsible for a greater share of yearly inputs of waste into the Mediterranean, further validating the correlation between plastic pollution and plastic waste mismanagement (Egypt: 95 per cent MWI, total leakage: 74,000 tonnes per year; Bulgaria: 69 per cent MWI, total leakage: 5,500 tonnes per year). Combined with

ming the Tide: Land-Based Strategies for a Plastic-Free Ocean, September 2015, https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf; Quantis and EA, *Plastic Leak Project Methodological Guidelines*, March 2020, https://quantis-intl.com/wp-content/uploads/2020/02/plastic_leak_project_pages.pdf.pdf.

[39] Laurent C.M. Lebreton et al., "River Plastic Emissions to the World's Oceans", in *Nature Communications*, Vol. 8 (2017), Article 15611, https://doi.org/10.1038/ncomms15611.

[40] For more on this topic, see Ellen MacArthur Foundation, *10 Circular Investment Opportunities for a Low-Carbon and Prosperous Recovery*, October 2020, https://www.ellenmacarthurfoundation.org/assets/downloads/Plastic-Packaging.pdf.

[41] David K.A. Barnes et al., "Accumulation and Fragmentation of Plastic Debris in Global Environments", cit.

[42] Julien Boucher et al., *The Marine Plastic Footprint*, cit.

[43] Ibid.

high coastal population and in some areas important water runoff, the study estimates total mismanaged waste in the Mediterranean region at 5,929,558 tonnes per year in 2018, creating a combined macro- and micro-plastic leakage of 229,000 tonnes per year (see Table 1).[44]

Table 1 | Share of each Mediterranean country in plastic leakage according to the Mare Plasticum report

Country	Macro-plastic waste	Micro-plastic waste	Total
Albania	8,625	101	8,726
Algeria	13,111	425	13,536
Bosnia & Herzegovina	901	13	914
Croatia	329	19	348
Cyprus	332	36	368
Egypt	74,031	1,208	75,239
Greece	592	212	804
Israel	1,009	154	1,163
Italy	34,309	3,413	37,722
Montenegro	2,146	37	2,183
France	959	871	1,831
Lebanon	3,321	149	3,470
Libya	2,777	127	2,905
Malta	35	34	69
Morocco	2,824	77	2,900
Slovenia	72	10	82
Spain	570	835	1,405
Syria	1,357	32	1,388
Switzerland	319	114	433
Kosovo	491	64	555
Macedonia	6,632	181	6,813
Kenya	5,954	406	6,361
Tanzania	1,274	246	1,519
Burundi	813	167	981
Sudan	3,913	867	4,780
South Sudan	1,571	317	1,888
Bulgaria	5,566	79	5,645
Ethiopia	766	908	1,673

[44] Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit.

Uganda	7,744	993	8,736
Turkey	23,966	637	24,603
Rwanda	1,909	312	2,220
Serbia	17	0	18
Tunisia	8,034	154	8,187
Total	**216,269**	**13,196**	**229,466**

Note: African countries of the Nile river basin are included.
Source: Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit., p. 49-50. Courtesy of IUCN.

While macro-plastics already represent a key threat for the environment and sustainability, micro-plastics pollution is an even more worrisome phenomenon. Flowing through the waste-water system, micro-plastics reach the marine environment in high concentrations. In the Mediterranean region, this leakage is estimated at 13,000 tonnes per year for four main types: tyre dust generated while driving, synthetic fibres shed during washing, release of microbeads present in cosmetics and accidental spillage of plastic pellets.[45]

Each type has its own specific routes to the marine environment, with a few similar patterns. Tyre dust generation for example, is mainly linked to the increased reliance on personal cars. Once generated, an estimated 12 per cent of total tyre dust particles can flow into surface waters because of road run-off.[46]

This is especially true for Mediterranean countries such as Italy (2,950 tonnes per year), France (779 tonnes per year) or Spain (790 tonnes per year).[47] In addition, the absence or small coverage of waste-water treatment in other parts of the Mediterranean region is a driver for the inflow of synthetic fibres to the sea. In this case, grey water (household or office

[45] Ibid.

[46] Stephan Wagner et al., "Tire Wear Particles in the Aquatic Environment – A Review on Generation, Analysis, Occurrence, Fate and Effects", in *Water Research*, Vol. 139 (1 August 2018), p. 83-100; Pieter Jan Kole et al., "Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment", in *International Journal of Environmental Research and Public Health*, Vol. 14, No. 10 (October 2017), Article 1265, https://doi.org/10.3390/ijerph14101265.

[47] Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit.

building water without faecal contamination) is directly released into sewage systems, which will generally flow into rivers or streams without prior treatment. Such water can contain microbeads added in personal care products, and synthetic fibres released by hand or machine washing (acrylic, polyamide).[48] Uganda illustrates this example, where the share of waste-water treatment is 5 per cent, and the emission of synthetics reaches 578 tonnes per year. This challenge is particularity shared by many Nile river basin countries which were considered in the study.[49]

Reliable data on collection and recycling rates is difficult to access. Such data are generally derived from municipal waste management metrics[50] which are often not homogeneous and directly comparable, and also lack specificity for plastics. When there is a need for higher granularity (e.g., investigating waste collection in specific cities), analyses are dependent on the quality of the data entered by local authorities which in some cases is insufficient, and therefore requires assumptions. When investigating MWI, there seems to be an impossibility in finding specific polymer and country values, especially true for low-value plastics as they will have a much higher index than high-value ones. This will be further addressed in the policy recommendation section.

Therefore, a context-specific approach is needed to drive action and monitor progress. This requires higher transparency on waste management performance, e.g., the classification of landfills as "sanitary" or "non sanitary", and the spatial distribution of existing dumpsites. The latter, being mainly informal, require field investigations and mapping that will greatly benefit more precise estimations of leakage. A methodology has been developed for generating these metrics at national or sub-national levels and will be discussed in the section below. A better understanding of leakage pathways is key to refining the release/leakage rates. A greater understanding is needed to assess the influence of

[48] Mark Anthony Browne et al., "Accumulation of Microplastic on Shorelines Woldwide: Sources and Sinks", in *Environmental Science & Technology*, Vol. 45, No. 21 (2011), p. 9175-9179.

[49] Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit.

[50] Slipa Kaza et al., *What a Waste 2.0. A Global Snapshot of Solid Waste Management to 2050*, Washington, World Bank2018, http://hdl.handle.net/10986/30317.

slope, hydrology, wind and other parameters related to the infrastructure (e.g., combined versus separate sewers).

Finally, field data collection using remote sensing would be a great asset, and help localise dumps and areas of high-intensity waste disposal. Such technology has mainly been field-tested by research laboratories in experimental surveys, using Landsat thermal images. Though there is still a need for models to be correctly calibrated, experiments have proven to be fruitful, especially when measuring land-surface temperatures for outlining waste disposal in poorly documented landfills. [51] Several years of fine-tunning will be necessary before it can become a widespread option for pollution prevention. As of today, there is a general lack of field data measuring plastic stocks and flows throughout the value chain, which often leads to erroneous assumptions and analyses.[52]

The higher the granularity, the better the understanding and possibility of deriving specific release rates for different mismanaged routes. Indeed, waste will not leak in the same way when littered or stocked in dumps. Therefore, more specific data on the impact of leaked plastic will also help set better priorities for decision makers (e.g., which polymer or product design is better than another), while knowledge on the efficiency of action is also key to orienting towards better solution pathways.

4.4 Review of existing policies

Despite the adverse effects of plastic pollution on the marine environment, and the knowledge gaps hindering a wider understanding of the topic, some effective actions can be, and have already started to be undertaken to reduce plastic leakage. Since the early 2000s, policy regulations aiming to reduce plastic pollution in the environment have increased. European regulations appear to be the most numerous (62 per cent of all policies aimed at this subject arise from the European Union, see below). If correct upstream and downstream measures are

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[51] Jasravia Gill et al., “Detection of Waste Dumping Locations in Landfill Using Multi-Temporal Landsat Thermal Images”, in *Waste Management & Research*, Vol. 37, No. 4 (April 2019), p. 386-393, https://doi.org/10.1177/0734242X18821808.

[52] PEW Charitable Trusts and SystemIQ, *Breaking the Plastic Wave*, *cit*.

adopted, ocean leakage could drop 80 per cent from its current level by 2040.[53] This could be achieved by reducing plastic consumption, substituting plastic with compostable materials and paper, designing products in a way that facilitates recycling, increasing collection rates, expanding mechanical recycling and disposing of waste in a secure way, i.e., sanitary landfills.[54] Importantly, leakage reduction around the world, and in the Mediterranean in particular, requires a full view on the plastic life cycle and value chain.

Despite these efforts, the plastic industry is expected to grow: in 2021, the compound annual growth rate of plastics is estimated to reach 7.5 per cent, further stabilising at 6.5 per cent in 2025.[55] Moreover, some specific applications, such as the covid-19-led increase of personal protective equipment, are projected to lead to an approximate 20 per cent spike from 2020 to 2025 in plastic generation for such equipment.[56] Thus, the amount of waste exported to the marine environment will inevitably increase. In this context, current commitments will only slow the increase of leakage by 7 per cent by 2040, meaning that such leakages are still expected to triple in absolute terms.[57]

Among the most commonly adopted commitments taken by European countries are bans on single-use bags and straws, setting more ambitious recycling rates and limiting the export of waste to developing countries. This is expected to lead to a reduction of 19 million tonnes per year in plastic production and consumption.[58]

Although increasing recycling rates is critical and a welcomed necessity, funnelling all plastic waste into this process in neither economically nor technically feasible. One setback of recycling is the contamination of

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[53] Ibid.

