SUSTAINABLE DEVELOPMENT, CLIMATE CHANGE AND MEDITERRANEAN AREA: A WATER-ENERGY-FOOD-ECOSYSTEM NEXUS APPROACH

Philippe Drobinski[1], Mohamed Abdel Monem[2], Marta G. Rivera Ferre[3], Fabio G. Santeramo[4], Assem Abu Hatab[5], Mohamed Behnassi[6], Tarik Chfadi[7], Wolfgang Cramer[8], Marta Debolini[9], Fatima Driouech[7], Joël Guiot[10], Ahmed El-Kenawy[11], Margarita García-Vila[12], Emilia Lamonaca[4], Feliu López-i-Gelats[13], Žiga Malek[14], Maria P. Papadopoulou[15]

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MedEC Mediterranean Experts on Climate and environmental Change

Union for the Mediterranean
Union pour la Méditerranée
الاتحاد من أجل المتوسط

UN environment programme

Mediterranean Action Plan
Barcelona Convention

Plan Bleu

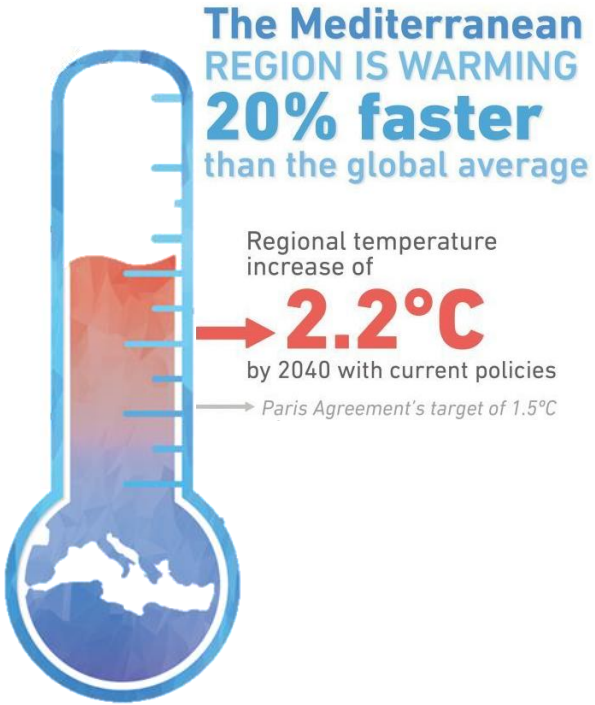
Summary of key risks for the Mediterranean basin

CLIMATE-RELATED DRIVERS

By **2040**, mean temperature will be **2.2°C** above pre-industrial levels. Per **1°C** warming, rainfall will decrease **4%**.
Sea level could rise by more than **90** cm by **2100**.

NON CLIMATE-RELATED DRIVERS

- Air and water pollution increase overall.
- Urbanization & land degradation reduce agricultural land.
- Overfishing & non-indigenous species threaten marine biodiversity.



Source: MedECC MAR1 (2020)

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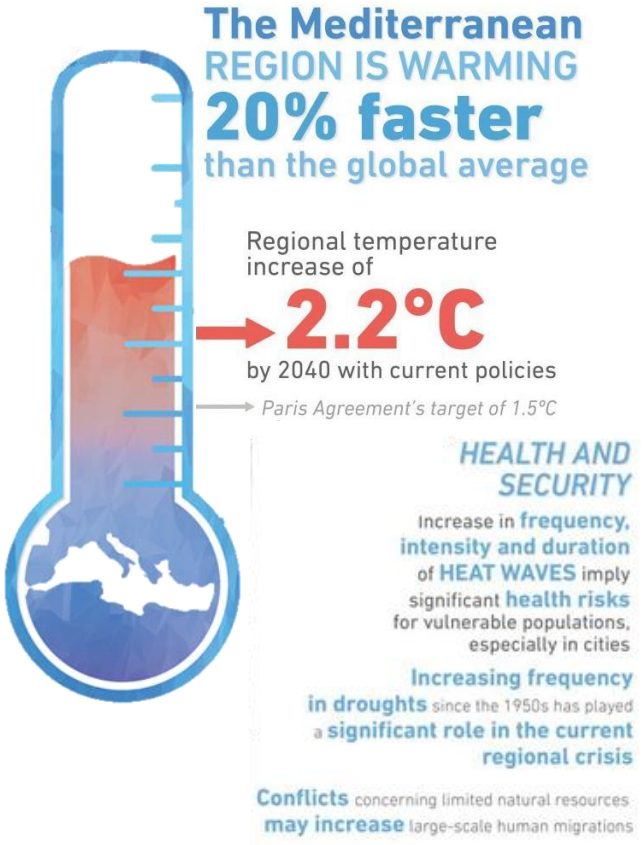

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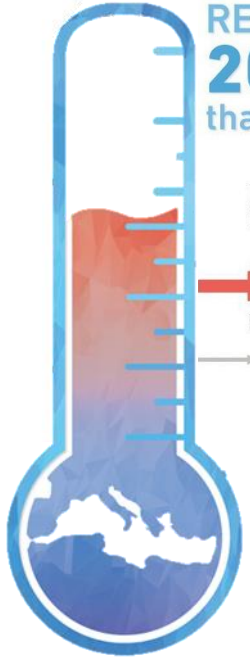
The Mediterranean REGION IS WARMING 20% faster than the global average



Regional temperature increase of **2.2°C** by 2040 with current policies

Paris Agreement's target of 1.5°C

SEA LEVEL

Sea level rises may exceed 1 metre by 2100, impacting **1/3 OF THE REGION'S population**

Half of the 20 global cities set to suffer most from **sea level rises by 2050** are in the Mediterranean

HEALTH AND SECURITY

Increase in **frequency, intensity and duration** of **HEAT WAVES** imply significant **health risks** for vulnerable populations, especially in cities

Increasing frequency in droughts since the 1950s has played a **significant role in the current regional crisis**

Conflicts concerning limited natural resources **may increase** large-scale human migrations

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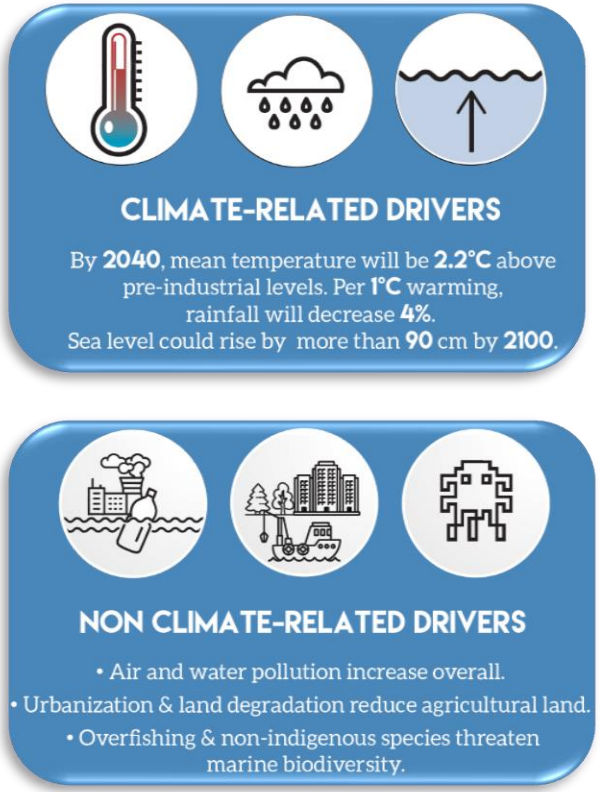

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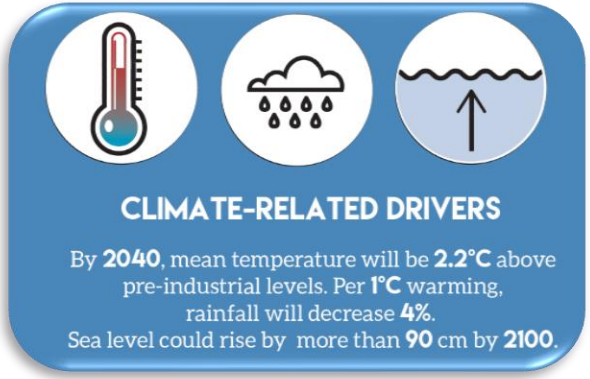

