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nexus

Understanding the opportunities and challenges of the WEFE Nexus

Session 1 of the PRIMA Online training: „Addressing the Water-Energy-Food-Ecosystems (WEFE) Nexus in the context of Climate change in the Mediterranean region"

Annika Kramer, Dr Sabine Blumstein

Implemented by

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We want to get to know you and your background!

1. From which country are you joining this online training today?
2. In which of the Nexus sectors lies your main professional expertise?
3. Have you previously participated in a WEF Nexus training?
4. What are your expectation on the training? What would you like to learn about?

Outline

Chapter 1:	**Background to the Water-Energy-Food (WEF) Nexus** ▪ Introduction to the WEF Nexus
Chapter 2:	**Water-Energy-Food Interactions** ▪ Concepts of water, energy and food security and trade-offs ▪ WEF Nexus Solutions
Chapter 3:	**Assessment** ▪ Assessment tools for Decision Support

Water, Energy and Food Security: pillars of development!

- Water, Energy and Food Security are at the heart of human survival/wellbeing and economic development
- Therefore, communities strive to achieve water, energy, and food security
- Actions to achieve this may take place at local, national and global level
- Achieving each of these securities requires resources and has external effects

Achieving WEF development goals in a dynamic world

Present

Unmet demands!

- 2.0 billion people have no access to safely managed drinking water (2020)
- 0.8 billion people have no access to electricity (2021)
- 2.4 billion people are food insecure (2020)

Future

Increasing demands!

- Due to population growth, economic development and changing consumption patterns
- The uncertainties of global change exacerbate the difficulty in achieving these goals

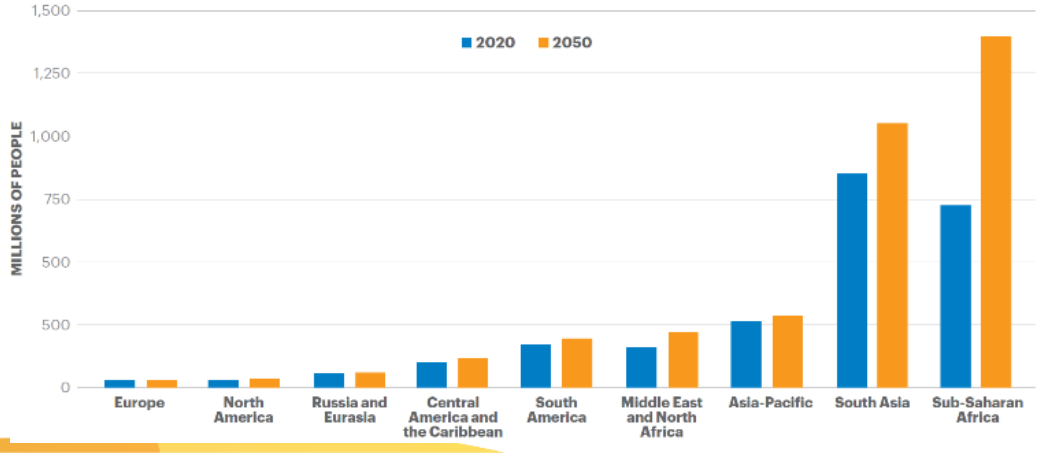


Figure: Food-insecure people by region, 2020 and 2050 projections

Source: IEP, 2021

Single-mindedly pursuing individual goals may interfere with other goals

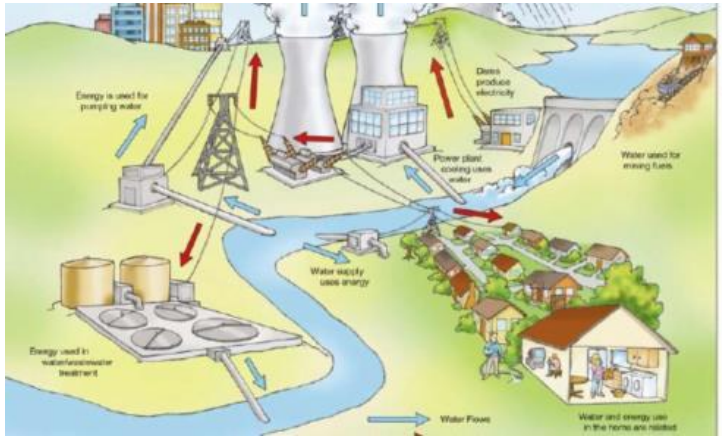
Example: Increasing electricity production

- More abstraction of water for cooling
- Less water for other sectors and the environment
- Less water security

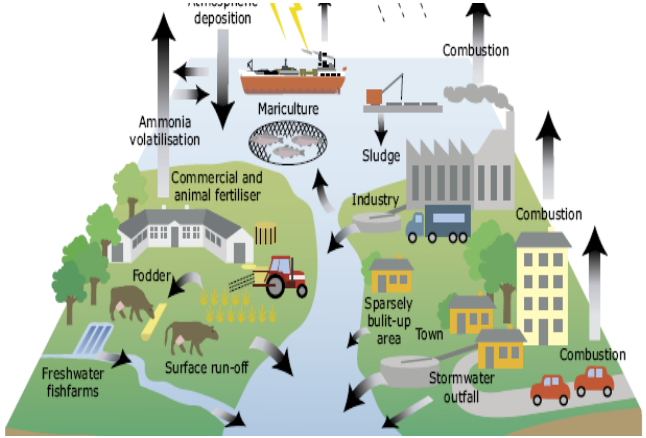
Example: Intensifying agricultural production

- More land used for growing food
- Competition over land resources (eg. biofuels vs. crops as food)
- More use of fertilisers
- Contamination of water resources
- Less water security downstream

→ Need for a systematic WEF Nexus approach!



U.S. Department of Energy, 2006



LaB, 2010

Time for a quick quiz game!

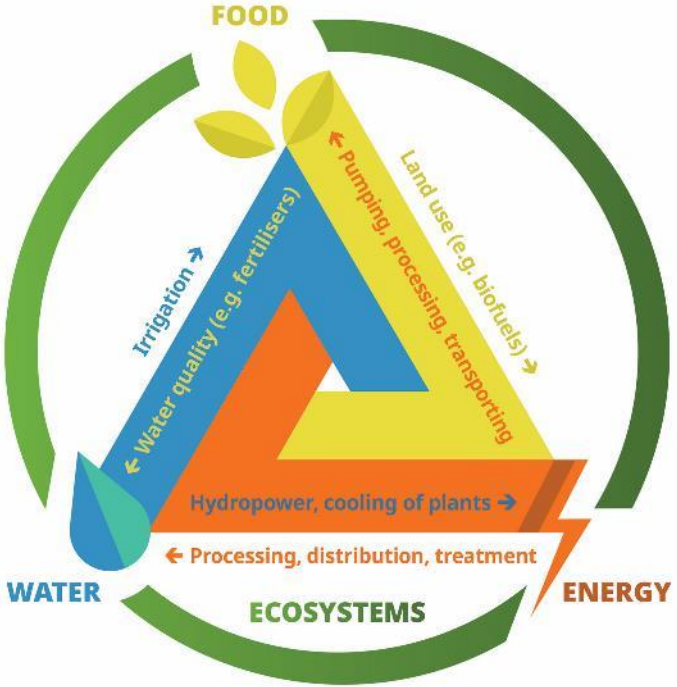
How closely are the WEF sectors interrelated globally?

1. How much water does agriculture withdraw (as a % of total global freshwater withdrawals)?
2. How much water does the energy sector withdraw (as a % of total global freshwater withdrawals)?
3. How much energy do agriculture & food chain account for (as a % of global energy demand)?