[54] Ibid.

[55] The Business Research Company, *Plastic and Rubber Products Global Market Report 2021: COVID19 Impact & Recovery to 2030*, January 2021.

[56] Neha Parashar and Subrata Hait, "Plastics in the Time of COVID-19 Pandemic: Protector or Polluter?", in *Science of the Total Environment*, Vol. 759 (March 2021), Article 144274.

[57] PEW Charitable Trusts and SystemIQ, *Breaking the Plastic Wave*, cit.

[58] Ibid.

waste that has not been separated into different categories for targeted recycling (with 50 per cent assumed to be either contaminated or incompatible with a pyrolysis plant).[59]

Among the different policies, a milestone in the Mediterranean region is the Regional Plan for Marine Litter Management, co-led by UN Environment and the Mediterranean Action Plan. The Plan has led 19 Mediterranean countries to address marine litter, and 17 Mediterranean countries to adopt measures for the reduction in use of single-use plastic bags.[60]

This action plan commits to:

- *Capture post-leakage plastic*: Conduct beach clean-ups in protected areas, identify litter hotspots and conduct fish-for-litter campaigns.
- *Responsible handling of waste*: Ensure the highest standards with regard to sewer and waste-water treatment and waste management facilities to prevent leakage.
- *Economic instruments*: Participating states will develop instruments (taxes) to reduce the use of plastics (see below).
- *Research and data collection*: Each participating state will design national monitoring programmes.

The above would help to get the Mediterranean region on track in addressing SDG 14, aiming to increase scientific knowledge (14.a); prevent and reduce marine pollution (14.1) and sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts (14.2).[61]

At the EU level, it is worth noting Directive 2019/904 on reduction of the impact of certain plastic products on the environment. It aims to give priority to sustainable and non-toxic re-usable products and re-use systems. This includes bans on specific single-use items which have an

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[59] Ibid.

[60] Rachel Karasik et al., *20 Years of Government Responses to the Global Plastic Pollution Problem. The Plastics Policy Inventory*, Durham, Duke University, May 2020, https://nicholasinstitute.duke.edu/node/10677.

[61] UN Department of Economic and Social Affairs (UNDESA) website: *Sustainable Development, Goal 14*, https://sdgs.un.org/goals/goal14.

alternative (e.g., cutlery) and a 90 per cent collection rate for plastic bottles by 2029.[62] This will also be a key priority of the Circular Economy Action Plan of the European Union, emphasising a legislative initiative on re-use in food services to substitute for single-use food packaging. Presently, most measures implemented in the region relate to bans on specific plastic applications however (straws and bags).

At the country level, there is a growing awareness in the Mediterranean region of the pervasive plastic issue, with at least seven countries adopting or planning a plastic bag ban. Morocco for example in 2016 adopted a ban on production, import and distribution of plastic bags, with regular seizures and enforcement by local authorities.[63] The aim was to progressively replace plastic bags by paper or woven bags (up to 4.6 billion paper bags and 100 million woven bags). However, as of 2018, plastic bags are still largely used, as current alternatives are considered impractical and expensive by the population and therefore a parallel black market has appeared.[64]

Other countries followed a similar approach. For instance, in January 2018 Greece adopted a 0.04 euro fee for all plastic bags in the country, raising this to 0.09 euro in 2019. The aim is to finance the production of eco-friendly alternatives. The Research Institute of Retail Consumer Goods (IELKA) reported a 75 to 80 per cent drop in the use of single-use plastic bags, when comparing the benchmark year of 2017. This has shifted consumer habits. It is estimated that 2 in 3 households now rely on reusable bags.

In addition, in March 2017 Tunisia adopted a decree to ban the distribution of plastic bags in supermarkets, replacing them by biodegradable bags. By March 2018, the ban was extended to pharmacies, while in January 2021 production, manufacturing and use of all plastic bags was prohibited in the country. The benefits of such measures, however, will

[62] European Parliament and Council of the European Union, *Directive (EU) 2019/904 of 5 June 2019 on the Reduction of the Impact of Certain Plastic Products on the Environment*, http://data.europa.eu/eli/dir/2019/904/oj.

[63] Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit.

[64] Zéro Zbel, *Enquête sur l'usage des sacs en plastique et des alternatives aux sacs en plastique*, June 2018, http://www.zerozbel.ma/?p=17079.

require a few years to be assessed correctly. In a similar fashion, France and Italy, along with Malta, have also taken similar measures (taxes and bans), yet the benefits of such policies still need more years of implementation to be assessed properly.

Although bans on straws, plastic bags and microbeads can be considered a good sign, they will not fully abate plastic leakage. If this was the only regulatory policy implemented across all the Mediterranean countries, yearly leakage would still reach 400,000 tonnes per year in 2040 (compared to 220,000 today). Furthermore, if nothing at all is done, yearly inputs are estimated to peak at 500,000 tonnes per year, which is not significantly different from the full ban scenario, demonstrating its limited effectiveness.[65]

These measures are therefore only part of the strategy to reduce emissions to the environment, while others such as "cash for return" policies have significantly increased the level of recyclability of plastic beverage containers in high-income countries in general (United States, Europe). Hence, following policy implementation, Mediterranean countries have seen a steady yet disproportionate increase in recycling rates. In 2018, Spain and France recycled their plastic packaging waste up to 50 per cent and 27 per cent respectively, Italy 43 per cent and Greece 41 per cent according to Eurostat figures.[66] Turkey however recycled its waste up to 10 per cent in 2018, the remaining fraction being landfilled. These differences across countries need to be reduced, in order to boost the efforts to increase the recyclability of plastic in the whole region.

Other mitigation plans that are foreseen in the Mediterranean basin concern plastic offsetting and extended producer responsibility (EPR) schemes. Similar to carbon offsetting, this measure encourages manufacturers and consumers to become responsible for the waste they produce, against a fee. This in turn creates funds to be directed to clean-up campaigns for example, or other impact-limiting initiatives. This is especially addressed in the Regional Plan for Marine Litter Management cited

[65] Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit.

[66] Eurostat Database: *Waste*, https://ec.europa.eu/eurostat/web/waste/data/database.

above. Participating states will implement EPR strategies when possible to make the producers and manufacturers of plastics fully responsible for the waste produced by their products on the market (generally the life-cycle of the product).

At the producers level, this will imply rules that make product design suitable for reuse, encouraging recycling and material reduction (weight and toxicity).[67] However, as this can be a costly enterprise, especially in medium- to low-income countries of the Mediterranean, economic incentives to help producers who otherwise cannot implement such measures are needed.[68]

Finally, at the consumer level, some measures such as bag taxes, or timid increases in the amount charged for a plastic bag, can lead to a behaviour adjustment. However, research suggests that only through substantial taxation can these measures ensure a noticeable impact, thus adding different challenges to the debate.[69]

4.5 Conclusion and policy recommendations

The pervasive nature of plastic pollution has led to an overwhelming number of recommendations and actions. The sheer volume of such initiatives tends to hinder effective implementation. We are currently in a blurry landscape, where choosing the best policy response is akin to doing a jigsaw puzzle.

However, one of the most viable mitigating strategies for Mediterranean countries would be to aim for a 30 per cent reduction of plastic consumption by 2040. Worldwide, this could abate 125 million metric tonnes of avoidable macro-plastic waste without major economic or technical drawbacks.[70] Reducing overpackaging could alone decrease plastics by 8 per cent, and better designing products and packaging would enhance recyclability from the present 21 per cent to 54 per cent by 2040. In the

[67] Rachel Karasik et al., *20 Years of Government Responses to the Global Plastic Pollution Problem*, cit.

[68] Ibid.

[69] Johane Dikgang and Martine Visser, "Behavioural Response to Plastic Bag Legislation in Botswana", in *South African Journal of Economics*, Vol. 80, No. 1 (March 2012), p. 123-133.

[70] PEW Charitable Trusts and SystemIQ, *Breaking the Plastic Wave*, cit.

middle- to low-income countries of the Mediterranean, waste collection should be a priority, in both urban and rural areas.

Improving separate waste collection and waste-water management by 4 per cent is also estimated to have a valuable effect throughout the Mediterranean region. This could eliminate the majority of plastic fluxes from land to sea in the area, as models estimate a decrease up to 196,000 tonnes per year if such measures are widely adopted, on an estimated 220,000 tonnes per year leakage in 2018.[71] This would mean increasing collection rates and generally expanding infrastructure in areas where such technology is lacking, particularly rural areas.[72] In this sense, there is a need to reduce the mismatch between plastic inputs in the market and the treatment capacities of countries, which lead to saturation and pollution.

