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Deliverable 7.4: Report on Impacts on Key Economic Sectors

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v1	07/3/2023	Initial version		CEA
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I. Introduction

I.1. Contribution to WP7

This document is Deliverable D7.4 ***"Report on Impacts on Key Economic Sectors"*** which describes the efforts and outcome of the work of Task 7.4. A brief overview of how this Task is contributing to WP7 "***Impact and Policy Department***" and interconnects with other Tasks and Deliverables of this WP is summarized below.

- **Task 7.1. Creation of an Impact and Policy Department** (Lead: MPG) (M12 -M48)

Status: **Completed**. Submission on M48 of Deliverable D7.1 "***Report on the structure of the Impact and Policy Department***"

- **Task 7.2. Health impact assessment (air quality, climate change)** (Lead: MPG) (M12-M84).

Status: **On-going**. Submission on M48 of the Deliverable D7.2 "***Report on health impacts assessment***"

- **Task 7.3. Methodologies to support implementation of national adaptation plans** (Lead: CyI) (M12-M84). Status: **On-going**. Submission on M48 of Deliverable D7.3 "***Report on methodologies to support implementation of national action plans***"

- **Task 7.4. Impacts on key economic sectors** (Lead: CEA) (M24-M72).

Status: **On-going**. Submission on M48 of Deliverable D7.4 "***Report on impacts on key economic sectors***"

Climate change impact assessments including an economic perspective not yet performed in Cyprus and the EMME. Regional impacts on economic sectors including health, agriculture, energy and tourism. Evaluation of vulnerabilities to these impacts at individual country level (central topic of the Professorship Programme). This will lead to an assessment of adaptive capacities of EMME societies.

- **Task 7.5. Impacts of GHG emission mitigation scenarios** (Lead: CEA) (M36-M84). Status: **On-going**. Submission on M48 of Deliverable D7.5 "***Report on impacts of mitigation scenarios with contribution of EMME and other emitters to the Paris goals***"
- **Task 7.6. Legal framework and policy aspects of (inter)national climate initiatives** (Lead: MPG) (M36-M48). Status: **On-going**. Submission on M84 of Deliverable D7.6 "***Report on legal and policy aspects of (inter)national climate initiatives***"

I.2. Structure of the Deliverable

We present here summary assessments of the main impacts that climate change has for the aforementioned sectors in the regional context of the EMME: Energy (Section II), Human Health (Section III), Agriculture and Food chain (Section IV), Tourism (Section V) (as per description of Task 7.4), as well as Maritime Section (Section VI). **Policy suggestions** are provided systematically for each sector so as to align with the General Objectives of WP7 on Impacts AND Policies.

These assessments are primarily based on the very detailed reports prepared by thematic "Task Forces" of the Eastern Mediterranean and Middle East Climate Change Initiative (EMME-CCI; https://emme-cci.org/) coordinated by the Cyprus Institute along with EMME-CARE.

- A thorough description of the structure, goals and achievements of the EMME-CCI (and its 13 scientific Task Forces) is presented in more details in Deliverable 7.6.
- Additionally, complete lists of the authors of the Task Force reports referenced in this Deliverable are presented in Annex 1.

I.3. General context

Human influence on Earth's climate is undeniable, with greenhouse gas (GHG) emissions and changes in land-use (e.g. deforestation and urbanization) causing a significant increase in global surface temperatures and altering meteorological factors like rainfall. The Eastern Mediterranean and Middle East (EMME) region is a climate change hotspot, experiencing nearly twice the global average warming rate, particularly during summertime. Over the last decades, the region has seen a decrease in precipitation and a transition to a drier climate regime, amplifying the environmental stress already present. Rising sea levels and an increase in extreme weather events such as heatwaves, droughts, and flash floods further impact coastal infrastructure, agriculture, and native ecosystems.

The EMME region has experienced a fivefold increase in greenhouse gas emissions, now comparable to those of the European Union and India. Carbon dioxide and methane from the fossil fuel energy sector contribute to over 95% of the region's anthropogenic emissions. Climate projections indicate that without significant mitigation efforts, the region's warming trend will continue throughout the 21st century. A strong mitigation pathway could stabilize regional warming levels slightly, while a business-as-usual scenario would lead to a temperature increase close to 5°C by the end of the century (Figure 7.4.1), resulting in societally disruptive heat extremes and a northward expansion of arid climate zones.

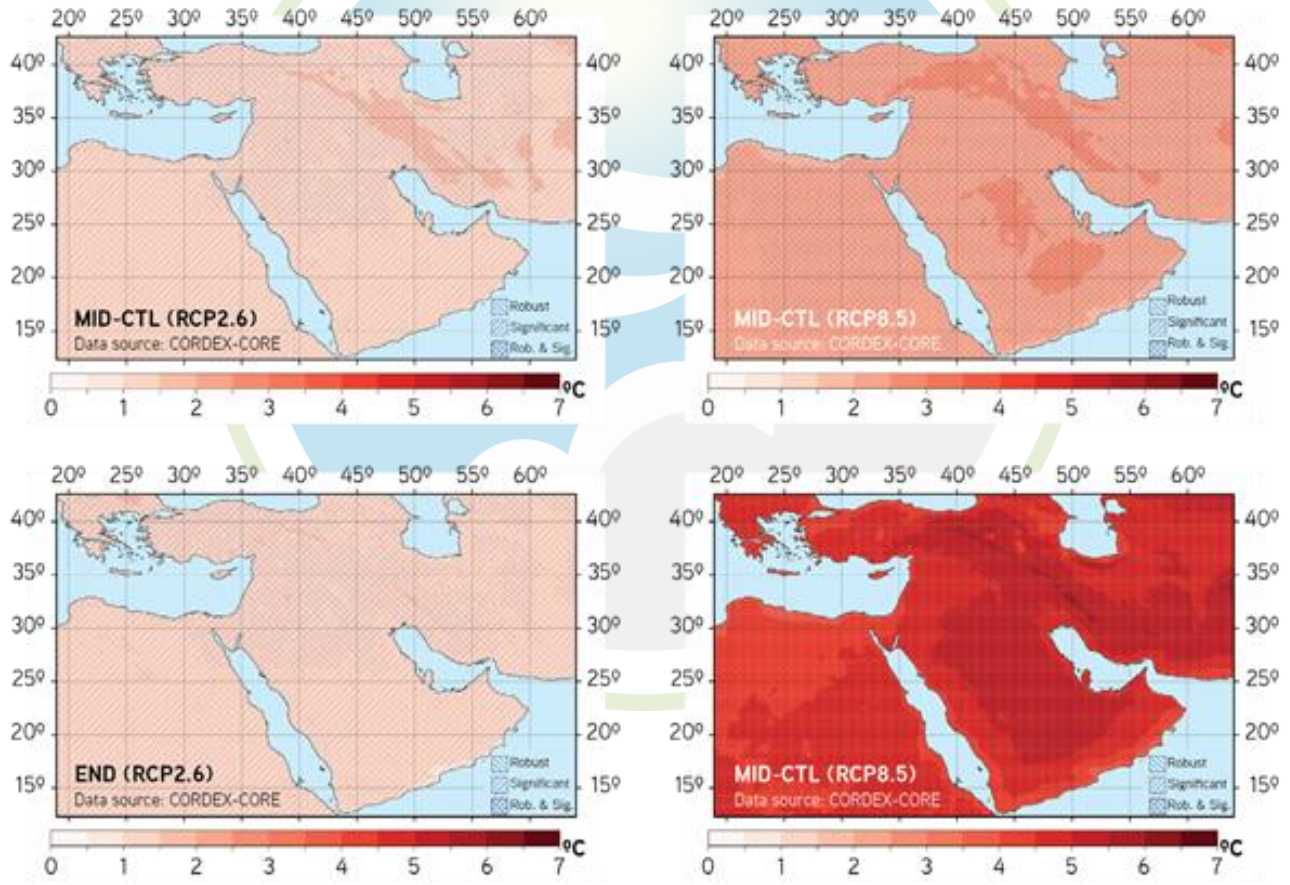

Figure 7.4.1. **Projected changes of mean annual temperature (with respect to the 1986-2005 reference period)**. Data source: Based on CORDEX-CORE climate projections, for RCP2.6 (left panels) and RCP8.5 (right panels) and for mid-21st (2041-60, top panels) and end-of-century projections (2081-2100, bottom panels). Reproduced from (1).

Various economic activities and sectors contribute to the emissions of greenhouse gases (GHG), and thus amplification of global warming, often disproportionally to their economic output. A recent study, in the framework of EMME-CARE (2), investigated the relationship between the production activities of the EU-27's economic system and GHG emissions at the macroeconomic level. This study found that across the 27 European Union Member States, the sectors of electricity and agriculture create the highest direct and indirect GHG emissions per unit of economic output. For every 1-million-euro-increase in the final demand for the products and services of the electricity and agriculture sectors, they emit 2,198 and 1,410 additional tons of GHG, respectively (Figure 7.4.2). Other sectors, with a much lower contribution to the total GHG emissions (e.g., services), had a much higher economic output, highlighting future directions when it comes to climate change mitigation strategies. Our analysis also revealed the importance of both direct and indirect contributions of economic sectors in the generation of GHG emissions, taking into consideration the size of the sector in terms of economic output formation and GHG emissions generation and the assumed growth rates.

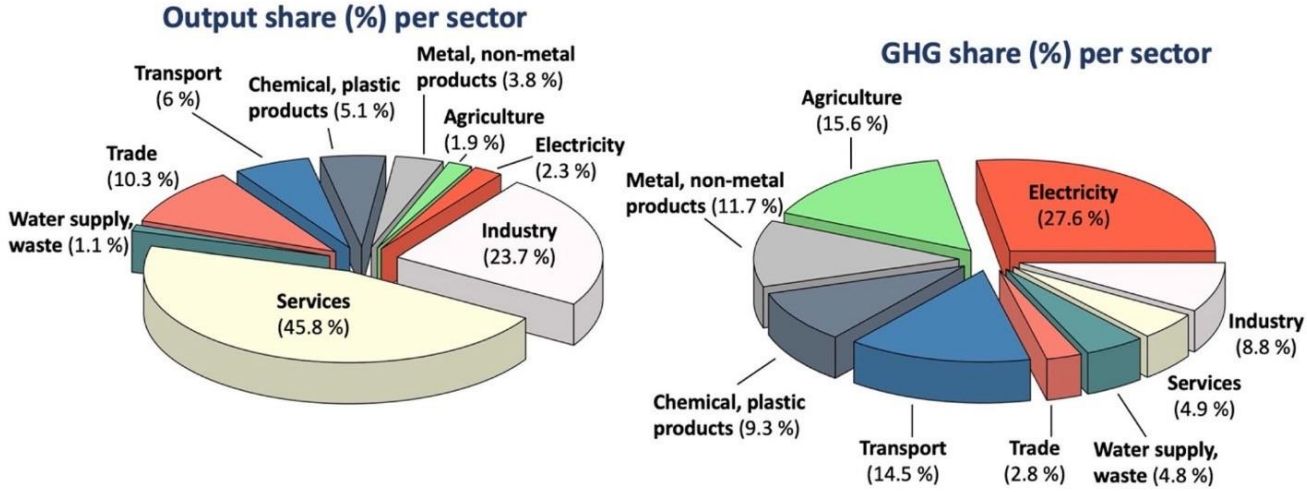

Figure 7.4.2. **Sectoral economic output and greenhouse gas (GHG) emission shares (%)**. Source: (2)

The projected changes in climatic patterns will severely affect various sectors of key social and financial relevance, including public health, agriculture, tourism, and energy management. Mitigation measures that focus on decarbonizing economic sectors, along with adaptation strategies such as utilizing non-conventional water resources, implementing early warning systems, and restoring ecosystems, are necessary to address these challenges. Strengthening regional research capacity and coordination among EMME countries is crucial for conducting independent assessments, verifying policies, and developing collaborative solutions to mitigate and adapt to climate change while ensuring energy, food, and water security.