The WEF sectors are closely related

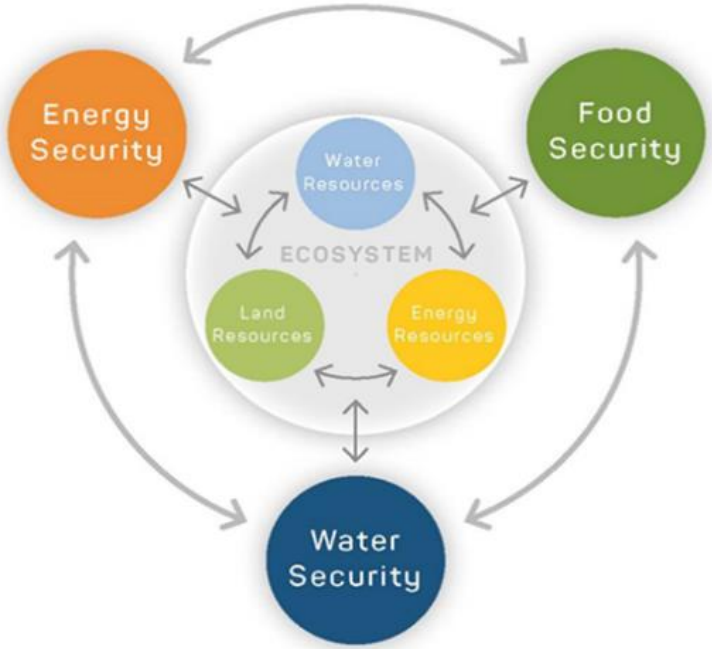
Examples of interconnections:

- Agriculture accounts for 70% of total global freshwater withdrawals
- The energy sector accounts for about 10% to 15% of the global freshwater withdrawal
- Agriculture & food chain account for 33% of global energy demand



GWP, 2019

WEF Nexus from the ecosystem perspective



GIZ, 2016

- Ecosystems take a central role in this WEF Nexus concept
- But there are numerous other frameworks (check out resources at: https://www.water-energy-food.org/)

What is the WEF Nexus approach?

The WEF Nexus provides a holistic and integrated approach in order to secure access to water, energy and food in the long term.

– Global Nexus Secretariat, 2020

What is the WEF Nexus approach?

Key components

A framework to determine trade-offs and synergies

Promotion of policy coherence and multi-sectoral cooperation

A tool to achieve sustainable development

Benefits of Nexus approach

Reducing sectoral trade-offs

Avoid or limit negative externalities

Enhancing resource efficiency

Solutions designed to address multiple challenges simultaneously

Political benefits

Increased political legitimacy, political stability

Leverage synergies towards overarching development goals

Synergies

Wastewater for energy and food production in Jordan

As-Samra wastewater treatment plant

- Treats 365,000m^{3}of wastewater/day
- Effluent is used for agricultural irrigation
- 80% of energy used is produced by plant itself (biogas and hydraulic energy)

Source: Consolidated Contractors Company

Synergies

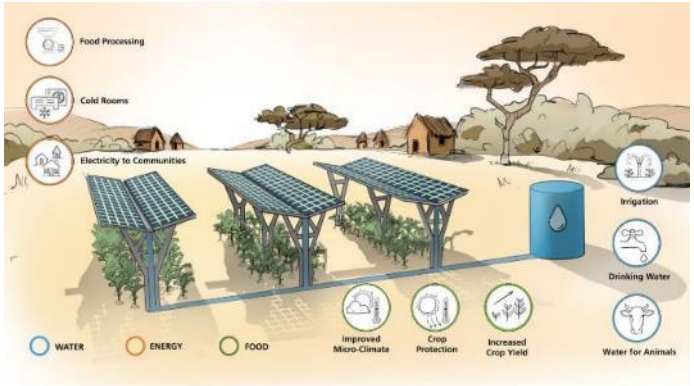
Agrivoltaics in Mali and Gambia: sustainable electricity by integrated WEF systems

Integrated triple land-use system

- Includes food production, energy generation and water harvetsing

- Using the synergies to:
  - increase the land use efficiency
  - enhance agricultural conditions
  - decrease water requirements

Figure: Schematic diagram of a triple land use through agrivoltaics



Synergies

Manantali multi-purpose dam – Mali, Senegal, Mauretania

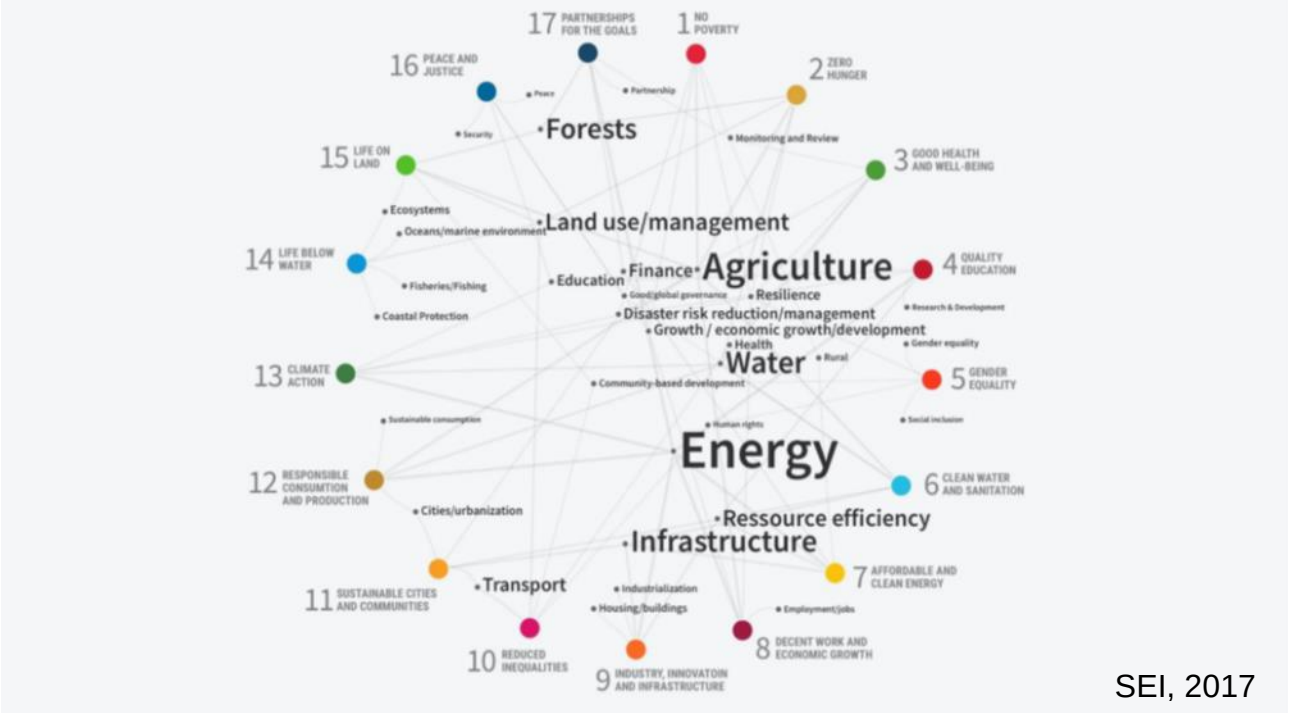
- Manantali is jointly owned and operated by three countries
- 200 MW power plant generates electricity for Senegal, Mali and Mauretania
- Reservoir provides water for irrigation of 130,000 ha of agricultural land
- Water regulation component for navigation (not realized)

Source: Benoît Rivard/Flickr CC BY-NC-ND 2.0

The Sustainable Development Goals

UN, 2015

Understanding the links between SDGs



SEI, 2017

Nexus interlinkages with other concepts and resulting global policy processes

- Disaster risk reduction: Sendai Framework
- Climate Change: Paris Agreement and resulting Nationally Determined Contributions (NDCs)
- Circular Economy

