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WEF Nexus Research Group

System View to Sustainable Development

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Outline

- SDGs: Global and Mexico Progress
- Mexico WEF Challenges
- WEF Nexus System Approaches
- Geo-Thematic Applications of WEF
- Concluding remarks

FIGURE C

Global risks ranked by severity over the short and long term

"Please estimate the likely impact (severity) of the following risks over a 2-year and 10-year period."

Risk categories

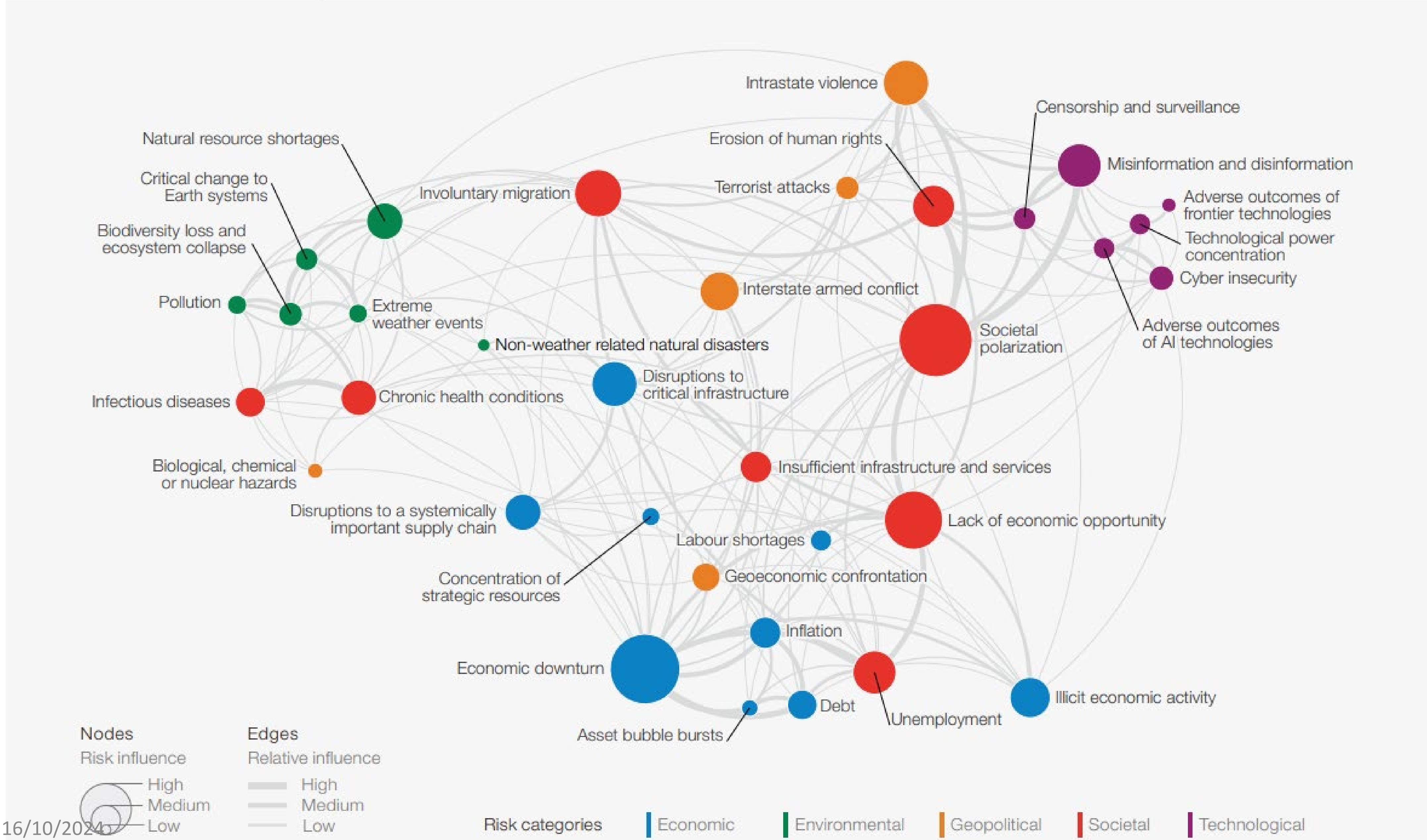
- Economic
- Environmental
- Geopolitical
- Societal
- Technological

Rank	2 years	10 years
1st	Misinformation and disinformation	Extreme weather events
2nd	Extreme weather events	Critical change to Earth systems
3rd	Societal polarization	Biodiversity loss and ecosystem collapse
4th	Cyber insecurity	Natural resource shortages
5th	Interstate armed conflict	Misinformation and disinformation
6th	Lack of economic opportunity	Adverse outcomes of AI technologies
7th	Inflation	Involuntary migration
8th	Involuntary migration	Cyber insecurity
9th	Economic downturn	Societal polarization
10th	Pollution	Pollution

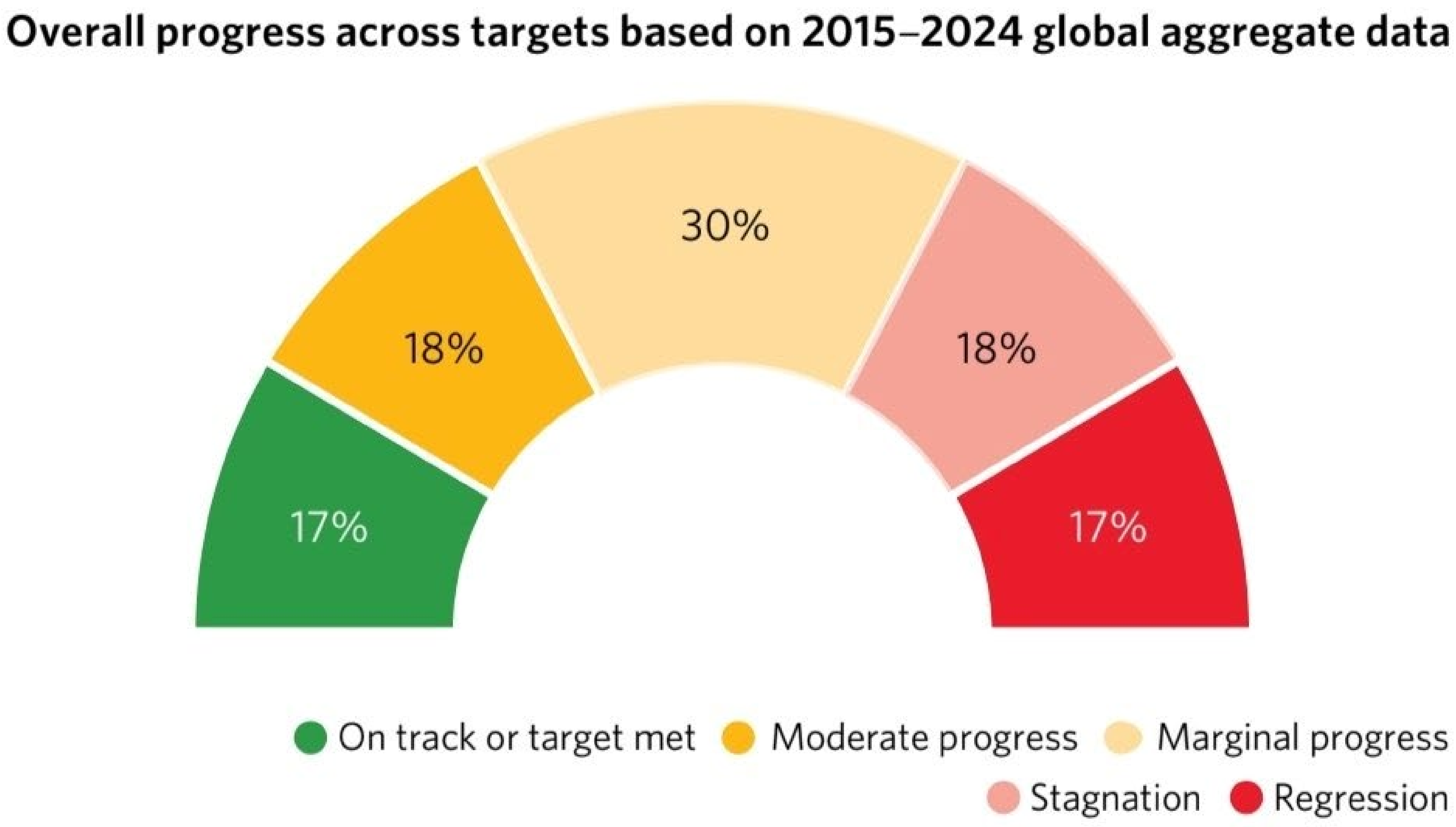
Source

World Economic Forum Global Risks Perception Survey 2023-2024.