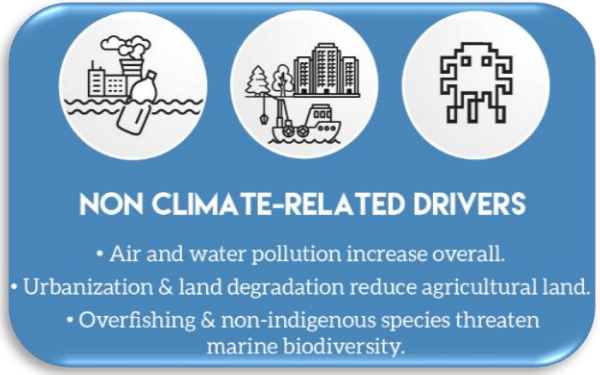

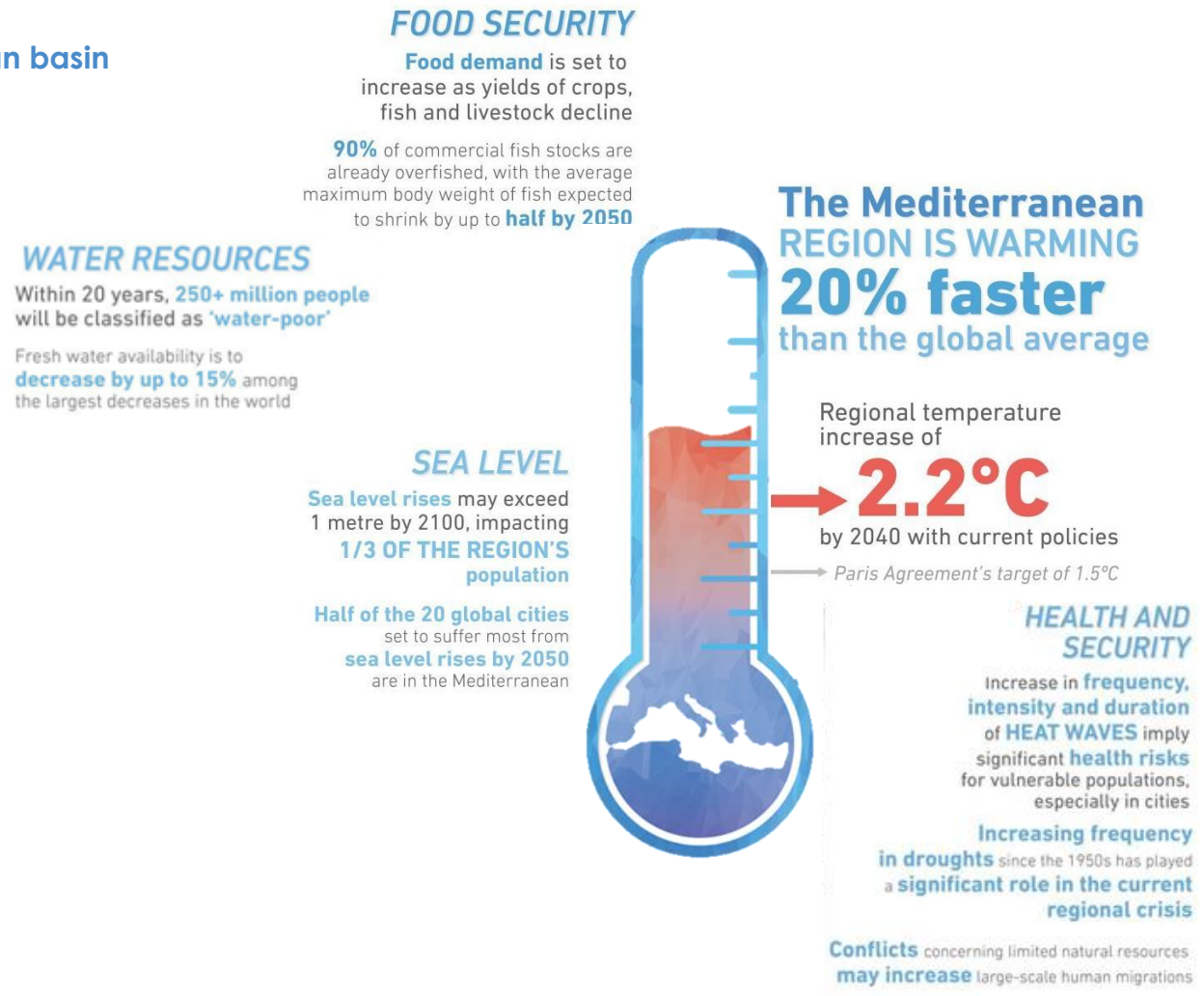

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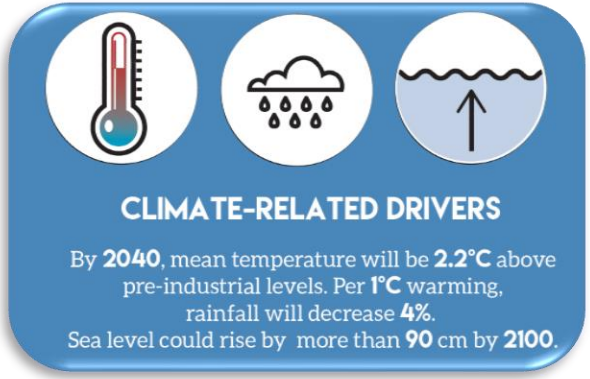

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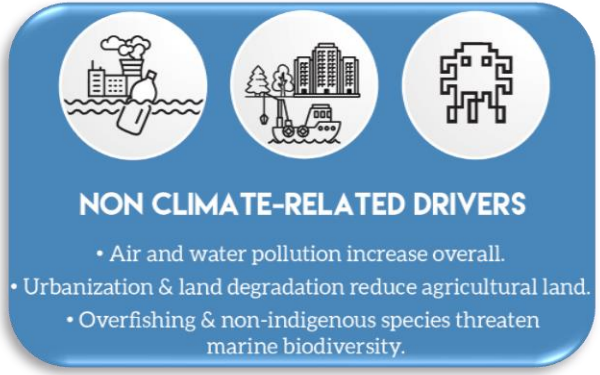

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FOOD SECURITY

Food demand is set to increase as yields of crops, fish and livestock decline

90% of commercial fish stocks are already overfished, with the average maximum body weight of fish expected to shrink by up to **half by 2050**

WATER RESOURCES

Within 20 years, **250+ million people** will be classified as **'water-poor'**

Fresh water availability is to **decrease by up to 15%** among the largest decreases in the world

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ECOSYSTEMS

The Mediterranean basin is **ONE OF THE MOST PROMINENT hotspots of climate and environmental change**

700+ non-indigenous animal species recorded due to warmer conditions

Increasing water acidification causes **mass deaths of marine species**

Mega fires have destroyed record areas of forest due to climate change

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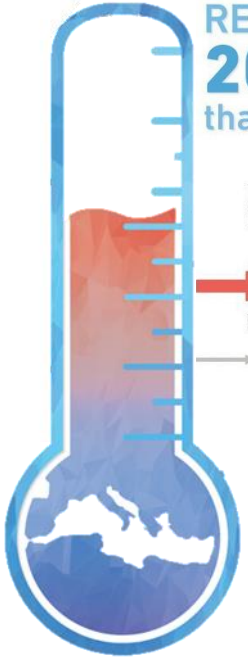

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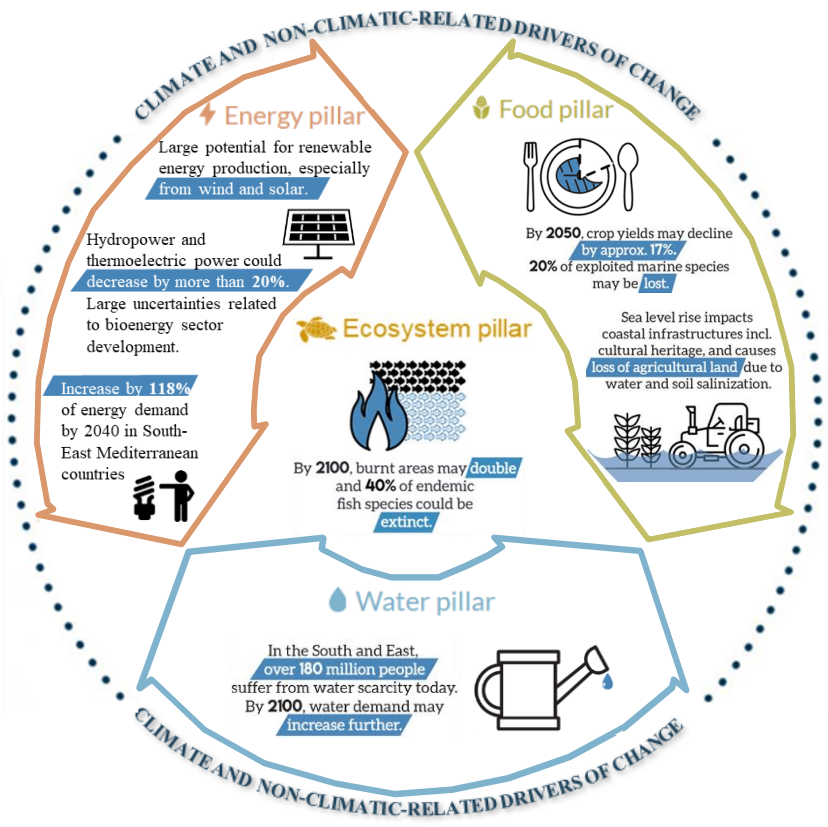

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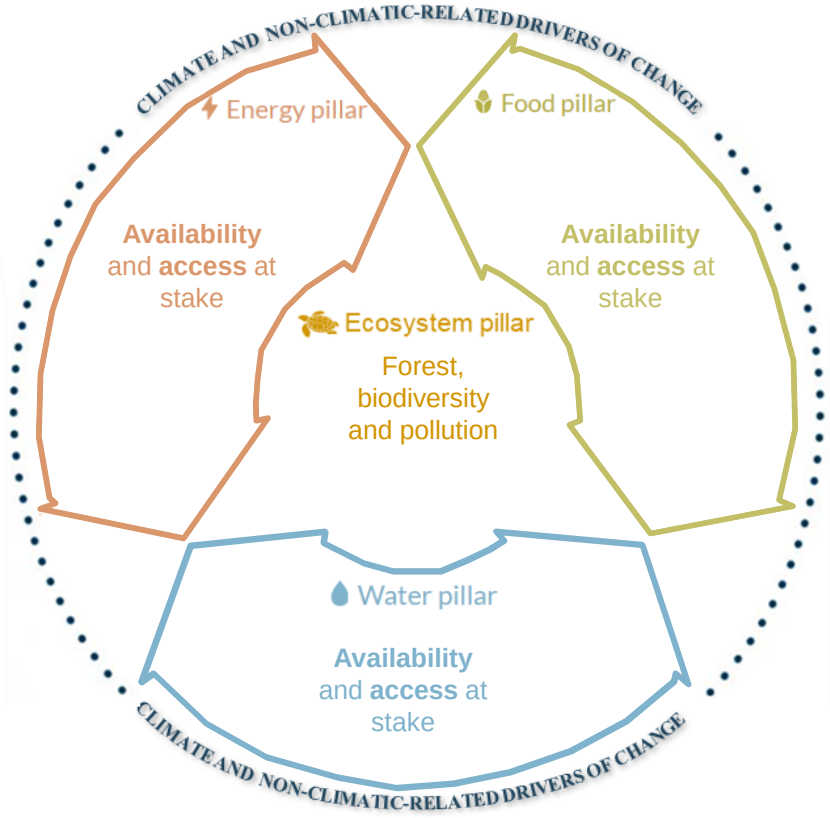

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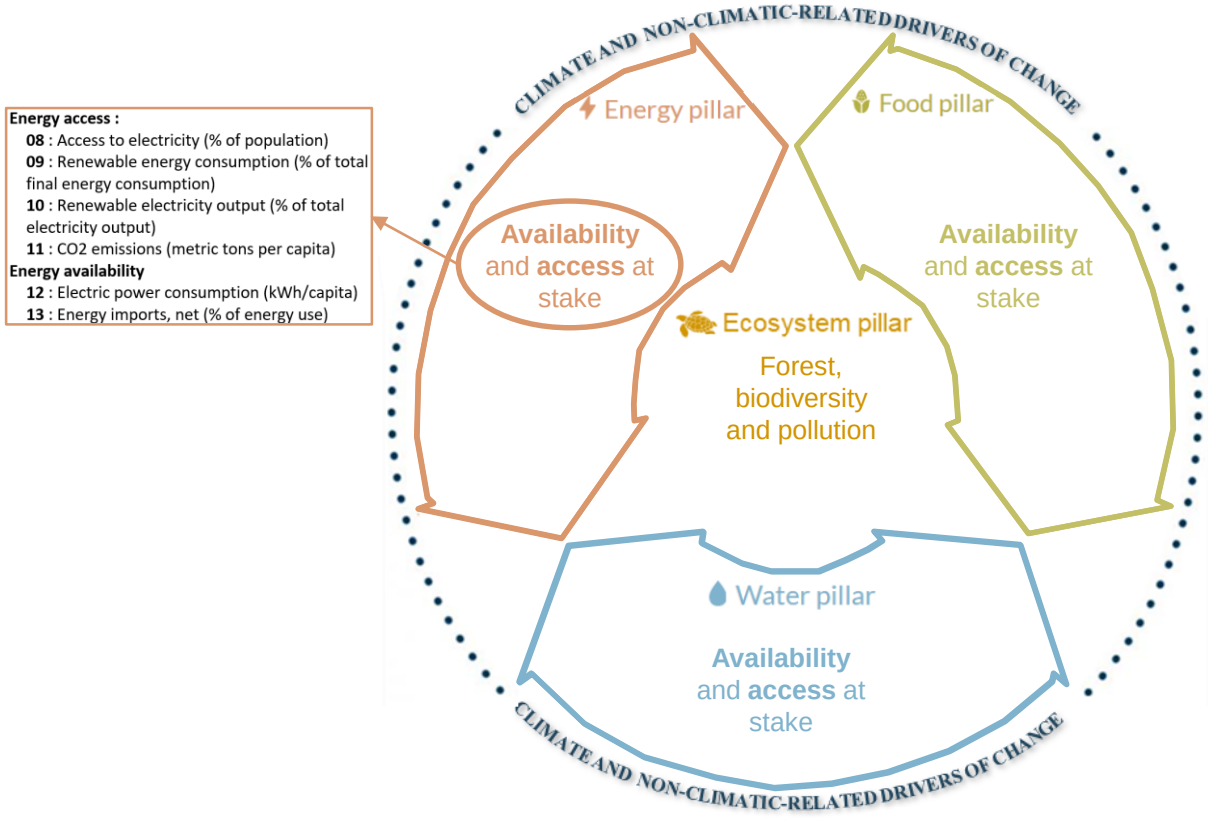