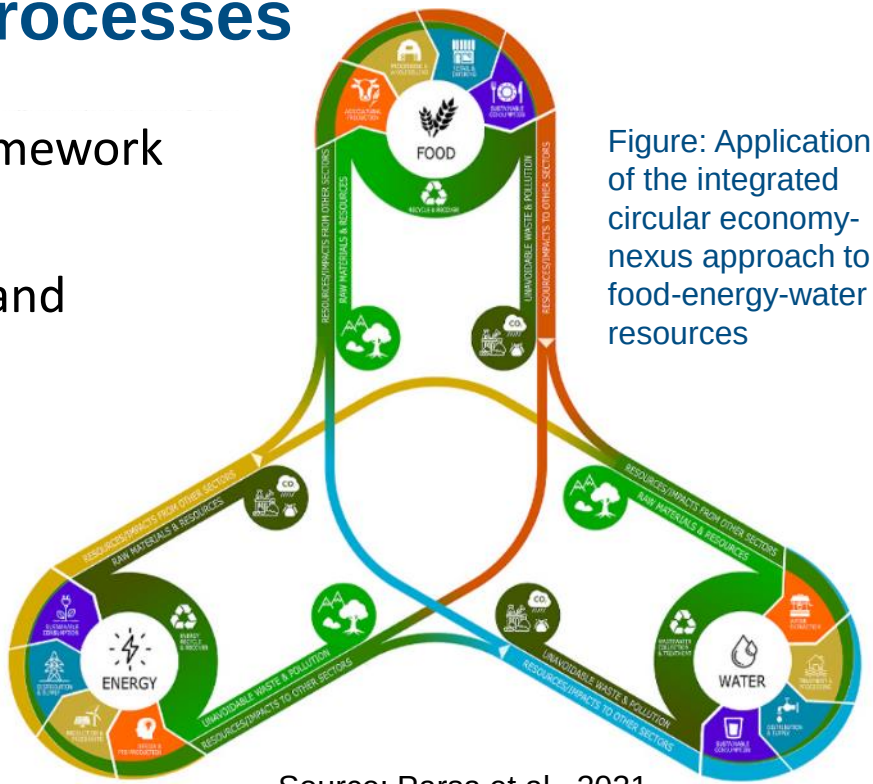


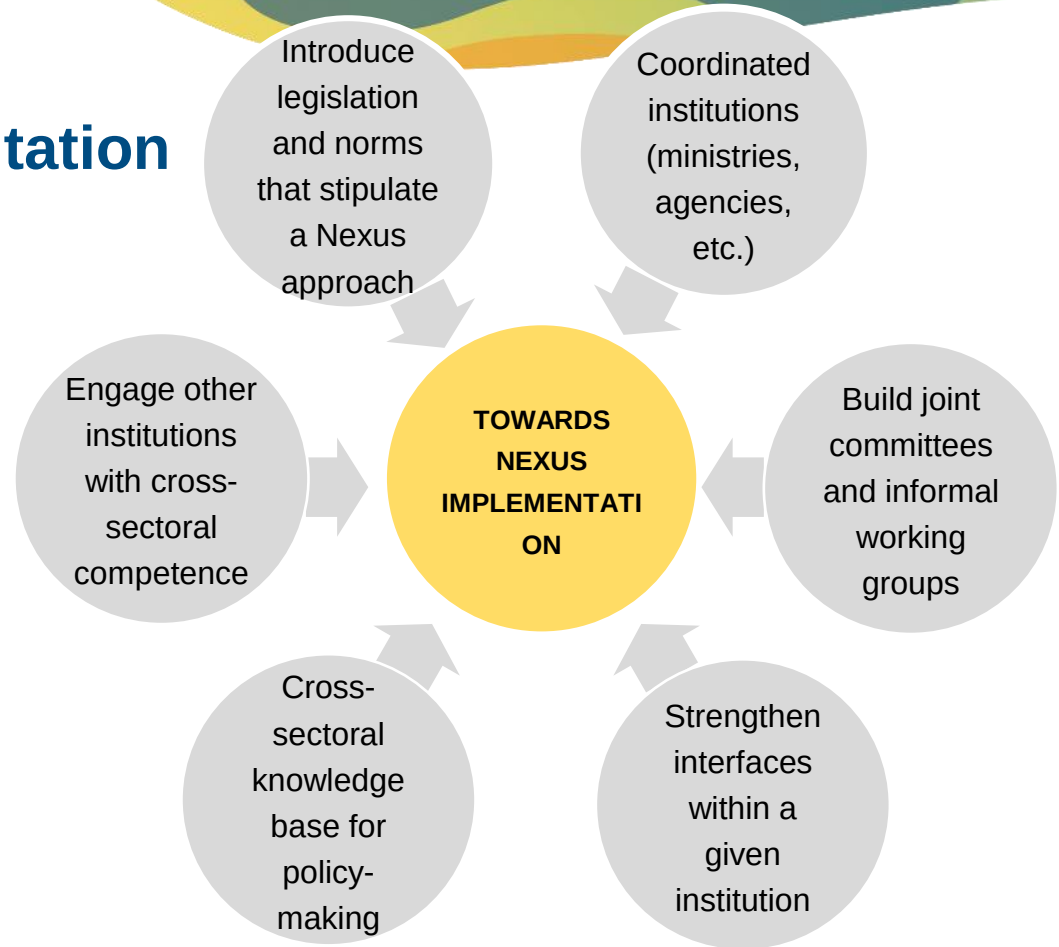
Figure: Application of the integrated circular economy-nexus approach to food-energy-water resources

Source: Parsa et al., 2021

Governance Challenges of Nexus Implementation

- Government structures organized in silos, lack of coordination (horizontally and vertically)
- Lack of up-to-date data on status of WEF sectors that can be used for decision-making
- Deficiencies in knowledge about complex Nexus interlinkages
- Lack of transdisciplinary science
- Lack of (knowledge of) applicable assessment tools such as modelling tools, scenario-development, participatory processes etc.

Possible measures for Nexus implementation



Summary

- The Water-Energy-Food security Nexus is a concept and approach which looks at interconnections which are usually overlooked, yet are very important
- The WEF Nexus concept is about harnessing synergies and addressing trade-offs
- The next section will focus in more detail on the interactions between water, energy and food sectors

Q & A on Introduction to the WEF Nexus

Any questions on Chapter 1?

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Thank you for your time!

Break: see you again in 10 Minutes!

17 December 2021

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Concepts of water, energy and food security and trade-offs

Chapter 2: Water-Energy-Food Interactions

Overview: Water, Energy and Food Security

Water security:

- 2.0 billion people lack safely managed drinking water services (2020)
- Global water demand could exceed total water supply by 40% in 2030 (based on 2015 levels)

Energy security:

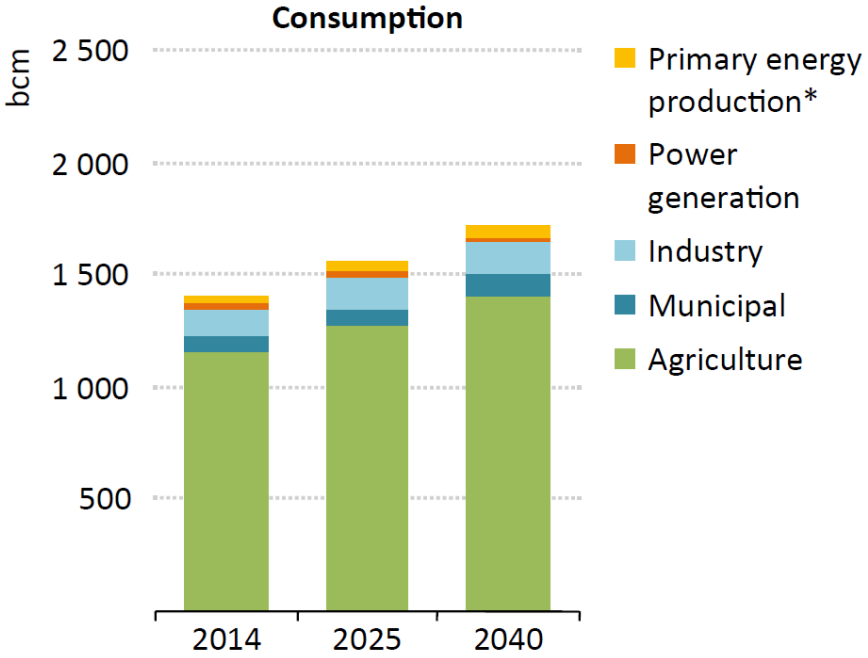
- 0.8 billion people are without access to electricity (2021)
- Total primary energy demand is projected to increase by 9% in 2030 (based on 2020 levels)

Food security:

- 2.4 billion people are food insecure from which 930 million face a serve form (2020)
- Food demand is expected to increase by 50% in 2050 (based on 2020 levels)