FIGURE D | **Global risks landscape: an interconnections map**



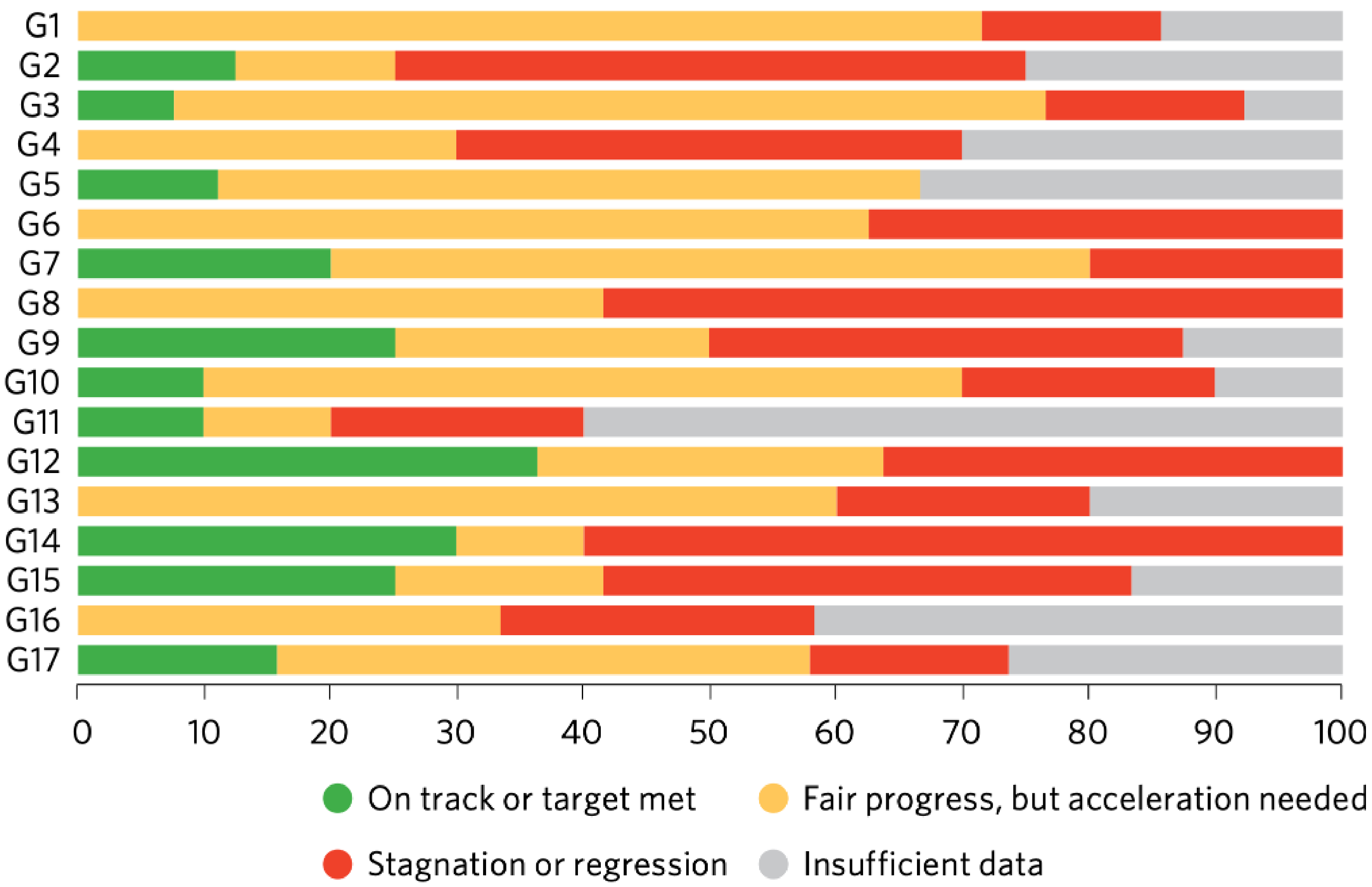
Global Progress of SDGs



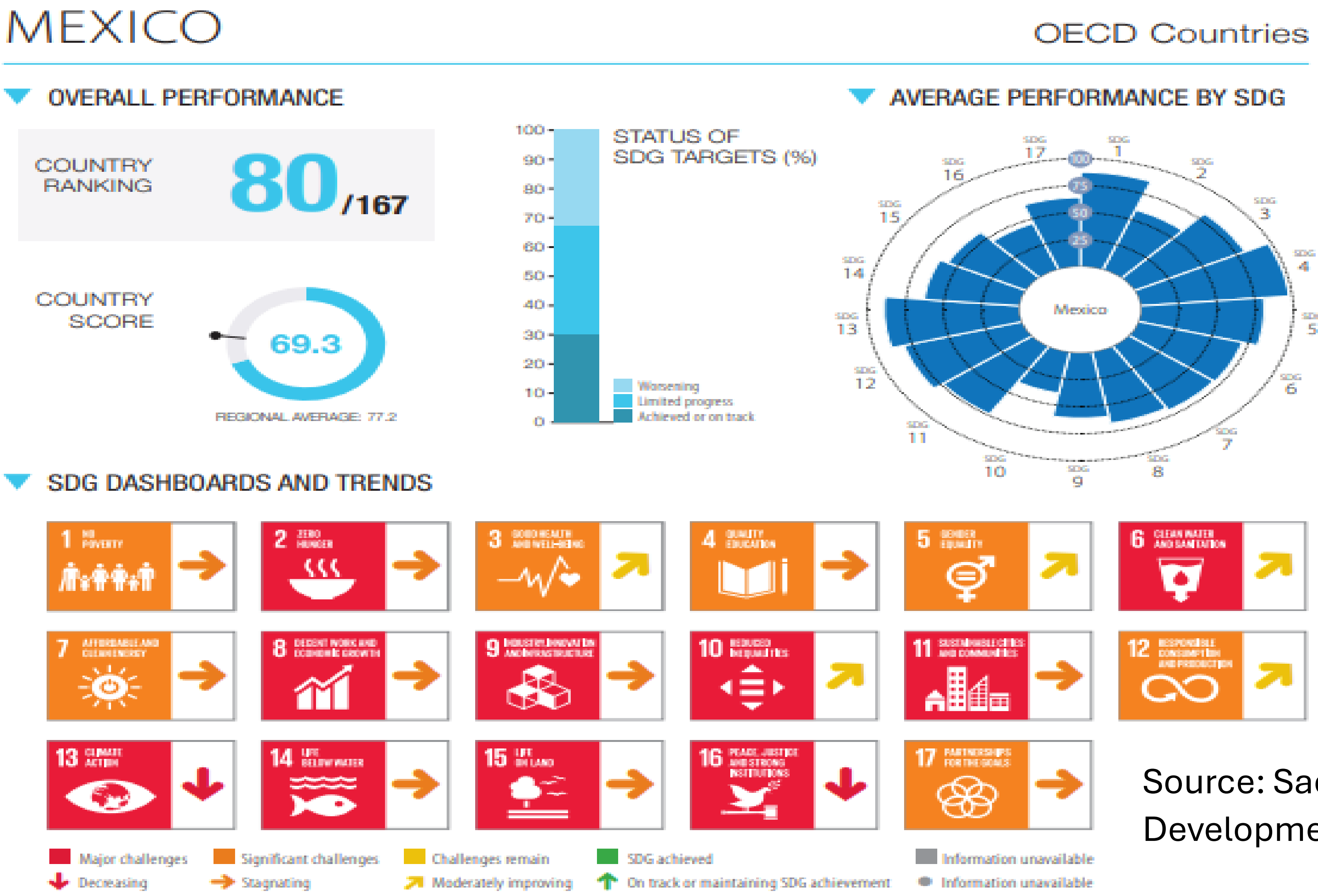
Source: Sachs et al. Sustainable Development Report (2024)

Global Progress of SDGs

Progress assessment for the 17 Goals based on assessed targets, 2023 or latest data (percentage)

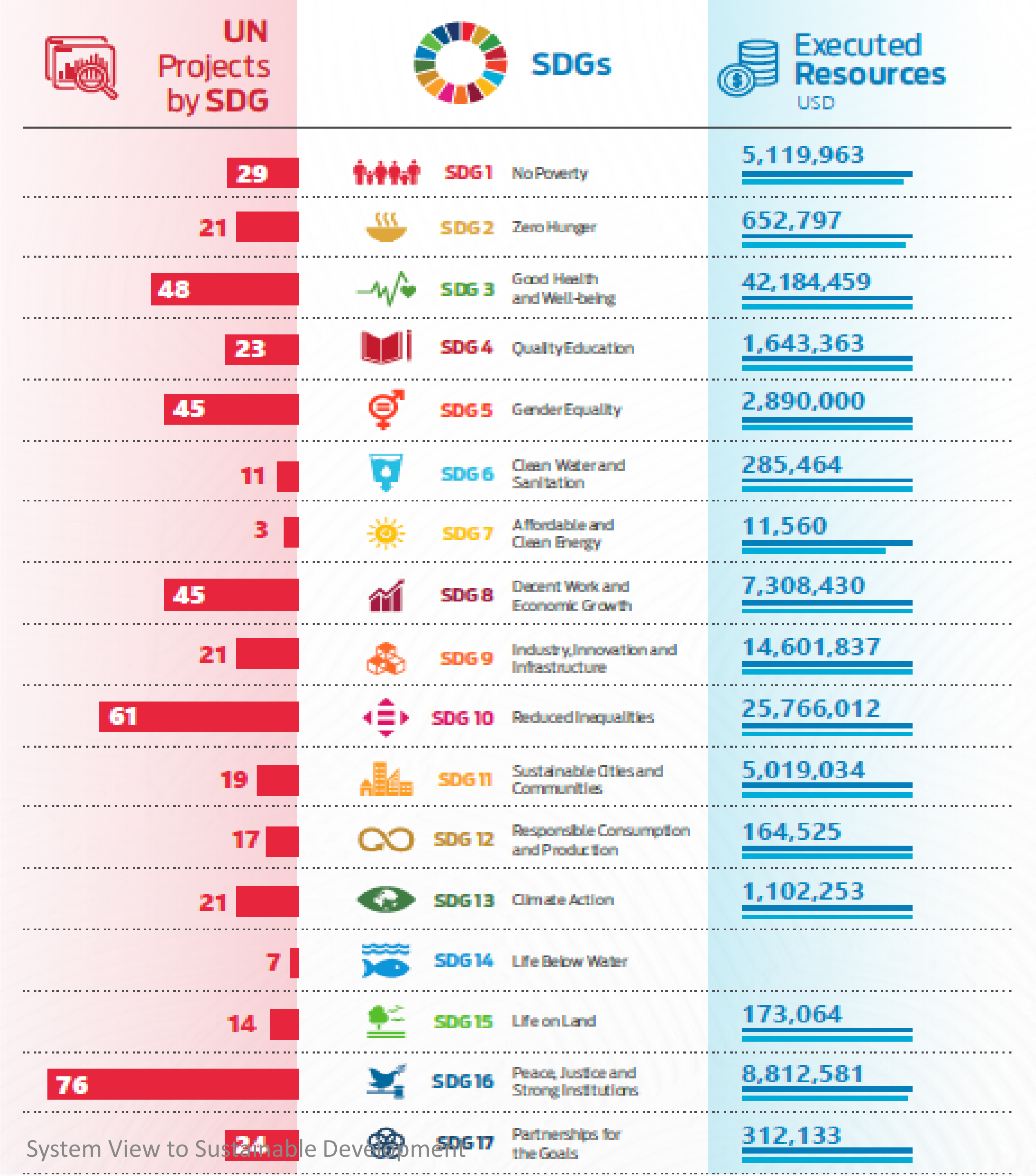


Progress of SDGs in Mexico



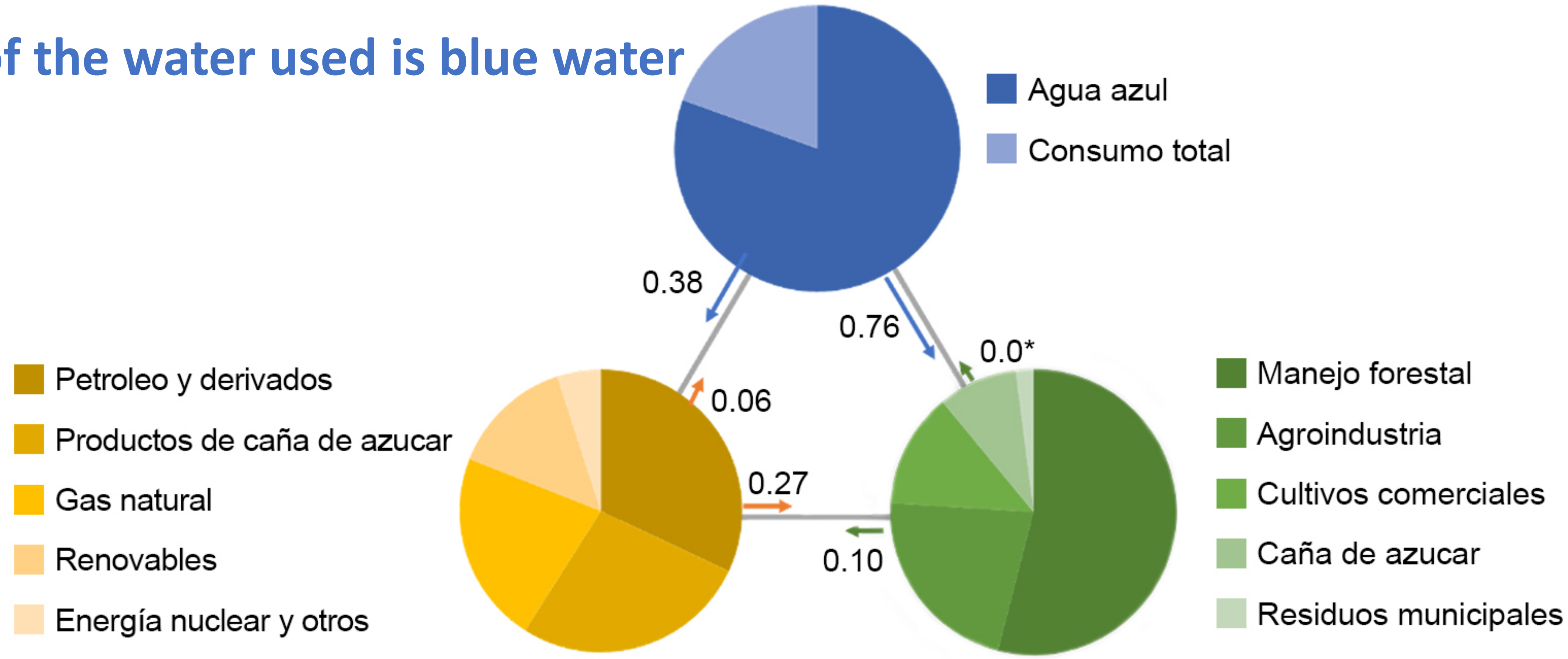
Source: Sachs et al. Sustainable Development Report (2024)

Projects and investment in SDG6 (**water**), 7 (**energy**) and 13 (**climate** action) **<u>have not received a lot of attention</u>** compared to **Health**, **Inequality**, **Decent Work**, **Peace**, **Justice** and **Institutions**.