Although much light has been shed on macro-plastic pollution due to mismanaged waste, it must not be forgotten that micro-plastics are also key players in the loading of marine environments and that these are mainly emitted from high-income countries.[73] This input can be dramatically decreased by better designing products, improving waste-water treatment facilities and totally banning microbeads from cosmetic products. Tyre dust emissions will not decline until there is a major innovation in tyre components. If nothing is done to change the paradigm, it is estimated that more than 3 million tonnes of micro-plastics will enter the marine environment by 2040.[74]

Against this backdrop, private and public sectors need to work together so that effective measures are planned and undertaken. Any science-based approach relies on good data, which generates information and ultimately actionable knowledge. This is usually challenging when working on waste management as data comes both from private and public sectors (manufacturer and municipalities for example). Collection and recycling rates of common polymers are in many areas unavailable, which prevents the development of good metrics.

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[71] Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, cit.

[72] McKinsey Center for Business and Environment and Ocean Conservancy, *Stemming the Tide*, cit.

[73] PEW Charitable Trusts and SystemIQ, *Breaking the Plastic Wave*, cit.

[74] Ibid.

As a consequence, there is a need for common reporting schemes, with unified methods and reconciling tools to allow consistency throughout the whole dataset. In this sense, approaches such as the one developed by the United Nations Environment Programme and the International Union for the Conservation of Nature[75] are now available for countries to generate such appropriate datasets. This is one of the few methodologies capable of steering the plastic problem in three major directions: identify where to act, i.e., gathering sound data for modelling and identifying polymers leaking out of the plastic value chain; what to do to address the situation; and finally how and with whom to do it (i.e., local stakeholders, businesses and governments). To reduce this data knowledge gap, an innovative platform has been developed to gather sound environmental analytics, including mismanaged waste index, leakage, polymer and applications data.[76] It would have a greater impact if accompanied by binding treaties specifically addressing plastic pollution, adopted at the international level.

What is clear, however, is that there is an urgent call to create a binding international agreement, similar to the International Convention for the Prevention of Pollution from Ships (MARPOL) and the London Protocol, to help international action on confronting plastic waste pollution.[77] The consensus on these agreements is that they have led to positive outcomes in reducing maritime sources of plastic pollution, and a new global treaty focusing on land-based sources is urgently needed.[78] Attempts to break the plastic wave are been widely implemented in the Mediterranean region, with initiatives such as the BLUEMED Pilot for a plastic free Mediterranean Sea. Many solutions are at hand (circular economy, improving waste management, fostering recycling etc.) which are currently being carried out by many international actors such as the

[75] See UNEP, IUCN and Life Cycle Initiative, *National Guidance for Plastic Pollution Hotspotting and Shaping Action. Introduction to the Methodology*, 20 July 2020, https://wedocs.unep.org/handle/20.500.11822/33166.

[76] PLASTEAX website: https://www.plasteax.org.

[77] Rachel Karasik et al., *20 Years of Government Responses to the Global Plastic Pollution Problem*, cit.

[78] PEW Charitable Trusts and SystemIQ, *Breaking the Plastic Wave*, cit.

EU via the Interreg programme and Plastic Busters among others.

The Mediterranean region is in need of such a change of paradigm, and more ambitious actions are needed from both the private and public sectors to recover a great blue pristine sea, that is free of plastic and will continue to be able to provide sustenance and sustainability to people and communities inhabiting this space.

References

Eva Alessi and Giuseppe Di Carlo, *Out of the Plastic Trap: Saving the Mediterranean from Plastic Pollution*, WWF, June 2018, https://awsassets.panda.org/downloads/a4_plastics_med_web_08june_new.pdf

Luís Gabriel A. Barboza et al., "Microplastics in Wild Fish from North East Atlantic Ocean and Its Potential for Causing Neurotoxic Effects, Lipid Oxidative Damage, and Human Health Risks Associated with Ingestion Exposure", in *Science of the Total Environment*, No. 717 (May 2020), Article 134625, https://doi.org/10.1016/j.scitotenv.2019.134625

David K.A. Barnes et al., "Accumulation and Fragmentation of Plastic Debris in Global Environments", in *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol. 364, No. 1526 (27 July 2009), p. 1985-1998

Nicola J. Beaumont et al., "Global Ecological, Social and Economic Impacts of Marine Plastic", in *Marine Pollution Bulletin*, No. 142 (May 2019), p. 189-195, https://doi.org/10.1016/j.marpolbul.2019.03.022

Juan Bellas et al., "Ingestion of Microplastics by Demersal Fish from the Spanish Atlantic and Mediterranean Coasts", in *Marine Pollution Bulletin*, No. 109, No. 1 (15 August 2016), p. 55-60

Julien Boucher and Guillaume Billard, *The Mediterranean: Mare Plasticum*, Gland, IUCN, 2020, https://portals.iucn.org/library/node/49124

Julien Boucher et al., *The Marine Plastic Footprint*, Gland, IUCN, 2020, https://doi.org/10.2305/IUCN.CH.2020.01.en

Mark Anthony Browne et al., "Accumulation of Microplastic on Shorelines Woldwide: Sources and Sinks", in *Environmental Science & Technology*, Vol. 45, No. 21 (2011), p. 9175-9179

The Business Research Company, *Plastic and Rubber Products Global Market Report 2021: COVID19 Impact & Recovery to 2030*, January 2021

Edward J. Carpenter et al., "Polystyrene Spherules in Coastal Waters", in *Science* Vol. 178, No. 4062 (17 November 1972), p. 749-750

Marina Codina-García et al., "Plastic Debris in Mediterranean Seabirds", in *Marine Pollution Bulletin*, Vol. 77, No. 1-2 (15 December 2013), p. 220-226

Robert Costanza et al. "Changes in the Global Value of Ecosystem Services", in *Global Environmental Change*, No. 26 (May 2014), p. 152-558

Dalberg Advisors and WWF Mediterranean Marine Initiative, *Stop the Flood of Plastic. How Mediterranean Countries Can Save Their Sea*, World Wide Fund for Nature (WWF), 2019, https://awsassets.panda.org/downloads/a4_plastics_reg_low.pdf

Renaud de Stephanis et al., "As Main Meal for Sperm Whales: Plastics Debris", in *Marine Pollution Bulletin*, Vol. 69, No. 1-2 (April 2013), p. 206-214

Nikoletta Digka et al., "Microplastics in Mussels and Fish from the Northern Ionian Sea", in *Marine Pollution Bulletin*, No. 135 (October 2018), p. 30-40

Johane Dikgang and Martine Visser, "Behavioural Response to Plastic Bag Legislation in Botswana", in *South African Journal of Economics*, Vol. 80, No. 1 (March 2012), p. 123-133

European Parliament and Council of the European Union, *Directive (EU) 2019/904 of 5 June 2019 on the Reduction of the Impact of Certain Plastic Products on the Environment*, http://data.europa.eu/eli/dir/2019/904/oj

Eurostat, *Turkey: Main Destination for EU's Waste*, 16 April 2020, https://europa.eu/!rD78jp

Jasravia Gill et al., "Detection of Waste Dumping Locations in Landfill Using Multi-Temporal Landsat Thermal Images", in *Waste Management & Research*, Vol. 37, No. 4 (April 2019), p. 386-393, https://doi.org/10.1177/0734242X18821808

Murray R. Gregory, "Environmental Implications of Plastic Debris in Marine Settings – Entanglement, Ingestion, Smothering, Hangers-on, Hitch-Hiking and Alien Invasions", in *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol. 364, No. 1526 (27 July 2009), p. 2013-2025

Jenna R. Jambeck et al., "Plastic Waste Inputs from Land into the Ocean", in *Science*, Vol. 347, No. 6223 (13 February 2015), p. 768-771

Rachel Karasik et al., *20 Years of Government Responses to the Global Plastic Pollution Problem. The Plastics Policy Inventory*, Durham, Duke University, May 2020, https://nicholasinstitute.duke.edu/node/10677

Slipa Kaza et al., *What a Waste 2.0. A Global Snapshot of Solid Waste Management to 2050*, Washington, World Bank2018, http://hdl.handle.net/10986/30317

Pieter Jan Kole et al., "Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment", in *International Journal of Environmental Research and Public Health*, Vol. 14, No. 10 (October 2017), Article 1265, https://doi.org/10.3390/ijerph14101265

Laurent C.M. Lebreton et al., "River Plastic Emissions to the World's Oceans", in *Nature Communications*, Vol. 8 (2017), Article 15611, https://doi.org/10.1038/ncomms15611

Christopher G. Leggett et al., *Assessing the Economic Benefits of Reductions in Marine Debris: A Pilot Study of Beach Recreation in Orange County, California*, Cambridge, Industrial Economics, Incorporated, July 2014, https://marinedebris.noaa.gov/node/357

Ellen MacArthur Foundation, *10 Circular Investment Opportunities for a Low-Carbon and Prosperous Recovery*, October 2020, https://www.ellenmacarthurfoundation.org/assets/downloads/Plastic-Packaging.pdf

McKinsey Center for Business and Environment and Ocean Conservancy, *Stemming the Tide: Land-Based Strategies for a Plastic-Free Ocean*, September 2015, https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf

Robert J. Morris, "Plastic Debris in the Surface Waters of the South Atlantic", in *Marine Pollution Bulletin*, Vol. 11, No. 6 (June 1980), p. 164-166

John Mouat, Rebeca Lopez Lozano and Hannah Bateson, *Economic Impacts of Marine Litter*, KIMO International, September 2010, http://www.