Water for Food

Global water demand by sector between 2014 and 2040



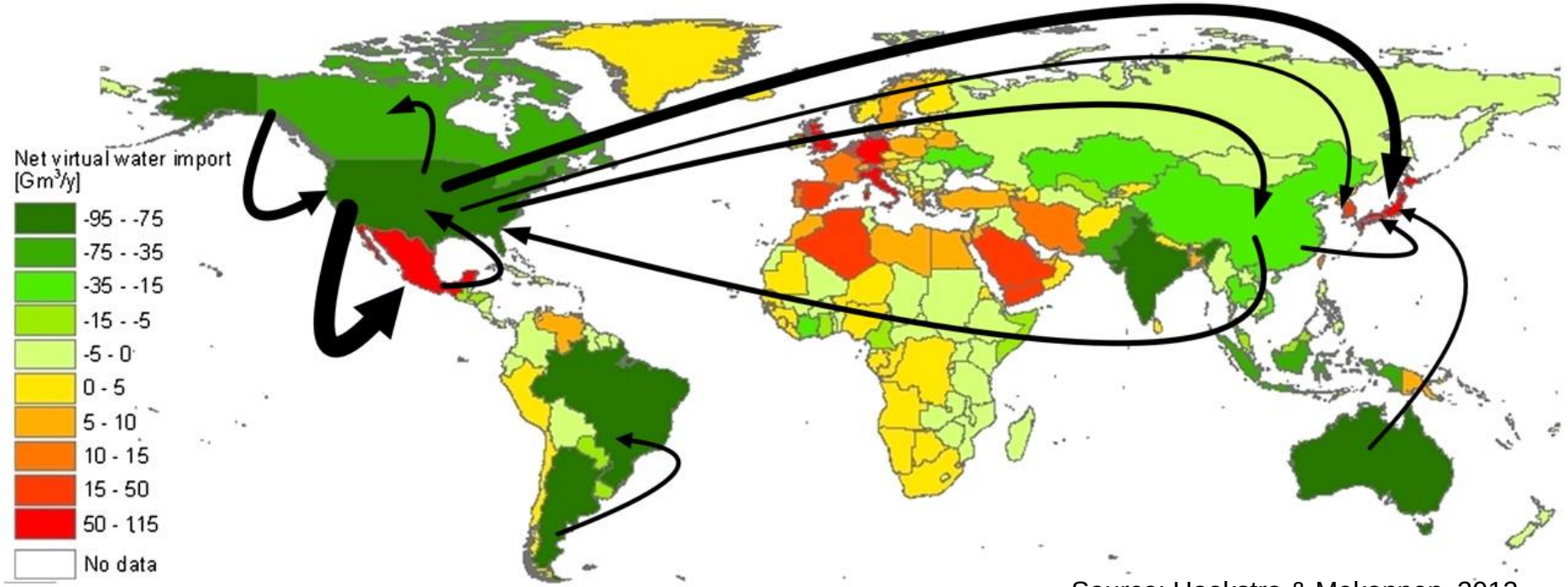
Source: IEA, 2016

Agricultural water withdrawals by region, 2010

Region	Agricultural water withdrawal as % of total water withdrawal
Africa	81
Americas	48
Asia	81
Europe	27
Oceania	58
World	**70**

Source: own illustration based on UN, 2021

Local water uses versus global trade of agricultural products



Source: Hoekstra & Mekonnen, 2012

Increasig food production: Main trade-offs

Increasing food production

Growing land use

Less land for energy (biomass, solar, wind,)

Removal of woods

Increase in water abstraction

Decrease of water available for WASH, energy production, environment

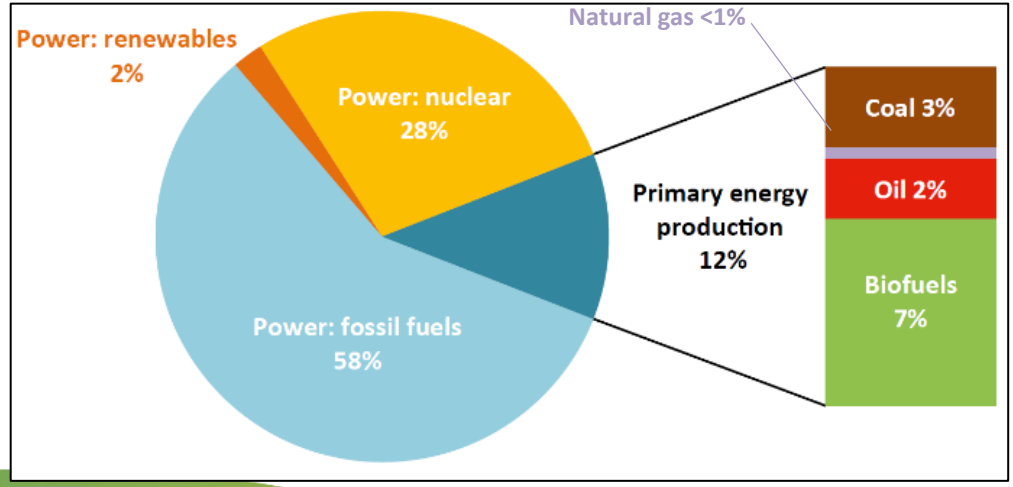
Time for a quick quiz game!
How much water is needed in the energy sector?

1. We have seen previously that 90% of energy produced today is water-intensive, meaning that nearly all forms of energy rely on water.
   - Which part of the energy sector accounts for the largest amount of water withdrawals?

Water for Energy

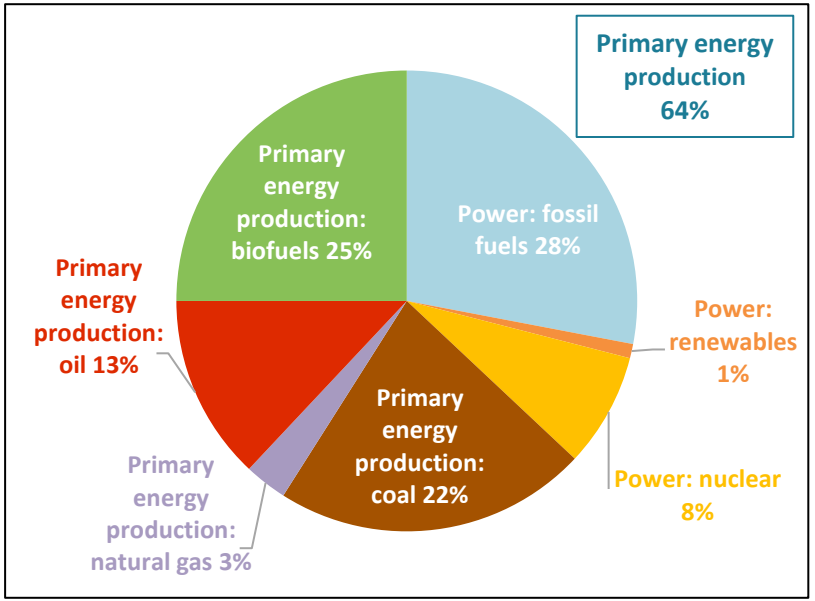
Water withdrawals and consumption in the energy sector, 2014