The Interdependencies of WEF in Mexico

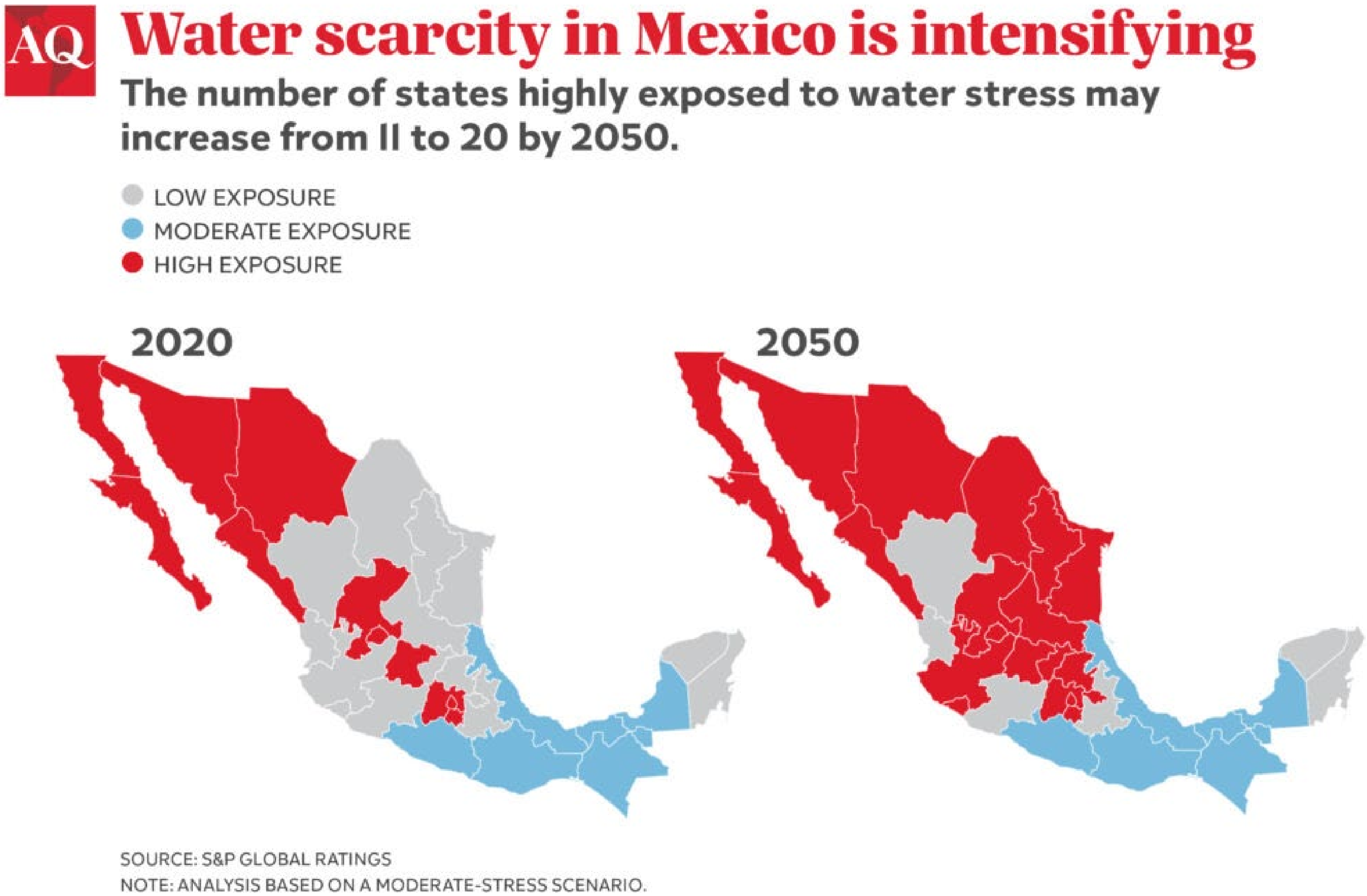
Most of the water used is blue water



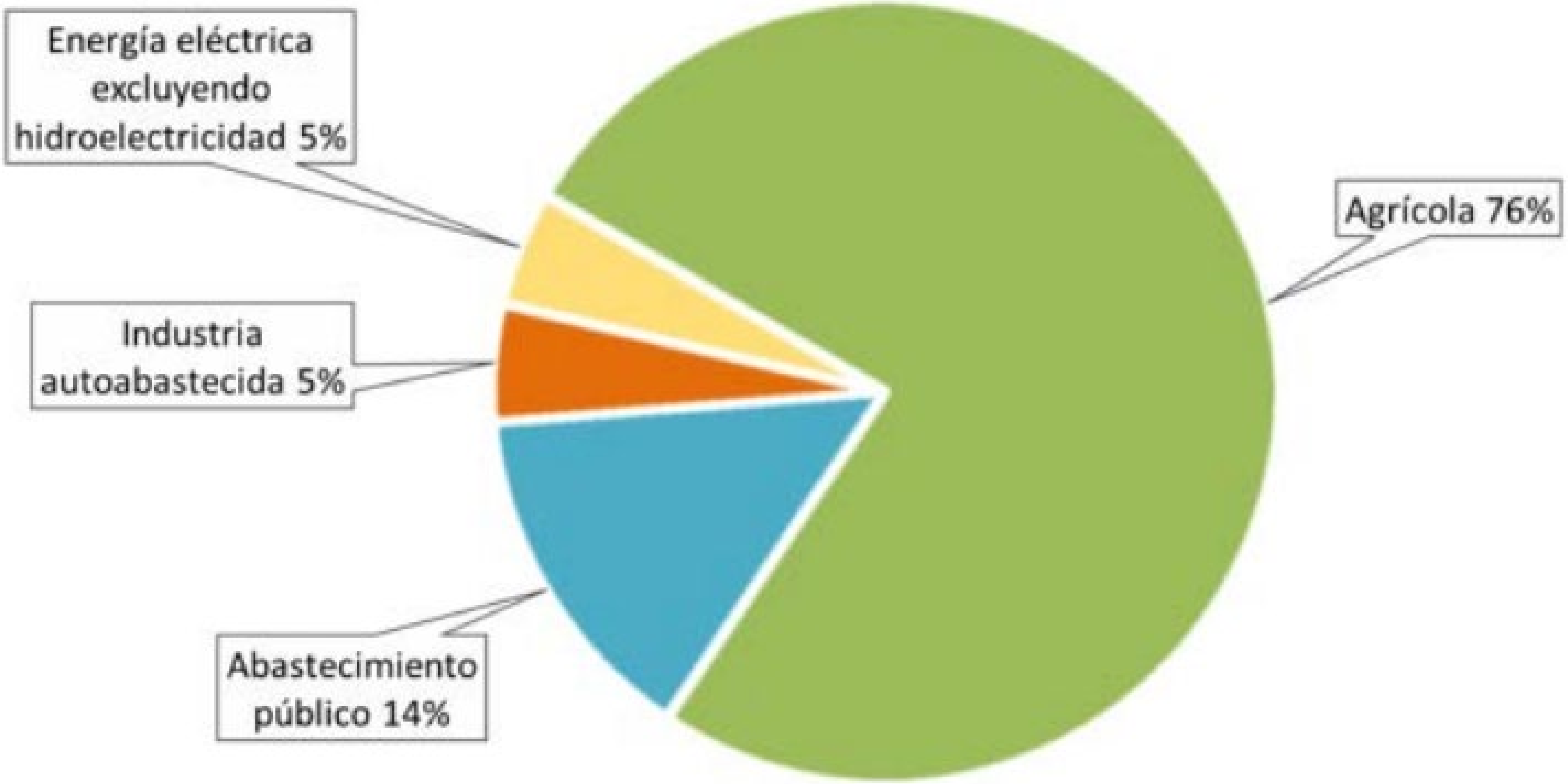
The numbers represent the degree of interlinkages between sectors (0-1)

Source: Malhknekht, 2022

Water Security in Mexico



Water Security in Mexico



Source: Conagua 2018

Water Security in Mexico

- The agricultural sector accounts for 76% of water use
- Municipal supply accounts for 14% , Industry 5%
- Power Production (excluding Hydropower) uses 5% of the water produced
- There are 6.4 million hectares of irrigation infrastructure in the country and productivity in irrigated areas is 2 to 3 times higher than in rainfed areas
- Water losses in agricultural irrigation are estimated to be 40 %
- It is estimated that by 2050 the population in Mexico will increase by 31 million inhabitants.

Highlights of Water Security in Mexico

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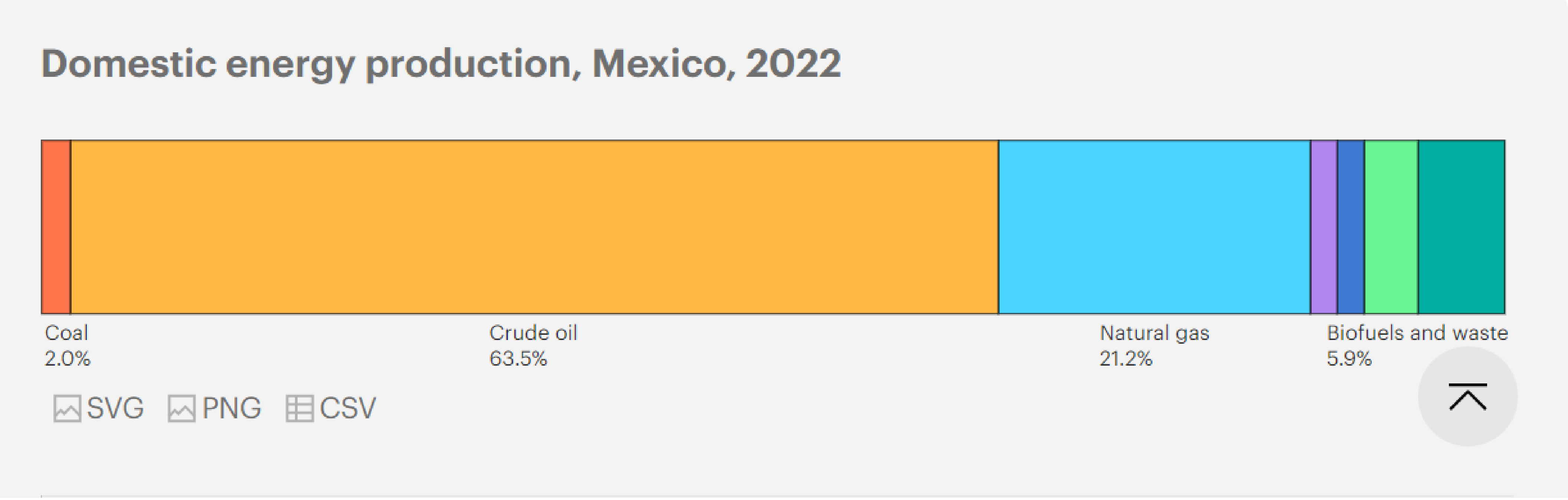
- Around 45% of Mexico City's population have access to uninterrupted supplies of water; around 25% have accesss 3 times per week and around 30% have to buy intermitently by truck-loads or 'pipas'. (El Economista, 2024)
- Nationwide, groundwater accounts for 64% of the volume for public water supply, the rest mostly surface water. No significant use of alternative water was reported.
- Water stress: Mexico City (120% of resources), Baja California (86% of resources) and in Sonora in the Northwest (79% of resources).