II. Impacts of Climate Change on the Energy Sector

The EMME region consists of countries at different stages of economic development, facing ecological, political and economic challenges while being located in a climate change hotspot. Despite hosting 5.5% of the global population and generating 4.7% of the world's economic output, the region produces over 8% of global carbon dioxide emissions (3). Some EMME countries emit significantly more carbon dioxide per capita than the world average. Most major emitters in the region are far from the trajectory required to stabilize the global climate according to the Paris Agreement (4).

In this region, oil has historically been the primary energy source, followed by natural gas (which has been gradually increasing in supply over time). In the 1990s, oil had the largest share in the energy mix, but by 2017, natural gas had reached a 50% share, while oil accounted for 41%. The remaining 8% of the energy mix comes from other sources, with coal being the most significant contributor.

The EMME contains very large reserves of crude oil and natural gas, as well as a substantial (and mostly untapped) potential for renewable energy production. The countries in this region exhibit varying levels of dependency on fossil fuels (figure 7.4.3). Most countries rely heavily on natural gas and/or oil due to the region's significant reserves. Coal is also a significant source of energy for countries like Greece, Israel, Lebanon, and Turkey. Renewable sources, biofuels and hydropower also contribute to fulfilling the region's energy needs to various degrees in several countries. Additionally, certain countries in the region are investing in nuclear power capacity (3,5).
The energy system is responsible for three-quarters of all emissions in this region, as well as half of its atmospheric pollution (6); therefore, it is paramount that it bears most of the burden associated with decarbonisation efforts. The transition to green energy is crucial for mitigating climate change, adapting to worsening climate conditions, and building climate-resilient societies.

In the context of the EMME Climate Change Initiative (EMME-CCI), the Task Force on Energy Systems conducted a review of the region's energy systems, identifying gaps in policy and knowledge that require immediate attention. The report (3) provides a comprehensive analysis of the evolution of energy supply and demand in EMME countries, covering oil, gas, renewables, and nuclear energy. Additionally, the report examines the energy and climate policies in the region, including national strategies, decarbonisation plans, regulatory approaches for clean energy uptake, market-based instruments to abolish fossil fuel subsidies, and institutional reforms. The review highlights gaps in the design and implementation of effective decarbonisation policies, both in energy supply and energy use, including power generation and clean fuel production. Additionally, the review also outlines a regional decarbonisation agenda.
The transition to low-carbon economies requires a comprehensive approach that focuses on reducing overall energy demand, while meeting the remaining demand with low or net-zero carbon footprint sources. This necessitates political commitment to design a low-carbon economy and implement actionable policies. Regional cooperation and collaboration are crucial in sharing technical expertise and best practices for policy implementation and capacity building. The energy sector cannot be considered in isolation, but should interact with the socioeconomic system, requiring a holistic systems approach that addresses economic, social, and environmental challenges. Cross-cutting policies on industry, skills, society, and finance are necessary to support the scaling up of zero-carbon energy deployment.

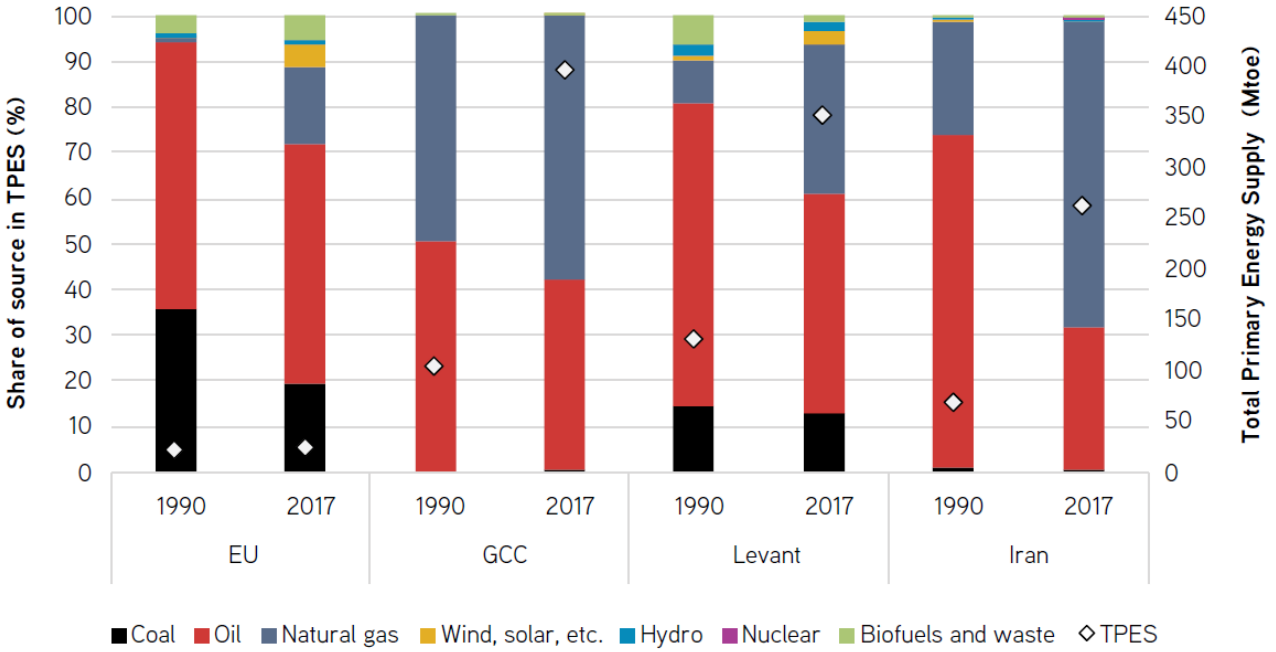

FIGURE 7.4.3. **Primary energy supply by source (% on the left axis) and total primary energy supply (white diamond in Mtoe on the right axis), by different geographical areas of the EMME region**. Note: European Union (EU) countries include Cyprus and Greece; Gulf Cooperation Council (GCC) countries include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates; and Levant includes Egypt, Iraq, Israel, Jordan, Lebanon, Syria and Turkey. Reproduced from (3).

II.1. Impacts on Energy Demand

Rising temperatures in the EMME region caused by climate change have already increased the demand for space cooling and air conditioning, resulting in higher electricity consumption and, thus, more CO_2 emissions. This is expected to increase further under warmer and drier conditions.

A recent study, led by the EMME-CARE Advanced partner CEA, in collaboration with CARE-C researchers, focused on Qatar as a representative case for understanding the effect of future regional warming on electricity demand and CO_2 emissions (7). A model that relates daily electricity demand with temperature was developed. By combining this model with temperature projections from the CMIP6 database (bias adjusted and statistically downscaled) and population and GDP projections from four shared socioeconomic pathways (SSPs), we calculated Qatar's demand for electricity until the end of the century. The model identifies an average sensitivity of +4.2%/◦C for the electricity demand and projects an increase in electricity demand by 5–35% due to warming alone at the end of this century (Figure 7.4.4). The model suggests that under SSP1-2.6, warming-induced CO_2 emissions could be offset by carbon intensity improvements. Furthermore, under SSP5-8.5, assuming no carbon intensity improvement, future warming could add 20–35% of CO_2 emissions per year by the end of the century, with half of the electricity demand related to more frequent hot days. We further found that the temperature effect on power demand and CO_2 emissions is small compared to the effects from socioeconomic factors such as population, GDP, and carbon intensity.

Climate change and extraordinary regional warming levels, more pronounced during the summer months, may impose welfare reductions on EMME societies, also by affecting thermal comfort. A different approach for estimating the demand for cooling is the 'Cooling Degree Days' (CDD), a measure of how much (in degrees) and for how long (in days) outdoor air temperature is higher than 18°C, which

is assumed to be the temperature threshold above which air-conditioning is required to provide comfortable conditions.