kimointernational.org/wp/wp-content/uploads/2017/09/KIMO_Economic-Impacts-of-Marine-Litter.pdf

Natural Capital Coalition, *Natural Capital Protocol*, 2016, https://capitalscoalition.org/?p=24809

Neha Parashar and Subrata Hait, "Plastics in the Time of COVID-19 Pandemic: Protector or Polluter?", in *Science of the Total Environment*, Vol. 759 (March 2021), Article 144274

PEW Charitable Trusts and SystemIQ, *Breaking the Plastic Wave. A Comprehensive Assessment of Pathways Towards Stopping Ocean Plastic Pollution*, 2020, https://www.pewtrusts.org/-/media/assets/2020/10/breakingtheplasticwave_mainreport.pdf

Quantis and EA, *Plastic Leak Project Methodological Guidelines*, March 2020, https://quantis-intl.com/wp-content/uploads/2020/02/plastic_leak_project_pages.pdf.pdf

Julie Raynaud, *Valuing Plastic. The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry*, UN Environment Programme (UNEP), 2014, https://wedocs.unep.org/handle/20.500.11822/9238

Lorena M. Rios, Charles Moore and Patrick R. Jones, "Persistent Organic Pollutants Carried by Synthetic Polymers in the Ocean Environment", in *Marine Pollution Bulletin*, Vol. 54, No. 8 (August 2007), p. 1230-1237

Peter G. Ryan, "Intraspecific Variation in Plastic Ingestion by Seabirds and the Flux of Plastic Through Seabird Populations", in *The Condor*, Vol. 90, No. 2 (May 1988), p. 446-452

Simon Speakman Cordall, "Tunisia Minister Sacked and Arrested in Scandal over Illegal Waste from Italy", in *The Guardian*, 24 December 2020, https://www.theguardian.com/p/fptaa

Giuseppe Suaria et al., "The Mediterranean Plastic Soup: Synthetic Polymers in Mediterranean Surface Waters", in *Scientific Reports*, Vol. 6 (2016), Article 37551, https://doi.org/10.1038/srep37551

Richard C. Thompson et al., "Lost at Sea: Where Is All the Plastic?", in *Science*, Vol. 304, No. 5672 (7 May 2004), p. 838

UNEP, IUCN and Life Cycle Initiative, *National Guidance for Plastic Pollution*

Hotspotting and Shaping Action. Introduction to the Methodology, 20 July 2020, https://wedocs.unep.org/handle/20.500.11822/33166

Patricia Villarrubia-Gómez, Sarah E. Cornell and Joan Fabres, "Marine Plastic Pollution as a Planetary Boundary Threat – The Drifting Piece in the Sustainability Puzzle", in *Marine Policy*, Vol. 96 (October 2018), p. 213-220, https://doi.org/10.1016/j.marpol.2017.11.035

Stephan Wagner et al., "Tire Wear Particles in the Aquatic Environment – A Review on Generation, Analysis, Occurrence, Fate and Effects", in *Water Research*, Vol. 139 (1 August 2018), p. 83-100

Chao Wang et al., "Structure of the Global Plastic Waste Trade Network and the Impact of China's Import Ban", in *Resources, Conservation and Recycling*, Vol. 153 (February 2020), Article 104591

Zongguo Wen et al., "China's Plastic Import Ban Increases Prospects of Environmental Impact Mitigation of Plastic Waste Trade Flow Worldwide", in *Nature Communications*, Vol. 12 (2021), Article 425, https://doi.org/10.1038/s41467-020-20741-9

Zéro Zbel, *Enquête sur l'usage des sacs en plastique et des alternatives aux sacs en plastique*, June 2018, http://www.zerozbel.ma/?p=17079.

5.

Greening the Mediterranean: Pathways for Sustainable Energy and Climate Cooperation

Luca Franza

New political and economic developments are shaping the context in which energy and climate cooperation in the Mediterranean is being pursued. These include the launch of the European Green Deal, which has a strong external dimension and will significantly impact the southern shore of the Mediterranean; the release of the European Commission's new Agenda for the Mediterranean, which promises to spur investment and public-private partnerships to promote socio-economic sustainability in Europe's southern neighbourhood; and a renewed attention to establishing a strong partnership between Europe and Africa, with the Mediterranean as a key connector. Outside of Europe, important shifts include the momentum for global climate action created by the election of President Biden in the United States; the opportunities unlocked by post-covid-19 recovery packages to invest in new projects and transform economic development models; and increasingly ambitious energy transition visions put forward by certain Middle East and North Africa states.

The European Green Deal in particular is being framed as an overreaching political vision that sums up the EU's energy, climate, economic and geopolitical ambitions.[1] It is not just one of the many initiatives under-

[1] European Commission, *The European Green Deal* (COM/2019/640), 11 December 2019, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640.

taken by the EU, but rather *the* European Commission's flagship initiative. The European Green Deal is the strategy that underpins the EU's ambitious objective to reach climate neutrality by 2050, now entrenched in the European Climate Law; the vision that puts forward guidelines for green economic recovery from covid-19; and one of the key instruments to pursue the European Commission's declared ambition of being a more "geopolitical" actor on the international scene.[2] In addition to promoting energy transition and the fight against climate change, the European Green Deal is also the lighthouse for pursuing sustainable development and channelling the EU's efforts to achieve the Sustainable Development Goals.

There is however a risk that calls to engage in energy and climate cooperation through so-called "Green Deal diplomacy" remain empty words. The reason is that the European Green Deal remains a broad and fairly vague statement of purposes that still needs to be implemented in practice. Targets and visions are easy to announce, particularly when they take a very long-term view, but the devil is in the details. In particular, it is still largely unclear what instruments will be put in place to achieve those targets, what unintended consequences might be triggered, and how relative costs of various energy transition solutions might evolve in the future, when there could be technological breakthroughs that cannot be fully foreseen today.

A number of obstacles could compromise the realisation of the EU's most ambitious plans, particularly on stirring climate action in third countries. One illustrative example is the mismatch between the narrative on green recovery and the fact that, apart from those adopted by the EU, most recovery plans around the world are actually favouring carbon-intensive sectors, with a significant risk of carbon lock-in.[3] The EU calls itself a "climate leader" and aims to "set the example". But it is unclear how the EU can concretely persuade other countries to step up climate ambition, not least if Europe approaches such issues in an exces-

[2] Lili Bayer, "Meet von der Leyen's 'Geopolitical Commission'", in *Politico*, 4 December 2019, https://www.politico.eu/?p=1245002.

[3] Nicola Bilotta, Fabrizio Botti and Luca Franza, "The World Powers Confront the Crisis", in *World Energy*, Year 11, No. 47 (November 2020), p. 86-91, https://www.eni.com/static/en-IT/world-energy-magazine/the-world-to-come.html.

sively top-down or paternalistic manner that avoids acknowledging its own higher pollution rates and necessity to shoulder increased financial burden associated with the green energy transition in third states within its neighbourhood. Win-win rhetoric abounds in Brussels. The truth, however, is that the fight against climate change is going to be a hard process and there are going to be losers and not just winners. Sacrifices are going to be needed and the possibility of free-riding is real, leaving early movers exposed to risks of failure and relative loss of economic competitiveness along the way.

An additional layer of complexity is that the world is an increasingly fragmented place where countries appear more and more jealous of their sovereign prerogatives, an element that has also been reinforced by the present pandemic. In this context, collective action to preserve global commons and resort to multilateral instruments such as the United Nations Framework Convention on Climate Change to tackle a quintessentially global issue like climate change is not easy to mobilise. The EU's proposition to set the example on climate could actually even irritate other developing countries, which feel that EU member states have polluted the environment for decades to achieve their present level of wealth and it is now their turn to do so without external interference. EU lobbying and conditionality thus needs to be carefully planned so as not to be perceived as "neocolonial" in other parts of the world, including the southern shore of the Mediterranean.

Reluctance to follow the EU could be increased by the fact that the EU is currently often regarded as a somewhat struggling and vulnerable bloc of countries, an impression that has seemingly been further fuelled by the difficulties encountered by the EU in reacting to covid-19 in a cohesive and coherent way, especially regarding the vaccination campaign. In contrast, China's reputation as an effective and powerful country has been strengthened by the pandemic and its development and energy transition models could look more appealing to developing countries, including in the Mediterranean region.

5.1 The Mediterranean: United in diversity, including on energy and climate

A further challenge that arises when imagining concrete ways to boost energy and climate cooperation and promote sustainable development in the Mediterranean is that this region is extremely diverse. While most countries enjoy high levels of safety and political stability, others are still affected by dwindling conflicts, including Libya, Syria and Palestine; or political or financial distress, like Lebanon, Egypt, Tunisia, Algeria and Turkey. Mediterranean countries are also at very different levels of economic and social development, with some being industrialised or service-driven economies with low energy intensity and others grappling with poverty, unemployment, poor infrastructure and a lack of access to basic services, including reliable energy supplies. The ease of doing business is very different across the region, as are legislation and regulations that govern economic activity, including the energy sector. Moreover, trade and economic integration among southern Mediterranean states – even beyond the energy sector – is significantly below that which exists between south and north Mediterranean countries, adding a further layer of complexity to developing common approaches to tackle energy and climate transitions across a highly diverse Mediterranean.