Total water withdrawals: 398 bcm



Source: IEA, 2016

Total water consumption: 48 bcm



Source: own illustration based on IEA, 2016

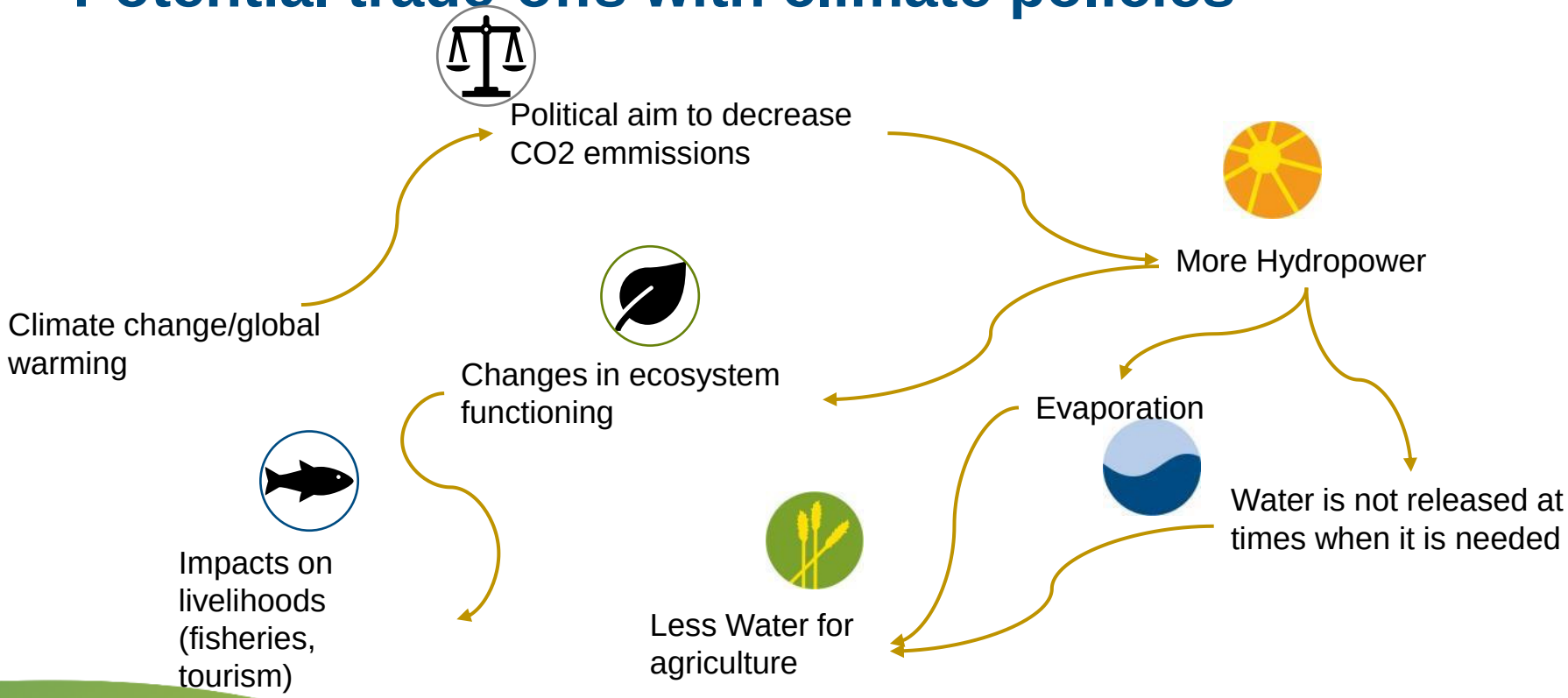
Water for Energy

Energy-related water consumption

Region	Consumption (bcm)		
	2014	2025	2040
OECD	21	24	22
Eastern Europe/ Eurasia	4	4	4
Asia	15	23	37
Middle East	2	2	3
Africa	1	2	2
Latin America	4	4	7
World	**48**	**59**	**76**

Source: own illustration based on IEA ,2016

Potential trade-offs with climate policies

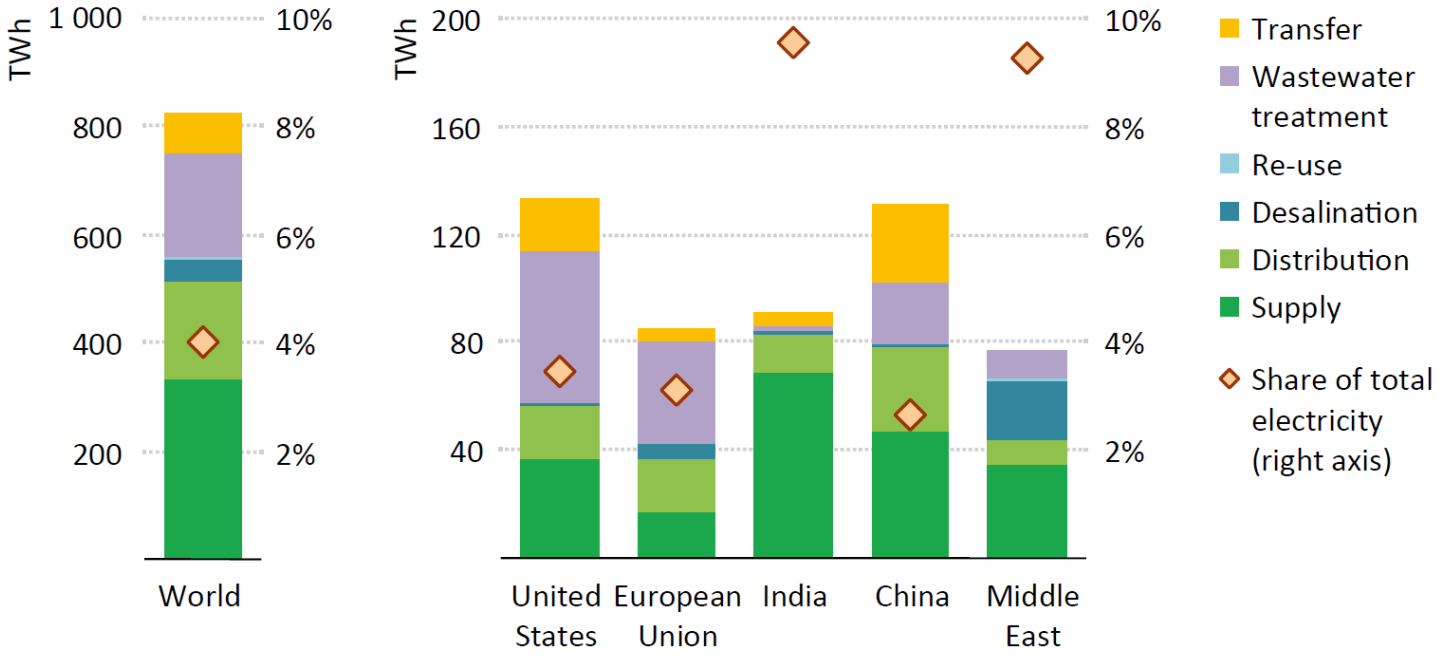


Time for a quick quiz game!
How much energy is used in the water sector?

1. What share of the global electricity is consumed in the water sector (in %)?
2. Which part of the water sector uses most electricity?
3. Which part of the water sector is projected to use most electricity 20 years from now?

Energy for Water

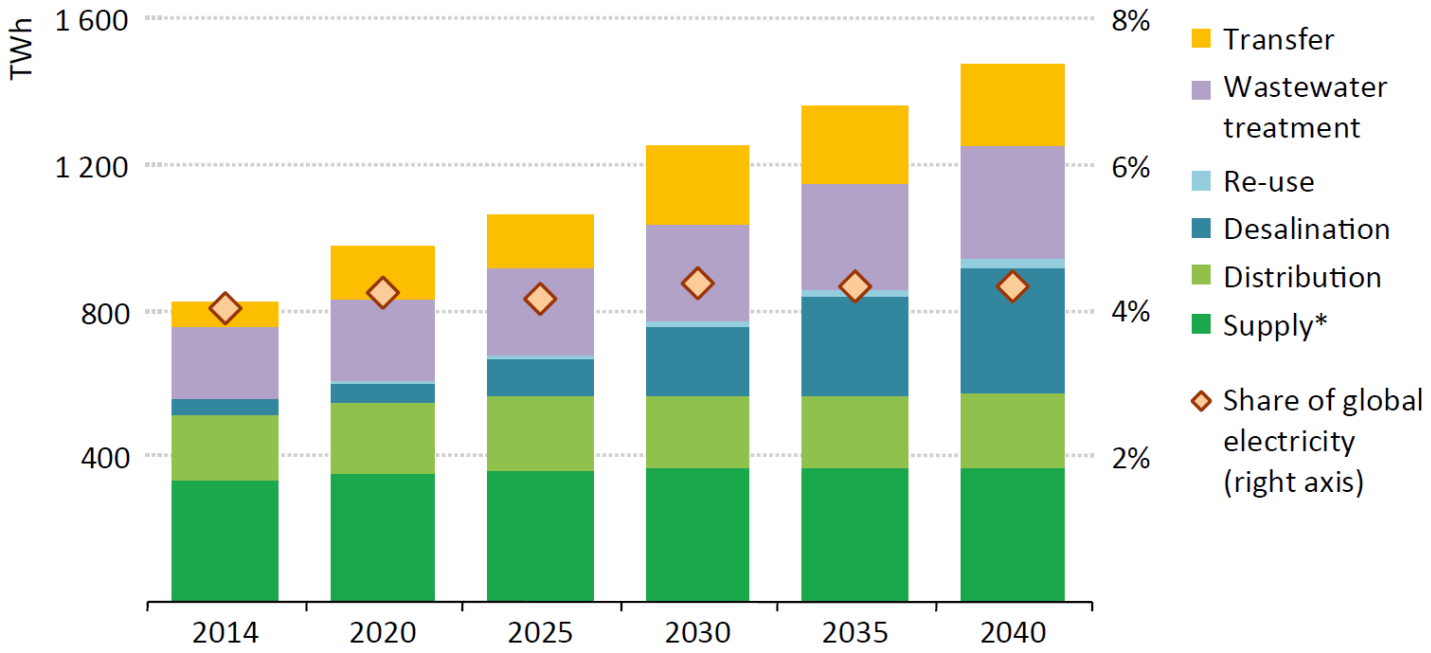
Electricity consumption in the water sector by process and region, 2014