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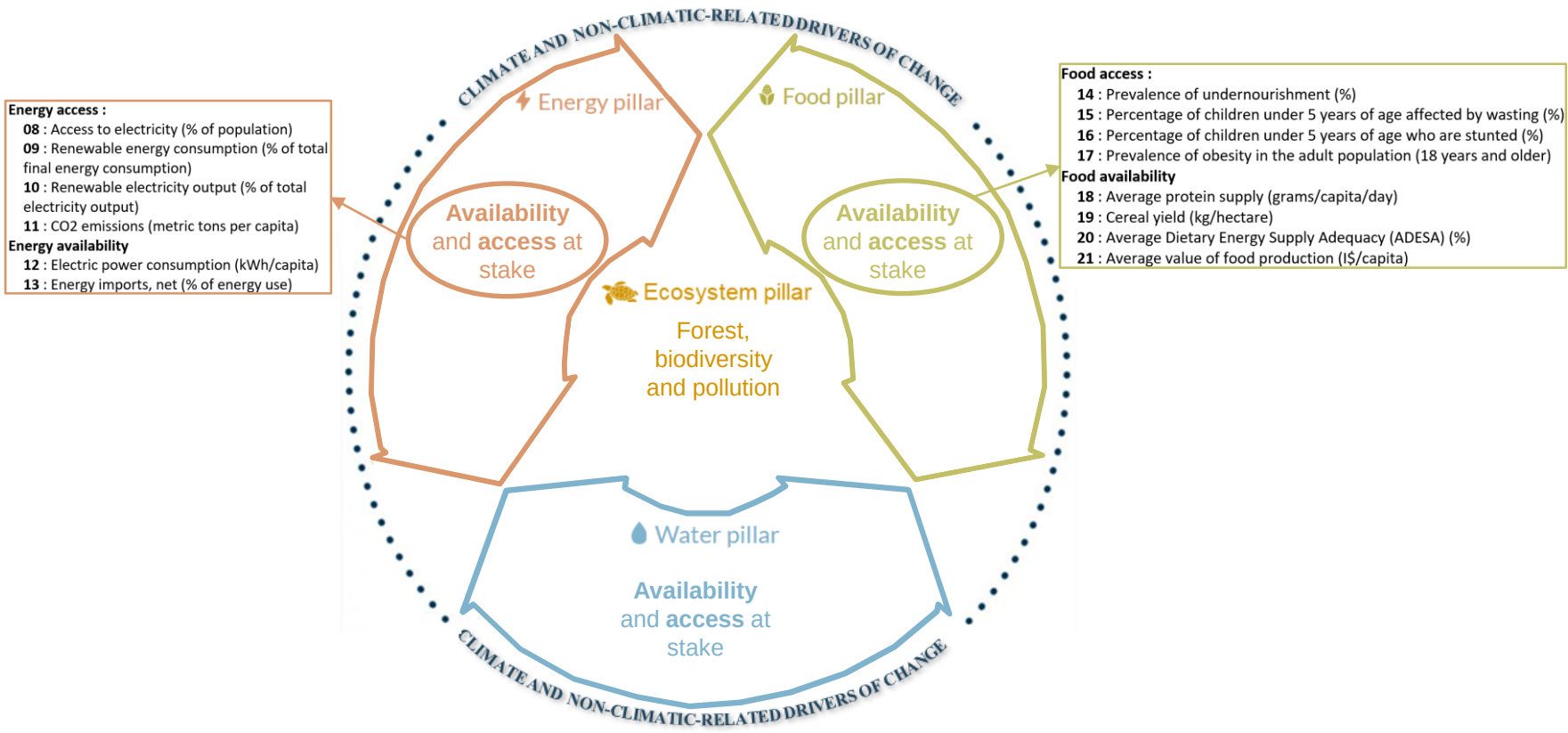

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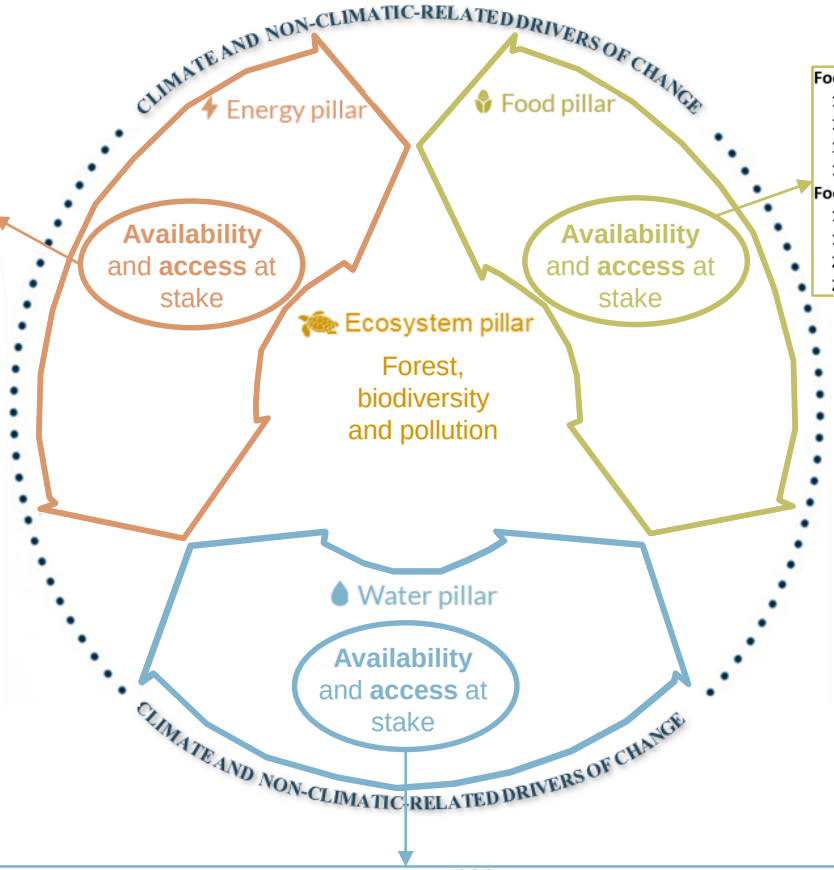

Energy access :
- **08** : Access to electricity (% of population)
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- **11** : CO_2 emissions (metric tons per capita)

Energy availability
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Food access :
- **14** : Prevalence of undernourishment (%)
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- **16** : Percentage of children under 5 years of age who are stunted (%)
- **17** : Prevalence of obesity in the adult population (18 years and older)

Food availability
- **18** : Average protein supply (grams/capita/day)
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- **21** : Average value of food production (I$/capita)

Water access :
- **01** : The percentage of people using at least basic drinking water services (%)
- **02** : The percentage of people using at least basic sanitation services (%)
- **03** : Degree of IWRM implementation (1-100)

Water availability
- **04** : Annual freshwater withdrawals, total (% of internal resources)
- **05** : Renewable internal freshwater resources per capita (m^3)
- **06** : Environmental flow requirements (10^6 m^3/annum)
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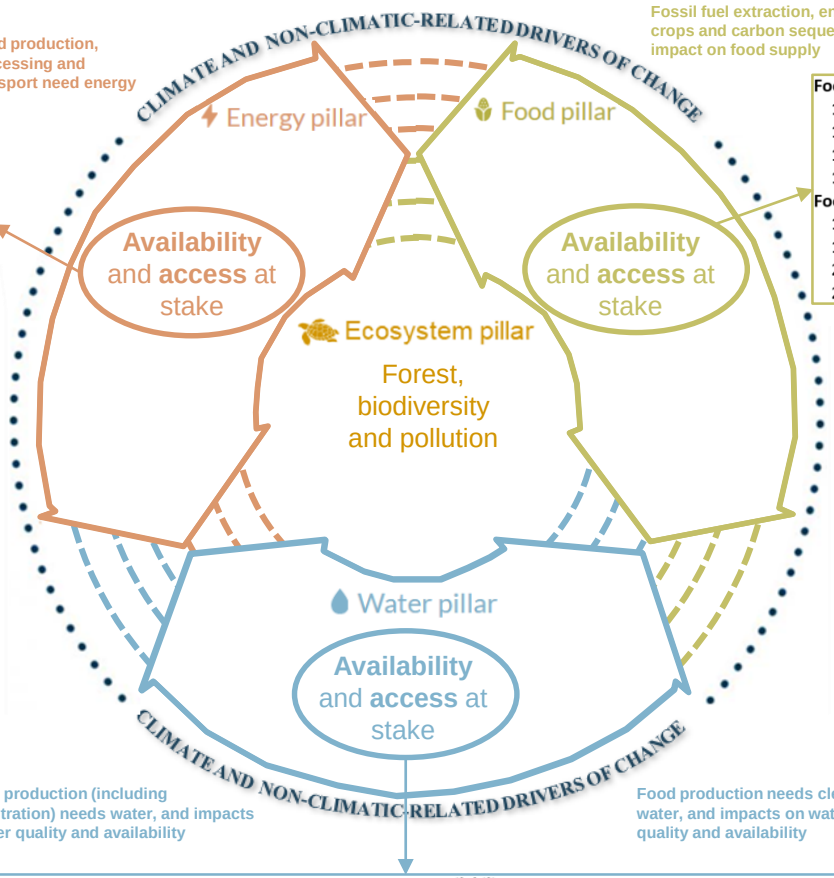

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Water infrastructure and use impacts on fish stocks, food supply and land use

Energy production (including sequestration) needs water, and impacts on water quality and availability