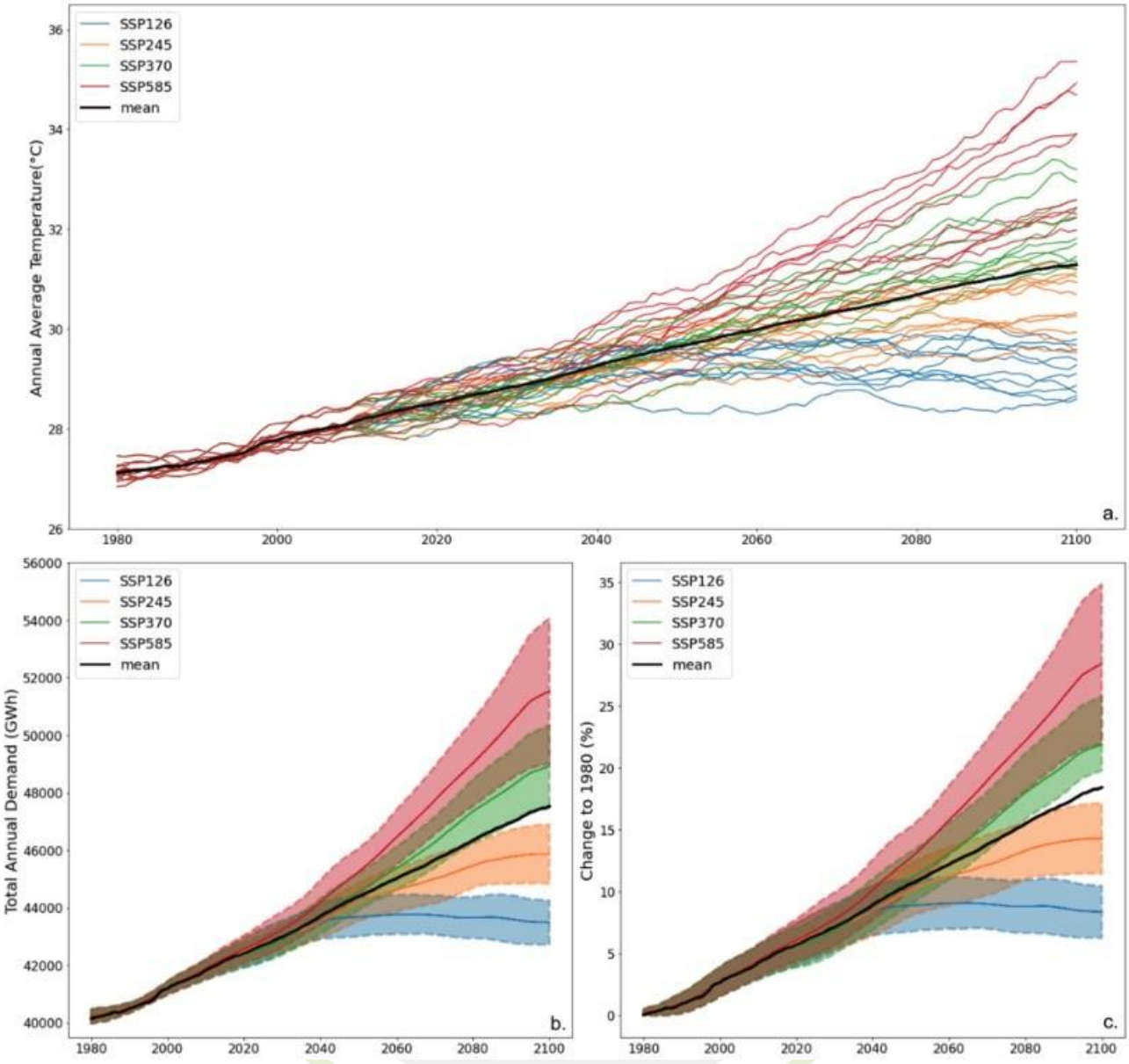

Figure 7.4.4. (a) Bias-adjusted annual average temperature over Qatar from the CMIP6 database for SSP1-2.6 (blue), SSP2-4.5 (orange), SSP3-7.0 (green), and SSP5-8.5 (red). (b) Total annual demand calculated with the statistical model. (c) Change in demand compared to the year 1980 (in percentage). Source: (7).

An example for Cyprus (synergy between EMME-CARE and SOCLIMPACT projects) is presented in Figure 7.4.5. In both future pathways, the demand for cooling in the island is expected to increase. For the low emission scenario (RCP2.6), this increase will be up to 40% with respect to the 186-2005 reference. Under a high-emission scenario (RCP85) and towards the end of the century, the number of CDDs is expected to be five times greater, providing a devastating prospect for the island.

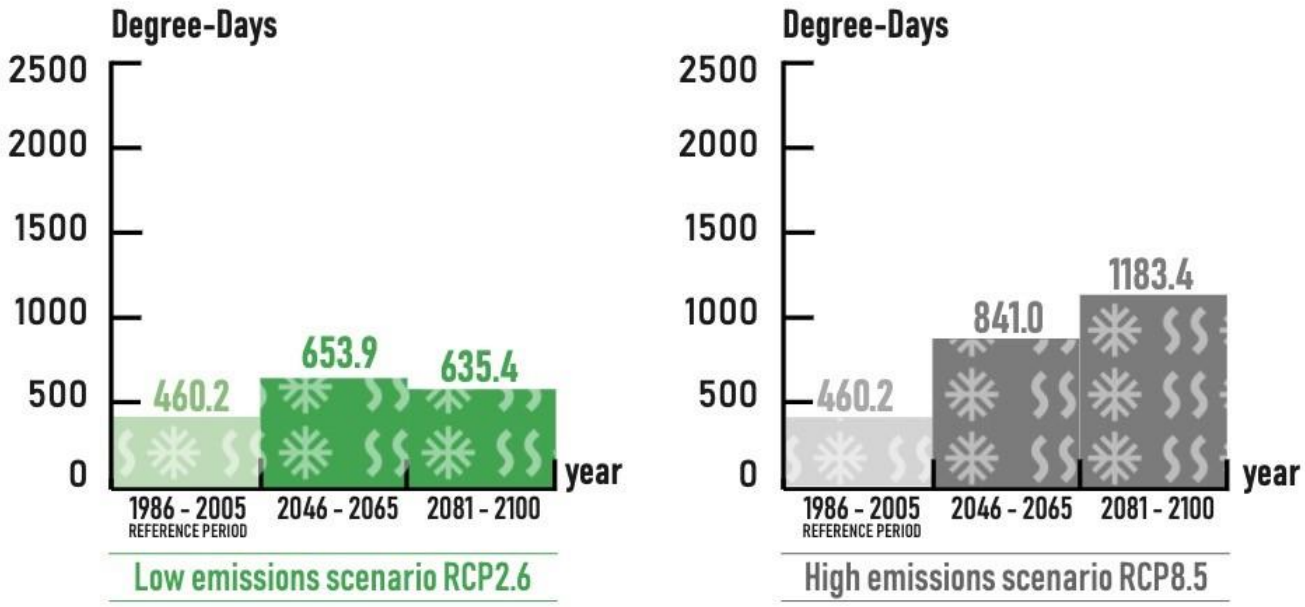

Figure 7.4.5. **Historical and future projections of the Cooling Degree Days for Cyprus, based on an ensemble of EURO-CORDEX regional climate projections**. Source: (8)

In the EMME countries, an increasing amount of energy is consumed for operating water desalination plants for meeting the domestic supply and irrigation needs. In a drier and hotter environment, with additional pressure from increasing population, agriculture, tourism activities, etc., the electricity demand for desalination could further increase. In a recent analysis (synergy between EMME-CARE and SOCLIMPACT projects), we used the Standardized Precipitation Evapotranspiration Index (SPEI) as a proxy indicator for increases in water demand for residents, tourists and agriculture activity in Cyprus. SPEI also provides an indication of the available water stored in dams or underground resources. To estimate the increase in energy demand due to the increase in water demand, it was assumed that most of the islands will have to produce desalinated seawater (or groundwater) to meet further increases in demand. Thus, the estimation of the increase in energy demand (GWh/year) to produce more drinking water has been done based on the energy consumption required to desalinate seawater. For example, a high-emission scenario (RCP8.5), implies a 159% increase in the energy demand for desalination due to the combined effect of strong warming and precipitation decrease in the region.

II.2. Policy suggestions

The EMME-CCI report of the Task Force on Energy (3) highlights three key pillars (Figure 7.4.6) for the clean energy transition: robust planning with data and research, mitigating energy demand growth through green technologies, and ensuring a competitive supply of low-carbon energy.

In this context, efforts for regional cooperation are crucial, including the sharing and co-developing energy infrastructures and networks, facilitating technical exchanges and capacity-building activities, and conducting regional integrated assessments. Furthermore, the report also proposed a comprehensive agenda for regional research and innovation, which covers the following topics:

- Technologies (clean fuels such as hydrocarbons and hydrogen, green desalination processes, zero-carbon power generation, energy storage, carbon capture and utilisation)
- Enabling infrastructure (inter-connections, energy communities)
- Digitalisation (smart grids, vehicle-to-grid systems, automation)

- Circular economy (impact of resource efficiency and waste prevention on the carbon footprint of industries and households)
- Attitudes (lifestyle changes and behavioural aspects to lower energy demand and adopt sustainability practices, especially after the pandemic)
- Policies (simulations of inter-connected/liberalised markets, decarbonisation path- ways and their impact on economic growth and social equity)

From this agenda, countries can choose those the options that best fit their particular needs and resources.

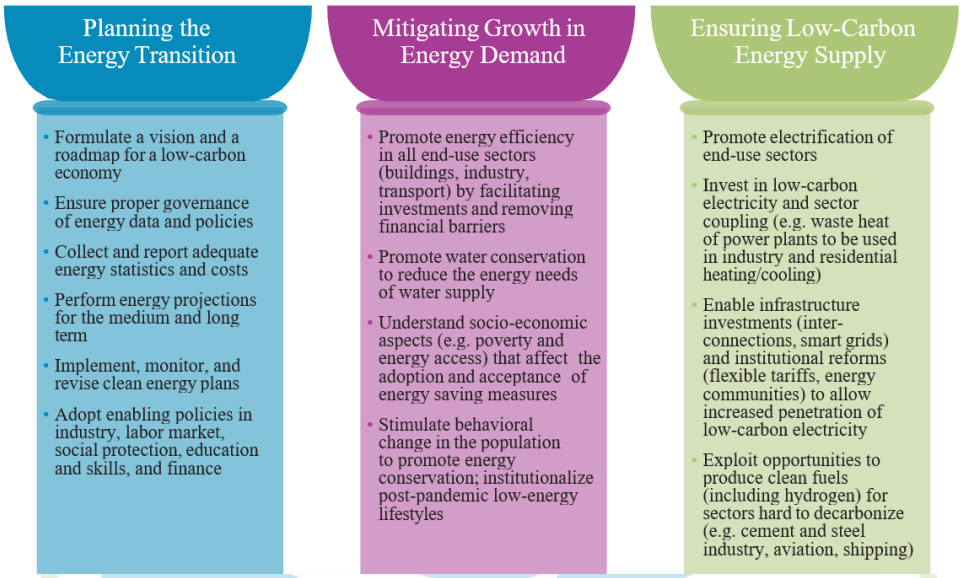

Figure 7.4.6: **Policy Priorities for decarbonisation in the EMME**. Source: (3)

While national strategies are important, regional cooperation can significantly accelerate research and innovation. To achieve this, it is recommended to foster the creation of regional energy/climate/economic modelling networks that involve research institutions and establish strong links with national decision makers. These networks would enable a policy-relevant decarbonisation agenda for the region's energy system.

Furthermore, the report of the EMME-CCI Task Force on Energy Systems (3) also provides a comprehensive policy toolkit, with over 30 proposed interventions that cover various aspects of public policy, such as regulations, institutional reforms, investment barriers removal, green fiscal measures, infrastructure investments, and information initiatives. This toolkit aims to decarbonize energy systems and emphasizes the use of zero-carbon electricity and heat, low- and zero-carbon fuels, improved energy efficiency, and alignment of economic and research priorities with the vision of a low-carbon future. Given the geography and climate of the EMME countries, coordinated action is crucial, and policymakers can utilize international knowledge and regional resources to facilitate the transition to climate-neutral energy systems for the benefit of the entire region.

III. Impacts of Climate Change on Human Health

Climate change has wide-ranging and complex effects on various aspects of human life. Its impacts on human health and well-being can be both direct, such as exposure to extreme temperatures and natural disasters and indirect, such as changes in infectious disease transmission patterns, as well as changes in the quality and availability of food. These effects are further compounded by a variety of biological, ecological, and socio-political factors, including age, gender, location, socio-economic status, occupation, and pre-existing health conditions.

In several countries of the EMME, high rates of population growth, urbanization, political tension and population displacement enhance the population's vulnerability to the effects of climate change. In this region, the main climate-related factors affecting human health include extreme heat, water scarcity, air pollution and vector-borne diseases. Population displacement is also considered a relevant factor due to its links to climate, and potential impacts on public health. Below, we present a brief summary of the main health effects of each one of these factors.

III.1. Extreme Heat

Exposure to extreme heat can have profound detrimental effects on human health. During heatwaves, adults (especially those aged 65 and above) may experience heat stroke, kidney injuries and heart attacks (9–11), while children may suffer from electrolyte imbalance, respiratory issues and renal problems (9). Mental health problems, sleep disturbances and increased suicide rates are also associated with extreme heat (9,12,13). Factors like air pollution, high humidity, and the "urban heat island effect" worsen the negative impacts of heat stress (14).