Virtual Water and Exports

The exports of the beverage industry, including bottled water, alcoholic and nonalcoholic products, has steadily been increasing. Similar trends in exported fruits and vegetables. They create a **negative water footprint.**

Industry: Virtual Water and Exports

Energy Security in Mexico



Source: IEA, 2022

Energy Security in Mexico

Net energy imports

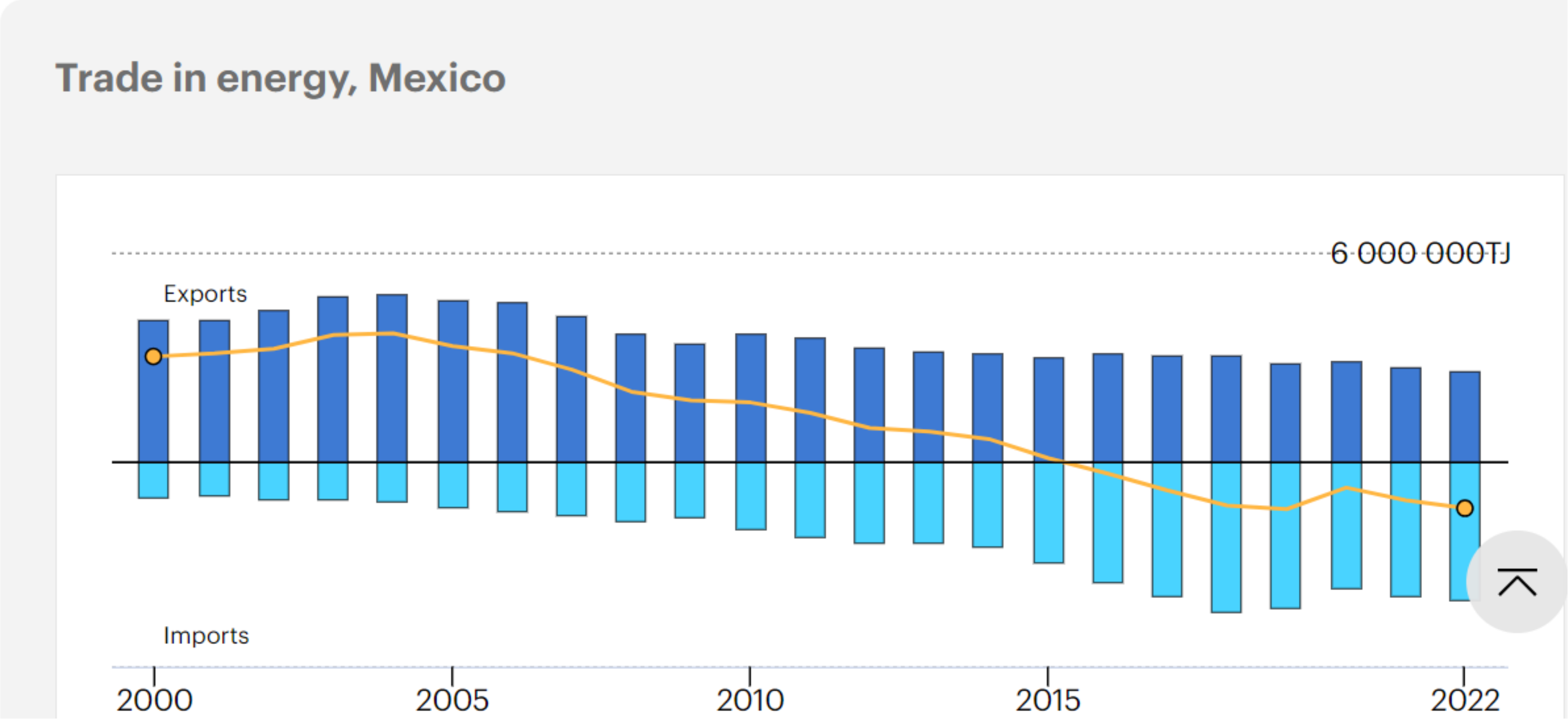
17.9%

of 2022 total energy supply

Trend in energy imports

↑274%

change 2000-2022



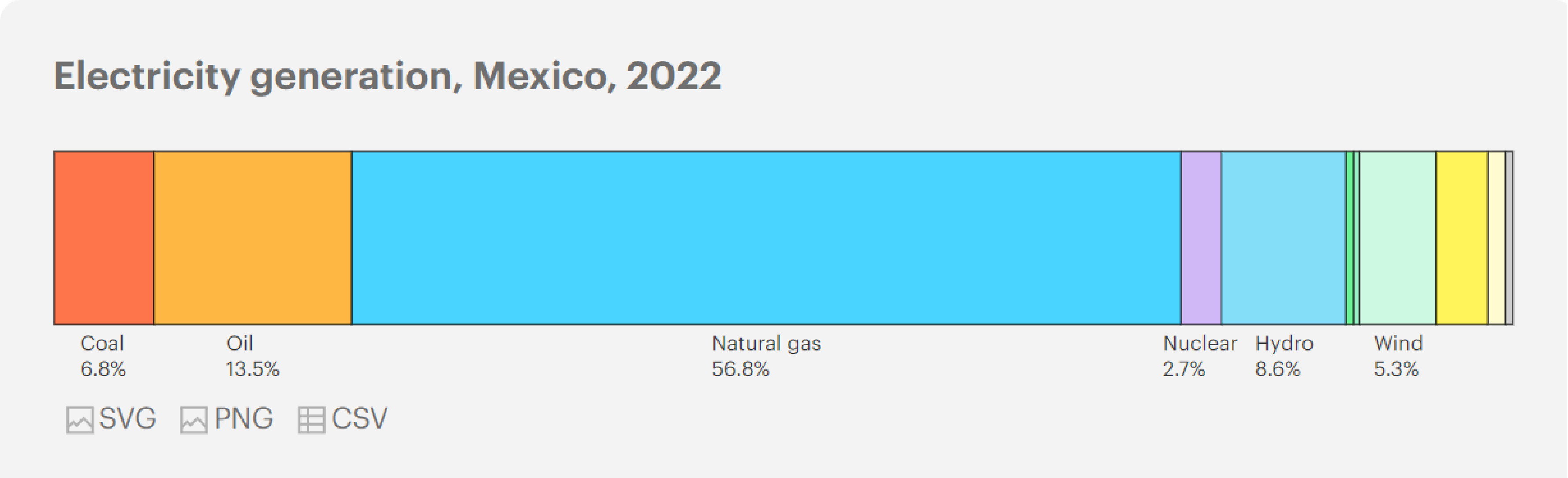
Source: IEA, 2022

Power Generation Portfolio

Natural gas

57%

of total generation



Source: IEA, 2022

Highlights of Power Generation

- A Mexican report to the UN reported **35%** of energy produced from **renewables**: hydro (14.7%), wind (8.1%), solar (6.7%), nuclear (1.9%) geotermal (1.1%).
- Pemex used a $2 billion bond to refinance some of its nearly $105 billion debt in the third quarter 2022.
- Private investment in Mexico's energy production and exploration is growing. In 2022, private companies funded 5% of total oil production, up from almost none in 2017.
- Still, there's a **downward trend in Mexico's oil production** that began in 2004. In 2022, Mexico's oil production was nearly 2 million barrels per day (b/d), 1.93 million b/d in 2023 and forecasted 1.91 b/d in 2024

Source: EIA

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Hydropower Power Generation

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- **Hydropower** makes up **80%** of Mexico's **renewable** energy supply. Yet following recent droughts, the industry is at risk.
- Mexico has established a goal of **increasing clean energy** within its energy matrix **to 35% by 2024**, from 25.5% in 2020. However, this transition is at **risk due** to more frequent **droughts**.
- Conagua defines water **limits for power generation** based on availability (with **irrigation** and **municipal** supply being the priority), hydroelectric plants located in states dependent on agriculture, such as Michoacan, face higher supply risks.
- So, how will the country fill the energy gap?

Energy Consumers

Transport

37%

of total final consumption

Industry

31%

of total final consumption

Source: IEA, 2022

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Industry Becoming Less Energy Intensive

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Despite the trend, industrial **electricity consumption is very high** (64% in 2023), partly because large commercial buildings are included and transnational companies moving to Mexico.