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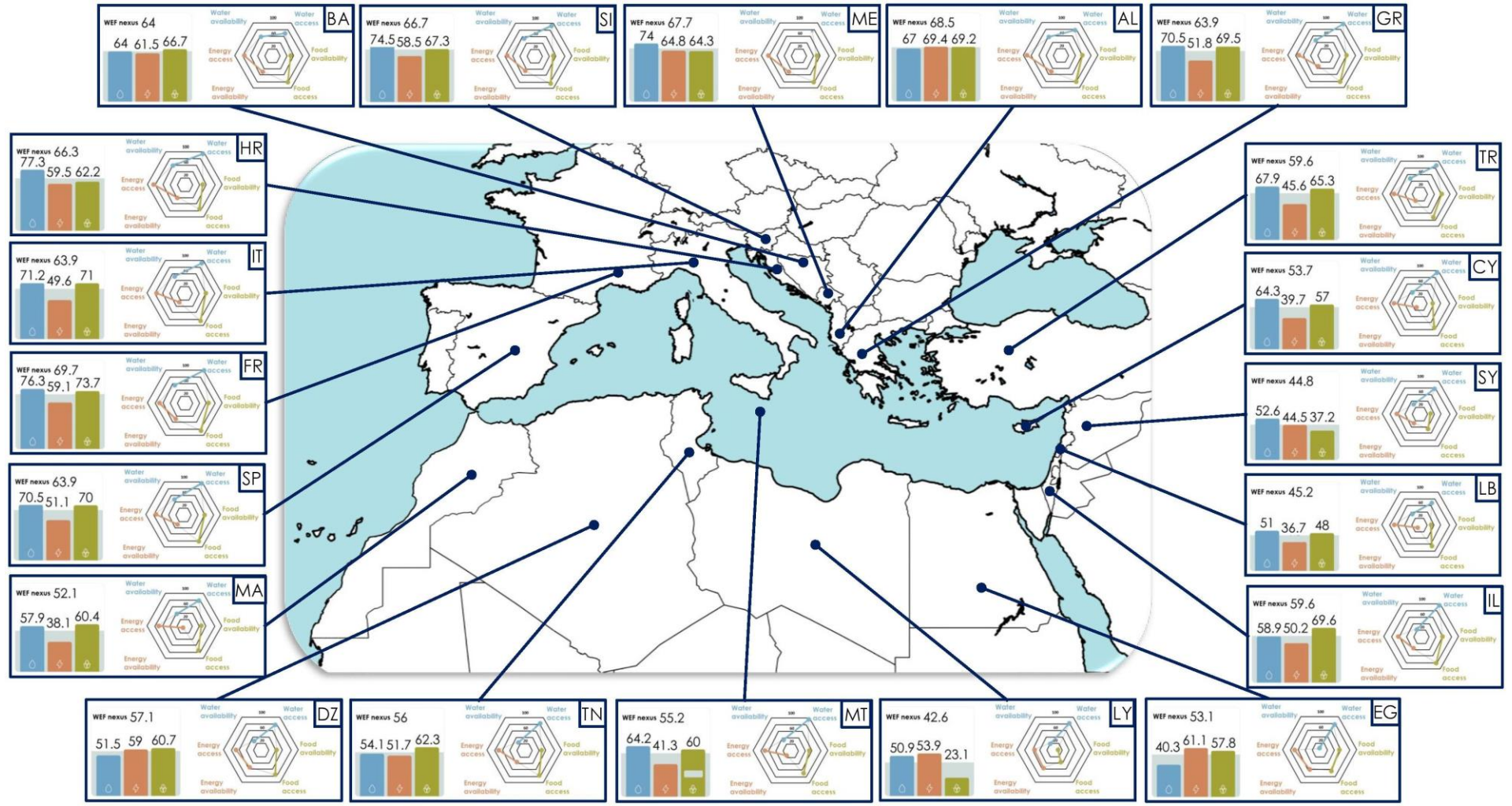
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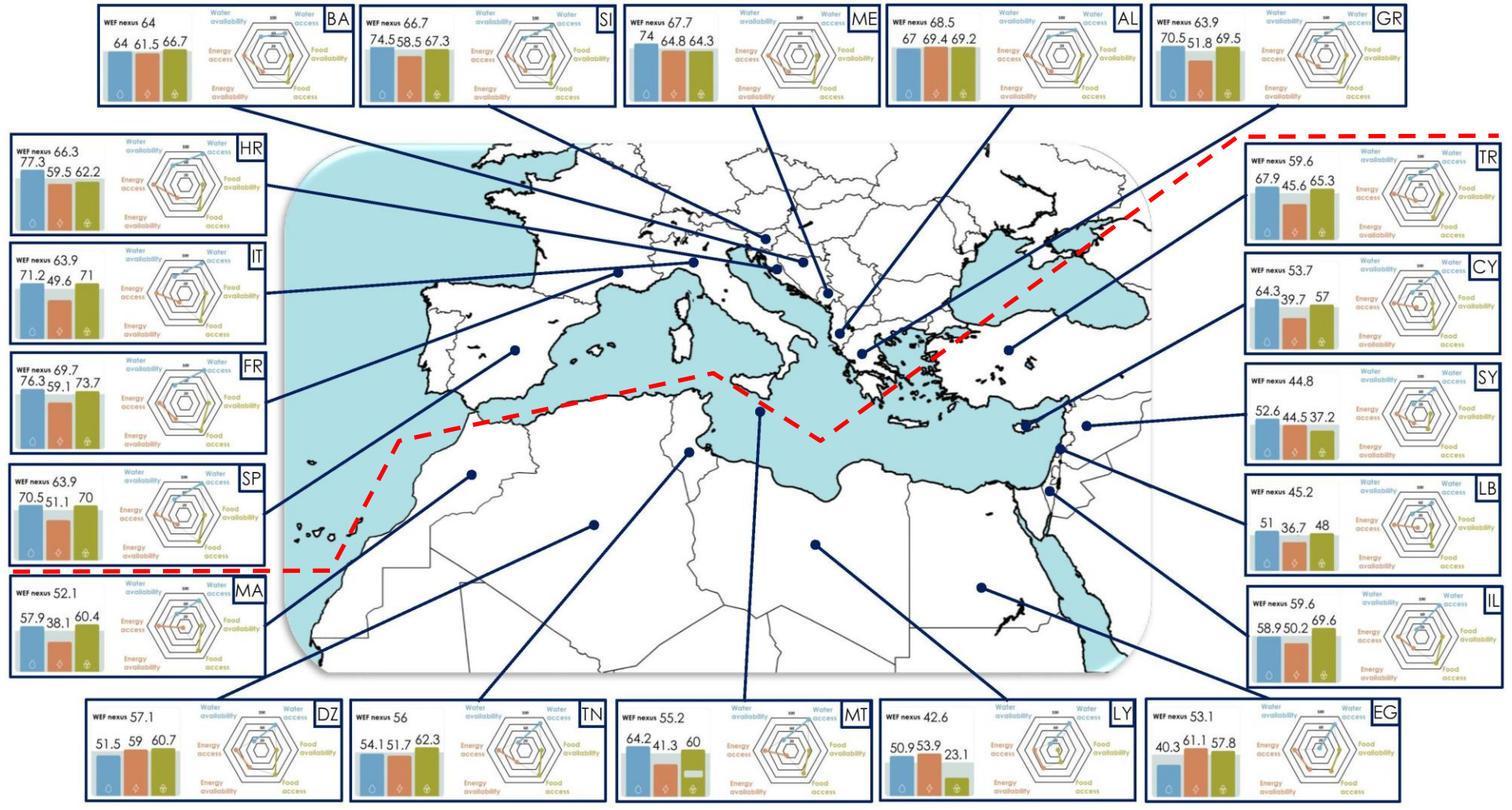
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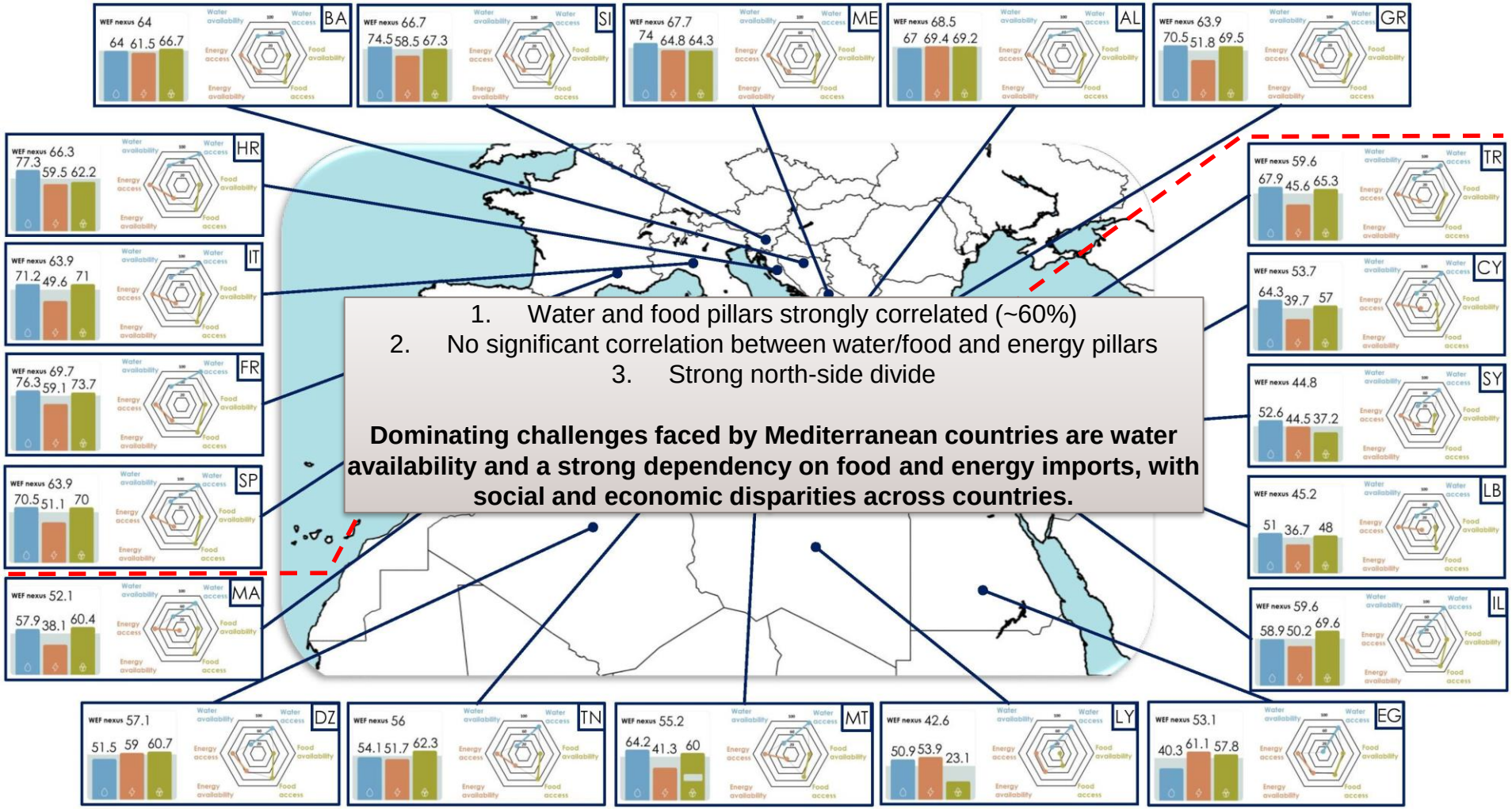

1. Water and food pillars strongly correlated (~60%)
2. No significant correlation between water/food and energy pillars
3. Strong north-side divide

Dominating challenges faced by Mediterranean countries are water availability and a strong dependency on food and energy imports, with social and economic disparities across countries.

