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Special Issue 2.2023

Burn or sink
Planning and managing the land

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Cover photo by Giuseppe Mazzeo. Rising wheat fields on the hills of Conza della Campania, Irpinia. January 31, 2023.

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The Water-Energy-Food Nexus in the Mediterranean Region in a scenario of polycrisis

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Abstract

Multiple global crises, including climate change, the COVID-19 pandemic, and Russia's war on Ukraine, have recently linked together in ways that are significant in scope, devastating in effect, but still poorly understood, triggering what experts call a real polycrisis. In particular, climate change and the Ukraine conflict, acting together, are increasingly putting at risk the availability and access to fundamental resources to human survival and well-being: water, energy and food. The Mediterranean region could be considered both a water, energy and food (WEF) nexus and a climate change 'hotspot'. Since Russia and Ukraine are central players in global commodity markets, the ongoing war and accompanying sanctions are dramatically unsettling energy and food markets, with ripple effects likely to extend well into 2024. The new global systemic risks call for a paradigm shift by adopting measures to reduce exposure and strengthen resilience turning the conventional WEF nexus into a virtuous circle. To face these challenges, three main actions are identified: mainstreaming climate change into the WEF nexus; decouple water, energy and food production from fossil fuel; develop sustainable WEF intra-regional and regional cooperation/integration models based on the principle of comparative advantages. To illustrate these mechanisms the cascading impacts of interactions between the Ukraine-Russia war and climate change on the WEF nexus in the Mediterranean countries are illustrate.

Keywords

Mediterranean; Climate change; Ukraine war; WEF nexus.

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1. Introduction

According to experts, the world has recently plunged into a new era of interconnected crises, reminiscent of the tumultuous periods at the end of the 1920s and the beginning of the 1970s, as well as the financial, political and food crises that marked the beginning of the new millennium. This phenomenon, known as a "polycrisis", occurs when multiple global crises converge, creating a combined impact that surpasses the sum of their individual effects.

The Mediterranean region has borne the brunt of this polycrisis over the past fifteen years. It has been hit by a series of systemic risks, including the financial crisis, the food crises of 2007-2008 and 2010-2011, the Arab Spring, the migration emergency, and, more recently, the COVID-19 pandemic. Additionally, the region faces the compounding challenges of climate change and the ongoing global crisis sparked by the Ukraine war.

In the Mediterranean region, the adverse effects of climate change primarily impact the water, energy, and food (WEF) sectors simultaneously. Given that Russia and Ukraine play pivotal roles in global commodity markets, a multifaceted resource crisis is emerging, which has a cascading impact on the WEF nexus. Supply crises, coupled with increasing demand for WEF resources, can be profoundly destabilizing. They expose the vulnerability of states and can lead to a deterioration in well-being, widespread violence, political upheaval, and involuntary migration. Recognizing this, it is imperative to shift our paradigm and implement measures aimed at reducing exposure to these risks and enhancing resilience at both national and regional levels.

This article seeks to emphasize the repercussions of the global polycrisis on the Mediterranean region, with a particular focus on the Water-Energy-Food (WEF) nexus, and how the interplay of climate change and the Ukraine conflict is affecting it. The study's objective is to uncover the obstacles and possibilities for transforming the WEF nexus from a vicious circle of trade-offs into a virtuous circle of synergies that mutually reinforce each other.

To address this challenge, several actionable steps are delineated, and concrete recommendations are formulated to guide the path forward.

2. Conceptual framework

In recent decades, it has become increasingly evident that global systems, ranging from finance and security to food, energy, and health, are highly vulnerable to systemic risks. As recent history has illustrated, systemic risks tend to transcend their point of origin, interacting, amplifying, cascading, and influencing one another in a way that gives rise to a complex, interconnected polycrisis. This polycrisis produces consequences that are more profound than the sum of what each individual crisis would generate in isolation. The concept of a polycrisis underscores the intricate web of cause-and-effect relationships among crises across global systems, and it identifies three key causal pathways: common stresses, domino effects, and inter-systemic feedbacks. These pathways interconnect multiple global systems, culminating in synchronized crises (Lawrence et al., 2022). Studies have demonstrated that the extended health, social, and economic impacts of the Covid-19 pandemic, the specter of stagflation, volatility in global food and energy markets, geopolitical conflicts, political instability, civil unrest, and the growing frequency and severity of weather events linked to climate change are all constituent crises contributing to the global polycrisis currently unfolding worldwide. This is not humanity's inaugural encounter with a polycrisis. In the past, we've grappled with similar multifaceted challenges. For instance, the oil shocks of the 1970s were born out of conflicts in the Middle East and gave rise to severe international energy shortages, which, in turn, contributed to and interacted with stagflation in the global economy (Homer-Dixon et al., 2015). However, the present-day polycrisis shares certain common elements with past crises but is remarkable in several unprecedented ways. Unlike the 1970s, where price shocks were primarily confined to oil, today's crisis encompasses all fossil fuels. Furthermore, this energy crisis has unfolded in a markedly different global landscape compared to the one characterizing the oil crisis of the previous century. The world today is far more interconnected, which, while beneficial in many respects, also makes it more susceptible to cascading effects and spillover. Lastly, the contemporary polycrisis is truly unparalleled in that human pressure on ecosystems and natural resources has pushed Earth's physical and ecological systems well beyond their previous equilibria. This poses a significant threat to the stability of many other global systems that are crucial for human well-being (Lawrence et al., 2023).