Manufacturing energy intensity in Mexico

Total, 2020

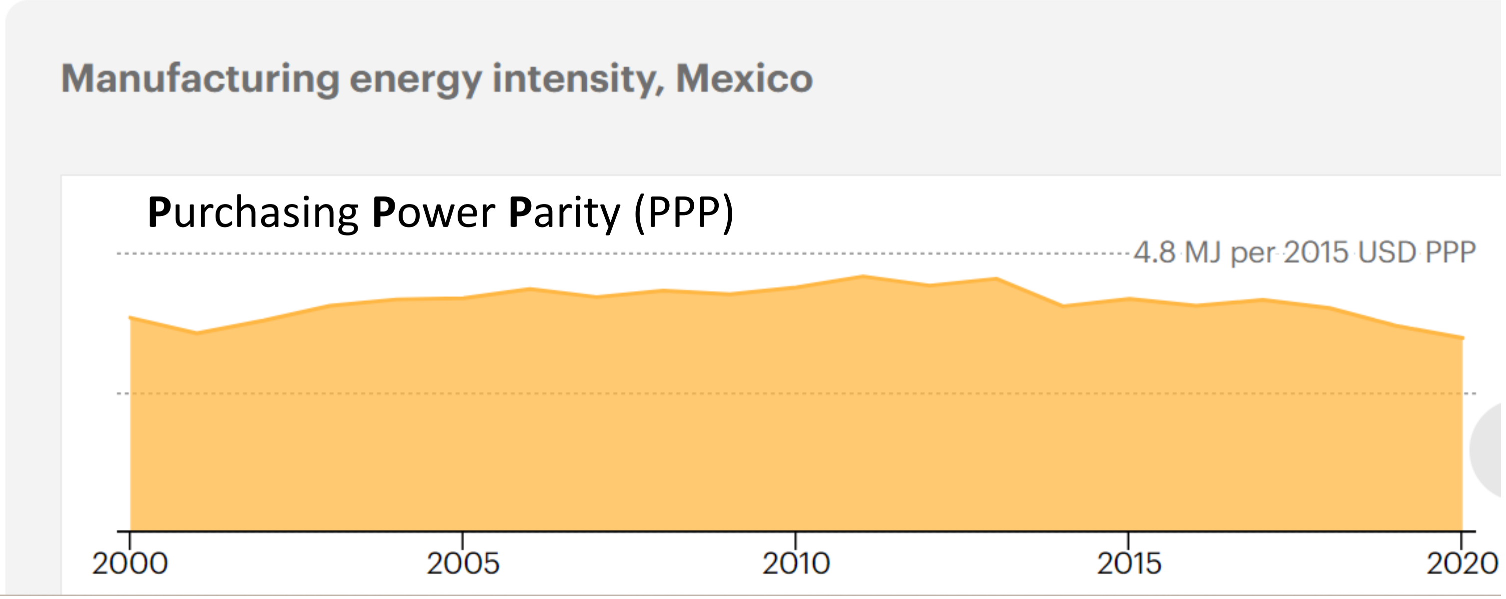
3.35

MJ per 2015 USD PPP

Trend

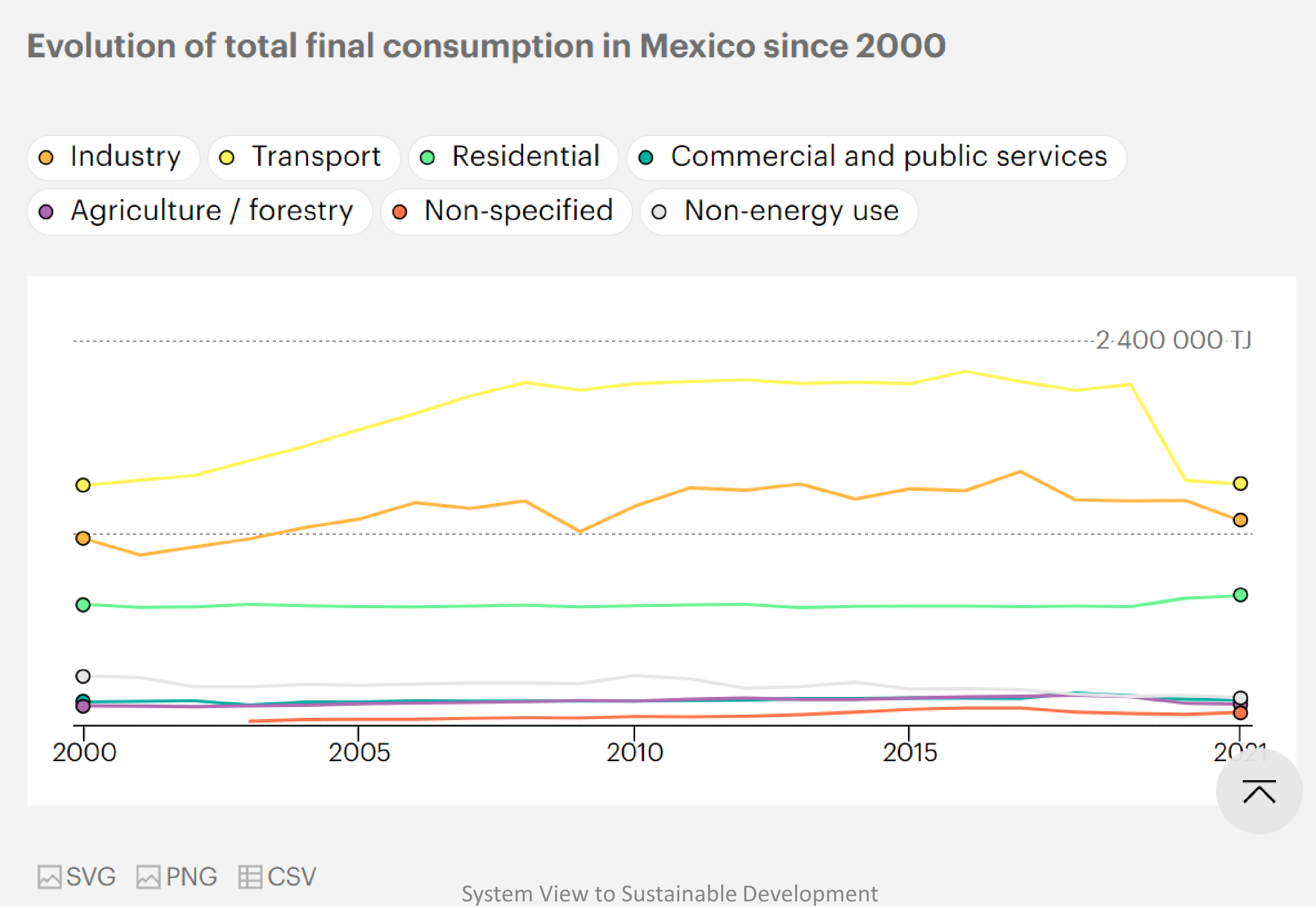
↓9%

change 2000-2020



Source: IEA, 2022

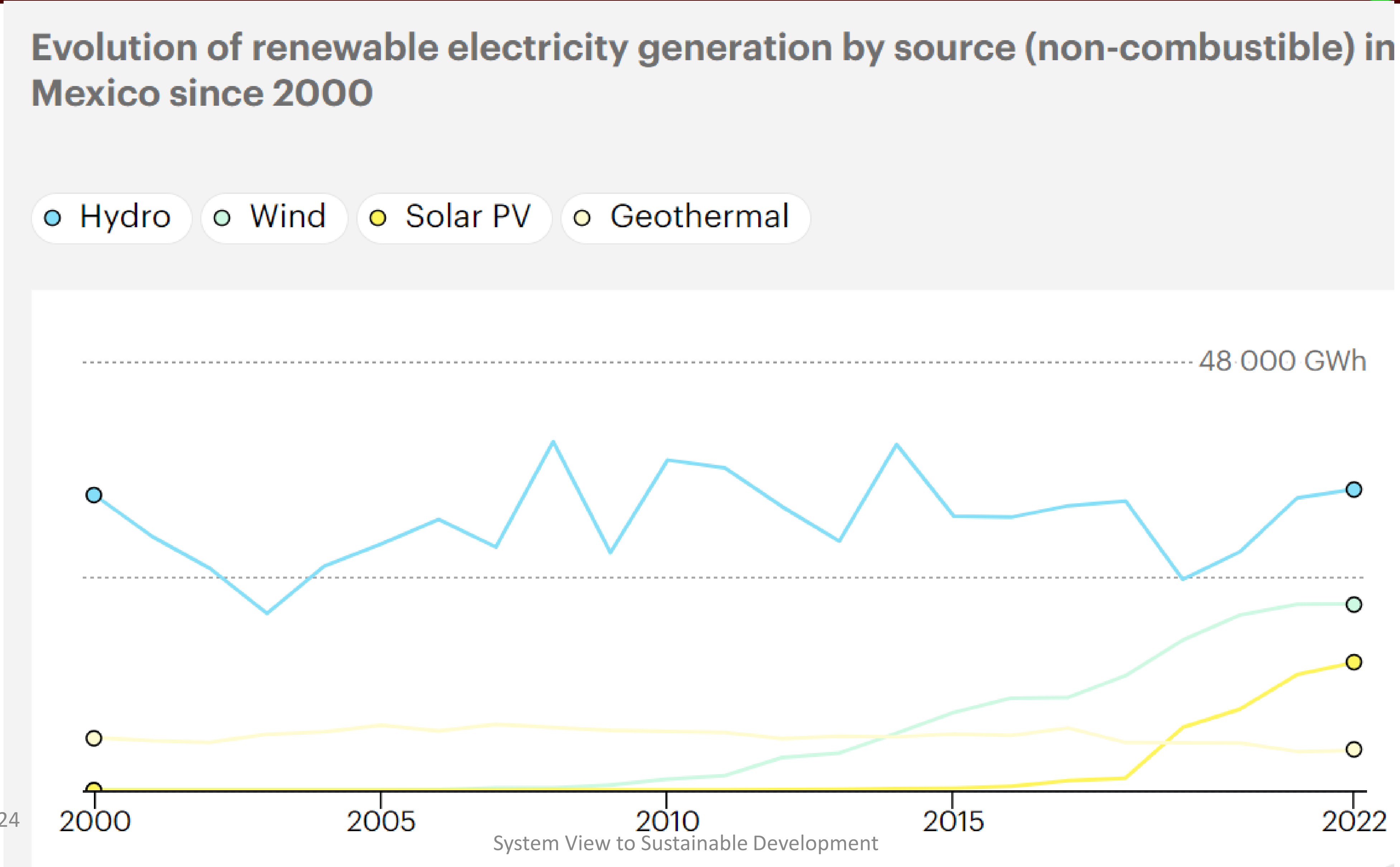
Energy Consumers



System View to Sustainable Development

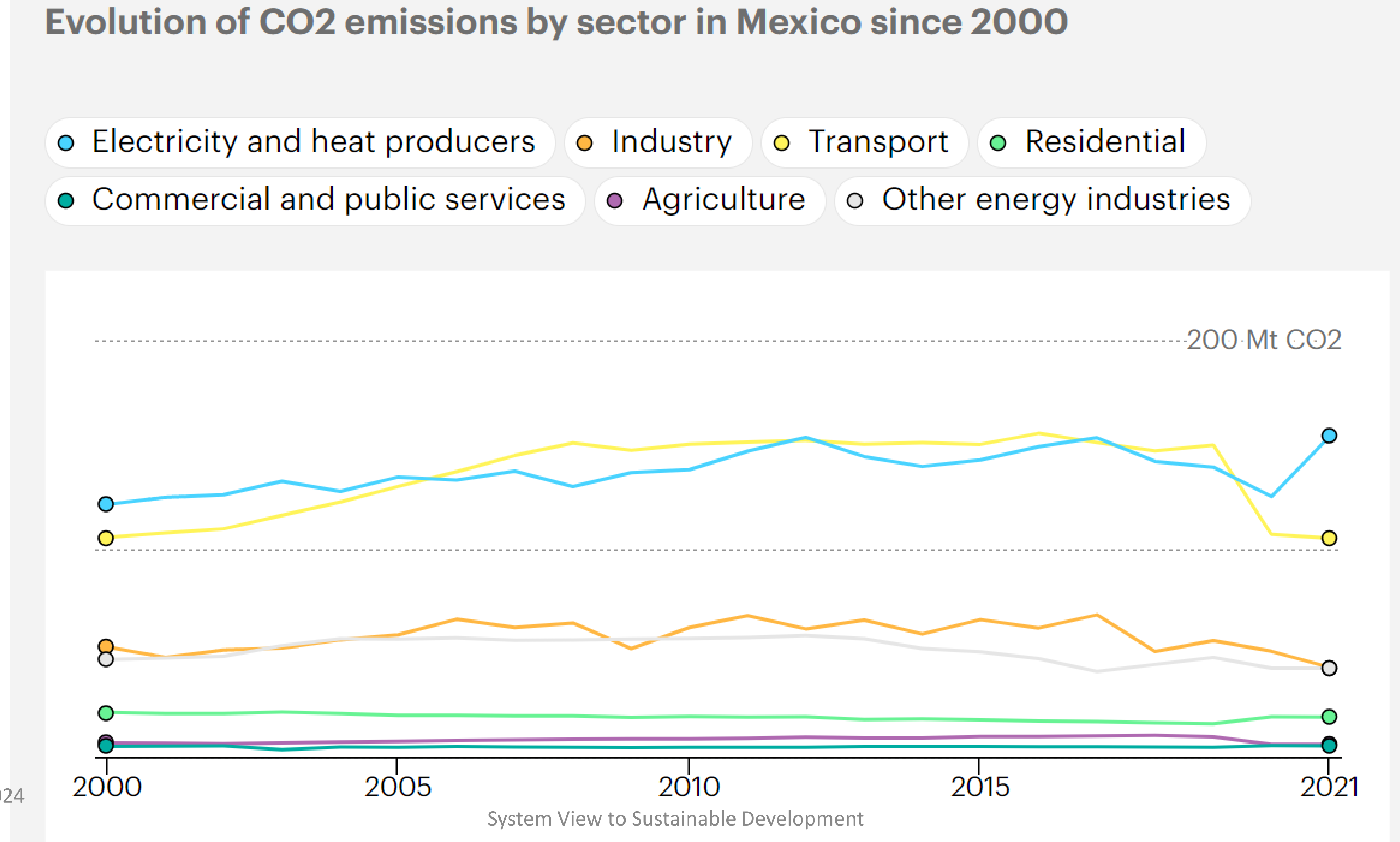
Source: IEA, 2022

Renewables Portfolio



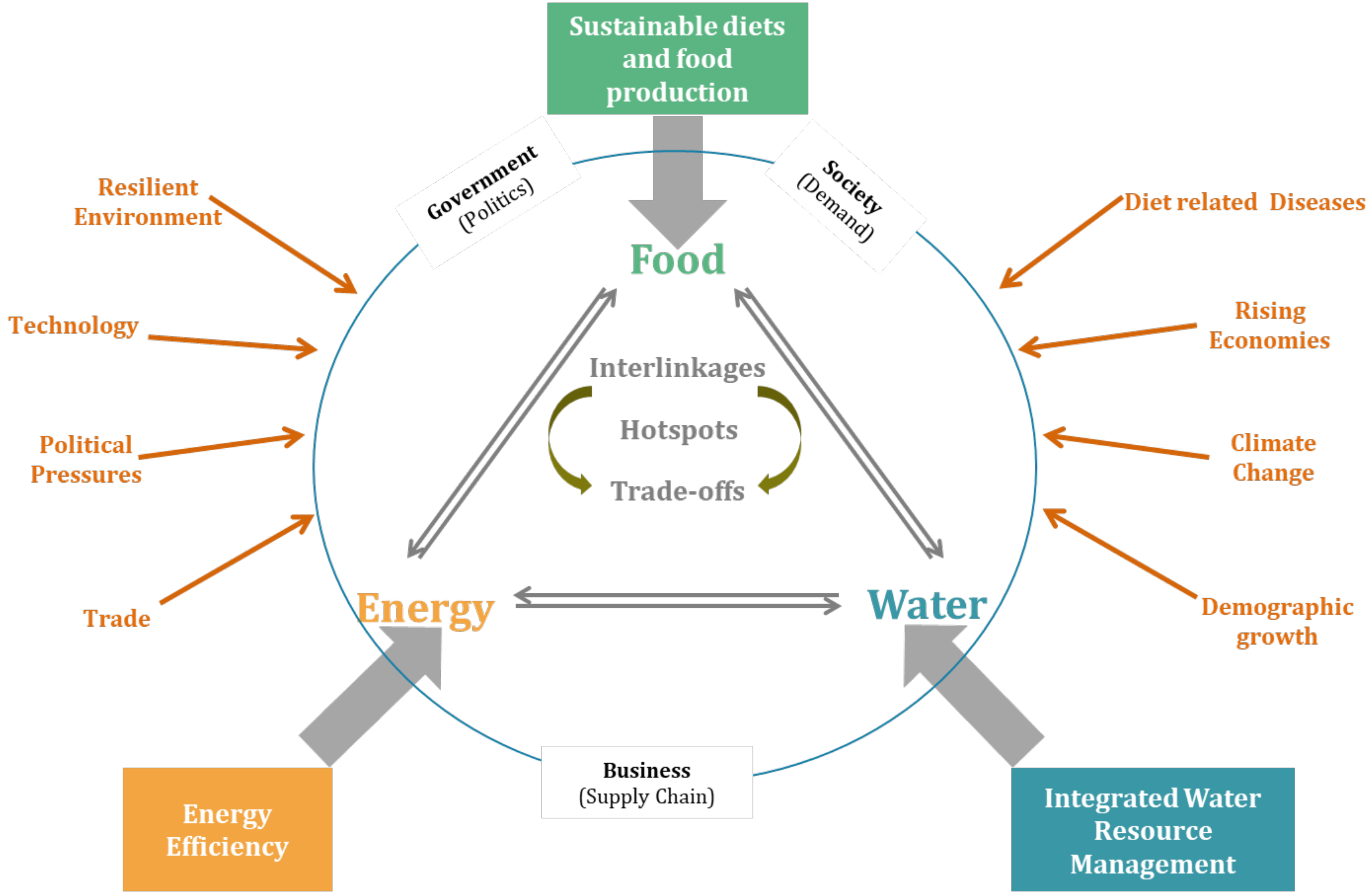
Source: IEA, 2022

CO2 Emissions by Sector



Source: IEA, 2022

A "Novel" Systems Approach



SDGs The Ultimate Nexus

SDGs Interactions

WEF Sustainable Development Goals in Morocco

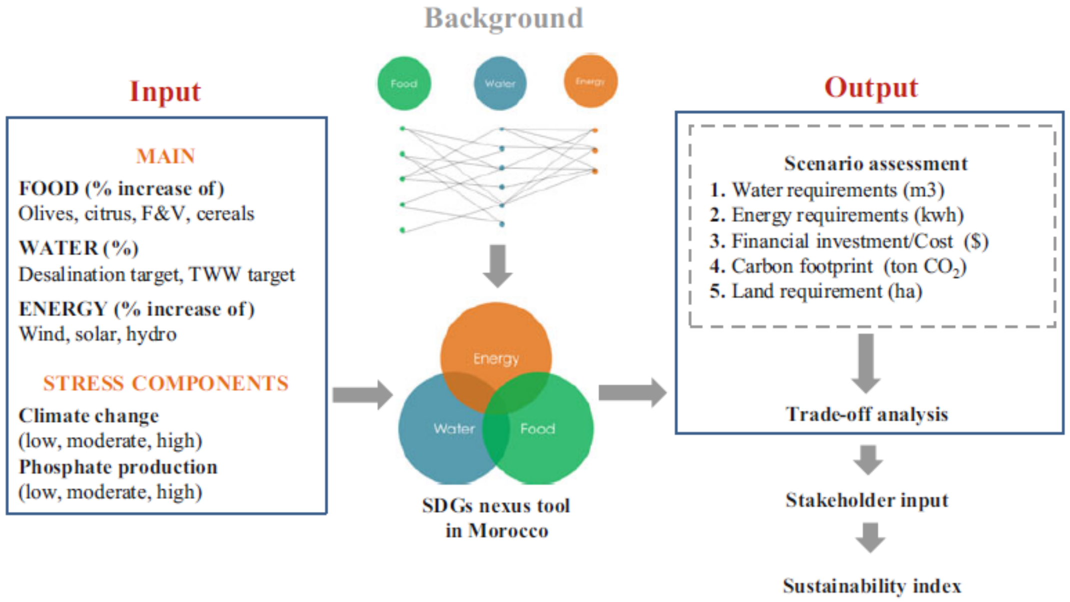
Goal 2: FOOD	Goal 6: WATER	Goal 7: ENERGY
2 ZERO HUNGER — End hunger, achieve food security and improved nutrition and promote sustainable agriculture	6 CLEAN WATER AND SANITATION — Ensure availability and sustainable management of water and sanitation for all	7 AFFORDABLE AND CLEAN ENERGY — Ensure access to affordable, reliable, sustainable, and modern energy for all
Target 2.4	**Target 6.6**	**Target 7.2**
By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production…	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	By 2030, increase substantially the share of renewable energy in the global energy mix

Local Indicators

Level of production of Olives, Citrus, Fruits, and Vegetables	Level of water stress (%) 35.7% (AQUASTAT, 2010)	Renewable energy share in the total final energy consumption – 11.3% (IEA, 2014)

National Strategies

Green Morocco Plan	Morocco Water Strategy 2030	Morocco Energy Strategy 2030