Water-energy-food-ecosystem nexus and sustainable development goals (SDGs)

Country/ Subregion	SDG index score 2020	Global rank 2020	SDG 2 2020	SDG 6 2020	SDG 7 2020	SDG 14 2020	SDG 15 2020	SDG index score 2022	
France	81.1	4							73.1
Greece	74.3	43							65.7
Italy	77.0	30							70.6
Malta	76.0	32							64.9
Spain	78.1	22							70.1
Europe West	*78.5*	*18*							
Albania	70.8	68							-
Bosnia and Herzegovina	73.5	50							-
Croatia	78.4	19							70.7
Cyprus	75.2	34							60.7
Montenegro	70.2	72							-
North Macedonia	71.4	62							62.9
Slovenia	79.8	12							74.0
Europe East	*74.8*	*38*							
Israel	74.6	40							
Jordan	68.1	89						67.4	
Lebanon	66.7	95						63.6	
Palestine	-	-						-	
Syria	59.3	126						50.8	
Turkey	70.3	70							56.7
Middle East (ME)	*70.2*	*72*							
Algeria	72.3	56						67.0	
Egypt	68.8	83						63.6	
Libya	-	-						57.1	
Morocco	71.3	64						66.7	
Tunisia	71.4	63						67.3	
North Africa (NA)	*70.2*	*72*							
Mediterranean area	*73.5*	*50*							
Source	*Riccaboni et al.* (2020)[70]							*Bayoumi et al.* (2022)[97]	*Sachs et al.* (2022)[98]

SDG achievement Challenges remain Significant challenges Major challenges Unavailable dat

Sources: Riccaboni et al. (2020)
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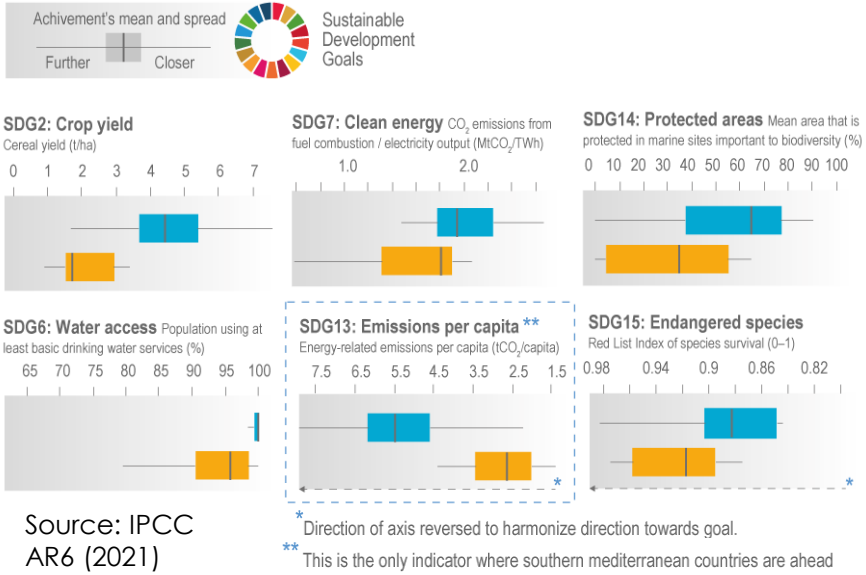
Sustainable Development Goal indicators

Comparison between northern and southern Mediterranean countries



Source: IPCC AR6 (2021)

* Direction of axis reversed to harmonize direction towards goal.

** This is the only indicator where southern mediterranean countries are ahead

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SDG achievement, Challenges remain, Significant challenges, Major challenges, Unavailable dat

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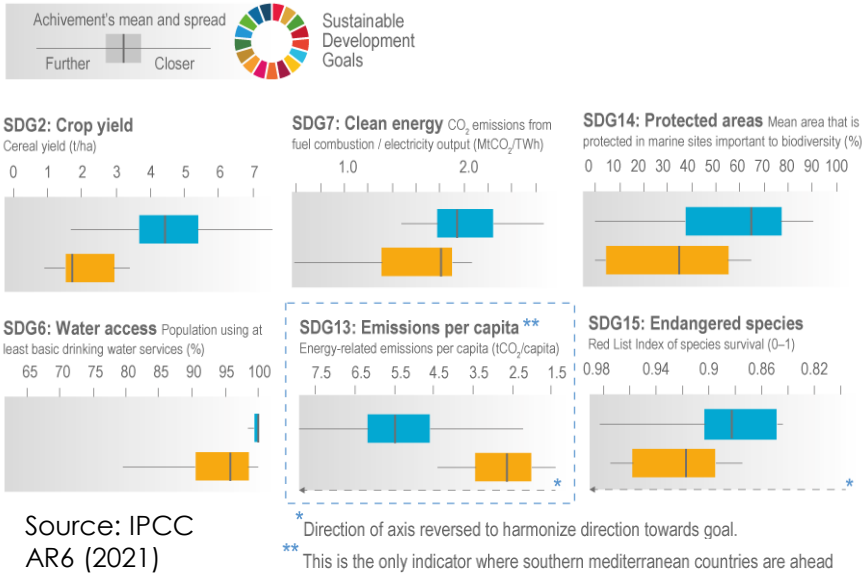
Water-energy-food-ecosystem nexus and sustainable development goals (SDGs)

Sustainable Development Goal indicators

Comparison between northern and southern Mediterranean countries



Source: IPCC AR6 (2021)

* Direction of axis reversed to harmonize direction towards goal.

** This is the only indicator where southern mediterranean countries are ahead

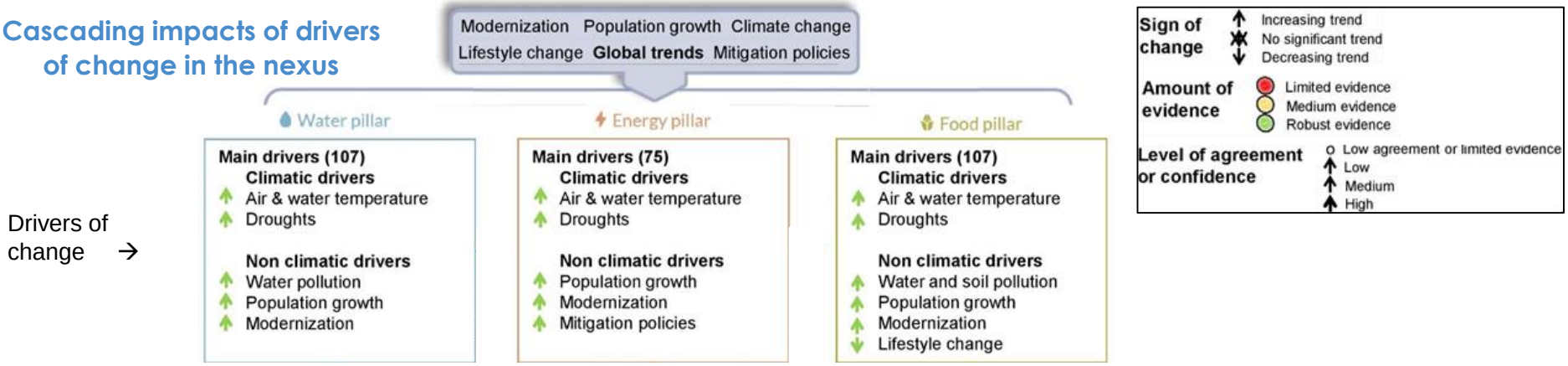
Country/ Subregion	SDG index score 2020	Global rank 2020	SDG 2 2020	SDG 6 2020	SDG 7 2020	SDG 14 2020	SDG 15 2020	SDG index score 2022	
France	81.1	4							73.1
Greece	74.3	43							65.7
Italy	77.0	30							70.6
Malta	76.0	32							64.9
Spain	78.1	22							70.1
Europe West	*78.5*	*18*							
Albania	70.8	68							-
Bosnia and Herzegovina	73.5	50							-
Croatia	78.4	19							70.7
Cyprus	75.2	34							60.7
Montenegro	70.2	72							-
North Macedonia	71.4	62							62.9
Slovenia	79.8	12							74.0
Europe East	*74.8*	*38*							
Israel	74.6	40							
Jordan	68.1	89						67.4	
Lebanon	66.7	95						63.6	
Palestine	-	-						-	
Syria	59.3	126						50.8	
Turkey	70.3	70							56.7
Middle East (ME)	*70.2*	*72*							
Algeria	72.3	56						67.0	
Egypt	68.8	83						63.6	
Libya	-	-						57.1	
Morocco	71.3	64						66.7	
Tunisia	71.4	63						67.3	
North Africa (NA)	*70.2*	*72*							
Mediterranean area	*73.5*	*50*							
Source	*Riccaboni et al.* (2020)[70]							*Bayoumi et al.* (2022)[97]	*Sachs et al.* (2022)[98]

SDG achievement, Challenges remain, Significant challenges, Major challenges, Unavailable dat

Resource overexploitation is contributing to their rapid depletion and consequent environmental degradation, limiting success in reaching the Sustainable Development Goals (SDGs) in the Mediterranean countries.