Although a significant portion of the population in the EMME region is acclimated to high temperatures, future heatwaves are projected to be more severe, disproportionately affecting vulnerable groups such as the elderly, people in poverty, those with disabilities or chronic illnesses, and outdoor workers. Urban areas with large susceptible populations in the EMME region will be particularly impacted by future extreme heat events.

It is predicted that under a business-as-usual emissions scenario, by the year 2100, several large cities in the EMME (particularly around the Persian Gulf region) could reach temperatures surpassing the thermal limits suitable for human survival (Figure 7.4.7) (15,16).

III.2. Water Shortage

Human health is strongly dependent on consistent access to safe water supplies. Most countries in the EMME region face at least some degree of water scarcity, with several countries facing severe water scarcity (17,18). The health consequences of this scarcity are both direct and indirect, resulting in health problems such as diarrhea, parasitic infections, vector-borne diseases, and nutritional deficiencies. Water scarcity also affects the agricultural sector, potentially leading to large reductions in export revenues (Figure 7.4.8) (19). This, in turn, can negatively affect national budgets destined for public health services and infrastructure, further compounding the health problems associated with climate change.

Figure 7.4.7. **Cities where future environmental temperatures could surpass the physiological limits for human survival**. Under a 'business-as-usual' emissions scenario, by the year 2100 five cities (represented with stars) located in four EMME countries (Iran, Qatar, Saudi Arabia and the United Arab Emirates) could reach environmental wet bulb temperatures above 35°C, surpassing the threshold for the human body's physiological adaptability. UAE: United Arab Emirates. Reproduced from (16).

Some EMME countries have successfully implemented strategies, such as desalination and wastewater re-use, to enhance water productivity through non-conventional means. Nevertheless, high monetery costs associated with these technologies still hinder their widespread application (20).

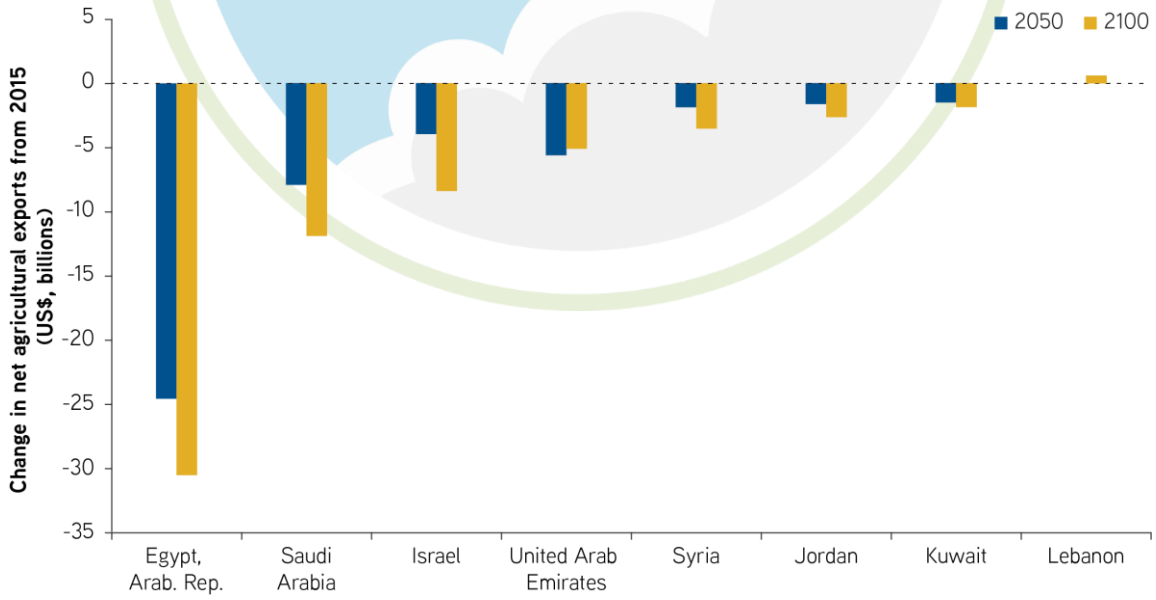

Figure 7.4.8. **Expected changes in revenue from agricultural exports in selected EMME countries**. Reproduced from (16)

III.3. Air pollution

Air pollution is associated with a variety of health issues, including chronic obstructive pulmonary disease, acute lower respiratory illness, cerebrovascular disease, ischemic heart disease and lung cancer (21,22). In Europe and the Eastern Mediterranean region, air contamination leads to approximately 1 million premature deaths annually (23,24). The primary sources of increased particulate matter in the air include energy generation, industrial pollutants, traffic, domestic energy use, and wildfires (25). In the EMME region, high concentrations of desert dust are another factor negatively affecting respiratory health (26,27). Vulnerable populations, such as infants, the elderly, and those with chronic cardiopulmonary diseases, are particularly affected.

High urbanization rates in the region worsens air pollution, as fossil fuel burning produces greenhouse gases, hazardous gases, and particulate matter. Urban heat islands and heatwaves further contribute to the degradation of air quality by facilitating the formation of harmful chemicals in the air.

III.4. Vector-borne Diseases

Vector-borne diseases (VBDs), transmitted by arthropod vectors such as mosquitoes, sandflies and ticks, are highly influenced by climatic variability due to their complex life cycles (28). Environmental conditions, including temperature, rainfall, and humidity directly influence the biology of disease vectors, thereby defining the epidemiology of VBDs (28,29). Human activities like urbanization and disruption of natural ecosystems further contribute to the potential for VBD transmission.

In the EMME region, ecological and socio-economic factors create favorable conditions for the transmission of VBDs like dengue, Chikungunya fever, leishmaniasis, West Nile fever, and malaria (Table 7.4.1) (16). Future climate change is expected to alter the epidemiology of these diseases by influencing the distribution, seasonality, abundance, and disease transmission capacity of the vectors.

Table 7.4.1. **Principal vector-borne diseases affected by climate change in the EMME region** (reproduced from (16)

	West Nile Fever	Malaria	Leishmaniasis	*Aedes*-borne arboviral infections
Causative agent	• West Nile Virus.	• Various species of *Plasmodium* parasites.	• Various species of *Leishmania* parasites.	• Dengue virus, Zika virus, chikungunya virus, among others.
Common vectors	• Various species of *Culex* mosquitoes.	• Various species of *Anopheles* mosquitoes.	• Various species of Psychodidae sandflies.	• Various species of *Aedes* mosquitoes.
Symptoms	• Ranging from mild and flu-like to encephalitis and death.	• Intermittent periods of high fever with a feeling of intense cold. • Nausea, headaches, and myalgia. • In severe cases, blood vessel blockage, organ failure and death.	• Varying from non-healing skin lesions (which can lead to disfigurement and disability) to internal organ enlargement, anemia and death.	• Large proportion of cases can be asymptomatic. • When present, symptoms vary from mild and flu-like to severe and potentially fatal, including haemorrhagic syndrome, polyarthralgia and neurological complications.
Relevant environmental influences	• High temperatures (particularly during the summer). • High precipitation in late winter/early spring, coupled with particularly dry summers. • Presence of migratory bird species.	• Rainfall, temperature, humidity, vegetation, hydrogeology and wind speed. • In areas where this disease has been eradicated, the presence of endemic competent vector species increases the risk of re-emergence.	• Precipitation, temperature, altitude, land use, water development projects and presence of potential reservoir species.	• Temperature, precipitation and host/reservoir availability. • Temperature is a major determinant of several important parameters, including habitat suitability for vectors, vector capacity and virus mutation rates.

III.5. Population Displacement

Over the past 50 years, the EMME region has experienced a significant increase in population displacement due to complex environmental, economic, and socio-political issues (30,31). Climate change can trigger population displacement through factors such as extreme weather events, rising sea levels, water scarcity and ecosystem degradation (32,33). Furthermore, climatic factors can have a catalytic effect on regional socio-political conflicts, resulting in increased rates of population displacement in conflict areas (34,35).

Several EMME countries have a high number of migrants and host large refugee populations (36). Refugees often face challenges such as inadequate living conditions, lack of resources, and uncertain legal status, making them vulnerable to health risks including extreme temperatures, water scarcity, malnutrition, infectious diseases, maternal and neonatal health issues, and mental health concerns. Limited access to medical and psychological healthcare further compounds the difficulties of displaced populations (32,34,37-40).

III.6. Research gaps

In the context of the EMME-CCI, the Task Force on Health has identified several areas where additional research is required to either better understand or better address the health challenges posed by climate change (16). These include:

- To collect more empirical evidence on exposure-response functions involving climate change parameters and specific health outcomes.
- To improve our understanding about the effects of climate change on ecological determinants of human health.
- To improve our understanding of the health effects of long-term exposure to climate change.
- To evaluate the interactions between adaptation & mitigation strategies, as related to human health.

III.7. Policy suggestions

Because most climate-related factors expected to impact human health are not contained by national boundaries, any effective adaptation and/or mitigation policies must be regional in nature and the result of collaborative efforts among EMME nations. Relevant regional policies suggested by the EMME-CCI Task Force on Health include:

- **Move decisively towards decarbonisation**: Reducing greenhouse gas emissions is crucial for protecting human health against the environmental stresses associated with climate change. Because various technologies capable of reducing emissions are currently available, but not fully exploited, it has been proposed that some of the main barriers to decarbonisation are not primarily technical or economic, but are instead related to deeply ingrained political and societal practices. To achieve meaningful and sustainable changes, it is imperative for consumers, institutions, and policymakers to make profound commitments. An effective and coordinated decarbonisation movement can only be achieved through strong political determination at the national and regional levels

- **Integration of environmentally-driven morbidity and mortality data throughout the region**: Based on a comprehensive review of scientific and medical data, it is evident that the EMME region would greatly benefit from the establishment of a system that enables the tracking of morbidity and mortality data related to climate factors. Such a system would enable the identification of clear correlations between regional climate variations and specific health issues, as well as the evaluation of the effectiveness of climate change prevention and mitigation policies at the national and regional levels. To develop this system, key steps need to be taken by EMME nations, including reaching a scientific consensus on health conditions influenced by climate factors, standardizing reporting criteria,

creating a regional data repository, archiving validated climate and pollution data, and establishing environmental health funds to support research on climate change and its impact on health throughout the region.

- **Advancing the development and widespread use of cheaper technologies for the production and management of drinking water by non-traditional means:** Addressing water scarcity is a critical challenge for EMME countries, necessitating the development of region-wide policies to manage and generate water for human consumption. Enhancing the efficiency of water distribution systems and promoting rational consumption through the implementation of smart-metering systems can help optimize water usage and reduce waste. While advancements in desalination and membrane technology have reduced production costs, they still remain prohibitively high for many countries in the region. Therefore, EMME nations should prioritize investments in research to optimize alternative water generation technologies, while at the same time mitigating their potential ecological impacts. Creating funding schemes for academic research groups and supporting start-up companies focused on developing innovative technologies can serve as potential mechanisms to achieve these necessary improvements.