% olive production: Increase 76%	Desalination: 400,000,000 m 3	Solar: 2 GW
% citrus production: Increase 54%	TWW: 300,000,000 m3	Wind: 2 GW
% fruits and vegetables: Increase 40%		Hydro: 2 GW
% cereals: Decrease 20%		% renewable: Increase up to 42%



Water-Energy-Food Sustainable Development Goals in Morocco

Bassel Daher[1] and Rabi H. Mohtar[2,3]
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[2]Department of Biological and Agricultural Engineering and Zachry Department of Civil Engineering, Texas A&M University, College Station, TX, USA
[3]Faculty of Agricultural and Food Sciences, American University of Beirut, Beirut, Lebanon

In September 2015, world leaders committed to work toward achieving 17 Sustainable Development Goals (SDGs) as part of their 2030 sustainable development agenda. Each Goal includes a list of quantifiable targets to achieve during the 15-year term. As each nation works toward achieving this agenda, there are risks of potential competition between specific targets, which could cause unintended consequences and additional. These issues become particularly complex when focusing on the three highly interconnected Water, Energy, and Food Goals (2, 6, and 7): the strategy for one directly affects the other two. While it is important that we work toward achieving all 17 Goals, it is equally important that we understand the level of their interconnectedness and the potential competition between them.

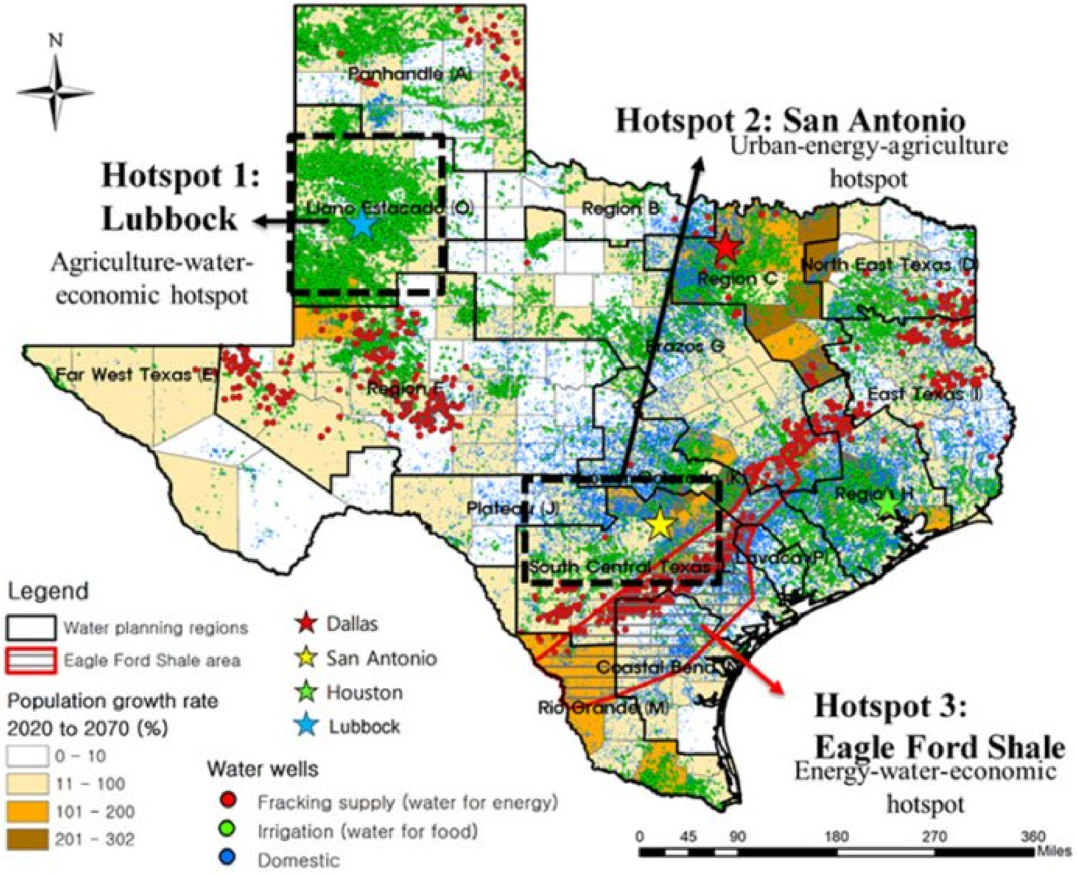
The challenges facing water, food, and energy