The enduring impacts of climate change and the ongoing Russian invasion of Ukraine are mutually reinforcing, causing reverberations across the globe. These events are disrupting worldwide supply chains and causing a surge in energy and food prices, while also exerting direct and indirect influences on water resources.

In this precarious situation, encompassing concerns about water, energy, and food security, it is crucial to recognize that water, energy, and food are intricately interconnected through various nexus linkages.

The WEF nexus concept has gained widespread usage in order to facilitate the comprehension of the interconnections between these three systems and how they can be sustainably managed to meet the increasing demand. It has been particularly promoted as a means to resolve conflicts among these sectors.

One of the most prominent relationships within the WEF nexus involves direct dependencies. For instance, energy relies on water for power generation, the extraction, transportation, and processing of fossil fuels, as well as the irrigation of biofuel crops. In turn, water is dependent on energy for its abstraction, purification, and distribution. Meanwhile, food production requires both water and energy to nurture crops, support livestock, and process food.

Beyond these direct dependencies, the nexus is further complicated by the fact that WEF systems are influenced by numerous dynamic exogenous variables (Burnett & Wada, 2018). Population growth, migration patterns, socio-economic development, human-made pressures, and the repercussions of climate change collectively shape the demand, allocation, availability, and accessibility of WEF resources over time and space (Fig.1).

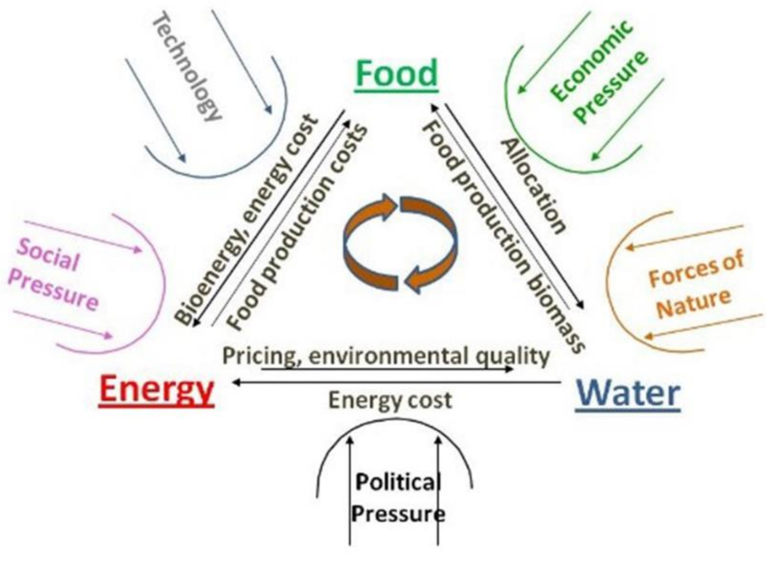

Fig.1 Direct and indirect interlinkages within the WEF nexus

As the demand for these resources rises within the constraints of scarcity and climate change effects, the interconnections within the WEF nexus become more pronounced. Furthermore, this heightened demand often leads to direct conflicts and trade-offs between sectors, thereby constraining nations' capacity to meet the essential needs of their populations sustainably (Markantonis et al., 2019). Climate change both affects and is affected by the WEF nexus, giving rise to a complex web of bidirectional interactions which initiates a chain of events that adversely impact water, energy and food security, intensifying conflicts within the nexus (Rasul & Sharma, 2016). Rising temperatures, shifts in precipitation patterns, the intensification of extreme weather events, and rising sea-levels, gradually disrupt the equilibrium among WEF resources and even transform the dynamics of their interactions (Cramer et al., 2018). Furthermore, it is important to note that existing mitigation and adaptation strategies can sometimes exacerbate rather than alleviate negative externalities and trade-offs within the nexus. While certain measures focused on specific sectors can create synergistic "win-win" possibilities across one or more of the other components of the nexus, other strategies like hydropower, first-generation biofuels, non-conventional water resources, and agricultural intensification are not always nexus-smart.

In situations where there is a lack of nexus-oriented thinking in the planning and policymaking processes related to WEF resources, the interactions between these systems have often been neglected. Such siloed approaches have led to disjointed policymaking, conflicting strategies, and the inefficient utilization of our natural resources. In recent years, the growing concerns over resource scarcity and the looming impact of climate change have prompted policymakers and planners to place a stronger emphasis on the connections between water, energy, and food systems. A comprehensive, integrated approach to the management of WEF resources, which a nexus approach demands, requires coordination, harmonising public policies, and the alignment of strategies, regulations and incentives as well as platforms for cross-sectoral coordination, decision- making and implementation. Advocates of the WEF nexus as a planning and resource management approach underscore the importance of enhancing resource utilization efficiency to curtail environmental degradation and optimize the social and economic advantages derived from the progressively limited natural resources. The governance framework, encompassing both formal and informal regulations that guide resource allocation decisions, plays a crucial role in shaping the outcomes of a nexus approach. This framework involves various stakeholders, including civil society, the private sector, and the public sector (Howells et al., 2013).