Mediterranean countries also have very different energy mixes. While most Mediterranean countries are net energy importers, others (namely Algeria, Egypt and Libya) are net energy exporters. The energy transition started long ago in some Mediterranean countries, especially in southern Europe, where renewable energy now accounts for a high share of the energy mix. While some countries (i.e., Albania, Croatia, Montenegro and Turkey) have achieved high shares of renewable energy in the electricity mix thanks to hydropower, others (i.e., Spain and Italy) have also done so with wind and solar, where most future growth potential lies. In yet other countries (i.e., Algeria, Lebanon and Tunisia), on the other hand, the energy transition has barely started. The dominance of fossil fuels is almost untouched in some countries, which still have in place fossil fuel subsidies,[4] still use oil in power generation and have only built negligible renewable energy capacity so far, in spite of great production potential in wind and solar (i.e., Algeria, Egypt, Lebanon, Libya, Syria and Tunisia).[5]

Table 1 | Key energy and carbon intensity metrics in Mediterranean countries

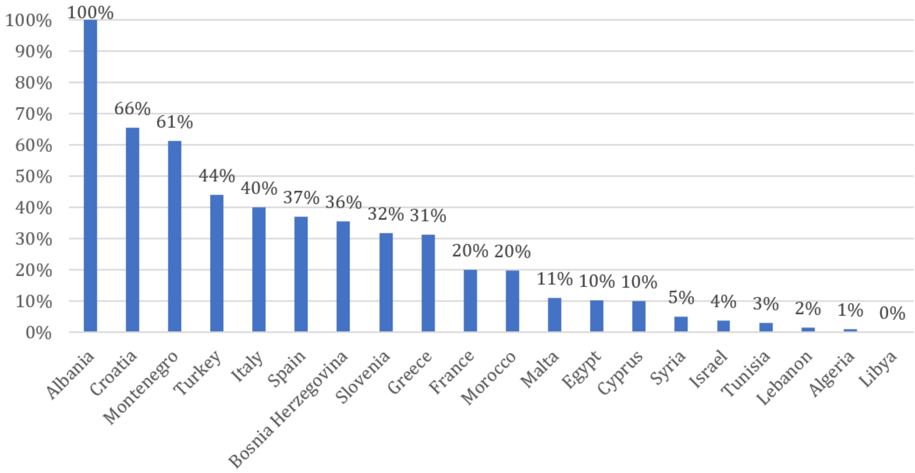
	Net energy imports (a)	GDP per unit of energy use (b)	Carbon intensity of energy (c)	Carbon intensity (d)	Carbon intensity of the economy (e)
Albania	14	13.2	2.4	2	0.2
Algeria	-177	10.2	2.8	3.7	0.3
Bosnia & Herzegovina	23	4.8	2.8	6.2	0.6
Croatia	46	10.7	2.1	4	0.2
Cyprus	94	12.9	3.1	5.3	0.2
Egypt	-7	12.1	2.7	2.2	0.2
France	44	10.2	1.2	4.6	0.1
Greece	64	11.1	2.9	6.2	0.3
Israel	65	11.5	2.8	7.9	0.2
Italy	76	13.8	2.2	5.3	0.2
Lebanon	98	10.3	3.2	4.3	0.3
Libya	-103	5.7	3.2	9.2	0.6
Malta	98	17.9	3	5.4	0.2
Montenegro	28	9.6	2.3	3.6	0.2
Morocco	91	13	3.2	1.7	0.2
Slovenia	49	9.1	1.9	6.2	0.2
Spain	71	12.6	2	5	0.2
Syria	48	N.A.	2.8	1.6	N.A.
Tunisia	36	11.4	2.7	2.6	0.2
Turkey	75	14.1	2.8	4.5	0.2

Note: (a) in percentage of energy use; (b) at 2011 PPP $ per kilogram of oil equivalent; (c) in kilograms per kilograms of oil equivalent energy use; (d) in metric tons per capita; (e) in kilograms per 2011 PPP $ of GDP.
Source: World Bank Data (2015).

[4] Stéphane Pouffary and Guillaume de Laboulaye, "La réforme des subventions aux énergies fossiles: enjeux et opportunités pour les pays du Sud et de l'Est de la Méditerranée", in *FEMISE Med Briefs*, No. 19 (May 2019), https://www.femise.org/?p=18009.

[5] Margherita Bianchi, "Prospects for Energy Transition in the Mediterranean after COVID-19", in *IAI Papers*, No. 20|18 (July 2020), https://www.iai.it/en/node/11910.

Figure 1 | Share of electricity from renewables in Mediterranean countries in 2019



Source: BP Statistical Review of World Energy 2019.

These divergences complicate the task of conceiving a common energy and climate approach in the Mediterranean, and even formulating observations that can be applied to the region as a whole, let alone finding common solutions. However, it is undeniable that a region like the Mediterranean would greatly benefit from cooperation in tackling a number of pressing issues, and that energy and climate take central stage. The creation of a sustainable, future-proof socio-economic development model (which can only rest on a sustainable – i.e., low-carbon – energy mix) is a key ingredient for regional stability.

Indeed, while highly diverse, the region is also united in facing many common threats. The risk of terrorism and other negative security spillovers from conflicts are still present. While it is controversial to frame migration as a security threat, it is undeniable that migration is fuelling nationalist narratives in receiving countries in Europe and creates political tensions between origin, transit and destination countries. When it is the skilled workforce that migrates, migration also contributes to brain drain, thus harming sustainability. Moreover, the Mediterranean is arguably grappling with a progressive loss of its strategic position due to political instability in the Middle East and North Africa region, southern Europe's economic weakness and the simultaneous rise of Asia and the Pacific Basin as new centres of gravity in the global economy.

Climate change is a particularly pressing threat for the Mediterranean, one that is shared by all states of this region, irrespective of their present socio-economic or political standing. This region is more exposed than most others to the risk of desertification and rising sea levels as well as salinisation of coastal areas, with negative effects on agriculture.[6] Climate change can exacerbate competition over scant resources like water and land, which can in turn create further opportunities for conflict, in combination with other factors. By threatening livelihoods, climate change can increase social tensions and migration.

The Arab uprisings, that were fostered and/or supported also by several non-Arab actors and communities, have shown the fragility of many countries in the Mediterranean. Southern European countries are also relatively vulnerable as they have been hit particularly hard by the latest economic and financial crises. Feedback loops exist between fragility and climate change. States and societies experiencing fragility have a more limited ability to adapt. This shortfall makes them more vulnerable and aggravates the negative impact of climate change, enhancing fragility. These trends call for increased attention towards and funding for climate adaptation, as we are coming to the realisation that climate change is to some extent unavoidable. Only 20 per cent of climate finance is currently devoted to adaptation.[7]

Also, the Mediterranean is more and more affected by extreme weather events. Natural disasters can compound pre-existing grievances and stress governance systems that are already stretched. They can aggravate economic crises and trigger further displacement. In fragile and conflict-prone areas the risk will be particularly severe and could represent the tipping point that leads to full-scale crises or even a relapse into armed conflict.

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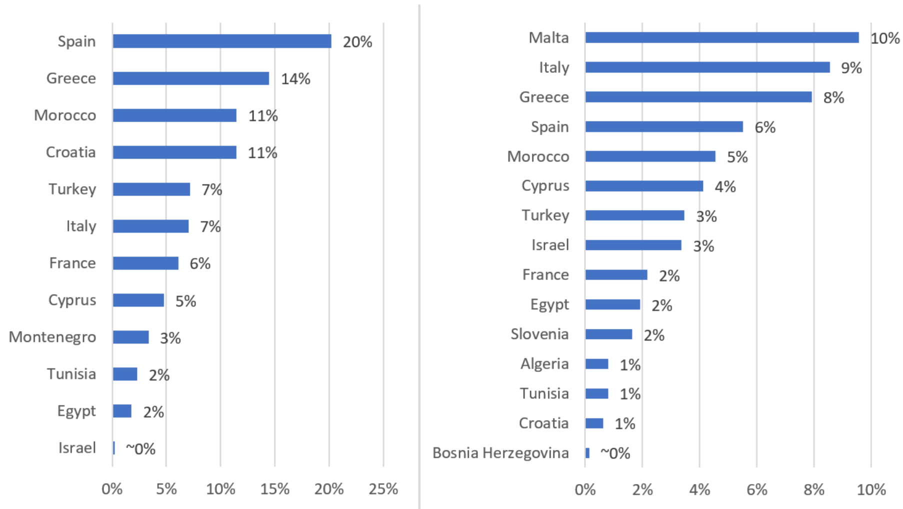
[6] Alexandre Tuel and Elfatih A.B. Eltahir, "Why Is the Mediterranean a Climate Change Hot Spot?", in *Journal of Climate*, Vol. 33, No. 14 (May 2020), p. 5829-5843, https://doi.org/10.1175/JCLI-D-19-0910.1.

[7] Isabelle Gerretsen, "Rich Nations Accused of Inflating Climate Adaptation Finance Figures", in *Climate Home News*, 21 January 2021, https://www.climatechangenews.com/?p=43256.