Source: IEA, 2016

Energy for Water

Electricity consumption in the water sector by process, 2014 - 2040



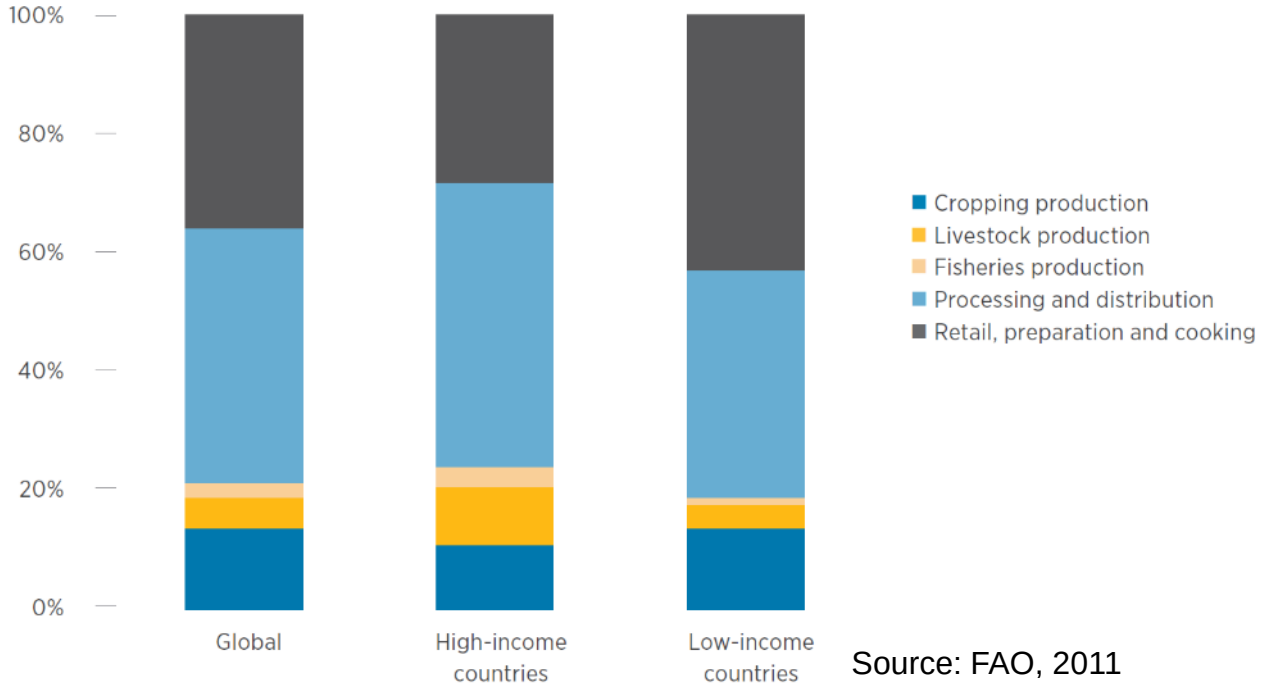
Source: IEA, 2016

Time for a quick quiz game!
How is energy used in agri-food systems?

1. We have previously seen that agri-food systems account for 33% of global energy demand.
   - Which segment of the agri-food chain needs the most energy (globally)?

Energy for Food

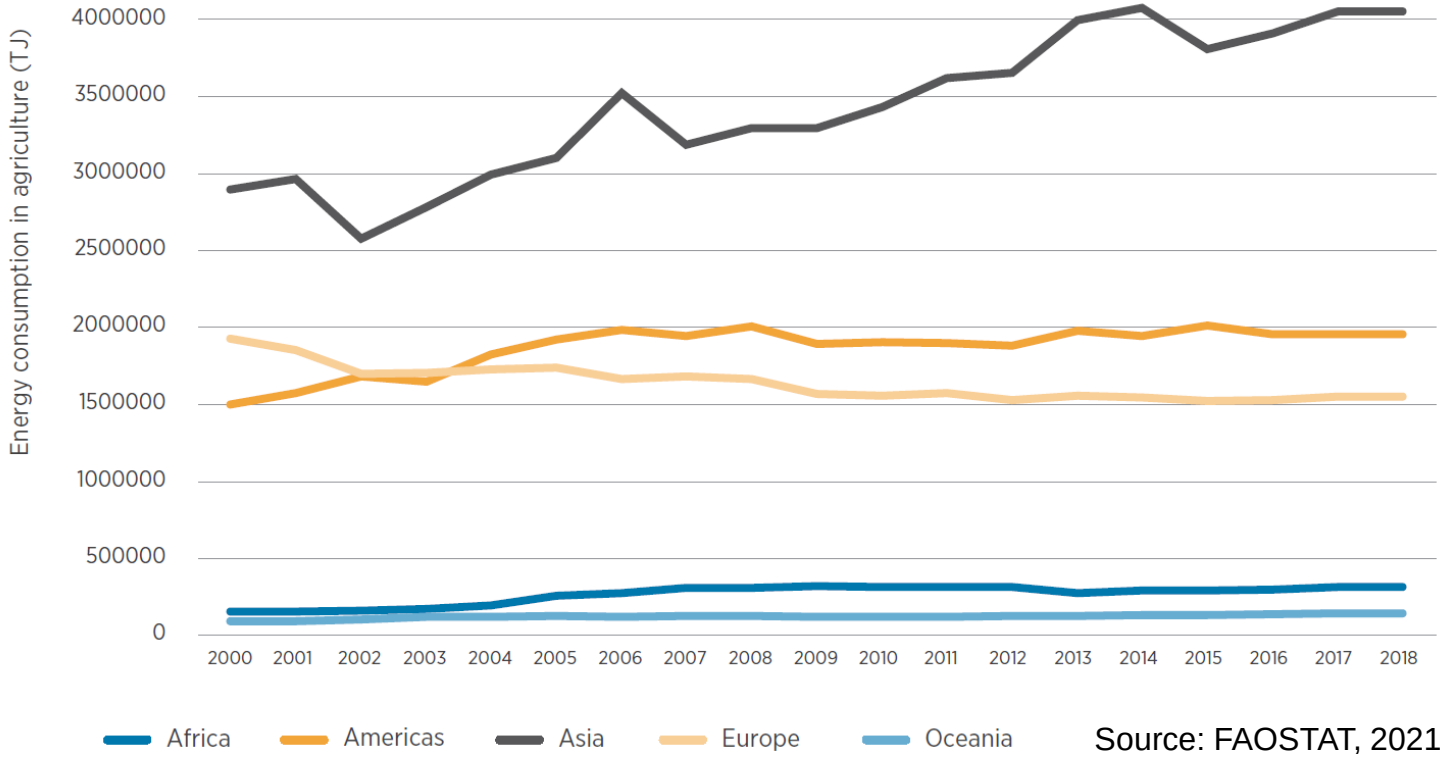
Share of total energy consumption globally and in high- and low-income countries, by segment of agri-food chain



Source: FAO, 2011

Energy for Food

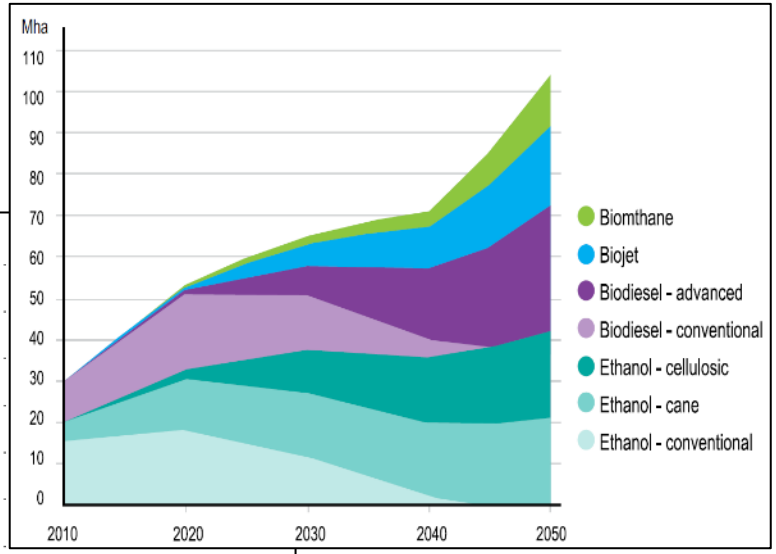
Energy consumption in agri-food systems by region, 2000-2018