Sources: Riccaboni et al. (2020)
Bayoumi et al. (2022)
Sachs et al. (2022)

Cascading impacts of drivers of change in the nexus



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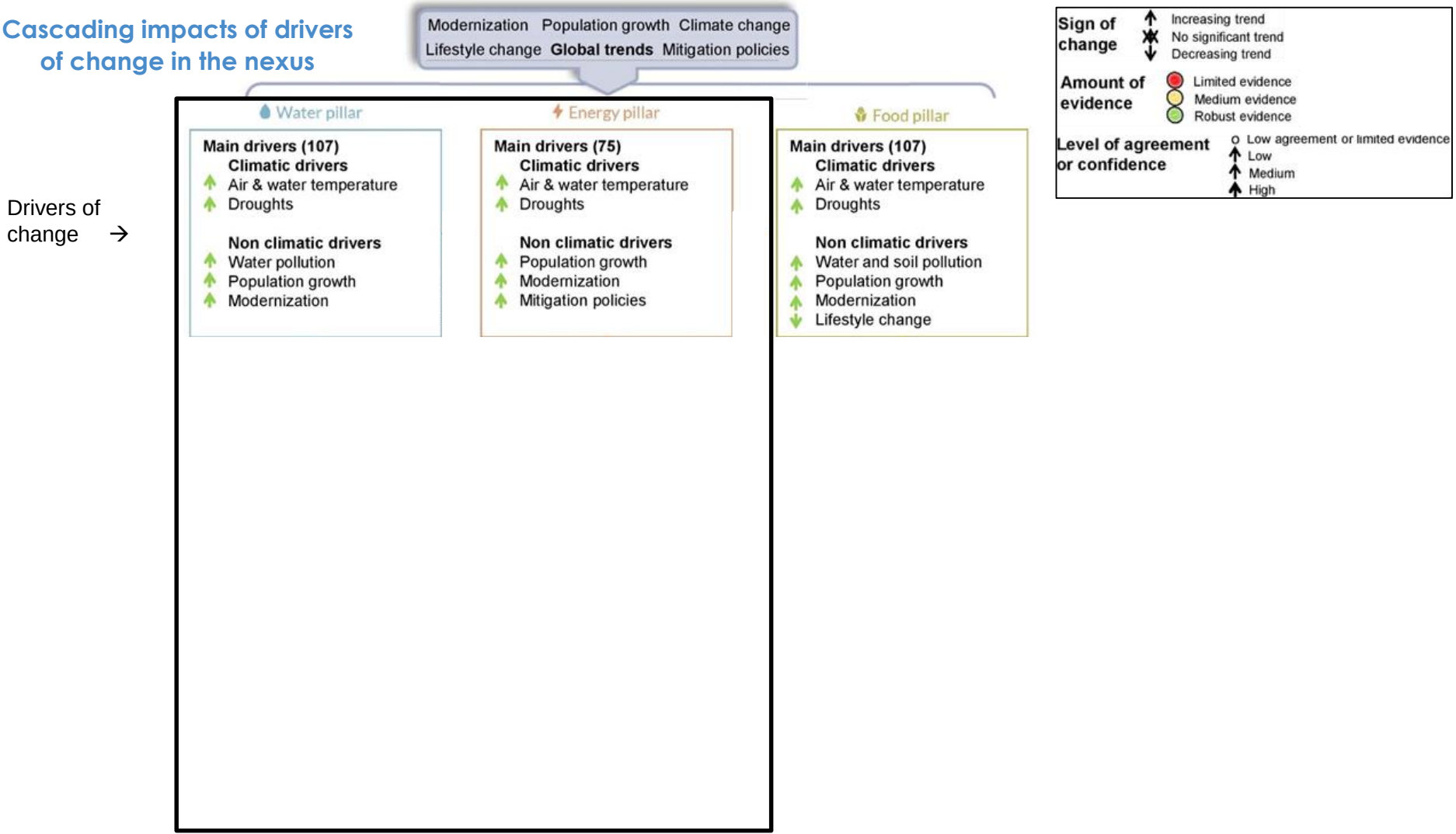

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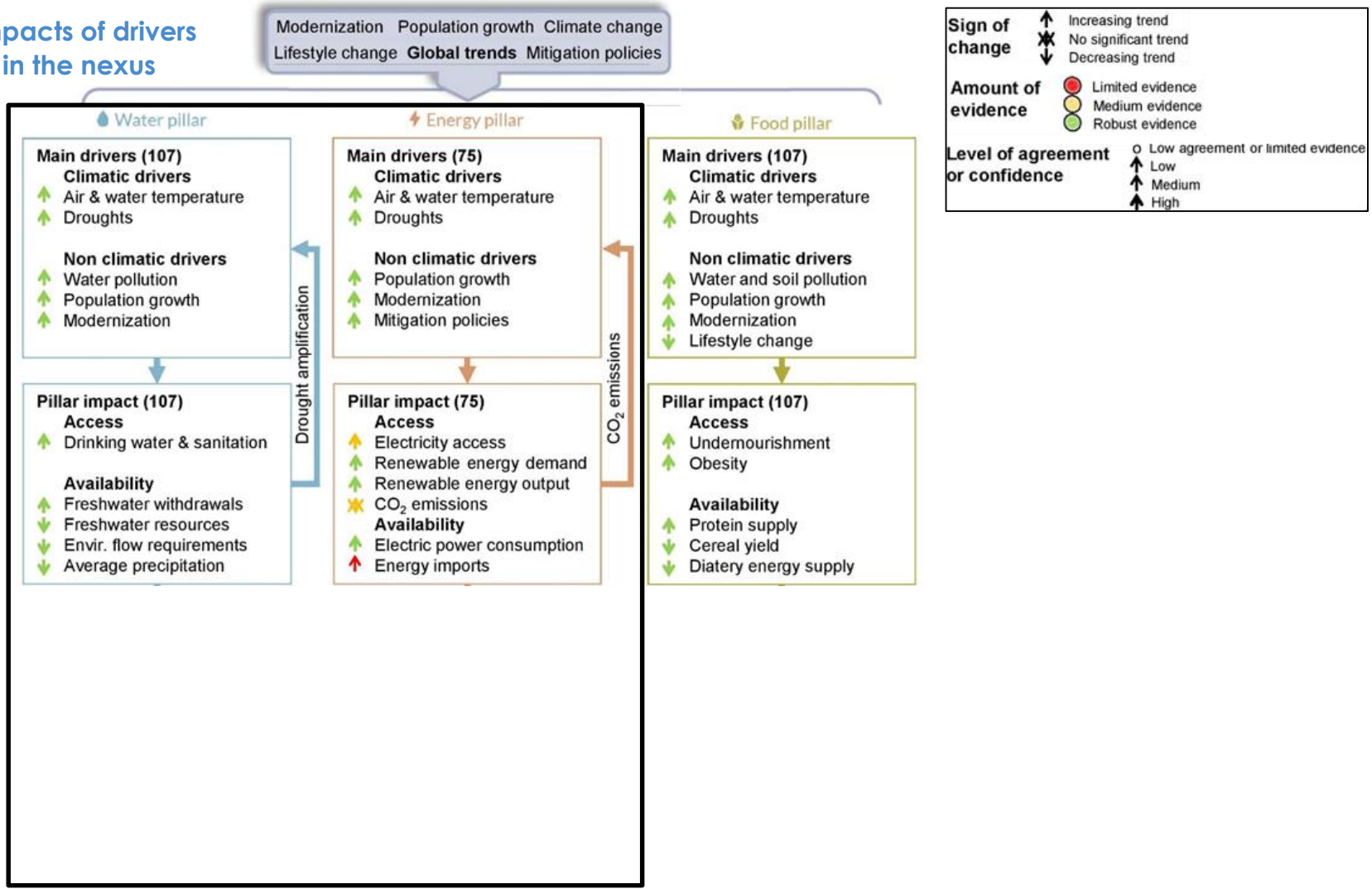

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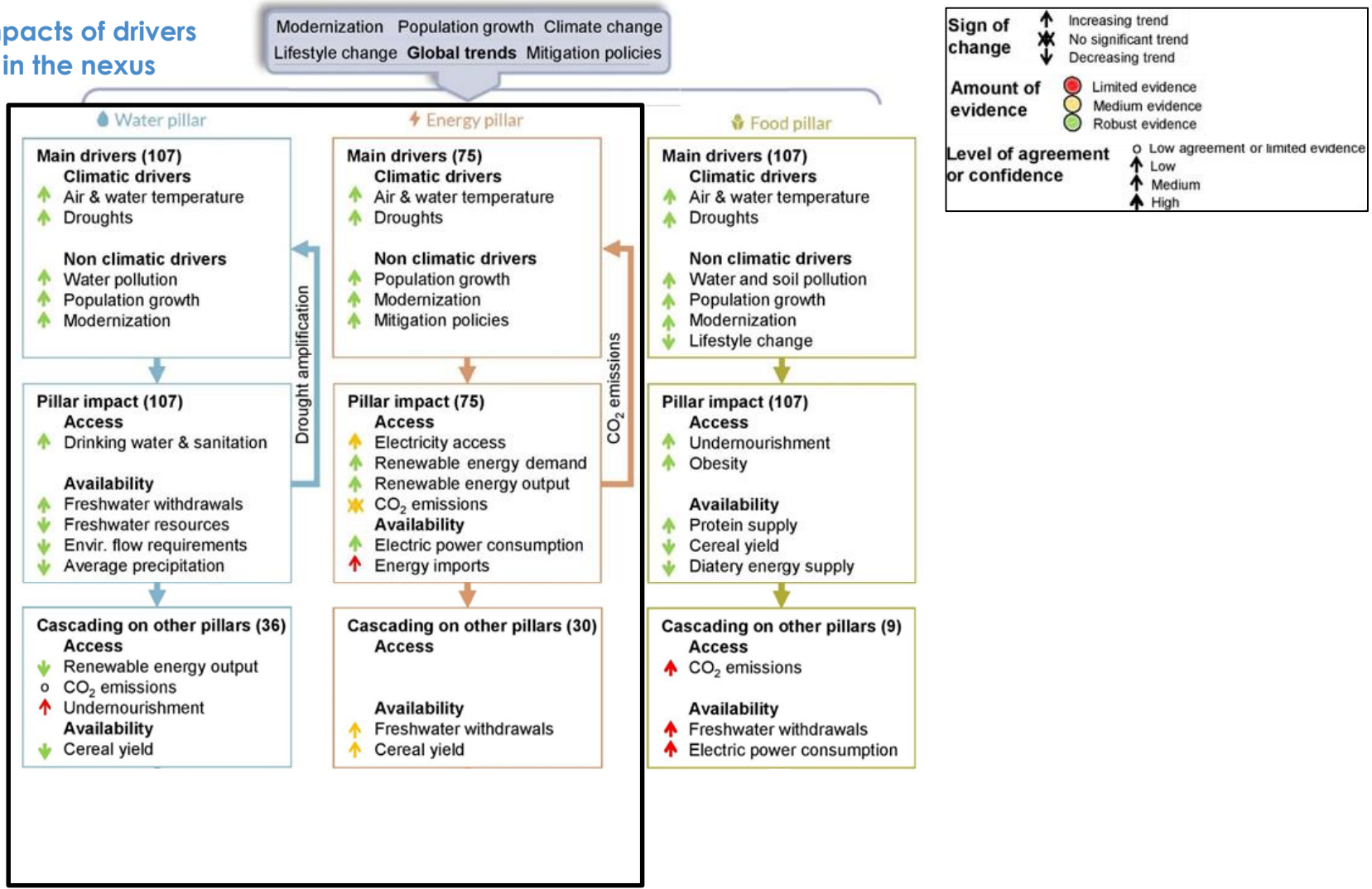

Drivers of change →

1st level impact →

Cascade in the WEFE nexus →

Sign of change
- Increasing trend
- No significant trend
- Decreasing trend

Amount of evidence
- Limited evidence
- Medium evidence
- Robust evidence

Level of agreement or confidence
- o Low agreement or limited evidence
- Low
- Medium
- High