Climate change is even more of a threat in regions that border Mediterranean countries where livelihoods depend almost fully on ecosystems, particularly to the south, in the Sahel region. Crises there have had and can have even more serious negative security spillovers on Mediterraenean States. In sum, climate change is a threat multiplier and thus risks aggravating all other security challenges, including those highlighted above.[8]

Figure 2 | Share of electricity from wind (left) and solar (right) in Mediterranean countries in 2019



Source: BP Statistical Review of World Energy 2019.

That being said, and independently from the broad diversity of states involved and the breadth of the challenges at hand, the European Green Deal and the post-covid-19 EU recovery packages may provide an opportunity for renewed cooperation, which in turn may help to diminish imbalances or divergences across Mediterranean states when it comes to

[8] Patrick Huntjens and Katharina Nachbar, "Climate Change as a Threat Multiplier for Human Disaster and Conflict", in *The Hague Institute for Global Justice Working Papers*, No. 9 (May 2015), https://www.thehagueinstituteforglobaljustice.org/?p=8509.

energy transition and climate policy. While primarily focussed on European member states, the European Green Deal also has a strong external dimension, as can be read in the European Commission communication with which it was announced on 11 December 2019.[9] The political and economic choices that will be made over the next years, particularly with regard to how post-pandemic money will be spent, are set to have a long-lasting effect and will impact on the greenhouse gas emission trajectory of the Mediterranean region for decades. This is why, in spite of the difficulties and obstacles highlighted above, promoting energy and climate cooperation across the Mediterranean is in itself a timely proposition and it is important to capitalise on the unique opportunities offered by the Green Deal and recovery plans.

5.2 Opportunities and challenges to promote energy and climate cooperation in the Mediterranean

The EU has many good reasons to promote energy and climate cooperation in the Mediterranean. Firstly, it has a general interest in seeing other countries contribute to lowering global greenhouse gas emissions; it cannot fight climate change alone as it only accounts for 8 per cent of global emissions.[10] Because the EU tends to have more leverage in its neighbourhood than in far-away regions, it should use this leverage to promote its energy transition and climate agenda there. Concretely, this could be done through political and diplomatic pressure, by including climate conditionality in cooperation agreements, by making use of tight-knit business and knowledge networks and especially by means of a positive financial assistance and investment agenda.

The world's two other largest emitters, the US and China, could do the same by focussing on promoting energy transition and climate mitigation in their neighbourhoods. A related argument in favour of

[9] European Commission, *The European Green Deal*, cit.

[10] 2019 data from Our World in Data and Global Carbon Project: Hannah Ritchie and Max Roser, "CO2 and Greenhouse Gas Emissions", in *Our World in Data* (May 2017, revised August 2020), https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions.

EU engagement on energy and climate cooperation with its neighbourhood is indeed that China, Russia or other proactive geopolitical players would fill the strategic void left by the EU and aggrandise their influence.[11] China in particular has shown its ability to become an important trade partner and strategic investor through the Belt and Road Initiative in the Mediterranean, including in energy.

Moreover, energy projects can have positive political, economic and security spillovers in the entire region. Low-carbon projects, which are characterised by a lower concentration of rents than hydrocarbon projects and can be implemented in every country regardless of mineral resource endowment, can contribute to creating employment and boosting sustainable economic development. Projects can also unlock profitable business opportunities for EU companies and for their partners in the south. In turn, the EU has energy network operators, utilities and renewable energy equipment producers with recognised leadership positions that could greatly benefit the neighbourhood by providing know-how and capital and by being stable, credit-worthy and reliable partners.

Moreover, an argument that is gaining traction is that the neighbourhood's renewable energy resources might actually be essential for the EU to fulfil its increasingly ambitious emission reduction targets.[12] The EU is much more densely populated than North Africa and the Western Balkans. As a result, land use is much higher and so is the risk of Not-in-My-Backyard-(NIMBY)ism. While this is not yet perceived as a pressing issue because the share of renewable energy in the EU energy mix is still relatively modest, it is quite possible that as decarbonisation deepens, the EU will not have enough available land to install the necessary renewable energy capacity. Besides, costs of producing renewable energy could very well be lower in parts of the neighbourhood in the long term thanks to better solar irradiation and

[11] Amine Bennis, "Power Surge: How the European Green Deal Can Succeed in Morocco and Tunisia", in *ECFR Policy Briefs*, 26 January 2021, https://ecfr.eu/?p=66735.

[12] Luca Franza, *Clean Molecules across the Mediterranean. The Potential for North African Hydrogen Imports into Italy and the EU*, Rome, IAI, April 2021, https://www.iai.it/en/node/13116.

ventilation, less variability in the renewable energy production profile, and lower labour and land costs compared to the EU.[13]

From the perspective of the neighbourhood, cooperating with the EU on the energy transition is desirable because the EU can be a source of coveted funds and know-how. Energy exports can also be an important source of hard currency for financially fragile states of the neighbourhood. The energy transition is indeed an opportunity for economic development also for those countries in the region that do not have mineral resources and could eventually develop a competitive advantage in renewable energy. In turn, the region's hydrocarbon producers such as Algeria, Egypt and Libya (once it is pacified) could use the energy transition as an opportunity to diversify their economies. Dependency on hydrocarbons tends to lead to a loss of competitiveness of non-hydrocarbon exports by boosting the value of the national currency and because the oil and gas sectors attract the most skilled workforce through higher salaries. Breaking the cycle is not easy. While several oil and gas countries in the Gulf are putting in place increasingly ambitious plans to diversify their economies, North African oil and gas producers lag behind.

Mediterranean oil and gas producing countries with more limited financial resources than wealthy Gulf nations are hoping to have access to EU financing to help the process of economic diversification. Recent volatility in oil and gas prices, which have hit new record lows as a result of the collapse in consumption provoked by the covid-19 pandemic, further strengthens the resolve of oil and gas producing countries to reduce their exposure to commodity price movements and diversify their economies. As shown in Table 2, international financial support is also indicated as a precondition by developing countries to reach more ambitious greenhouse gas emission targets.

[13] Ibid.

Table 2 | The first Nationally Determined Contributions (NDCs) of Mediterranean countries

Country	Nationally Determined Contribution (NDC)
Albania	11.5 per cent CO_2 emission reduction in 2016-2030 vs. business-as-usual (BAU) scenarios
Algeria	7–22 per cent greenhouse gas (GHG) emission reduction in 2016-2030 vs. BAU
Bosnia & Herzegovina	2 per cent GHG emission reduction in 2030 vs. 1990 (unconditional); up to 23 per cent with international financial support
Egypt	Actions only, no target
European Union	40 per cent GHG emission reduction by 2030 vs. 1990
Israel	26 per cent GHG emission reduction by 2030 vs. 2005
Lebanon	15 per cent GHG emission reduction by 2030 vs. BAU; 15 per cent power and heat demand generated by renewable energy systems (RES) in 2030; 3 per cent power demand reduction by 2030 vs. BAU (unconditional); 30 per cent GHG emission reduction by 2030 vs. BAU; 20 per cent power and heat demand generated by RES in 2030; 10 per cent power demand reduction by 2030 vs. BAU (with international financial support)
Libya	No submission
Montenegro	30 per cent GHG emission reduction by 2030 vs. 1990
Morocco	17 per cent GHG emission reduction in 2030 vs. BAU (unconditional); up to 42 per cent with international financial support
Syria	No submission
Tunisia	13 per cent GHG emission reduction in 2030 vs. 1990 (unconditional); up to 41 per cent with international financial support
Turkey	21 per cent GHG emission reduction in 2030 vs. BAU

Source: Author's compilation of NDCs as submitted to the UN Framework Convention on Climate Change.

In promoting energy and climate cooperation in the region, preference should go to low-carbon projects that can establish positive bonds of interdependence that thereby favour state and societal resilience and sustainability. Unfortunately, the energy transition discourse is increasingly hijacked by isolationist and protectionist agendas. On the contrary, in a context of growing fragmentation, it is important to stress that trade brings peace more often than not. The interdependence created by large-scale exchange of essential products can be a powerful deterrent to conflict and incentivises the cultivation of long-lasting political relationships. Averted energy crises do not unfortunately make headlines like energy crises do. A recent example of this is offered by the Ukrainian crisis that broke out in 2014, where Russian gas exports to the EU through Ukraine continued undisturbed in spite of a proxy war being fought by the two countries. In North Africa too there is a valuable example of how energy can bring countries to the negotiating table: in spite of tense political relations, Algeria and Morocco have effectively cooperated on energy to enable Algerian gas transit through Morocco, a clear win-win for both countries.

While the rationale for energy and climate cooperation is strong, there are also a number of caveats that need to inform its actual implementation. An important one is that projects promoted by the EU should be framed so that they are not experienced by countries of the neighbourhood as an external imposition. First of all, rather than purporting an "extractive" logic, energy projects should have a strong local content component and entail some local energy use for industrial development, helping socio-economic sustainability. Furthermore, local solutions to local challenges need to be favoured when possible. This is also because knowledge about the local environment is an asset that needs to be capitalised on, particularly when it comes to issues that are closely related to a specific context (for instance, those pertaining to the water, energy and food nexus). Given the diversity of the Mediterranean, tailor-made solutions are needed to take into account local specificities and maximise the yet to be expressed comparative advantages, which depend on a country's starting point and resource endowment. Local stakeholders and governments need to be genuinely on board and share a common vision rather than approving energy and climate cooperation plans with the EU just to obtain funds.