- **Comprehensive regional strategies for the improvement of the health status of displaced populations**: When formulating policies regarding the health of migrant populations, it is important to consider the disparities in healthcare access between displaced individuals and the local population, as well as the complex cultural dynamics found in refugee settlements with diverse backgrounds. To address these issues, EMME countries hosting displaced populations need to implement comprehensive health policies that provide access to essential services such as healthy food and water, mental health support, maternal and reproductive health resources, medication for chronic conditions, infant vaccination, diagnosis and treatment of infectious diseases, and disease vector control.

- **Fostering regional networks to monitor and control the spread of infectious diseases and disease vectors:** In today's highly mobile society, national boundaries no longer serve as effective barriers against the spread of infectious diseases, as exemplified by the COVID-19 pandemic. Therefore, efforts focused on monitoring and controlling pathogens and disease vectors at the national level must be complemented by coordinated regional strategies. Successful examples from other world regions demonstrate that multi-nation initiatives involving the production of epidemiological data, identification of dissemination routes, and implementation of control strategies, can effectively reduce the burden of infectious disease on a large geographic scale.

IV. Impacts of Climate Change on Agriculture and the Food Chain

The food supply sector in the EMME region is significantly impacted by climate change, and future climate scenarios suggest that this sector will face further challenges. Deforestation caused by forest fires, both globally and regionally, has transformed major forest ecosystems into greenhouse gas emitters rather than absorbers. This, coupled with additional forest losses due to local fires in the EMME region, is expected to exacerbate existing drought and high temperatures, which will have unprecedented consequences for the food chain. The region is also experiencing extensive urban expansion, population growth, and varying levels of economic growth and employment. Primary food production is a significant economic activity in some EMME countries (6.03% of the region's mean GDP), serving as a vital source of employment and social cohesion. Overall, it is estimated that approximately 9.4% of jobs in the region are related to agriculture (41).

Climate change is already exacerbating food insecurity in the EMME, and future models and scenarios predict increasingly unfavourable climatic conditions for food production. Water deficits, higher temperatures, and more frequent extreme climate events like droughts and floods will have adverse effects on crops, livestock, and aquaculture. Agricultural land in coastal regions will be affected by salt intrusion and flooding. The rise in temperature and increased variability in rainfall are expected to make the region even more arid, leading to decreased productivity in agricultural ecosystems and loss of biodiversity. While higher CO_2 concentrations may partially offset the negative impacts of high temperatures and aridity on some crop species (42), the region will also face the emergence of new plant pests, weeds, and pathogens, causing significant and unpredictable crop losses. Furthermore, profound socio-political conflicts and high rates of population displacement further compound the challenges related to food production and distribution in the region.

Heat stress has severe consequences for livestock production, leading to financial burdens for farmers due to decreased milk and meat production, reproductive inefficiency, and compromised animal health (43). The projected increase in air temperature directly impacts the livelihood of livestock. Furthermore, climate change indirectly affects livestock by reducing feed and water resources. Climate change disrupts forage production and quality, water availability for cultivating forage crops, and rangeland vegetation patterns. Heat-stressed animals eat less, drink more, experience endocrine changes, and have increased maintenance requirements, resulting in reduced performance and body weight (43).
In dairy cows, extreme heat causes reductions in milk yield and quality (e.g. lower contents of fat, lower-chain fatty acids, and lactose, as well as increased concentrations of palmitic and stearic acid). These effects tend to be more pronounced in highly productive breeds. Reproductive processes are also hampered by extreme heat: negative effects on ovarian function, oocyte competence and embryonic development can cause substantial reductions in conception rates. Heat stress during pregnancy slows foetal growth and increases foetal loss. In males, heat stress negatively affects sperm production (44).
Climate variations also influence livestock vector-borne disease, with warmer and wetter weather increasing the transmission and geographic spread of diseases carried by insect and tick vectors, including babesiosis, theileriosis, anaplasmosis, Rift Valley fever and bluetongue disease (45,46).
Predicted climate change scenarios highlight the urgency of implementing novel strategies for livestock production. However, science and technology in animal production systems have so far failed in two aspects: They have not effectively addressed climatic adaptation (which is crucial for ensuring the resilience of livestock in the face of changing climatic conditions), and they have not sufficiently disseminated new findings on rangeland ecology, which encompasses a holistic understanding of pastoral management. For instance, integrating grain production with pasture plants and livestock could create a more diverse and resilient ecosystem that can better withstand the effects of global climate change, such as higher temperatures, elevated carbon dioxide levels, and erratic precipitation patterns.

It has been shown that most countries in the Middle East and North Africa have experienced substantial land degradation, regardless of land-management efforts (47) (Figure 7.4.9). In the arid and semi-arid areas of the EMME region, climate change is expected to accelerate soil desertification, the most severe form of land degradation. Various anthropogenic factors contribute to this degradation, including managed agricultural ecosystems, urbanization, infrastructure development, changing fire regimes, soil salinization, encroachment of invasive species, and extraction of non-timber natural resources. Furthermore, protracted water scarcity and higher temperatures lead to increased mineralization of organic matter in the soil, making it more vulnerable to desertification. Soil productivity will be affected by erosion through changes in its physical and chemical properties, including aggregate stability and grain size. Other practices, such as inappropriate tillage in hilly arid and semi-arid areas, further contribute to the rapid degradation of soil resources.

Natural and human-induced environmental changes impact marine environments and reduce biodiversity, as has been documented in the eastern Mediterranean Sea (48). Declines in biodiversity threaten fisheries and aquaculture dependent on a functioning marine food web. Factors like higher water temperatures, rising sea levels, and decreased salinity threaten aquaculture, especially because they can intensify pathogen development, disease transmission, and susceptibility to infection. The effects of these maladies often lead to reduced growth rates and increased mortality, and can spread from aquaculture to the wild, affecting both economic viability and wild fisheries.

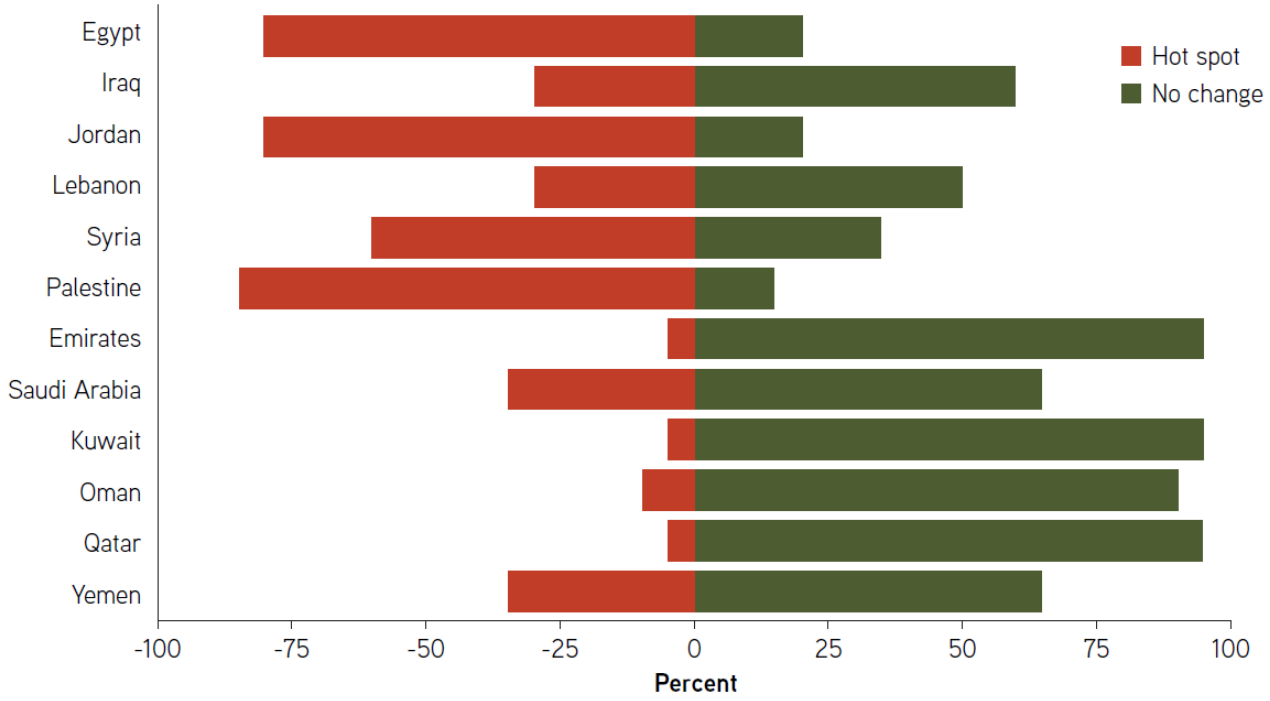

Figure 7.4.9. **Degraded land as a share of total land area in selected EMME countries**. Reproduced from (41).

IV.1. Policy suggestions

In order to face the effects of climate change in the EMME, actions are required at both the national and regional levels. Policy guidance should be determined by science-based solutions and strategies, and should flow out of institutional interactions. It is essential to mobilize regional resources, ensuring knowledge transfer and sufficient investment. In the context of the Eastern Mediterranean and Middle East Climate Change Initiative, the Task Force on Agriculture and the Food Chain has proposed the policy measures shown in table 7.4.2.

Table 7.4.2: **Proposed policy measures for climate change adaptation in the field of agriculture** (modified from (36)

Policy	Measures implementing the Policy	Examples of actions
Creating strong and direct links between Science and Administration	• Capacity building of a novel structure facilitating the communication between scientists and politicians.	
Production of new knowledge by research	• Prioritization of climate change and adaptation research in the National Research policies. • Establishment of a cooperative funding tool to support research activities in the Region.	• Understanding the physiology of crop and weed species of the region to climate change. • Surveys for predicting climate change impacts on agriculture and fisheries. • Utilizing local germplasm for producing new cultivars resilient in the new conditions
Emphasis on Education/ Outreach	• Creating public awareness on the initiative and its potential benefits to national economies and societies. • Develop efficient dissemination mechanisms of the joint research outcomes to all stakeholders.	
Developing policy tools for adaptation/mitigation measures	• Creating reliable indicators for assessing adaptation/mitigation frameworks and measures.	• Best practices of sustainable measures for agriculture and natural ecosystems. • Adopt and scale-up conservation practices in rainfed agriculture. • Best practices of integrated livestock-crop production systems.
Preparing a package of strong incentives for farmers	• Adopting sustainability measures for soil, water, biodiversity, energy. • Promoting low input agriculture.	
Predicting and facing environmental degradation and crop losses by pests and diseases	• Establishing networks of observatories for monitoring water resources, soil degradation, new invasive pests and pathogens	
Building appropriate infrastructures for facing extreme events	• Attracting investments from national/ international foundations	• Protection from floods. • Building reservoirs for water harvesting. • Reforestations, restorations. • Modernization of irrigations systems.
Protection of rural income	• Establishing or extending existing insurance policies for agricultural production from extreme events.	• Developing reliable crop-loss assessment methods.