WEF Sustainable Development Goals in Morocco

1. **Competition** exists between achieving different national strategies for **WEFL** and **Financial** resources.
2. Morocco's strategy to **reallocate 20%** of land currently used for **cereal production** to grow other crops **reduces stresses on land and water resources** for **less self-sufficiency in cereals**, and to **allocate** those resources to **renewable energy**.
3. Investing in **renewable energy** carries **high costs** and considerable **water use**; still, it provides Morocco with a higher **energy security and CO_2 reduction**.
4. **Trade-off** in using **desalination and TWW** for **water security** is **increased energy** use.
5. **Overall, SDGs** offer an important framework for goals toward which nations can work to **improve social, economic, and environmental indicators**.

WEF Nexus Approach to Bridging Texas Water Gap

Spatially distributed distinct and complex hotspots, which require a holistic system of system approach, yet with localized solutions for bridging the water gap.



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Towards bridging the water gap in Texas: A water-energy-food nexus approach

Bassel Daher [a,b], Sang-Hyun Lee [b], Vishakha Kaushik [c], John Blake [c], Mohammad H. Askariyeh [c,d], Hamid Shafiezadeh [e], Sonia Zamaripa [b], Rabi H. Mohtar [b,c,f,*]

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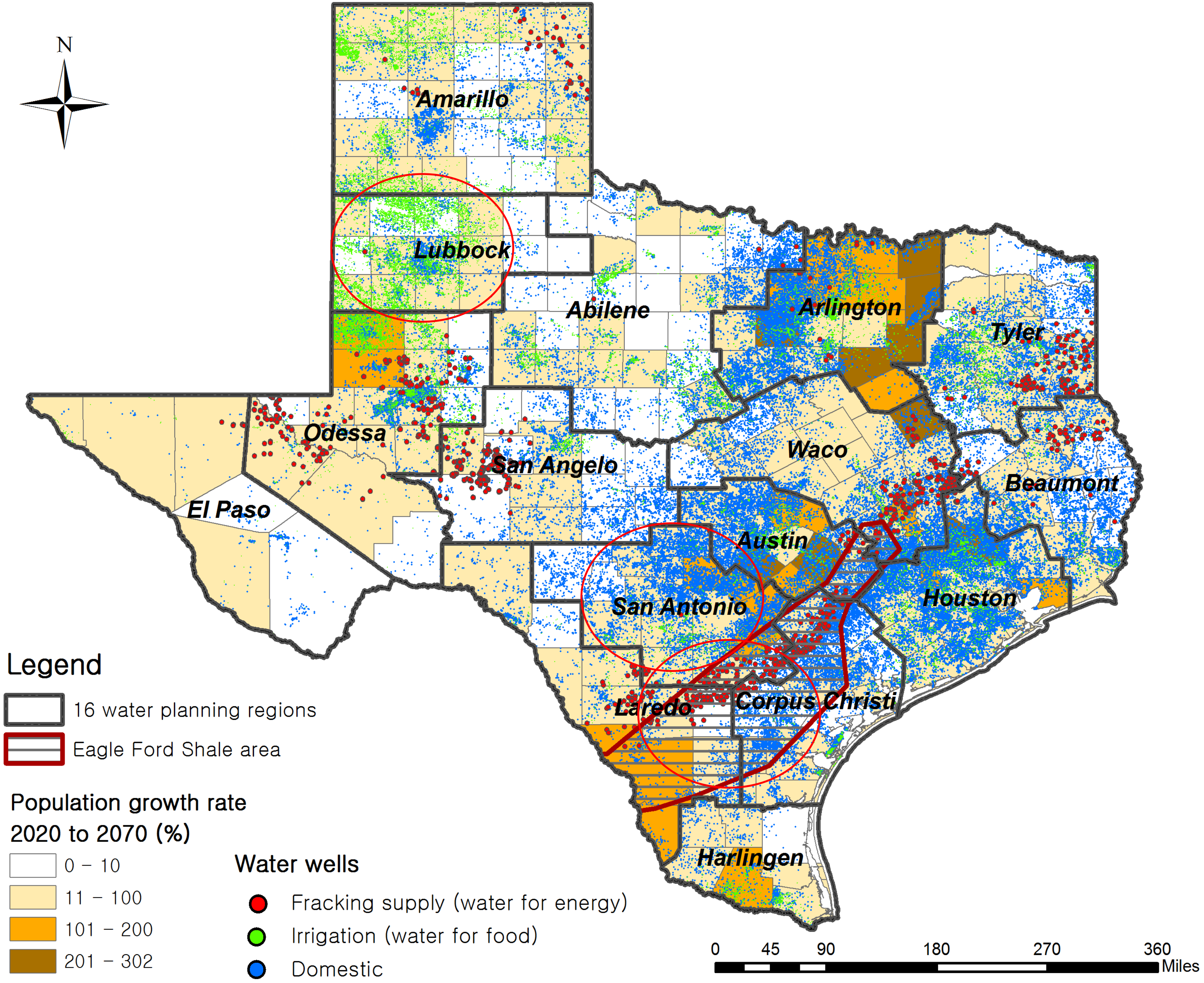
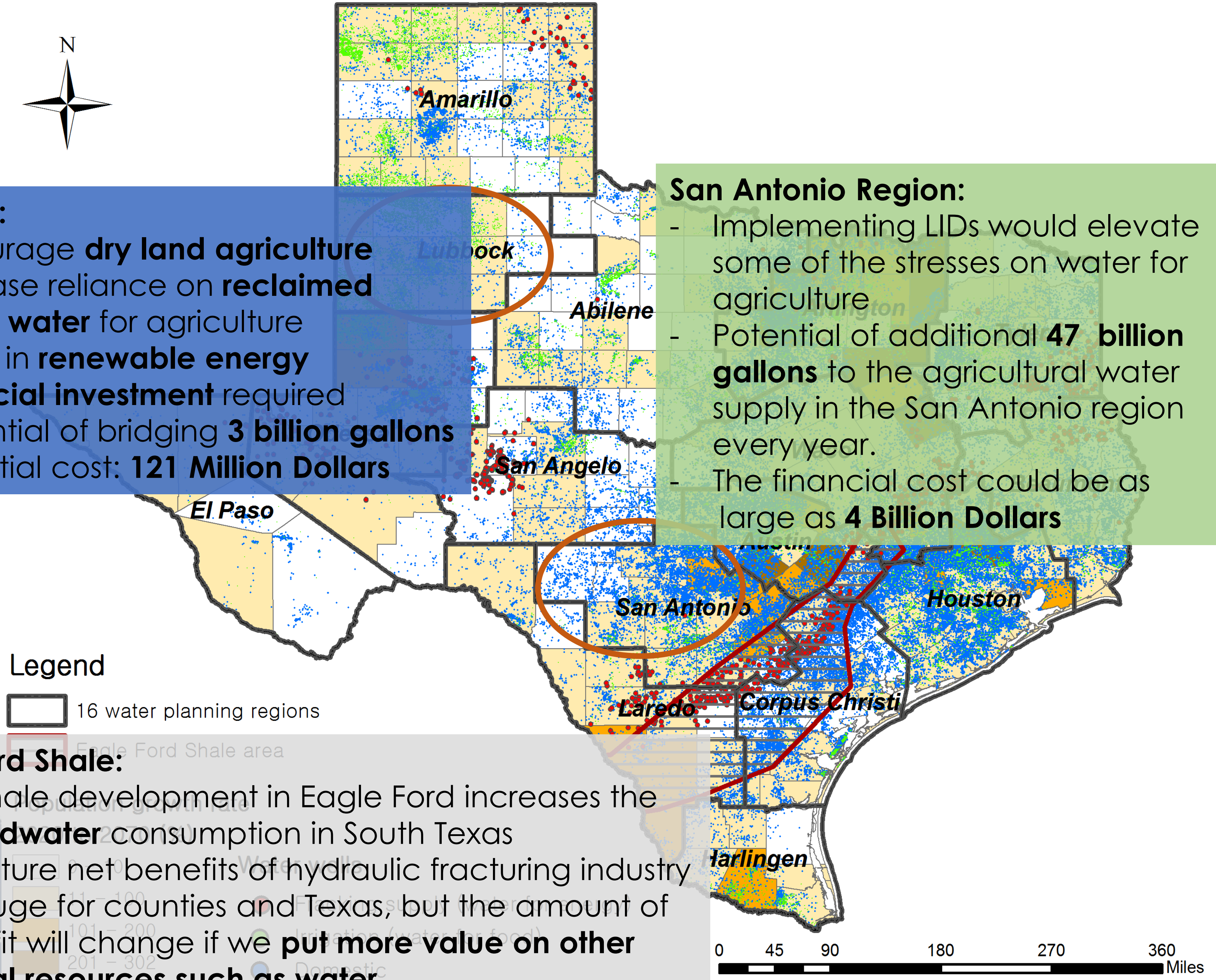

N
Amarillo
Lubbock
Abilene
Arlington
Tyler
Odessa
San Angelo
Waco
Beaumont
El Paso
Austin
San Antonio
Houston
Laredo
Corpus Christi
Harlingen
Legend
16 water planning regions
Eagle Ford Shale area
Population growth rate
2020 to 2070 (%)
0 – 10
11 – 100
101 – 200
201 – 302
Water wells
Fracking supply (water for energy)
Irrigation (water for food)
Domestic
0
45
90
180
270
360
Miles



Lubbock:

- Encourage **dry land agriculture**
- Increase reliance on **reclaimed waste water** for agriculture
- Invest in **renewable energy**

→ **Financial investment** required

→ Potential of bridging **3 billion gallons**
Potential cost: **121 Million Dollars**

San Antonio Region:

- Implementing LIDs would elevate some of the stresses on water for agriculture
- Potential of additional **47 billion gallons** to the agricultural water supply in the San Antonio region every year.
- The financial cost could be as large as **4 Billion Dollars**

Eagle Ford Shale:

- The shale development in Eagle Ford increases the **groundwater** consumption in South Texas
- The future net benefits of hydraulic fracturing industry are huge for counties and Texas, but the amount of benefit will change if we **put more value on other natural resources such as water.**

Energy Assessment Tools

WET Tool

Quantify the interrelations and trade-offs between the water, energy, and transportation sectors under different scenarios:

1. Increasing (or decreasing) production
2. Changes in oil and gas market price
3. Different lateral lengths
4. Amount of reused water
5. Varying modes of transport for water/oil/gas

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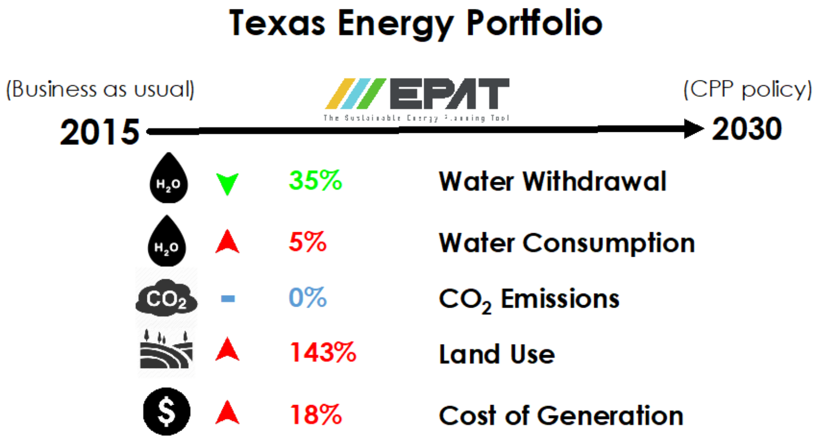
WEF NEXUS INITIATIVE

Matagorda County, Texas

Annual income could increase by as much as $32 million over the current "business as usual" mainly addressing the agricultural sector, which currently suffering from lack of water.