Sharing general EU frameworks and guidelines is desirable in a number of areas (for instance on feed-in tariffs design, guarantees of origin and, prospectively, carbon accounting), but the transfer of best practices to the neighbourhood is not always feasible because of remarkable differences in the region's regulatory contexts. This is why initiatives aimed at bringing energy regulation of the neighbourhood more in line with the EU *acquis*, like the Energy Community, should be welcomed.[14] With regard to this, it is also important to realise that regulatory and political risk is present and in some cases fairly high in the EU's neighbourhood. Obsolescing bargaining dynamics can thus unfold, particu-

[14] Energy Community website: *Who We Are*, https://www.energy-community.org/aboutus/whoweare.html.

larly once funds have been allocated, meaning that the EU should devote resources on energy and climate cooperation gradually and steadily, and offer prospects of long-term incremental collaboration. Obsolescing bargaining complicates the EU's ability to exert conditionality and obtain a country's alignment with its energy and climate ambitions in exchange for funds or other types of assistance.

Another important caveat is that, even if the resources allocated by recovery packages are large, they are not endless. In fact, the energy transition requires trillions of euro in investment and each stakeholder is trying to promote the solutions that favour it the most. To be sure, there is no silver bullet for the energy transition and, as a result, several options should indeed be supported. However, there also needs to be a selection. For example, it would be wise to promote solar in high-yield regions such as most of North Africa,[15] electrification in the sectors where it can be achieved more cost-efficiently and hydrogen use in hard-to-abate sectors and for international low-carbon energy evacuation. Coherent visions underpinned by solid and broad political consensus are key in this respect. This is to guarantee foresight and guidance to investors, and to avoid a dilution of efforts which would lead to squandering relatively scarce economic resources.

Vision is needed also because many energy transition investments are interdependent, particularly when new markets need to be built from scratch as in the case of hydrogen. A green hydrogen export scheme from the neighbourhood to the EU, for instance, would require deploying additional renewable energy capacity, building new electrolysers, adapting transmission and distribution networks so that they can carry hydrogen, and creating a demand for hydrogen in the receiving market. Clearly, high-level international coordination and sequential investments would be needed for such a complex venture to materialise. If just one of the pieces in the middle goes missing, the puzzle will not be completed.

[15] The Sahara's annual insolation levels reach 2,500–3,000 kWh per square meter. Parts of North Africa also have very good wind potential. In the Sahara, yearly ground level wind speed is 5 m/s on average. Along Morocco's Atlantic coast and in Central-Western parts of Egypt's Gulf of Suez, the figure goes up to 8–9 m/s. Cf. Luca Franza, *Clean Molecules across the Mediterranean*, cit., p. 29.

Finally, boosting Mediterranean energy integration remains a key challenge. Unlike the EU, where thanks to the process of liberalisation and creation of an internal market gas and electricity are now relatively free to travel across borders reacting to price signals, the Mediterranean region remains fragmented. Even two EU Member States in the Mediterranean are still isolated from an energy perspective. The EU recognises that energy infrastructure integration in the Mediterranean should be a priority. In June 2021, for instance, the Council of the EU amended the proposed regulation on Trans-European Energy Networks (TEN-E) in a way that will allow natural gas pipelines from Cyprus and Malta to be considered projects of common interest.

Infrastructural interconnections are limited and so is interoperability where connections exist, due to differences in regulation and barriers to entry. As was taught by the European experience, better integration of the Mediterranean region would boost both affordability and security of supply.[16] Replicating something similar to what occurred in Europe in the broader Mediterranean will be more complicated however. This is because when liberalisation and the process of establishing an internal energy market got started in Europe, the Continent already had a widespread, dense (and amortised) gas and electricity infrastructure that had been built in previous decades. By comparison, the southern shore appears fragmented, with limited south-south connections, not only in energy but also in trade and economic interdependence more broadly.

5.3 Highlights on concrete instruments and priorities to relaunch energy and climate cooperation

Building on what has been said above about the rationale for energy and climate cooperation in the Mediterranean and the challenges that it faces, it is possible to identify a number of priority areas where the European Green Deal and related EU policies could make a difference.

[16] Luca Franza, *The Political-Economic Dimension of Transformations in EU-Russia Gas Trade Mechanisms*, Clingendael, Clingendael International Energy Programme, October 2020, https://www.clingendaelenergy.com/publications/publication/developments-in-eu-russia-gas-relations.

The new Agenda for the Mediterranean sheds some light on the direction that the EU wishes to take in energy and climate cooperation in the Mediterranean and contains a first attempt to select priorities (even if the scope should be narrowed down further).[17] The Agenda also clarifies the relation between the European Green Deal and other relevant EU policy instruments. A principle that is explicitly established in the Agenda is that the level of EU financial support will be proportionate to the partners' ambitions and commitment to shared values, including greenhouse gas emission reduction targets. This is in line with what was said in previous sections about the importance of having local stakeholders genuinely on board in order to achieve a "co-ownership" of energy and climate projects.

In terms of actions, the identified priorities are supporting climate and environmental governance (including a specific effort to improve the monitoring of climate targets, cf. Table 2); the related objective of empowering administrative capacity and providing technical assistance to implement and enforce progressive energy and climate legislation; promoting carbon pricing initiatives (in line with the process of designing a Carbon Border Adjusted Mechanism to persuade trade partners to increase carbon price levels); and supporting education and awareness raising. Increasing climate change adaptation capacities and disaster risk reduction is also a priority. This includes efforts on climate change resilience, climate-proofing investments, investing in preventive measures, nature-based solutions and risk management capacities. These actions are desirable in light of the especially marked vulnerability of the Mediterranean to climate change. All of them are shared between the Agenda and the European Green Deal. In particular, the prominence of references to carbon pricing suggests that the increased geo-economic assertiveness engrained in the European Green Deal has filtered through to the new Agenda for the Mediterranean. The same holds true for the commitment contained in the European Green Deal to strike a

[17] European Commission, *Southern Neighbourhood: EU Proposes New Agenda for the Mediterranean*, 9 February 2021, https://ec.europa.eu/commission/presscorner/detail/en/ip_21_426.

new balance between climate mitigation and adaptation.

Another priority of the Agenda is favouring the strategic engagement of Mediterranean partners in joint initiatives on green finance between the EU and international finance institutions (IFIs). The development of sustainable finance policies in partner countries is especially encouraged, for instance through fora such as the International Platform on Sustainable Finance (IPSF). The EU and the other IPSF members could notably share best practices and coordinate efforts on sustainable investment, such as green taxonomies, climate disclosures and standards and labels for green financial products, including green bonds. Once again, support to green finance is also a central element of the European Green Deal.

On the other hand, the Agenda's focus on energy is still very broad as the strategic document expresses support for electric cables, hydrogen, measures to reduce the carbon footprint of hydrocarbon production and energy efficiency. A more important contribution of the Agenda is that it clarifies that the European Fund for Sustainable Development Plus (EFSD+) under the Neighbourhood, Development and International Cooperation Instrument (NDICI) will be the most important instrument of EU cooperation with neighbours in the Mediterranean basin. The innovative financial architecture of the EFSD+ has been designed to maximise private sector investment, in cooperation with the European Investment Bank (EIB), the European Bank for Reconstruction and Development, member state development banks and IFIs.

This is indeed important as the private sector will have to play a crucial role in the energy transition, considering that it is the depository of technical and operational know-how and that public funds alone are not enough to meet the decarbonisation challenge. The EIB in particular has a key function to play as it is estimated to reach a multiplier effect of 1:15 in real investment.[18] One might indeed wonder why so much solar energy has been installed in Germany, a country not renowned for clear skies, and so little in North African countries, which are endowed with great solar irradiation levels. An important part of the answer is the higher

[18] European Investment Bank (EIB), "Where Does the Money Come From?", in *Factsheets on the Investment Plan*, No. 2 (25 November 2014), https://europa.eu/!vuwRuN.

cost of capital in North Africa. By providing strong guarantees on projects through its triple-A credit rating, the EIB unlocks access to significantly cheaper capital and thus makes projects more cost-competitive.

A scheme that deserves special attention is the European plan to import hydrogen from the neighbourhood.[19] Hydrogen would contribute to achieving several energy, political, social and economic objectives at the same time. Relative to other solutions, it also appears to be future-proof, by being compatible with net-zero-by-mid-century objectives. Also, it would be an enabler of large-scale decarbonisation and win-win outcomes between exporting and importing countries.

In particular, North African hydrogen production and exports can benefit countries along both shores of the Mediterranean. Green hydrogen (produced from renewables by means of electrolysis) could enable North Africa to finally harness its untapped renewable energy potential after plans to do so through electric cables have stalled. Moreover, blue hydrogen produced from gas and Carbon Capture Utilisation and Storage is an option for current hydrocarbon producers in North Africa (Libya, Algeria and Egypt) to continue exporting energy to the EU, where the space for unabated fossil fuels will gradually diminish due to increasingly ambitious climate targets (55 per cent emission reduction by 2030 and climate neutrality by 2050).