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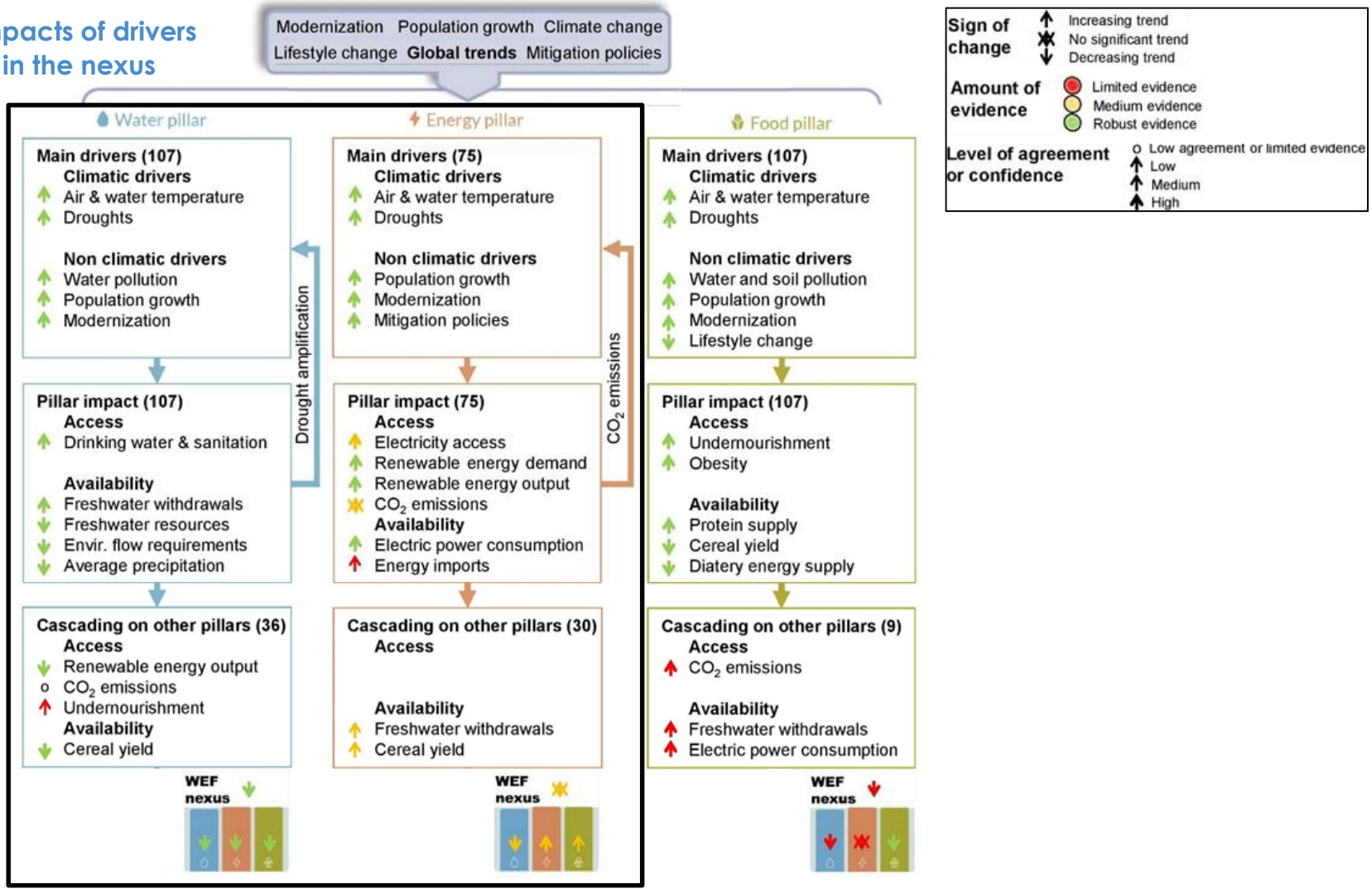

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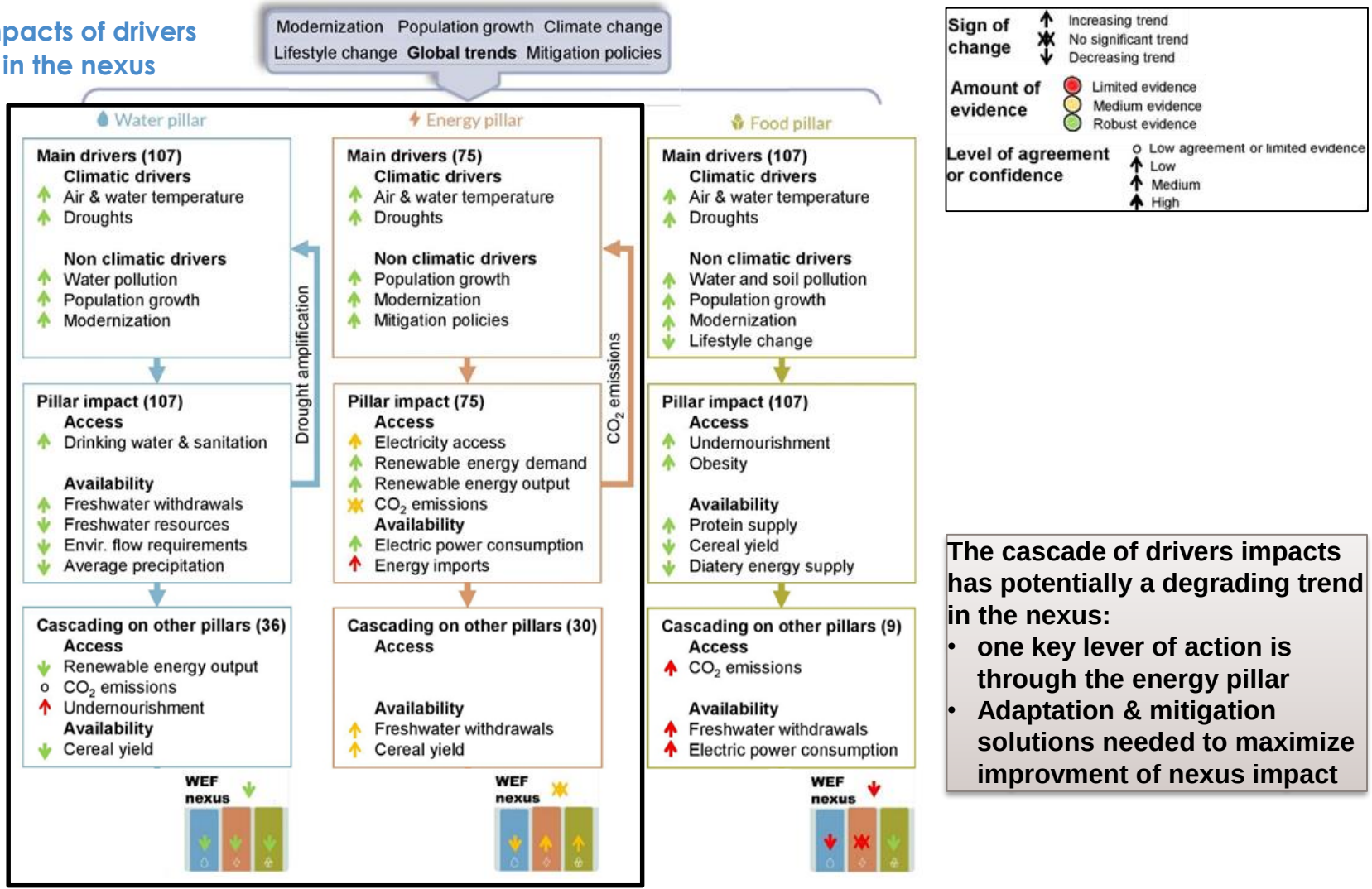

Drivers of change →

1st level impact →

Cascade in the WEFE nexus →

Impact on the WEFE nexus →

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- No significant trend
- Decreasing trend

Amount of evidence
- Limited evidence
- Medium evidence
- Robust evidence

Level of agreement or confidence
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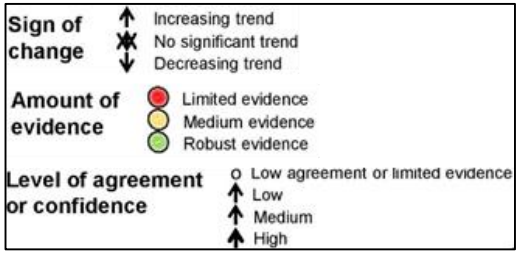
The cascade of drivers impacts has potentially a degrading trend in the nexus:

- **one key lever of action is through the energy pillar**
- **Adaptation & mitigation solutions needed to maximize improvment of nexus impact**

Implementing a nexus approach in the Mediterranean



Innovation

Governance
Incentives & enabling factors

Finance

Existing management response

Local experimentations
- Technological solutions
- Real or near-real-time digital services
- Ecosystem- and nature-based solutions
- Behavioural change and sobriety

Governance
- Union for the Mediterranean
- Center for Mediterranean Integration
- Global Water Partnership-Mediterranean
- Association of Agricultural Research Institutions in the Near East & North Africa

Funding
- Partnership for Research and Innovation in the Mediterranean Area
- MENA Regional Innovation Hub

Implementing a nexus approach in the Mediterranean

Technological solutions

- Alternative and more sustainable water irrigation techniques
- Use of renewable energy in agricultural and other sectors
- Desalinitation, often combined with power generation
- Non-conventional water resources and wastewater reuse
- Increase bio-energy crop production in marginal areas

Source: Toledo and Scognamiglio (2021)

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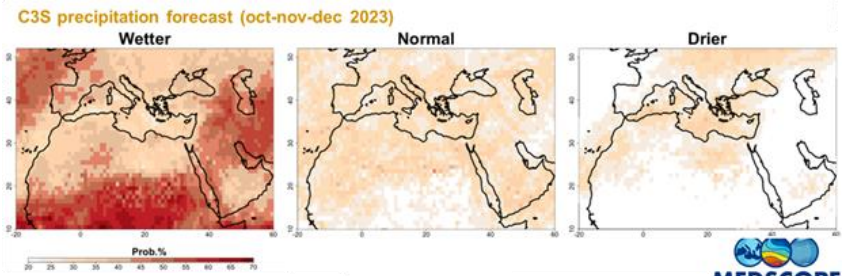
Real or near-real-time digital services

- Early warning systems
- Climate services



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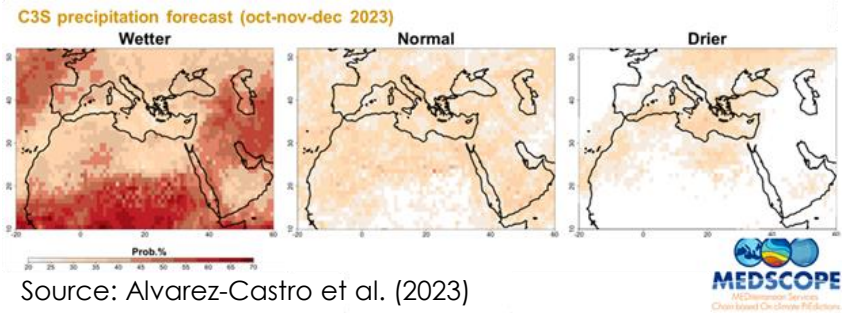

Source: Alvarez-Castro et al. (2023)

Ecosystem- and nature-based solutions

- Urban engineering (e.g. green roofs or walls, horticultural gardens,…)
- Constructed or naturalized wetlands and ponds
- Agroecosystems