Responding to the rapidly growing WEF demand in an increasingly resource-constrained climate change scenario, associated with the impact of Ukraine war is fueling a vicious circle in the Mediterranean countries. These challenges call for a paradigm shift to turn the conventional WEF nexus into a virtuous circle, one that aligns harmoniously with the objectives outlined in the United Nations Sustainable Development Goals (SDGs) and the commitments established in the Paris Agreement. In order to fully capture existing potential for benefits and synergies, the development and management choices in the WEF sectors require enhanced integration at the knowledge, policy, legislative and institutional levels/frameworks.

Using the WEF nexus as an indicator, in the next section the social implications of the ongoing conflict are assessed. Given that Russia and Ukraine are significant global providers of energy resources, food, and fertilizers, the imposition of limitations and the subsequent increase in prices pose new threats. Through an analysis of relevant data, the profound impacts on the Mediterranean societies are highlighted, particularly noting that nations that depend on the countries engaged in the conflict for their energy and food resources are particularly vulnerable to the WEF challenges.

3. Results

The "Global Risk Report 2023" by the World Economic Forum (WEF) illustrates a complex network of interconnections among various global risks and crises, underscoring the possibility of a "polycrisis" emerging (WEF, 2023). Within this intricate web of risks, it's challenging to identify an area that is not relevant for the Mediterranean. Additionally, the WEF nexus is notably pronounced in the Mediterranean region, with a particular emphasis on the Middle East and North Africa (MENA) countries. The MENA region includes approximately 21 countries, according to The World Bank: Algeria; Bahrain; Djibouti; Egypt; Iran; Iraq; Israel; Jordan; Kuwait; Lebanon; Libya; Malta; Morocco; Oman; Qatar; Saudi Arabia; Syrian Arab Republic; Tunisia; United Arab Emirates; West Bank and Gaza; and Yemen.

The region has vast reserves of oil, petroleum, and natural gas, which position MENA as a significant global source of economic resources. Nevertheless, the region grapples with ongoing conflicts in countries such as Syria, Iraq, Iran, Libya, and Yemen. With the United States and Russia supporting opposing factions and supplying military resources, the region continues to serve as a proxy for global economic influence.

Vulnerabilities in the WEF nexus within the region are the outcome of a combination of natural, demographic, socio-economic, and political factors, which collectively amplify the interconnected nature of the nexus. Nexus studies point out that the MENA region grapples with water scarcity, food shortages, high energy demands, and a significant vulnerability to the effects of climate change. Despite possessing 43% of the world's oil reserves and significant renewable energy potential, 35 million people in the region still lack access to electricity. Furthermore, the region has a mere 1.4% share of the world's freshwater resources. Persistent conflicts and security challenges in the region hinder the sustainable management of natural resources, underscoring the urgent necessity for WEF Nexus solutions. In addition, the imperative to meet the growing demand for water, energy, and food within a context of climate change and mounting resource constraints, compounded by inefficiencies in resource utilization and WEF sectoral policy, has given rise to a detrimental cycle. This cycle, instead of fostering synergies between sectors, has tended to perpetuate trade-offs, carrying substantial consequences at the local and regional levels (Giordano & Quagliarotti, 2020; FAO, 2014; Borgomeo et al., 2018). Furthermore, the conflict in Ukraine, due to its repercussions on major global commodity markets, presents an added threat to the various components of the nexus, affecting them both directly and indirectly.

3.1 The WEF nexus and the impact of climate change in the Mediterranean region

Water, energy, and food security share an intricate and inseparable connection in the Mediterranean countries, and this bond is even more evident in the MENA region. Here, the confluence of rapid population growth, accelerated socio-economic development, and the presence of market distortions has significantly amplified the demand for these resources and exacerbated inefficiencies within the WEF nexus. Inefficiencies are particular evident in fossil fuel producing countries, where the WEF nexus is predominantly dominated by oil. In such nations, the relatively abundant energy resources play a vital role in bolstering the availability and affordability of water and food, which can mask underlying scarcities in the other components of the nexus. The capacity to augment water supply and support domestic agricultural production is greatly contingent on revenue generated from oil resources. This financial capacity enables these countries to invest in the production of non-conventional water sources, such as seawater and brackish groundwater desalination, as well as the cultivation of agricultural goods in highly controlled environmental conditions within closed agricultural systems. This strategic approach allows them to overcome inherent geoclimatic constraints.