Source: FAOSTAT, 2021

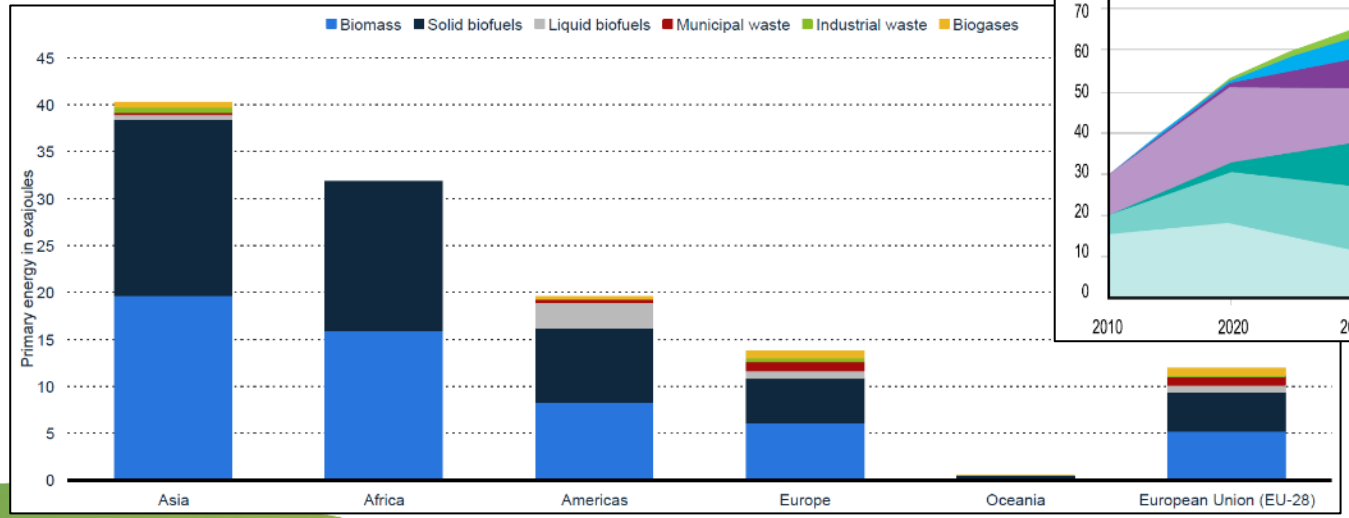
Agriculture for Energy

Land demand projected for future transport biofuel production, 2010 - 2050



Source: IEA, 2011

Sources of biomass supply of primary energy worldwide in 2018, by region (in exajoules)



Source: Statista, 2021 based on WBA, 2020

Discussion on WEF Interconnections

1. Any questions so far? (use chat function)
2. Which further trade-offs within the WEF Nexus or beyond are you aware of, from your own professional context or from your country/region? (mentimeter)

WEF Nexus Solutions

Chapter 2: Water-Energy-Food Interactions

WEF Nexus Solution Categories

Technical and Engineering

- Multi-purpose infrastructure
- Integrated waste(water) management

Nature-based Solutions

- Constructed wetlands
- Catchment management

Governance

Policy & financial frameworks

- Regulatory instruments (impact assessments, wastewater standards)
- Financial instruments (taxes, subsidies)

Planning Procedures

- Integrated infrastructure planning
- Policy coordination
- Strategic policy planning

Nature-based Solutions

Nature-based Solutions (NbS) are actions to:

- Protect, sustainably manage and restore ecosystems
- Address societal challenges
- Provide human well-being and biodiversity benefits

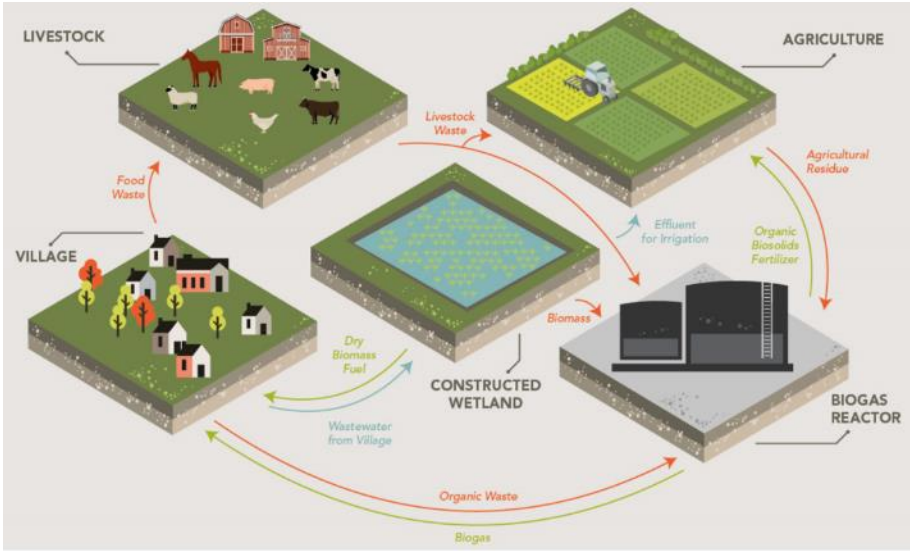
The umbrella term of NbS encomapsses different approaches, e.g. Ecosystem-based Adaptation (EbA).

Source: IUCN 2016

NbS Example – constructed wetlands

- Wastewater treatment by passage of water through man-made wetlands
- Nutrients remain in the effluent – beneficial use of reclaimed water in agriculture for food production
- Biomass grown in wetlands can be harvested as biofuel, e.g. biogas for cooking – reducing GHG emissions

The potential for constructed wetlands to influence WEF interactions at village and municipal scale



Source: Avellan et al., 2017

NbS Example – catchment management

Tana River Basin in Kenya

- provides 95% of the drinking water for Nairobi
- generates 70% of the country's hydropower
- irrigates about 645 km2 of farmland

Siltation issues caused by erosion impacts hydropower and drinking water supply

Upper Tana-Nairobi Water Fund: funding for sustainable land management in the catchment (terracing, reforestation, farm management) with benefits for agricultural production, energy and water supply)

Increased carbon storage and climate resilience

Hall in Abell et al., 2017

Governance Solutions

Policy and financial frameworks

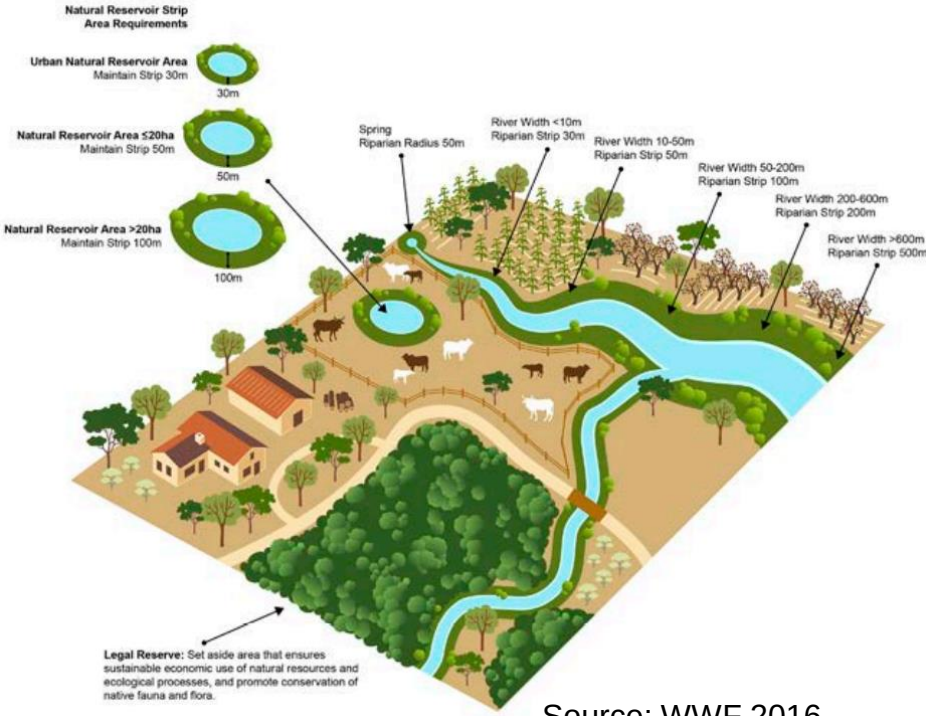
Type/ Example		Description
Regulatory instruments	Impact assessments	Systematize environmental and social impact assessment across WEF-sectors for all new infrastructure
	Wastewater treatment and reuse standards	Specify regulations for wastewater treatment and reuse (e.g. in agriculture or urban use)
Financial instruments	Water user charges	Levied by public authorities for services provided for water supply and treatment to incentivize efficient water use for food and energy production
	Subsidies	Linking subsidies to the efficient use of resources (e.g. link agricultural subsidies to efficient use of water and energy resources, environmental impacts)