V. Impacts of Climate Change on Tourism

The EMME is home to some of the most important touristic destinations of the world, attracting large numbers of tourists every year. According to the United Nations World Tourism Organization (UNWTO), this region received upwards of 150 million tourist arrivals in 2019 (the last regular year for tourism before the COVID-19 pandemic), with Turkey, Greece, the United Arab Emirates and Saudi Arabia being the top destinations (49) (Figure 7.4.10).

The far-reaching impacts of climate change are already jeopardizing the sustainability of global tourism. However, the vulnerability and adaptive capacity of destinations vary across regions, including the EMME countries. According to the European Travel Commission's 2018 global analysis of climate change risk for tourism (50), the EMME region faces a medium to high level of risk for its tourism economy due to climate change. Rising temperatures and heatwaves are expected to affect the comfort of tourists during summer months (June to August), reducing tourism flows during this important period of the year. Additionally, sea-level rise is likely to pose threats to coastal infrastructure and activities.

The expected reduction in access to the region's already limited freshwater resources, especially in the Middle East, will not only negatively impact tourism flow (and associated revenues), but is also likely to

escalate any conflicts over water usage for economic activities (51). Furthermore, the eutrophication of coastal and marine environments, caused by climate-related nutrient enrichment, could result in the deterioration of beach waters and the alteration (or loss) of the natural habitats that are considered primary resources for the type of tourism activities currently developed in the EMME. Sea level rise further exacerbates the risk of landscape degradation, and jeopardizes cultural heritage sites situated along the coast (51,52).

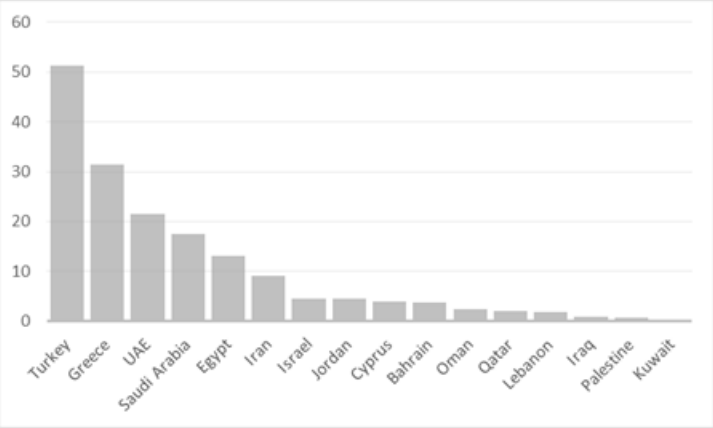

Figure 7.4.10: **Inbound tourist arrivals (in millions) in 2019 in EMME countries (overnight tourists)**. Data source: UNWTO Tourism Data Dashboard (49).

The tourism sector is widely recognised as being highly vulnerable to climate change, and research is still considered scarce to support destinations to enhance resilience capacities. In a recent study (synergy between CARE-C and EEWRC), we aimed to analyse tourists' preferences for adaptation measures that can be implemented at coastal destinations to face climate risks (53).

To this aim, 258 questionnaires were completed by tourists visiting Cyprus in the summer of 2019. Tourists were posed with hypothetical situations where several climate risks occur at the destination and were asked to choose between alternative combinations of policies to counteract these impacts. According to the majority of responses, environmental and climate hazards such as the spread of vector-borne diseases, the occurrence of wildfires and beach reduction are among the reasons that could change their travelling decisions (Figure 7.4.11). Results also indicate that the programs related to beach protection, heat waves amelioration, water supply and infectious diseases prevention are the most valued by tourists. The study provides recommendations aimed at being useful for all coastal destinations, highlighting the importance of climate-related preparedness and adaptive capacities to enhance the tourist experience value and promote economic impact.

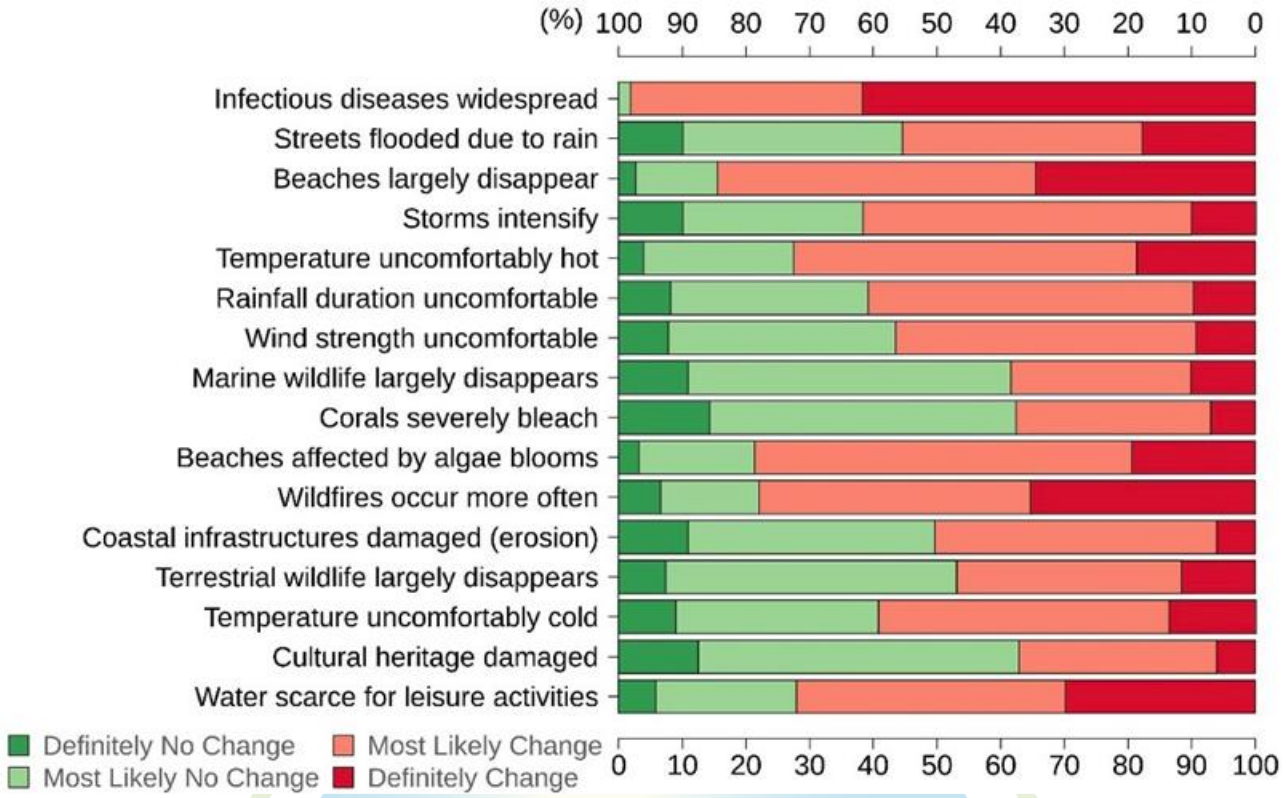

Figure 7.4.11. **Tourists' willingness to change travelling decisions under climate-related hazards in Cyprus**. Reproduced from (53)

V.1. Policy suggestions

Policy recommendations to improve resilience to climate change in the tourism sector will undoubtedly vary in territorial coverage and ease of implementation. However, in general terms, they should be complementary, collaborative, and compatible with other policy frameworks (at the global, regional and national levels) and in other areas (such as employment, transportation, heritage management and local well-being), while still promoting innovation, biodiversity protection, and the achievement of the Sustainable Development Goals. Below, we summarize the main policy suggestions presented by the EMME-CCI Task Force on Tourism:

Strengthening support for climate change adaptation in the tourism sector: To safeguard the vital tourism industry in the EMME region from the detrimental impacts of climate change, adaptation policies and mitigation measures are crucial. This requires comprehensive efforts, including raising awareness among all sub-sectors of the tourism industry, involving local communities in decision-making processes, garnering support from municipal and governmental authorities, evaluating potential actions, and enhancing managerial skills at various levels. Additionally, diversifying the tourism product by developing niche forms of tourism, such as rural, cultural, agricultural, urban, nature-based, and wellness tourism, is necessary to mitigate the environmental effects of mass tourism and ensure the industry's future. Fostering smaller-scale developments in the hinterland can promote sustainable utilization of natural and cultural resources, while establishing strong connections with other important sectors, like the agri-food industry.

Reorienting tourism to reduce concentration and overdevelopment: To adapt to climate change, the reorientation of tourism in the EMME region should involve spreading tourism activity beyond overcrowded hotspots, such as coastal destinations, and focusing on areas that are currently less

developed and less accessible. To achieve this, it is necessary to enhance the infrastructure and superstructure of said areas, catering to the specific needs of tourists.

Support development and transition towards greener tourist establishments: Another important policy suggestion is to transition towards greener tourism establishments and destinations by implementing green innovation measures in tourism services, as many current practices exploit local resources unsustainably, jeopardizing the attractiveness and resilience of destinations.

Repositioning of the tourist product: It is advisable to revise branding and marketing strategies that currently focus heavily on sun-and-sea options. Fostering a broader stakeholder perspective that includes the vision and involvement of local communities, as well as showcasing the full tourism potential of each destination, would contribute to building more resilient and sustainable tourist destinations throughout the EMME.

Decarbonisation of the tourism sector: In order to adapt to climate change in the EMME region, mitigation measures for decarbonisation of the tourism sector are essential (54). This entails reducing the environmental impacts of the industry, particularly in terms of water consumption and carbon footprint. Strategies such as improving energy efficiency, promoting renewable energy, monitoring emissions, and raising consumer awareness can contribute to achieving these goals. It is also crucial to foster a change in mentality among various stakeholders, including tourists, local communities, tourism companies, and governments at all levels. This requires effective governance, communication, and collaboration to align interests and create a common vision for the future. Governmental support, evaluation mechanisms, and consulting local stakeholders to identify and prioritize needs are also important for a successful transition to a greener future.

VI. Impacts of Climate Change on Maritime Transport

Maritime transport is a vital sector for global trade and the world economy. Particularly for islands, there is also an important social dimension of this sector, since island communities strongly rely on it for a connection with the mainland and the transportation of goods and passengers. Furthermore, islands are exceptionally vulnerable to climate change, as the rising sea level and extreme events are expected to induce severe impacts. Such hazards are anticipated to also affect the operations of the maritime transport sector by affecting either the port infrastructure or ships en route.

In a recent study, led by EMME-CARE, we tried to better comprehend and assess the future risk of maritime transport disruption in six European islands and archipelagos, aiming to support regional to local policy and decision-making (55). We employed state-of-the-art regional climate datasets (EURO-CORDEX), information and projections of relevant socioeconomic indicators and the widely used impact chain approach to identify the different components that might drive such risks. Larger islands (e.g., Corsica, Cyprus and Crete) are found to be more resilient to the impacts of climate change on maritime operations (port infrastructure and ships on-route). Our findings also highlight the importance of adopting a low-emission pathway, since this will keep the risk of maritime transport disruption similar to present levels or even slightly decreased for some islands because of an enhanced adaptation capacity and advantageous demographic changes. An example of future estimations for the risk of maritime transport disruption in Cyprus are presented in Figure 7.4.12 for different time-horizons and two future pathways. In both scenarios the relative risk is projected to remain at low levels; nevertheless, under pathway RCP8.5, an increased vulnerability component will likely imply higher risk values for disruption of maritime operations.