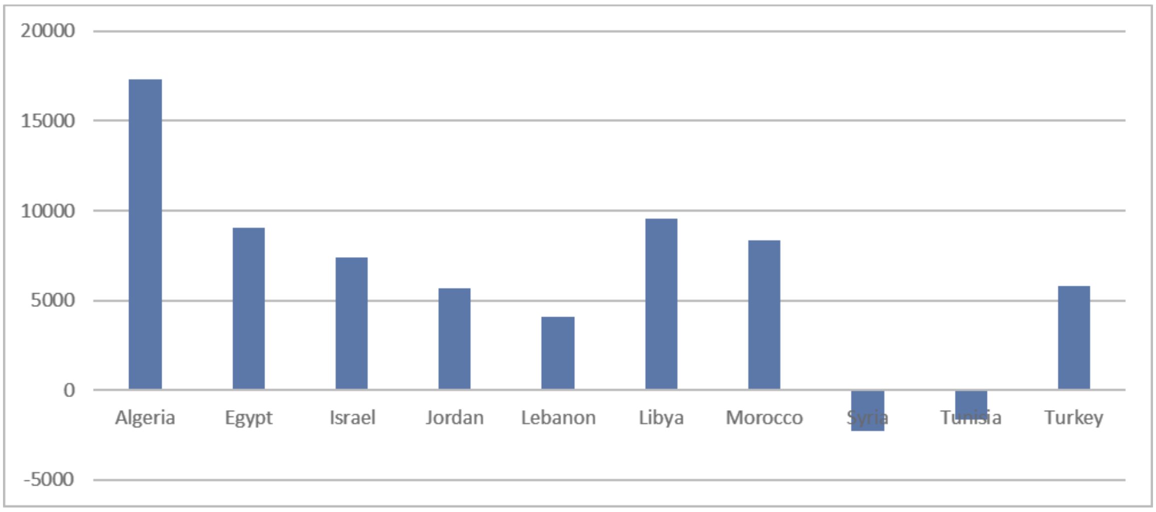

Fig.2 Net Virtual water imports in several MENA countries

At the international level, the trade dimension of the WEF nexus also looks like an effective solution to face domestic nexus challenges. Recognizing that domestic production of water-intensive food can be an inefficient utilization of scarce natural resources, many governments have adopted a trade-oriented food security strategy that aligns with the neoclassical theory of international comparative advantages. In this way, they have externalised the pressure on nations' own water resources importing water in virtual form (Allan, 1998) as illustrated in Fig.2.

Once again, the international dimension of the WEF nexus is particularly evident in oil-producing nations. These countries, fueled by revenue from oil exports, possess the means to rapidly offset their limited food production and the scarcity of water resources by engaging in virtual water imports.

The difficulties in fulfilling the increasing demand for WEF resources are anticipated to be exacerbated by the consequences of climate change. The Mediterranean region is considered a hot-spot of climate change. Various climatic scenarios concur that by 2050, several countries will face a 10% reduction in water sources, resulting in heightened food insecurity. Predictive models indicate an uptick in the intensity and frequency of extreme climatic events, with droughts and floods ranking at the top. Looking further ahead, long-term projections paint an even more dire picture: by 2100, a projected temperature increase of approximately 6 °C is expected, along with a 20% decrease in rainfall and a 100% increase in the land affected by wildfires.

While there may be variations in the conclusions drawn by different climate models, almost all of them concur that the Mediterranean region will undergo significant desertification, primarily driven by a substantial decrease in winter season precipitation, particularly in some areas where it could approach a 40% reduction (Guida & Pennino, 2022).

In order to assess vulnerability of the Mediterranean countries to climate change, the Notre Dame-Global Adaptation Index (ND-GAIN) has been used, which summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. The index assesses countries annually from 1995-2019 on a scale from 0 to 100, with higher numbers indicating that the country is better poised to respond to climate disruptions. As data show, the MENA countries are more susceptible to the impact of climate change than the countries on the northern shore due to their combination of high vulnerability and limited adaptive capacity (Tab.1).

In the face of rising demand for WEF resources amidst the backdrop of climate change, the interconnections within the WEF nexus become more pronounced. This heightened demand doesn't just intensify the nexus linkages, but also leads to a rise in direct competition and trade-offs between different sectors, ultimately constraining a country's capacity to meet the increasing demand in a sustainable manner (Markantonis et al., 2019). Additionally, it's important to recognize that climate change both exerts an impact on and is influenced by the WEF nexus through numerous bidirectional interactions that intricately interweave within the network of WEF connections. Global warming drives a series of feedbacks that negatively affect water, energy and food security that have detrimental consequences for water, energy, and food security, thereby intensifying conflicts within the region: rising temperatures, changes in precipitation patterns, extreme weather events, and sea-level rise gradually disrupt the balance between the nexus resources, and even transform the dynamics of their interactions (Cramer et al., 2018).

Simultaneously, the production of water, energy, and food can lead to increased greenhouse gas (GHG) emissions, further contributing to global warming. Additionally, it's worth noting that current sectoral approaches to climate change mitigation and adaptation may inadvertently exacerbate, rather than reduce, negative externalities and trade-offs within the nexus (Zucaro & Morosini, 2018). Although certain sector-specific mitigation and adaptation measures hold promise for creating synergistic "win-win" situations that benefit one or more sectors within the nexus, it's important to recognize that other measures, like hydropower, first-generation biofuels, the transition to non-conventional water sources, and agricultural intensification, may not always align with a nexus-smart approach. Furthermore, efforts to curtail GHG emissions, in line with the goals set forth in the Paris Agreement can have an impact on the demand for oil and, consequently, its price.