Hydrogen exports are not only technically feasible but also potentially cost-competitive with locally produced hydrogen. Firstly, the projected cost-competitiveness of North African green hydrogen is determined by affordable transportation options (namely, the possibility to use existing gas pipelines that have an aggregate capacity of 60 GW, or 50 times more than planned electric cables). Secondly, it is determined by expected low costs of renewable energy and electrolytic production in North Africa (with green hydrogen costs potentially as low as 1 euro per kg in 2030), which boasts not only excellent irradiation levels (2,500–3,000 kwh per square metre annually) but also outstanding ventilation in some areas (wind speeds up to 8–9 m/s).[20]

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[19] European Commission, *Southern Neighbourhood: EU Proposes New Agenda for the Mediterranean*, cit.

[20] Luca Franza, *Clean Molecules across the Mediterranean*, cit.

Hydrogen is also going to be a key enabler of EU decarbonisation plans, as it is becoming increasingly clear that not all energy uses can be electrified (with a direct electrification rate of 60 per cent achieved in the best-case scenario).[21] There is unprecedented momentum for capital-intensive hydrogen projects, including across the Mediterranean. The covid-19 crisis has led to the mobilisation of huge amounts of money, and decarbonisation is the policy area where the relative majority (37 per cent) of Next Generation EU funds will be spent. The European Hydrogen Strategy, launched in the context of the European Green Deal in July 2020, explicitly recognises a role for North African hydrogen, having embraced the 2x40 GW initiative (a plan to install 40 GW of electrolysers in the EU and 40 GW in the EU's neighbourhood by 2030).[22]

As shown by Moroccan plans to use hydrogen to produce ammonia for fertilisers, apart from contributing to decarbonisation on both sides of the Mediterranean, hydrogen could unlock new industrial opportunities for North African countries, favouring economic diversification. Hydrogen production and exports could have far-reaching socio-economic benefits for North Africa by providing much-needed export revenues and hard currency, thereby creating employment and strengthening socio-economic resilience and sustainability.

In the medium term, natural gas trade can also contribute creating bonds of positive interdependence, particularly if the abundant Eastern Mediterranean gas reserves are exported to the EU. Natural gas can play a role as a transitional fuel, particularly in Southern Europe, South-eastern Europe and East Mediterranean countries. In these regions, which lack significant nuclear capacity, natural gas remains an important energy source to back up intermittent renewables and replace more polluting oil and coal. East Mediterranean gas can also allow the EU to boost gas supply diversification.

Italy has a particularly strong strategic interest in all of these areas, given its geographic location in the central Mediterranean and marked

[21] Eurelectric website: *Decarbonisation Pathways: Full Study Findings*, https://www.eurelectric.org/decarbonisation-pathways.

[22] European Commission, *A Hydrogen Strategy for a Climate-Neutral Europe* (COM/2020/301), 8 July 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301.

exposure to social, political and security developments in North Africa which can only be expected to worsen in the future due to climate change and mounting socio-economic vulnerabilities across North Africa and the Middle East. North African hydrogen could also create interesting business opportunities for EU companies, which have valuable know-how to offer to North African countries. Strong coordination between the private sector and the Italian government is going to be key for cooperation schemes to succeed. Hydrogen can contribute to fighting climate change while preserving trade interdependence across the Mediterranean, which is beneficial to peace, security and sustainable development. This is an opportunity that needs to be seized now as conditions to kickstart hydrogen trade across the Mediterranean have never been so favourable as they are today.

5.4 Conclusion and policy recommendations

The rationale for greater energy and climate cooperation in the Mediterranean is strong. The EU has a fundamental interest in seeing other countries contribute to greenhouse gas emission reductions because it cannot meet the challenge of climate change by itself. Moreover, renewable energy resources of the neighbourhood might turn out to be essential for the EU to fulfil its own ambitious emission reduction targets in view of land availability, NIMBYism and limits to electrification which are emerging in the EU. Finally, energy transition projects can have positive political, economic and security spillovers on the entire Mediterranean region, thus promoting sustainability, which is a shared interest of both north and south Mediterranean states and societies. At the same time, it is important that the EU and individual member states avoid excessively patronising or euro-centric statements. This will be important to build more solid partnerships with third states and societies, while also assuming more of the burden to support energy transitions in the neighbourhood.

The energy transition is indeed an opportunity for economic development and sustainability in the EU's neighbourhood and an area where countries of the neighbourhood that do not have mineral resources could finally develop a competitive advantage – by virtue of their excellent solar irradiation and ventilation levels. Conversely, the region's hydrocarbon producers could use the energy transition as an opportunity to diversify their economies, achieving sustainable development.

Economic development and improved socio-economic sustainability are understood as indispensable ingredients for states and societies in the Mediterranean, particularly as the threat of climate change will continue to weaken their productive capacities. Improvements in these domains can help to stabilise south Mediterranean states, develop win-win cooperative solutions to overcome frozen or latent conflicts and in turn contribute to improved social harmony and stronger state-society relations. Ultimately, economic development and sustainability will also be key to address the migration challenge as well as other security threats stemming from criminal networks, radicalisation and terrorism, thus serving EU interests that also go beyond climate change and trade.

The EU can be a source of coveted funds and know-how for the neighbourhood. Potentially, the EU can also be a source of best practices (particularly on feed-in tariffs, carbon accounting and taxonomies for green finance), but remarkable differences in the region's regulatory contexts and starting points in the energy transition need to be taken into account when attempting best practice transfers.

The European Green Deal, covid-19 recovery packages and the EFSD+ under the NDICI create opportunities to mobilise substantial economic resources in favour of energy and climate cooperation in the Mediterranean. Even if there is great potential, economic resources are not going to be endless, making it important to prioritise their use and avoid a dilution or duplication of efforts. A key priority is to expand installed solar and wind capacity in the Mediterranean and especially in North Africa, the East Mediterranean and the Western Balkans. It is important for policy-makers to catalyse private investment, for instance by reducing cost of capital through EIB guarantees. When promoting energy and climate cooperation in the region, preference should go to low-carbon projects that can enable establishing positive bonds of interdependence. Hydrogen trade is key in this respect. Clean gas would in fact contribute to achieving several energy, political, social and economic objectives at the same time. Relative to other solutions, it also appears to be future-proof, by being compatible with net-zero-by-mid-century objectives. Finally, hydrogen would be an enabler of large-scale decarbonisation in hard-to-abate sectors and win-win outcomes between prospective exporting and importing countries.

References

Lili Bayer, "Meet von der Leyen's 'Geopolitical Commission'", in *Politico*, 4 December 2019, https://www.politico.eu/?p=1245002

Amine Bennis, "Power Surge: How the European Green Deal Can Succeed in Morocco and Tunisia", in *ECFR Policy Briefs*, 26 January 2021, https://ecfr.eu/?p=66735

Margherita Bianchi, "Prospects for Energy Transition in the Mediterranean after COVID-19", in *IAI Papers*, No. 20|18 (July 2020), https://www.iai.it/en/node/11910

Nicola Bilotta, Fabrizio Botti and Luca Franza, "The World Powers Confront the Crisis", in *World Energy*, Year 11, No. 47 (November 2020), p. 86-91, https://www.eni.com/static/en-IT/world-energy-magazine/the-world-to-come.html

European Commission, *The European Green Deal* (COM/2019/640), 11 December 2019, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640

European Commission, *A Hydrogen Strategy for a Climate-Neutral Europe* (COM/2020/301), 8 July 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301

European Commission, *Southern Neighbourhood: EU Proposes New Agenda for the Mediterranean*, 9 February 2021, https://ec.europa.eu/commission/presscorner/detail/en/ip_21_426

European Investment Bank (EIB), "Where Does the Money Come From?", in *Factsheets on the Investment Plan*, No. 2 (25 November 2014), https://europa.eu/!vuwRuN

Luca Franza, *Clean Molecules across the Mediterranean. The Potential for North African Hydrogen Imports into Italy and the EU*, Rome, IAI, April 2021, https://www.iai.it/en/node/13116

Luca Franza, *The Political-Economic Dimension of Transformations in EU-Russia Gas Trade Mechanisms*, Clingendael, Clingendael International Energy Programme, October 2020, https://

www.clingendaelenergy.com/publications/publication/developments-in-eu-russia-gas-relations

Isabelle Gerretsen, "Rich Nations Accused of Inflating Climate Adaptation Finance Figures", in *Climate Home News*, 21 January 2021, https://www.climatechangenews.com/?p=43256

Patrick Huntjens and Katharina Nachbar, "Climate Change as a Threat Multiplier for Human Disaster and Conflict", in *The Hague Institute for Global Justice Working Papers*, No. 9 (May 2015), https://www.thehagueinstituteforglobaljustice.org/?p=8509

Stéphane Pouffary and Guillaume de Laboulaye, "La réforme des subventions aux énergies fossiles: enjeux et opportunités pour les pays du Sud et de l'Est de la Méditerranée", in *FEMISE Med Briefs*, No. 19 (May 2019), https://www.femise.org/?p=18009

Hannah Ritchie and Max Roser, "CO2 and Greenhouse Gas Emissions", in *Our World in Data* (May 2017, revised August 2020), https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

Alexandre Tuel and Elfatih A.B. Eltahir, "Why Is the Mediterranean a Climate Change Hot Spot?", in *Journal of Climate*, Vol. 33, No. 14 (May 2020), p. 5829-5843, https://doi.org/10.1175/JCLI-D-19-0910.1

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