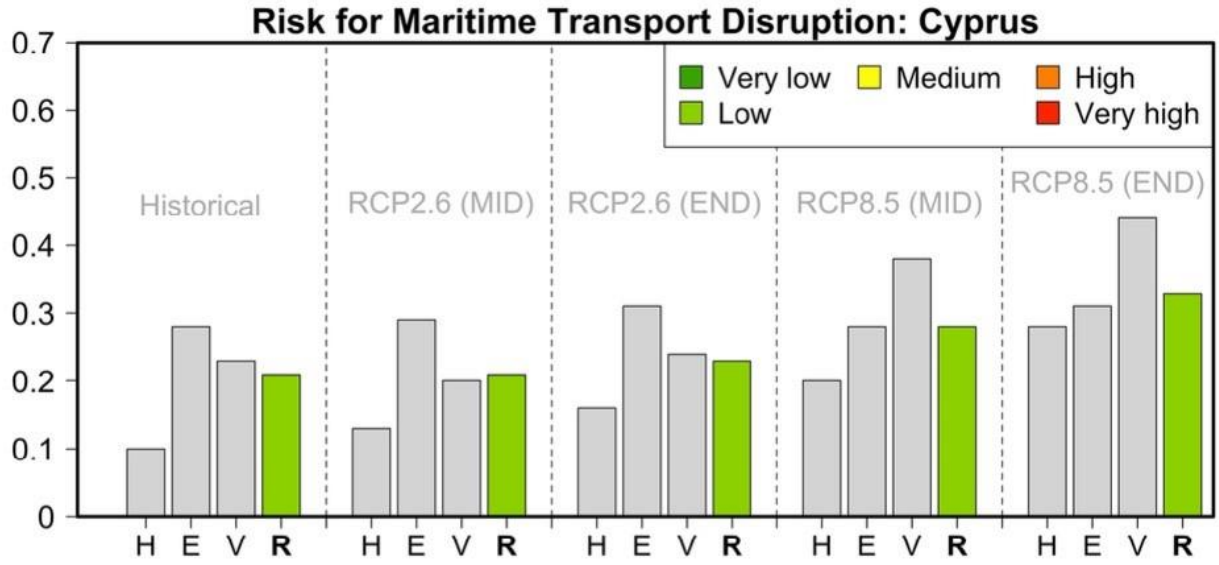

Figure 7.4.12. **Hazard (H), Exposure (E) and Vulnerability (V) components and relative risk (R) values for the risk of maritime transport disruption in Cyprus during the historical reference period and two future periods under pathways RCP2.6 and RCP8.5 (0: no risk; 1: very high risk).** Source: (55).

VII. Future Perspectives

Researchers at CARE-C are strongly engaged in collaborative projects aimed at deepening our understanding of the effects of climate change in areas of economic relevance to the EMME region, as well as creating strategies to address the negative effects of climate change on our society.
Below, we introduce a few examples of projects related to key economic areas, which include participation of CARE-C personnel and have been either recently funded, or recently presented for evaluation.

- **Impacts of Climate Change on the Cypriot Economy (ClImEconImpacts).** In a joint effort between CyI and the Economics Research Centre of the University of Cyprus, this project will represent a first attempt at assessing the macroeconomic risks induced by climate change to the Cypriot economy. The project will initially involve a review of existing studies on the physical and economic impacts of climate change in Cyprus and the EMME region. At a second stage, the project will generate more detailed assessments of climate change impacts in key sectors of the Cypriot economy (including energy, health, agriculture, water resources and tourism, among others) by the years 2030 and 2050. These two initial phases of the project will be primarily based on work to be carried out at CARE-C.
In addition to the physical risks of climate change to the economy, the project will also assess the transition risks, i.e. the costs of the transition of Cyprus to a net zero economy by 2050, in line with the European Climate Law; this will be based on work to be carried out by CyI's energy policy group, in collaboration with CARE-C. Although this is a project of limited budget, it can set the stage for broader collaborations in the future on a topic that has attracted great interest from national policy makers. The project is financed by a grant from the Ministry of Finance of the Republic of Cyprus, and its period of performance is June 2023 to December 2025.

- **Solar and Wind Energy Potential of the East Mediterranean and Middle East Region - Capturing the Effect of Climate Change through the WRF-Chem Model.** This is a project undertaken by members of the Environmental Predictions Department under the CARE-C unit and aims to deploy the WRF-Chem model to accurately simulate the electrical output of wind turbines and solar PV panels for the study region, considering the effect of climate change.
Aerosol radiation, wind and cloud feedback schemes will be utilised to produce the climatological base year (recent past), short-term future (decadal simulations) and the long-term future mid-century (2050) for IPCC representative concentration pathways. The expected accuracy improvement for electricity production forecasts incorporating the impact of climate change will provide guide optimisation for the deployment and performance of solar and wind farm projects, ultimately reducing investment risks. The possibility of a partnership with Ernst & Young is being investigated to incorporate physical variables in financial models for predicting the profitability of wind and solar energy projects. The project has a 3-year timeline.

- **Agricultural Policy Roadmap for Digitisation, Innovation, Growth and High-Tech Automation**.
Agriculture and digitalisation are integral elements of a secure, sustainable and competitive agri-food supply chain. However, integration of these terms in development initiatives and funding instruments is often lacking. Despite the growing importance and relevance of the agri-food sector, digital technologies and innovations are not fully exploited, so it is crucial to increase the availability of innovations for key actors to be more competitive.
The overall objective of AGRI-MAP is to improve regional development policies and programmes under the Investment for Growth and Jobs goal in order to boost uptake of existing digital innovations by the national agri-food sectors, stimulate transregional collaboration and harness opportunities to ensure sustainable and inclusive agricultural transformation. The main outputs will be: Diagnosis reports of the regional agri-food sectors, Good Practice Guide with recommendations and methodology guidance and National Strategy Roadmaps - long-term development strategy for the sector with the objective of

increasing added value and competitiveness of national agri-food sectors through application of climate-friendly practices and new digital and automation technologies.
AGRI-MAP will develop a holistic approach towards an integrated value chain, promoting the creation of an ecosystem of industries and cooperation. Priority ranking of recommended government actions depends on context, including the overall development level of a country or region and the agro-climatic and topographic characteristics of agriculture. Cross-borders cooperation and knowledge sharing will be crucial to scaling adoption given its potential outreach.
AGRI-MAP will provide initial or new region-specific pathways identifying key steps on the road to achieving long-term socio-economic impacts while addressing existing or potential inadequacies in infrastructures, including national data and financial policies, as key enablers of adoption. The project has been presented for evaluation within the Interreg Europe Programme.

- **A National Infrastructure for Smart and Precision Farming (SMARTFARM)**. The overall objective of SMARTFARM is to federate the research and innovation potential of several Cypriot Institutions and Companies with the help of leading institutions, in order to lay the foundation of a National Research Infrastructure (RI) for Smart Farming for Cyprus, being also relevant to the Mediterranean basin at large. Our SMARTFARM-RI will combine high-resolution sensor networks, state-of-the-art scientific instruments, new data collection and processing technology to further establish itself as a sustainable Technology Infrastructure, as defined by the European Commission.
SMARTFARM will also carry out a specific set of research and innovation tasks to showcase the benefits from the transition to precision farming in Cyprus so that the local industry becomes more competitive and welfare-friendly. We will integrate fundamental scientific knowledge and technological capacity to facilitate the transition to a totally new and locally-adapted model for the livestock industry by federating expertise in animal husbandry, crop selection, soil fertility, sensor technology, environmental monitoring, Internet of Things (IoT) solutions, data storage/analysis and Artificial Intelligence. Using smart farming technologies and applications, SMARTFARM will establish the necessary infrastructure that will generate knowledge and innovation that is critically missing in Cyprus (and the broader Mediterranean region) to address urgent needs to better mitigate/adapt to climate change and the impact it will have on agriculture.
Partners for this project include the Ministry of Agriculture, Rural Development and Environment of Cyprus, The Cyprus Research and Innovation Center and Vettaky Ltd. The project proposal has been presented to Cyprus' Research and Innovation Foundation (RIF) for its evaluation.

- **Centre of Excellence for Smart and Sustainable Farming.** Cyprus is in the epicentre of climate change in the Easter Mediterranean and agriculture will be the one most negatively affected sectors of the economy. The projected warming in the period 2031-2060 compared with 1971-2000, mostly in spring and summer, will expose crops and animals to conditions, which are likely to have an adverse impact on production and quality. The livestock industry is an important part of the country's agricultural sector. The increasing demand in meat and other products have increased animal production and the sector has gradually transformed into industrial-based units. It is an important component for the economy and the society, employing over 5,000 (about 1.3% of the national workforce). The contribution of animal production to the gross agricultural output increased from 39% in 2000 to 54% in 2021. This upward trend is mainly due to the demand for important dairy products, such as halloumi cheese and, to a lesser extent, meat. The value of halloumi exports increased more than eight-fold in the last few years and the product became the second largest export for Cyprus. In addition to the impact of climate change in the area of agriculture, recent developments in the dairy market, are creating several challenges that need to be addressed.
The overarching objective of this proposal is to establish a Centre of Excellence (CoE) for Smart and Sustainable Farming in Cyprus (SMARTFARM-CoE), aspiring to constitute a global case study in semi-arid areas for a multi-level integrated approach, within a single Centre, for the use of fundamental knowledge and capacity building to facilitate the transition to a totally new and locally-adapted model

for the livestock industry. Through its activities the CoE will synergize local and international expertise in animal husbandry, genomic technologies in crops-livestock-microorganisms, soil fertility, sensor technology and Internet of Things (IoT) solutions, data storage/analysis, artificial intelligence and environmental impact assessment. The Mission of the centre will be to address and provide solutions to specific challenges faced by agriculture in Cyprus in a sustainable, innovative and environmentally responsible manner, while at the same time increase the value and security of products through a farm-to-fork holistic approach.
Potential partners for this project include Cyprus' Ministry of Agriculture, Rural Development and Environment, The Volcani Center, Israel, and The *Institut national de recherche pour l'agriculture, l'alimentation et l'environnement*, France. The project proposal has been presented for evaluation within the Horizon Europe programme.