This, in turn, can reduce the revenue generated from oil and gas exports in oil-producing nations, thereby limiting their capacity to import food and engage in desalination for water supply.
What becomes evident is a rather stark scenario, depicting a WEF nexus fueled by a vicious cycle and particularly vulnerable to the impact of climate change.

Country	**ND-GAIN Index**		**Vulnerability**		**Readness**	
	Rank	***Score***	***Rank***	***Score***	***Rank***	***Score***
France	17	66.7	7	0.297	23	0.631
Slovenia	19	65.9	23	0.340	20	0.658
Spain	24	62.9	10	0.308	33	0.566
Portugal	26	62.0	31	0.348	29	0.589
Israel	29	61.4	19	0.338	32	0.567
Italy	32	60.6	15	0.320	40	0.533
Greece	36	58.3	29	0.347	48	0.512
Cyprus	38	57.9	35	0.360	46	0.518
Malta	41	57.0	33	0.355	52	0.494
Croatia	42	56.9	45	0.373	49	0.511
Turkey	47	56.3	21	0.339	66	0.464
Macedonia	53	54.9	39	0.366	64	0.465
Montenegro	57	54.1	63	0.389	61	0.470
Serbia	70	51.1	82	0.410	78	0.431
Albania	73	50.6	91	0.423	76	0.434
Morocco	73	50.6	51	0.380	102	0.393
Jordan	81	50.0	50	0.378	108	0.378
Tunisia	84	49.6	71	0.393	106	0.385
Bosnia and Herzegovina	87	49.1	42	0.371	117	0.352
Egypt	98	46.1	93	0.426	119	0.348
Lebanon	106	45.2	78	0.408	133	0.311
Algeria	109	44.5	41	0.370	166	0.260
Libya	125	40.9	56	0.382	183	0.200
Syria	134	39.2	102	0.439	179	0.222

Tab.1. Notre Dame-Global Adaptation Index (ND GAIN)

3.2 The impact of the Ukraine war on WEF resources in the Mediterranean region

Russia's unwarranted conflict with Ukraine has exerted a significant influence on global energy and food markets, resulting in diverse consequences for the Mediterranean countries depending on their underlying conditions and vulnerabilities.
Prior to the outbreak of the conflict, European nations relied heavily on Russia for their energy needs, with approximately 40% of their gas supply and nearly a third of their oil supply originating from Russia, as reported by the European Union (2023). Therefore, the decision by EU leaders to reduce their dependence on Russian fossil fuels has carried significant implications for the availability and accessibility of energy sources.
The energy crisis has presented a range of pivotal challenges, leading to substantial trade-offs between short-term energy security objectives and long-term climate-mitigation goals, as well as trade-offs between supply security and the cost of energy. existing energy matrix. From a climate change perspective, the war is contributing to two contrasting dynamics. Firstly, numerous European nations are scrambling to identify alternative sources of fossil fuels, which includes reopening coal-burning plants and making investments in oil

and gas ventures abroad. Consequently, in the short term, one aspect of the energy trilemma – sustainability – appears to be potentially overlooked in favor of prioritizing energy security. However, simultaneously, the disruptions in global energy markets have heightened the sense of urgency regarding the energy transition and the imperative to reduce dependency on fossil fuel supplies (Mecklin, 2023).
Narrowing our analysis to the potential impacts of the war on food security, while the availability of essential food supplies for European countries remains secure due to the stability of the Single Market, the significant rise in energy and fertilizer prices has led to an increase in agricultural production costs (European Union, 2023). Consequently, the affordability of food for low-income households, which was already under strain due to the pandemic, may be further jeopardised.
In the MENA region, the repercussions of the Ukraine crisis concerning WEF resources are intricately linked to its socio-economic and agro-ecological attributes. This region is typically characterized as being highly dependent on energy, facing water scarcity, experiencing food deficits, and exhibiting substantial vulnerability to the effects of climate change (Al-Zubari, 2016). As a result, rising energy prices translates into increased petrodollar inflows for the MENA region, to the point that the International Monetary Fund (IMF) has had to revise its forecast for growth in the region as a whole by 0.9 percentage points to 5 percent (IMF, 2022). Nonetheless, this favorable outcome conceals several adverse consequences within the region. The surge in oil and gas prices may tempt governments in oil-exporting nations to postpone crucial structural fiscal reforms aimed at broadening their revenue sources and scaling back substantial subsidies. This delay can mean missed opportunities to capitalize on the elevated energy prices and implement much-needed reforms to foster economic diversification and facilitate the transition to cleaner energy sources. Furthermore, while oil and gas exporting nations in the MENA region reap the rewards of increased oil export revenues, non-oil-importing economies in the same region are burdened by mounting energy import costs. This, in contrast, triggers inflation and erodes purchasing power.