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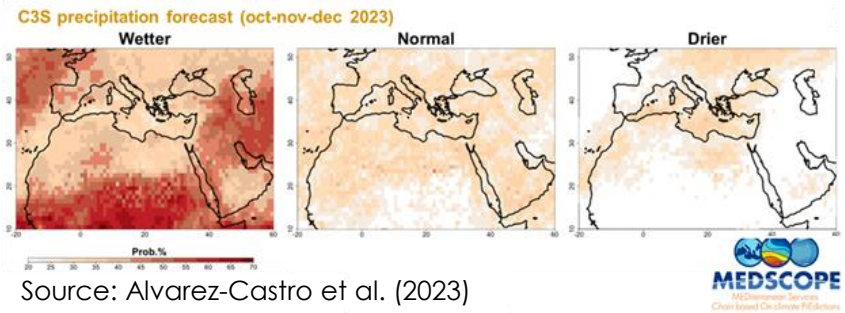
Behavioural change

- Mediterranean diet and sobriety

Real or near-real-time digital services

- Early warning systems
- Climate services



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Implementing a nexus approach in the Mediterranean

Impacts and risks

- \+ Positive impacts on WEFE nexus pillars
- \- Risk or trade-off on WEFE nexus pillars

Amount of evidence

- Limited
- Medium
- Robust

Level of agreement/ confidence

- +++ High
- ++ Medium
- \+ Low
- o Low agreement or limited evidence

Relation with Sustainable Development Goals

WEFE nexus adaptation and mitigation strategies	Existing management responses in the Mediterranean basin	Water pillar SDG 6		Energy pillar SDG 7		Food pillar SDG 2		Ecosystem pillar SDG 14 SDG 15	
Innovative integrated social, technological and nature-based solutions to promote water, food and ecosystem synergies and loosen inter-dependencies	Alternative and more sustainable water irrigation techniques (7)	+++	-	+	-	+++	o	+	o
	Agroecosystems (9)	+	o	+	o	+++	o	+++	o
	Non-conventional water resources and wastewater reuse (10)	++	-	+	o	++	-	+	- -
	Urban engineering (e.g. green roofs or walls, horticultural gardens,…) (6)	++	-	++	o	+	o	++	o
	Constructed or naturalized wetlands and ponds (4)	+++	o	o	o	+	o	+	o
	Early warning systems (3)	+++	o	+	o	+++	o	+	o
	Climate services (8)	+++	-	+	o	++	o	+	o
	Mediterranean diet and sobriety (21)	++	o	++	o	++	o	++	o
Renewable energies and efficiency for improved resource use	Use of renewable energy in agricultural and other sectors (11)	++	o	+++	o	++	o	+	o
	Increase bio-energy crop production in marginal areas (5)	o	o	o	- - -	o	o	o	o
	Desalinitation, often combined with power generation (2)	+++	o	++	- -	++	o	o	o
	Increase urban water efficiency by reducing leakage (1)	o	o	o	o	o	o	o	o

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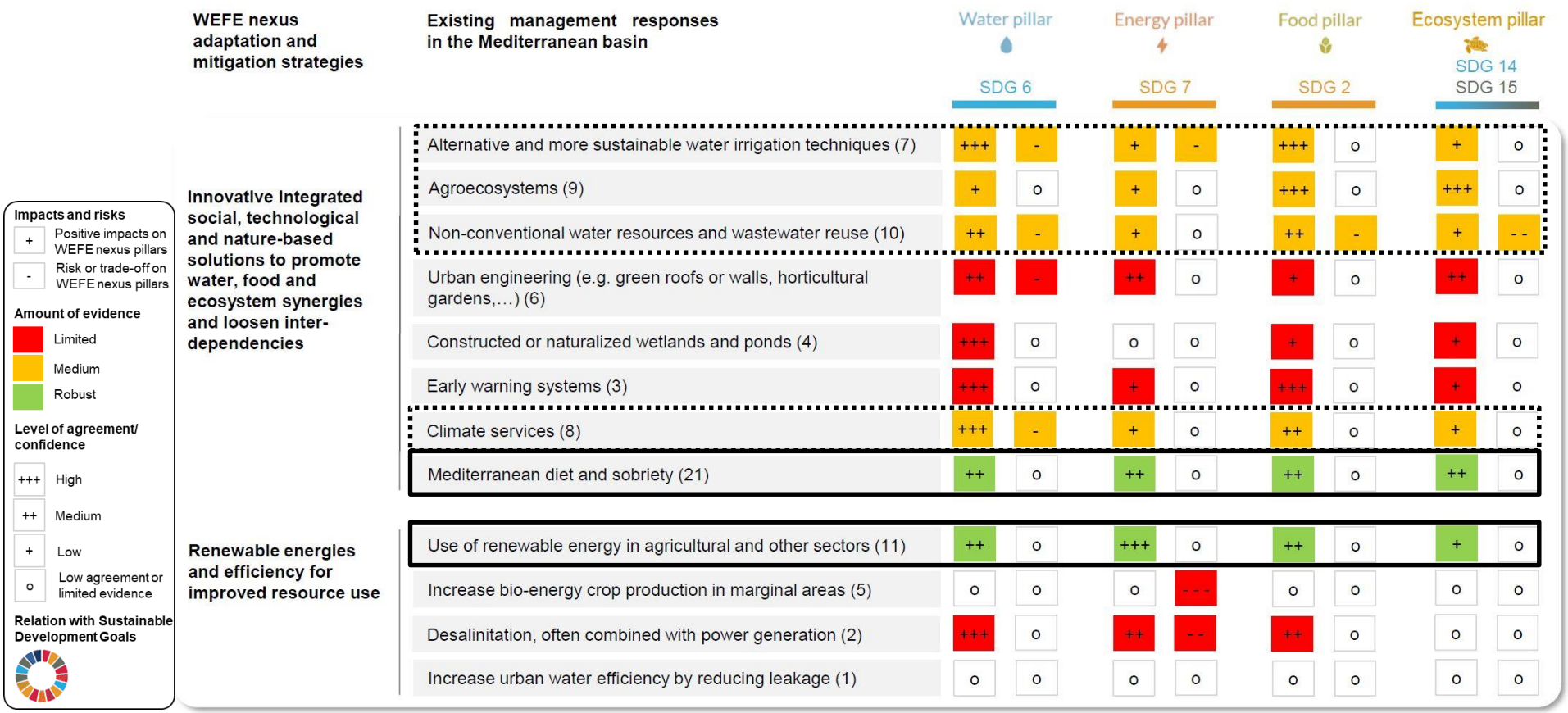

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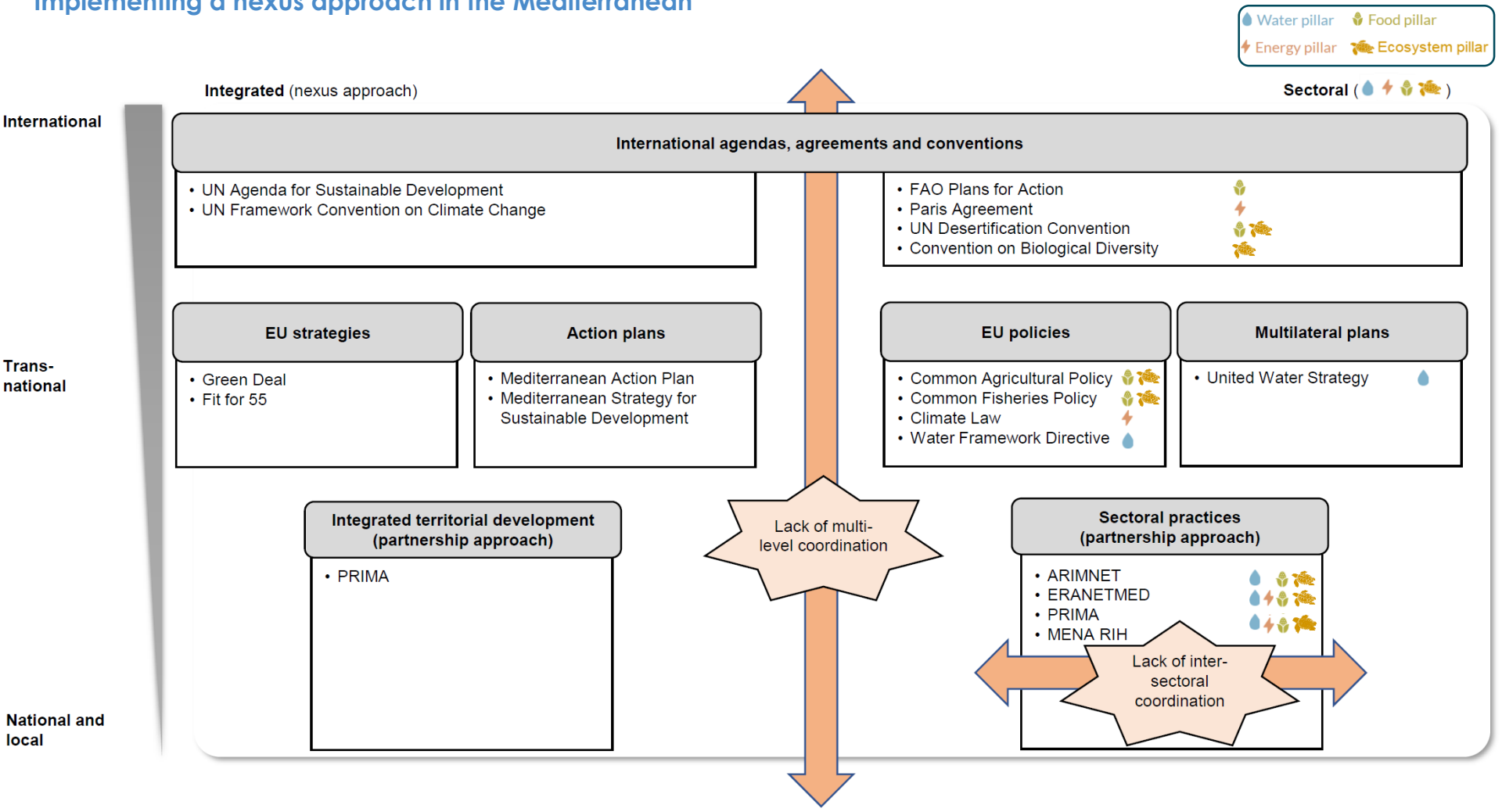

Boosting local experimentation to global implementation : concept-to-implementation gap

Lack of concrete examples of global implementation of a nexus approach → many measures still designed in “silos” due to:

- insufficient understanding of nexus trade-offs amongst science-policy-stakeholder interactions
- insufficient incentives
- limited vision, knowledge, development and investment
- higher costs of nexus approaches than those of silo approaches, due to the information, expertise, time, coordination and financial resources required

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Actions to overcome the poor integration of nexus approach

Science found as a tool for overcoming the poor integration of nexus approach in the Mediterranean region

Actions and interventions needed to build institutional capacity which include:

- **enhance finance mechanisms**
- **intra-regional dialogue between implementers of the nexus approach, policy makers, and the general public**
- **pilot nexus approaches through modeling and assessment**


Thank you for your attention