Energy Portfolio Assessment Tool (EPAT)



EPAT shows that the **CPP policy succeeds in mitigating the carbon emissions** by:

- sustaining same level even after capacity increase,
- in **decreasing the water withdrawal volumes in generation by 35%.**

On the other hand, the **CPP policy increases water consumption by 5%, land use by 143%** and **cost by 18%.**

WET – Tool: Economic, Social, and Environmental Evaluation of Energy Development in the Eagle Ford Shale Play

Science of the Total Environment 646 (2019) 1601–1614

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Economic, social, and environmental evaluation of energy development in the Eagle Ford shale play

Rabi H. Mohtar [a,b,c,*], Hamid Shafiezadeh [d], John Blake [b], Bassel Daher [a,e]

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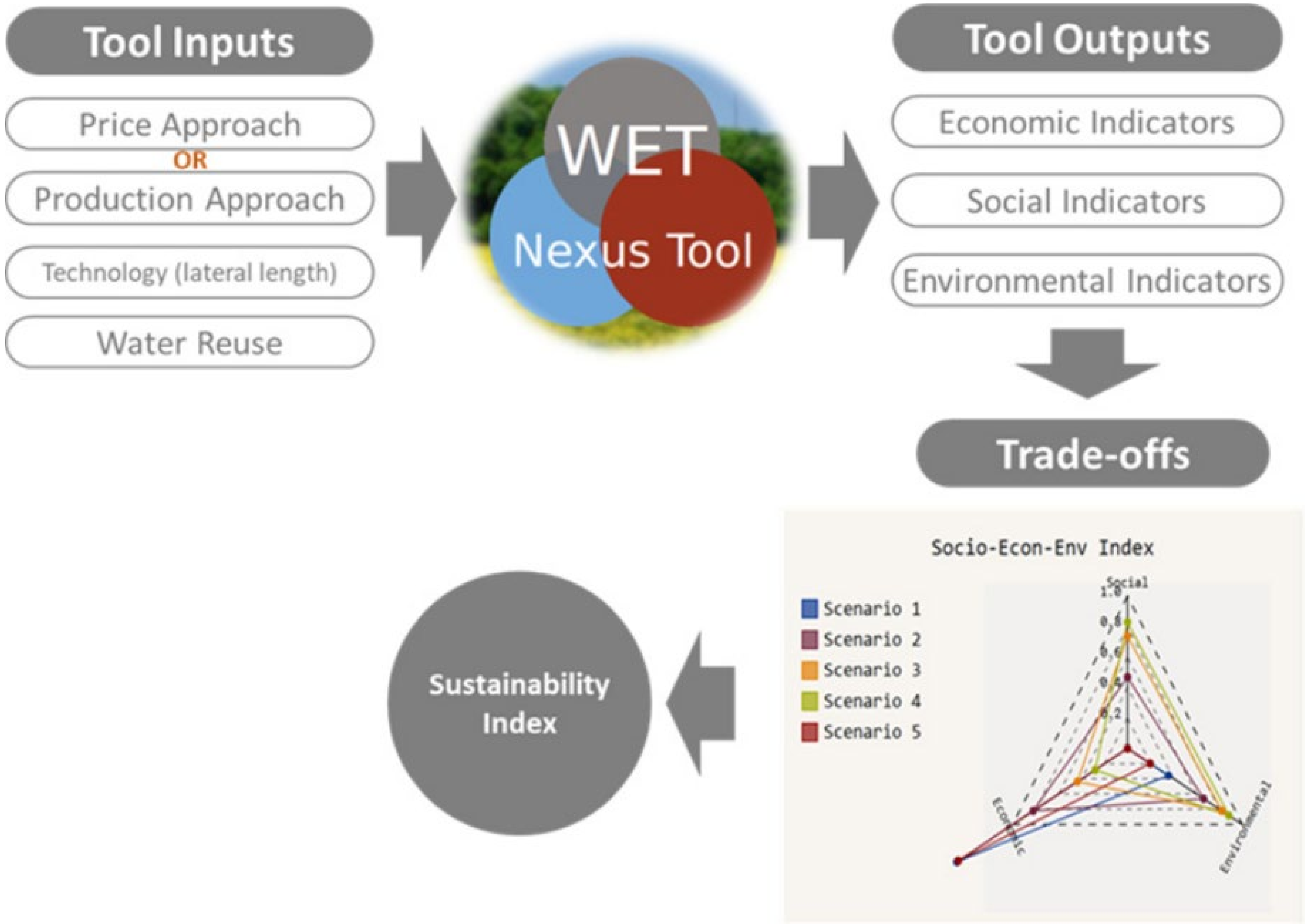
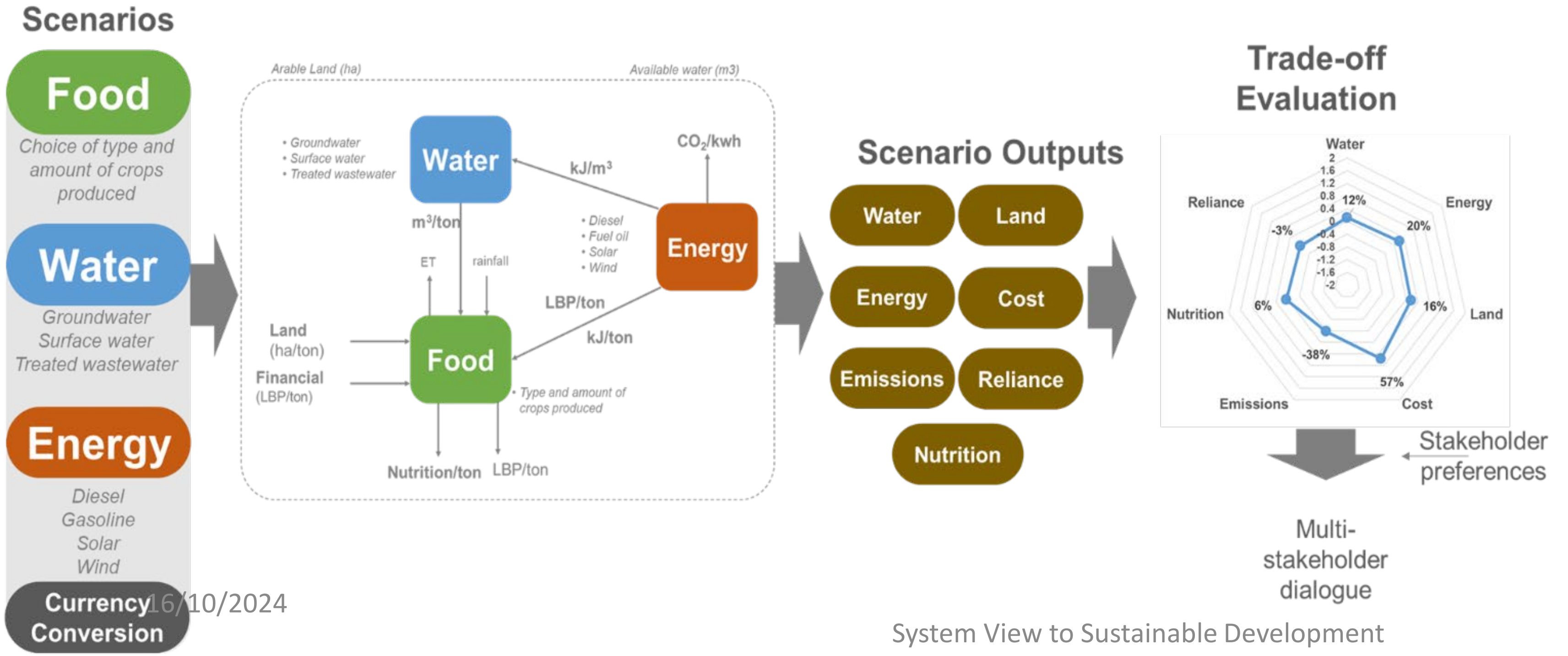


A Water-Energy-Food Nexus Approach for evaluating the sustainability of the Mediterranean Diet: *The case of Lebanon*

Food and Agriculture Organization of the United Nations

Study Objectives:

1. **Develop a framework to quantify the trade-offs** associated with adopting interventions within current water, energy, nutrition, and agriculture portfolios and practices.
2. **Evaluate producers'** perceptions toward their **willingness to implement** proposed changes in crop selection, renewable energy, and water reuse.



Accepted
Original Research

Food security under compound shocks: Can Lebanon produce its own Mediterranean food basket?

Bassel Daher, Roula Bachour, Sandra Yanni, Sasha Koo-Oshima and Rabi H. Mohtar

Handling Editor:
Yanjun Shen

Frontiers in Sustainable Food Systems
Water-Smart Food Production

Circular Food and Agricultural System (FAS) – in Partnership with FAO and ASABE

Inputs:

Renewable Water

Renewable Energy

Recycled Nutrients

Waste / Water Reuse

Outcomes

Nutrition/Human Centric

Reduced CO_2 emission

Reduced Chemical/ Biological Pollutants

Reduced Food Waste and Loss

Reduced Water, Land, Energy Footprint

Scenarios for:

1. Dairy System
2. Open field Agriculture
3. Indoor production

Mohtar, 2021

Final Remarks (WEF Nexus)

Bridging the resources gap (Water-Energy-Food) requires:

- **multi-stakeholder** approaches
- Accounting for the **spatial and temporal distribution** of resources
- Accounting for **interconnections** between competing resource systems and growing stresses
- Proper **communication of trade-offs** between resource systems associated with different growth trends among resources demanding sectors
- Governance challenges: **who pays for it?**
- Solutions are **Holistic** yet **localized!**

Final Remarks (SDGs)

- From the 169 targets set to achieve the **SDGs, only 15%** are on track and many of them have shown either stagnation or regression.
- The Water-Energy-Food nexus approach has highlighted the utmost importance of understanding the **interconnections of systems** to accelerate the achievement of the Sustainable Development Goals.
- We must look at **integrative outcomes**, integrative metrics that allow us all to converge and not diverge.
- Overall, there is a lack of **governance coherence**, even the national plans of one sector are sometimes infringing on the national plans of other sectors.

Thank You