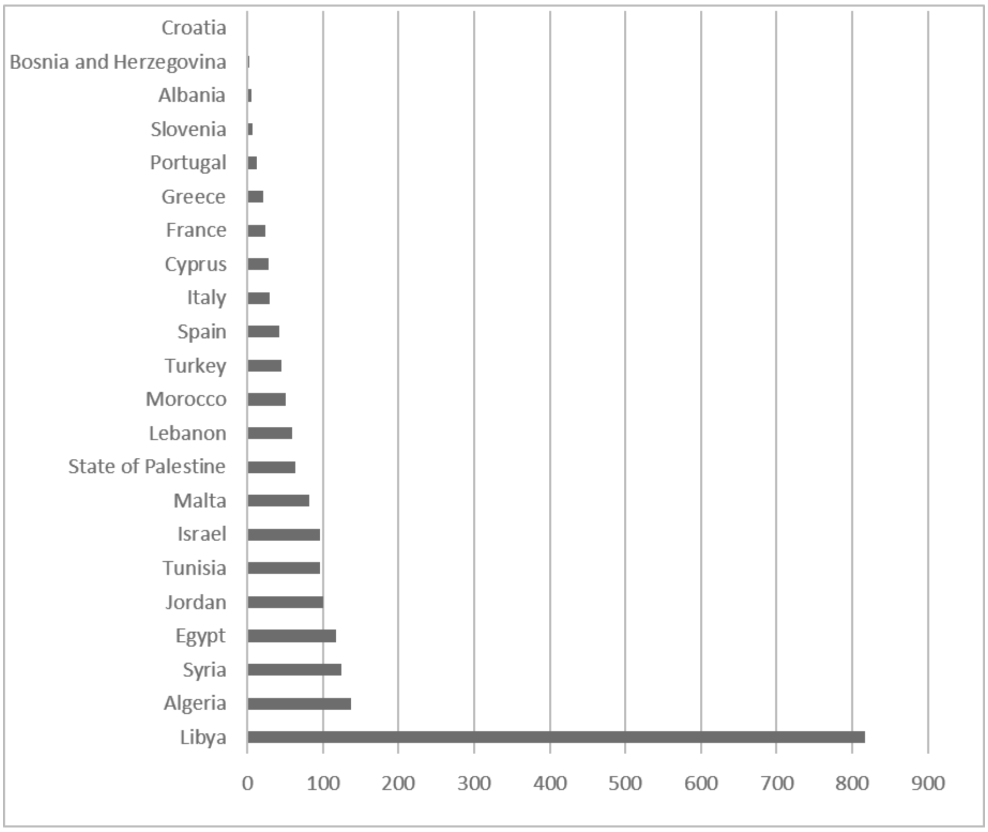

Fig.3 Water stress index in the Mediterranean countries in 2020 (%)

The repercussions of the Ukraine conflict also extend to other facets of the WEF nexus, as the MENA region stands as one of the world's most water-scarce areas. Natural water resources are relatively abundant in the northern Mediterranean countries, while in the MENA countries, 83% of the population is exposed to very high-water stress. Libya, Algeria, Syria, Egypt, Jordan, Tunisia and Israel particularly suffer from low resource availability showing a water stress index, defined as the ratio of total annual freshwater withdrawal to total renewable freshwater resources, ranging from 95 to 820% (820% means that the annual water withdrawal is eight times higher than the water supply from renewable resources) (Fig.3).
Given this bleak water scarcity picture in the southern and eastern parts of the Mediterranean, it is evident that nonconventional water supplies, including wastewater recycling and reuse and desalination, will need to be significantly augmented to meet growing demands and achieve water security. According to the World Bank, considering current technologies and production costs, over $40 billion will be required for investments in nonconventional water sources within the broader MENA region by 2050.

Country/Region	**Arable land (% of land area)**	**Arable land (ha per person)**
Albania	22.40	0.21
Bosnia and Herzegovina	20.10	0.29
Croazia	15.10	0.20
Francia	33.70	0.28
Greece	17.30	0.21
Italy	22.40	0.11
Portugal	12.40	0.11
Slovenia	9.10	0.09
Spain	24.70	0.27
NMCs	19.65	0.18
Israel	13.70	0.04
Jordan	2.60	0.02
Lebanon	12.90	0.02
Syria	25.40	0.25
Turkey	26.80	0.26
West Bank and Gaza	10.60	0.01
Middle East	15.30	0.10
Algeria	3.10	0.19
Egypt	2.90	0.03
Libya	1.00	0.28
Morocco	18.20	0.23
Tunisia	18.70	0.26
North Africa	8.78	0.20
SEMCs	12.40	0.15

Tab.2 Arable land in the Mediterranean countries

A significant portion of these investments will be directed towards developing desalination infrastructure (Borgomeo et al., 2018). Indeed, desalination plays a crucial role in the interlinkage between water and energy, as it involves energy consumption to increase water supply. According to the IRENA (2015; 2016), the Middle East hosts nearly half of the global installed desalination capacity, primarily concentrated in the wealthier Gulf countries. Projections indicate that desalinated seawater production in the MENA region will be 13 times higher in 2040 compared to 2014. Currently, the use of desalination for municipal purposes is gaining significance, particularly in islands and coastal cities with limited water resources. In terms of absolute production, the Mediterranean region's largest freshwater production through desalination occurs in Algeria in Algeria (0.62 x 10^9 m^3/yr), Egypt (0.20 x 10^9 m^3/yr), Israel (0.14 x 10^9 m^3/yr) and Italy and Spain (both 0.10 x 10^9 m^3/yr). However, in relative terms, Malta stands out as the desalination leader, with over half of its drinking water supply being sourced from desalination.