- **Climate Change Impacts on Ecosystem Services**. CARE-C is actively involved in the ongoing COST Action SMILES: Enhancing Small-Medium IsLands resilience by securing the sustainability of Ecosystem Services (CA21158). European islands are hotspots of biological and cultural diversity, which, compared to mainland, are more vulnerable to climate change, tourism development, uncontrolled land use changes and financial crisis. These factors have increasingly resulted in severe impacts on socio-economic and environmental services. Projected climate and land use change will impact on islands' biodiversity but also on ecosystem services and in turn on the quality of life of island inhabitants. Even if the existing techniques can adequately predict climate-induced ecological changes of the larger islands, this is not the case for small and medium size islands where there is a need for refinement. Although ecosystem services (ES) assessments have been carried out worldwide in different geographical areas, islands are still underrepresented. Despite the islands' importance and vulnerability, efforts to date have focused solely on the pressures they face. Still, we know little about ES supplies, flows and demands and their spatio-temporal variability, whilst integrated approaches that consider ES cross island realms (terrestrial, marine and their interface) remain scarce. Moreover, the current conceptual approaches guiding ES mapping and assessment need further refinement to account for the complex manifestations of nature and culture arising from peoples' interaction with island spaces. The aim of this action is to provide a platform for coordinated interdisciplinary research on several aspects of mapping and assessment of ES in small and medium European Islands in order to synthesize and strengthen the knowledge base for conservation of island realms and contribute to their sustainable development.
CARE-C is co-leading Working Group 3 – Effects of Land use and climate changes (LU/CC) on Ecosystem Services. LU/CC are the main drivers on island environments. In close collaboration with other WGs, WG3 will assess projected global change impacts on European islands. Its objectives are to (1) perform an integrated LU/CC assessment on European islands and (2) evaluate the relationship between LU & CC interaction and ES provision in European islands. Currently we are coordinating the preparation of a review paper that will assess these impacts at a global scale.

New research projects that will address climate change impacts in the broader Euro-Mediterranean and Middle East Europe. CARE-C is a partner in two Horizon Europe projects that contribute to understanding the socio-economic impacts of climate change in the region:

- **OptimESM**: Optimal High Resolution Earth System Models for Exploring Future Climate Changes (OptimESM) is a 5-year (01/2023-12/2027) project, coordinated by the Swedish Hydrometeorological Institute (SMHI). OptimESM will develop a novel generation of Earth system models (ESMs), combining high-resolution with an unprecedented representation of key physical and biogeochemical processes. These models will be used to deliver cutting-edge and policy-relevant knowledge around the consequences of reaching or exceeding different levels of global warming, including the risk of rapid change in key Earth system phenomena and the regional impacts arising both from the level of global warming and the occurrence of abrupt changes. OptimESM will realise these goals by bringing together four ESM groups with Integrated Assessment Modelling teams, as well as experts in model evaluation,

Earth system processes, machine learning, climate impacts and science communication. OptimESM will further develop new policy-relevant emission and land use scenarios, including ones that realise the Paris Agreement, and others that temporarily or permanently overshoot the Paris Agreement targets. Using these scenarios, OptimESM will deliver long-term projections that will increase our understanding of the risk for triggering potential tipping points in phenomena such as, ice sheets, sea ice, ocean circulation, marine ecosystems, permafrost, and terrestrial ecosystems. OptimESM will further our understanding of the processes controlling such tipping points, attribute the risk of exceeding various tipping points to the level of global warming, and develop a range of techniques to forewarn the occurrence of tipping points in the real world. CARE-C will contribute to several tasks, including climate downscaling and study of regional socio-economic impacts.

- **PREVENT**: Improved predictability of extremes over the Mediterranean from seasonal to decadal timescales is a 3-year Horizon Europe project (10/2023-9/2026), coordinated by the Aristotle Univarsity of Thessaloniki, Greece. The overall objective of PREVENT is to improve the predictability of impact-relevant extremes in the Mediterranean region on timescales from seasonal to decadal using state-of-the-art dynamical, statistical, and machine learning methods. Additionally, PREVENT brings together experts in different disciplines and geographical regions for a comprehensive study of impact-relevant climate extremes in the Mediterranean with the goal to improve their seasonal and decadal predictions in a changing climate. PREVENT intent to:

1. Define for local climate extreme hotspot regions, including major urban centers in the Mediterranean.
2. Provide new management tools that can be used in many domains, to guide and direct processes, support monitoring activities, and increase organizational efficiency
3. Develop awareness and competencies by enabling policymakers, industry, farmers, and other producers to understand, promote and practice the inclusion of seasonal and decadal data in their project management.

CARE-C was actively involved in the proposal and will have a leading role in several tasks including the assessment of impacts on key socio-economic sectors, including tourism, human health, water resources and agriculture.

- **New networking activity on climate change impacts in Mediterranean societies: FutureMed - A Transdisciplinary Network To Bridge Climate Science And Impacts On Society** (CA22162) is a new COST Action expected to start in Autumn 2023. CARE-C had an active role on the proposal phase, is well-represented in the Management Committee of the Action and will mainly contribute in Working Group 1 - Hazards and socio-economic impacts in weather and climate scales. The Mediterranean is a climate change hotspot suffering severe consequences of global warming. Several types of risks are currently affecting the region, from frequent extreme weather events to coastal erosion from rising sea levels or increased pollution. In addition, climate change impacts also propagate as “cascades” across socio-economic sectors. In urban areas, such sequential or concurrent compounding hazards are more disastrous than single events. The impacts affect ecosystems, economic activities, and human health. Despite the ubiquity of these connections, scientists and decision makers are typically working addressing isolated risks, advancing in parallel and missing added value from cooperative efforts. It is thus necessary to move beyond siloed approaches towards integrated efforts that promote effective science-based and agent-based decision-making. It is necessary to establish unprecedented networks of transdisciplinary partnerships, including scientific, human health, social approaches, to governance, and risk management. Such networks facilitate stakeholders and researchers to reach more accurate recommendations, strategies and policies addressing climate change impacts and risk management.
FutureMed will foster new climate change-related science and synergies serving as a transdisciplinary and integrative platform effectively connecting scientific knowledge on high-impact weather (HIW) events and climate change impacts with stakeholders from priority socio-economic sectors such as energy supply and demand, agriculture, health and migration. For the first time, an Action coordinates a platform where scientific communities, key stakeholders and citizens can interact for the ends of

promoting climate change impacts awareness, establishing future research priorities, and building capacities based on knowledge exchange in a living lab.

VIII. Acknowledgements

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Annex 1. Authors of relevant EMME-CCI Task Force Reports

Annex1.1. Energy Systems Task Force Report

Management Board
Theodoros Zachariadis, The Cyprus Institute
Kamal Araj, Jordan Atomic Energy Commission
Rabia Ferroukhi, International Renewable Energy Agency

Cyprus Institute Liaison Scientist
Nestor Fylaktos, The Cyprus Institute

Members of the Task Force
Tareq Abu Hamed, Arava Institute, Israel
Mohammad A. Al-Ramadhan, Kuwait Foundation for the Advancement of Sciences, Kuwait
Omar Al-Ubaydli, Bahrain Centre for Strategic, International and Energy Studies, Bahrain
Derek Baker, Middle East Technical University, Turkey
Manuel J Blanco, The Cyprus Institute, Cyprus
Steven Griffiths, Khalifa University of Science and Technology, United Arab Emirates
Sameh Nada, Egypt-Japan University of Science and Technology
Holger Rogner, International Institute for Applied Systems Analysis, Austria
Jan Steckel, Mercator Research Institute on Global Commons and Climate Change, Germany
Christos Tourkolias, Centre for Renewable Energy Sources, Greece
Sara Vakhshouri, SVB Energy International, Washington, DC
Eric Williams, King Abdullah Petroleum Studies and Research Centre, Saudi Arabia

Editorial Review and Assistance
Constantinos Taliotis (lead), The Cyprus Institute
Dr. Marios Karmellos, The Cyprus Institute
Bahjat Aulimat, Jordan Nuclear Power Company
Arslan Khalid, International Renewable Energy Agency
Gerardo Escamilla, International Renewable Energy Agency
Diala Hawila, International Renewable Energy Agency
Costanza Strinati, International Renewable Energy Agency
József Kádár, Arava Institute, Israel

Annex1.2. Health Task Force Report

Task Force Management Board
Dr. Marco Neira, Climate and Atmosphere Research Center (CARE-C), The Cyprus Institute, Cyprus
Prof. George Christophides, Climate and Atmosphere Research Center (CARE-C), The Cyprus Institute, Nicosia, Cyprus; Department of Life Sciences, Imperial College London, London, United Kingdom

Task Force Members
Kamil Erguler, Climate and Atmosphere Research Center (CARE-C), The Cyprus Institute, Cyprus
Hesam Ahmady-Birgani, Department of Rangeland and Watershed Management, Faculty of Natural Resources, Urmia University, Iran
Nisreen DaifAllah AL-Hmoud, Bio-Safety and Bio-Security Centre, Royal Scientific Society, Jordan
Robin Fears, European Academies Science Advisory Council (EASAC)
Charalambos Gogos, School of Medicine, University of Patras, Greece
Nina Hobbhahn, European Academies Science Advisory Council (EASAC)
Maria Koliou, University of Cyprus Medical School, Cyprus
Leontios Kostrikis, Laboratory of Biotechnology and Molecular Virology, University of Cyprus, Cyprus

Jos Lelieveld, Climate and Atmosphere Research Center (CARE-C), The Cyprus Institute, Cyprus; The Max Planck Institute for Chemistry, Mainz, Germany
Azeem Majeed, Department of Primary Care & Public Health, Imperial College London, United Kingdom
Shlomit Paz, Department of Geography and Environmental Studies, University of Haifa, Israel
Yinon Rudich, Faculty of Chemistry, The Weismann Institute of Science, Israel
Amal Saad-Hussein, Environment and Climate Change Research Institute, National Research Centre, Egypt
Mohammed Shaheen, Damour for Community Development – Research Department, Palestine
Aurelio Tobias, Institute of Environmental Assessment and Water Research (IDAEA), Spanish Council for Scientific Research (CSIC), Spain

Annex1.3. Agriculture and the Food Chain Task Force Report

Task Force Management Board
Professor Andreas Karamanos, Agricultural University of Athens (Coordinator)
Dr. Reem Nejdawi, Sustainable Development Policies Division, UN House, Lebanon
Dr. Michalis Omirou, Agricultural Research Institute, Cyprus

Task Force Members
Professor Tayel El-Hasan, Mutah University, Jordan
Dr. Pauline Y. Aad, Notre-Dame University Louaize, Lebanon
Professor Konstantinos Kormas, University of Thessaly, Greece
Professor Ioannis Ipsilantis, Aristotle University of Thessaloniki, Greece
Professor Athanasios Tsikliras, Aristotle University of Thessaloniki, Greece
Dr. Dionysia Fasoula, Agricultural Research Institute, Cyprus
Dr. Georgia Hadjipavlou, Agricultural Research Institute, Cyprus
Professor Mark Tester, King Abdullah University of Science and Technology, Saudi Arabia
Professor Constantinos Kosmas, Agricultural University of Athens
Professor Mohtar Rabi, American University of Beirut, Lebanon

Annex1.4. Tourism Task Force Report

Task Force Management
Harry Coccossis, University of Thessally, Greece

Task Force Members
Nikolaos Boukas, European University of Cyprus, Cyprus
Anthi Charalambous, Cyprus Employers and Industrialists Federation, Cyprus
Anna Farmaki, Cyprus University of Technology, Cyprus
Dimitrios Stylidis, Middlesex University, United Kingdom