Water scarcity, coupled with limited agricultural land (Tab.2), renders the MENA region one of the most reliant regions in the world on food imports (Tab.3).

Particularly, in Arab countries, because of their limited agricultural potential, international trade has always played a key role in achieving macro-level food security. Due to scarce resources endowments, domestic production of water-intensive food, especially of cereals, has never been considered an efficient way of using natural resources and countries have generally adopted a trade-oriented food security strategy based on the neoclassical theory of international comparative advantages.

This awareness has generally pushed governments' choices to focus on the production of other goods (oil, manufactures, services, or less-water-intensive crops) and use foreign exchange earnings to import most of their food requirements. Consequently, the MENA countries have acutely felt the repercussions of the Ukraine conflict, which have disrupted global food production and exports. However, fiscal disparities between oil-exporting and oil-importing nations also extend to the realm of food security.

Oil-rich states possess significantly greater purchasing power compared to their regional counterparts. While the MENA countries are actively exploring alternative markets for their cereal supply, especially in countries like India, the USA, Canada, Argentina, and Uruguay, this transition is not immediate and comes with additional costs due to longer shipping distances and the spike in fuel prices (WFP, 2022).

Country/Region	**Food self-sufficiency ratio (%)**			**Cereal self-sufficiency ratio (%)**		
	2005	**2011**	**2014**	**2005**	**2011**	**2014**
Jordan	56.26	53.09	66.60	5.05	3.66	3.70
Lebanon	73.23	61.03	74.70	18.05	10.96	13.80
Syria	85.23	80.62	84.30	74.00	57.98	47.86
Palestine	81.55	72.26	79.30	19.69	10.00	9.48
West Asia	74.07	66.75	76.23	29.20	20.65	18.71
Algeria	53.48	70.04	75.20	29.88	31.96	21.65
Egypt	83.68	78.96	88.00	69.63	56.30	66.04
Libya	44.95	43.09	38.30	10.79	7.06	9.49
Morocco	89.60	80.40	100.00	46.09	58.96	68.00
Tunisia	71.78	68.49	89.50	47.82	46.79	42.42
North Africa	68.70	68.20	78.20	40.84	40.21	41.52
Total	71.38	67.47	77.21	35.02	30.43	30.12

Tab.3 Self-sufficiency ratio in total food commodities and cereals in several MENA countries

As the global food crisis continues to worsen, especially in a context of growing climate variability that hints at the possibility of multiple breadbasket failures, MENA governments are increasingly aware of the risks associated with their heavy reliance on food imports. This has prompted a sense of urgency in implementing robust measures to tackle the underlying causes of food insecurity.

4. Discussion

The conflict in Ukraine, compounded by the effects of climate change, is having a profound impact on both energy and food security, and it is also causing direct and indirect implications for water resources. As a result,

it is crucial to identify effective solutions that can ensure the supply of water, energy, and food while minimizing the interconnected consequences across the nexus.
MENA countries need to tailor their responses to the food security challenges arising from climate change and the Russia-Ukraine war, taking into account varying timeframes and the prevailing environmental, socio-economic, and institutional circumstances.
In the short term, it is essential for these countries to expand their existing social protection programs to encompass a broader spectrum of households. Social safety nets emerge as the most effective mechanisms for aiding low-income individuals in coping with rising food prices, and several nations have already recognized their importance in this regard (WFP, 2022).
In the long term, amidst the increasing volatility in food markets, MENA governments must reassess their food security strategies to strike a balance between the advantages of trade openness and the potential drawbacks of susceptibility to trade shocks. This evaluation should include a consideration of the possibility of increasing food self-sufficiency. While this approach might be politically and strategically justified due to its potential to stabilize domestic food prices and reduce dependence on international markets, it does come at a substantial economic cost. This is primarily because the resource endowments of most MENA countries are not well-suited for food production, especially cereal crops, and their comparative advantages are found in other economic activities. To address these challenges, nations should focus on what could be called "macro food sovereignty". This strategy involves blending self-sufficiency with trade-oriented food security measures, with a strong emphasis on encouraging the cultivation of crops that align with their specific geoclimatic conditions (Quagliarotti, 2023).
Given that energy plays a pivotal role as a fundamental input at various points in the water and food supply chain and is also the primary contributor to GHG emissions, it is imperative to regard the energy transition as the initial and crucial step toward establishing sustainable integrated solutions. These solutions have the potential to bolster security and sustainability within the WEF sectors while concurrently supporting global climate ambitions. The joint development of unconventional water and energy sources, such as desalinated water and renewable energy, offers a promising approach to tackling the dual challenges of water and energy security. This approach not only enhances economic efficiency and social equity but does so while adhering to the imperative of environmental preservation (Giordano & Quagliarotti, 2020). The MENA region boasts substantial potential for the development of renewable energy, particularly solar power. Generally, renewable energy technologies are less water intensive than conventional options. According to IRENA, the water requirements for solar photovoltaics (PV) are almost negligible when compared to conventional thermoelectric generation, using up to 200 times less water to generate the same amount of electricity (IRENA, 2015; 2016). Clean energy not only contributes to substantial water conservation but can also be harnessed to enhance non-conventional water supply in a more sustainable manner, particularly in the production of desalinated water. The latter has traditionally incurred high economic and environmental costs due to the significant amount of fossil energy required for reverse osmosis. Hence, the adoption of renewable energy sources can serve a dual purpose. It can not only meet the energy requirements of countries lacking abundant oil reserves but also enhance the resilience and adaptability of nations facing environmental constraints and grappling with the scarcity of two critical resources essential for human well-being, namely water and food. These countries are more susceptible to the adverse effects of climate change, making the shift to renewables a pivotal step in their sustainable development.
Furthermore, considering the unequal distribution of WEF resources across the Mediterranean region, it is crucial for countries to enhance their collaborative efforts in addressing WEF challenges in a mutually supportive manner. In this context, the application of the principle of comparative advantages within the WEF nexus can serve as an effective mechanism for amplifying synergies and complementarities among nations. By taking into account countries' diverse factor endowments, nations can specialize in the production and

exchange of goods for which they have a comparative advantage, resulting in lower opportunity costs compared to other countries. The Pre-Feasibility Study for Mid-East Water-Renewable Energy Exchanges carried out jointly by EcoPeace Middle East and the Konrad-Adenauer-Stifttung (Katz & Shafran, 2017) serves as a compelling illustration of the advantages that can be harnessed when the nexus approach extends beyond national borders, enabling countries to cooperate to attain increased economic efficiency in resource management. Recognizing the challenges related to energy and water security, coupled with the disparities in factor endowments between countries, the project adopts a strategic approach. It uses the relative abundance of resources in each state as a basis to construct a non-conventional water-energy exchange model to create interdependencies rather than dependencies among the three participating countries.

Great opportunities could also emerge from a Euro-Mediterranean partnership in the realm of renewable energy. Considering the advantageous geo-climatic conditions in the MENA region for harnessing solar energy, the expansion of renewable energy sources could be leveraged to establish a mutually beneficial and integrated EU/MENA WEF system, driven by a North-South exchange of technology, expertise, capital, and agricultural products (virtual water), along with a reciprocal flow of clean energy. A significant byproduct of the expansion of solar power plants in MENA nations could be the desalination of a substantial volume of seawater, which could help mitigate the projected water shortages in the region (Kennou et al., 2018).

This innovative model of Euro-Mediterranean cooperation holds the potential to serve as a proactive response to the challenges posed by the Ukraine crisis and climate change, addressing both the increasing energy needs of European countries hungry for non-fossil energy sources and the rising water demands of Arab nations thirsty for virtual and non-conventional water resources.

5. Conclusions

Climate change and the conflict in Ukraine stand as quintessential examples of the systemic risks that our world is currently grappling with. Since the agricultural and industrial revolutions, humanity has shaped the face of the Earth to such an extent that today's geological epoch has been called "Anthropocene". In this critical situation for the future of our planet, on February 24, 2022, the world faced a violent geopolitical conflict involving major powers, which has altered the dynamics of the international system.

These dual crises underscore the profound vulnerability of the Mediterranean countries concerning their water, energy, and food security, all of which are intricately interconnected in this region. Particularly in the MENA countries, the WEF nexus presents an escalating challenge, primarily due to a negative feedback loop that exacerbates trade-offs rather than fostering synergies across sectors (Zhang et al., 2018).

The consequences of climate change and the aftermath of the Ukraine conflict are conveying distinct messages to the two shores when it comes to WEF components.

In the European countries, the ongoing energy crisis, exacerbated by the repercussions of the Ukraine conflict, is generating mixed signals. On one hand, the need to secure immediate energy requirements has spurred a frantic pursuit of readily available, conventional energy sources like oil and gas. On the other hand, this unfolding energy security crisis serves as a stark reminder to member states of the crucial importance of developing energy self-sufficiency, achievable through an accelerated integration of renewables into the national energy mix.

In the MENA region, the impact of the conflict has unfolded differently, with oil and food importers primarily bearing the brunt of the economic shockwaves caused by the war. Despite a reduction in food prices to pre-war levels, the region, heavily reliant on food imports, remains exposed to trade disruptions as an ongoing concern.

As a result, the main challenges today revolve around providing Europe with clean energy supplies while ensuring the MENA region's access to increased food and water resources.

Given the stressors and drivers outlined above, delivering water, energy and food for all in a sustainable way is one of the major challenges that the Mediterranean countries face. Overall security can be achieved by creating intelligent synergies and fair trade-offs among sectors to minimize risks and enhance resource efficiency and equity.

The application of a WEF nexus approach in the Mediterranean region, guided by the principle of leveraging comparative advantages, presents a unique opportunity to mitigate trade-offs and address the urgent water, energy, and food challenges at both national and regional levels.

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Image Sources

Fig.1: Mohtar (2022);

Fig.2: Mekonnen & Hoekstra (2011);

Fig.3: FAO (2023).

Table Sources

Tab.1: University of Notre Dame, https://gain.nd.edu/our-work/country-index/;

Tab.2: World Bank, World Development Indicators. https://databank.worldbank.org/source/world-development-indicators;

Tab.3: Saab (2017).

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