Governance Solutions

Brazil – Agricultural subsidies

- Since 2008 all subsidies provided to farmers are linked to fulfilling environmental cirteria
- Agricultural subsitence tool: mainly rural credits that aim to improve productivity and manage risks
- To receive subsidized credits farmers have to fulfill requirements of the rural environmental registry (CAR)

Figure: Areas of permanent protection and legal reserve under the Rural Environmental registry



Source: WWF 2016

Governance Solutions

Planning Approaches

Type/ Example		Description
Policy coordination	Cross-departmental working groups	Permanent or issue-specific groups working across horizonal and vertical (in federal states) lines to discuss different WEF perspectives
	Expert and public consultations	
Strategic policy planning	Cross-sectoral strategies	Coordination of policies at a strategic, higher authority level (e.g. sutainability strategy)

Governance Solutions

South African National Waste Management Strategy 2020

- Developed under lead of Department of Forestry and Fisheries and the Environment (DFFE) with broad cooperation of other sectors including energy and land/food
- Addresses key interlinkages with other WEF sectors:
  - promotion of energy recovey from sewage and organic waste
  - Prevention of food waste is key pillar for strategy minimize waste minimization

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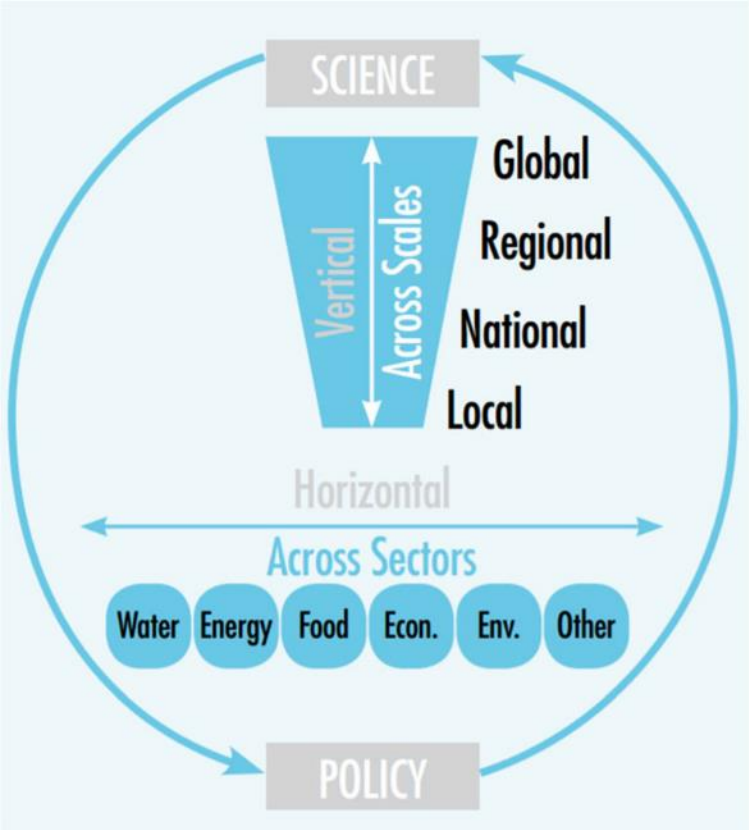
Value of nexus assessments

- Facilitating **inter-sectoral dialogue**: shared knowledge base for prioritizing issues, identifying synergies and trade-offs
- Joint identification of cross-sectoral **nexus solutions** e.g. synergetic RE projects, sustainable catchment management, etc. and discussing necessary nexus **investments**
- Initiating, broadening, revisiting **coordination/cooperation frameworks** (baskets of benefits)
- **Insights on impacts of policies and strategic decisions** from modeling and scenarios on key questions

Interconnectedness and Scale



Daher et al., 2017

Various scopes of assessment

Context analysis – what is the current situation in the Nexus sectors and how are they interlinked

Assessing impacts of changes: develop development/policy scenarios and analyse/quantify impacts on sectors and sustainability

Assessment of specific interventions in terms of their efficiency in resource use, social, economic and envi. impacts

Comparison of interventions

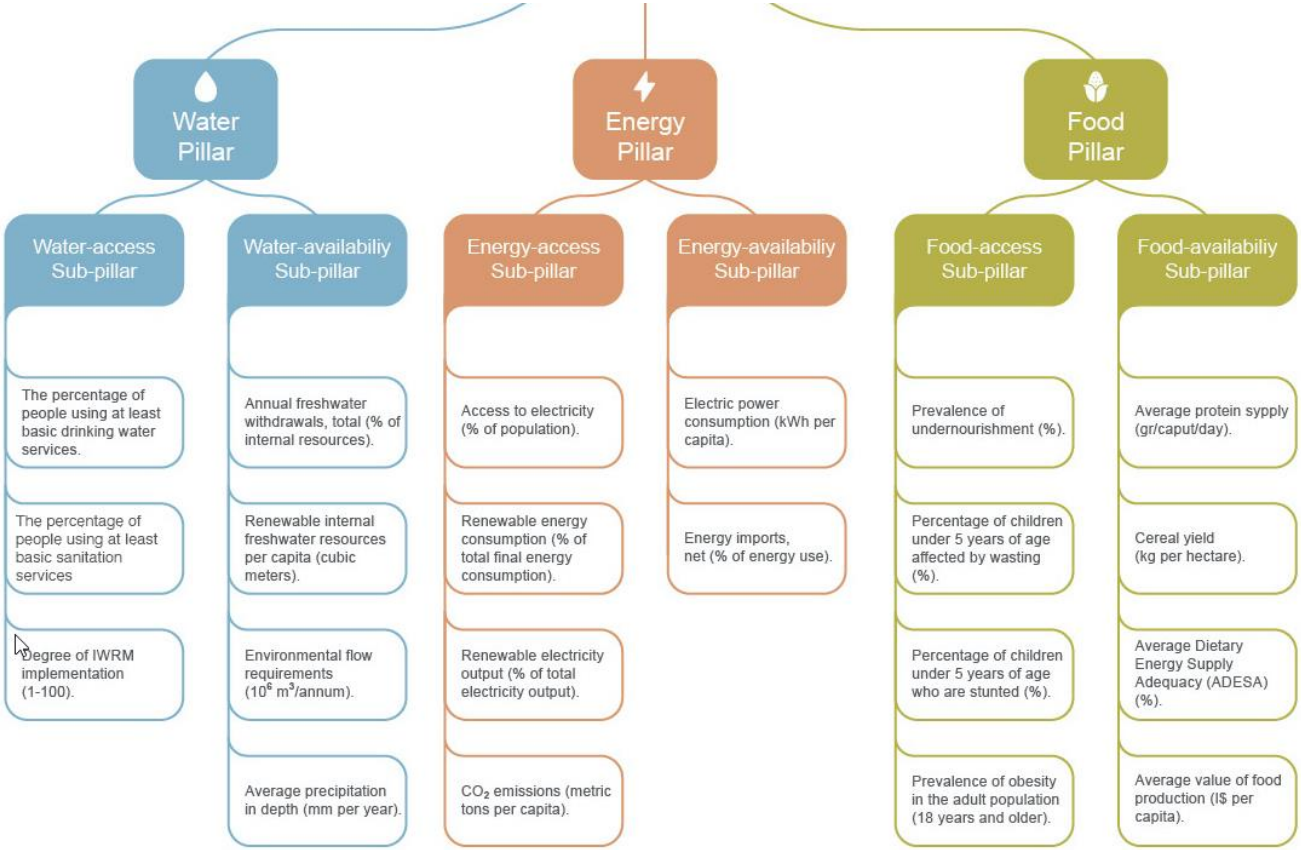
Examples of assessment approaches

- Collaborative/participatory tools (workshops, questionaires, focus groups, etc.)
- Indicator frameworks (sectoral/cross sectoral)
- Conceptual visualisation tools/mapping
- Modelling tools
- Governance assessment
- Policy coherence assessment

Context Analysis – what is the current situation?

- The current state of WEF security and pressures on natural resources systems
- Socio-economic situation and expected developments, trends and drivers on resources systems
- Interconnections between water, energy and food systems
- Governance framework: sectoral goals, policies and strategies; coherence of policies, extent of regulation of uses
- Planned investments, acquisitions, reforms and large-scale infrastructure
- Key stakeholders, decision-makers and user groups, existing coordination mechanisms

WEF Nexus Index



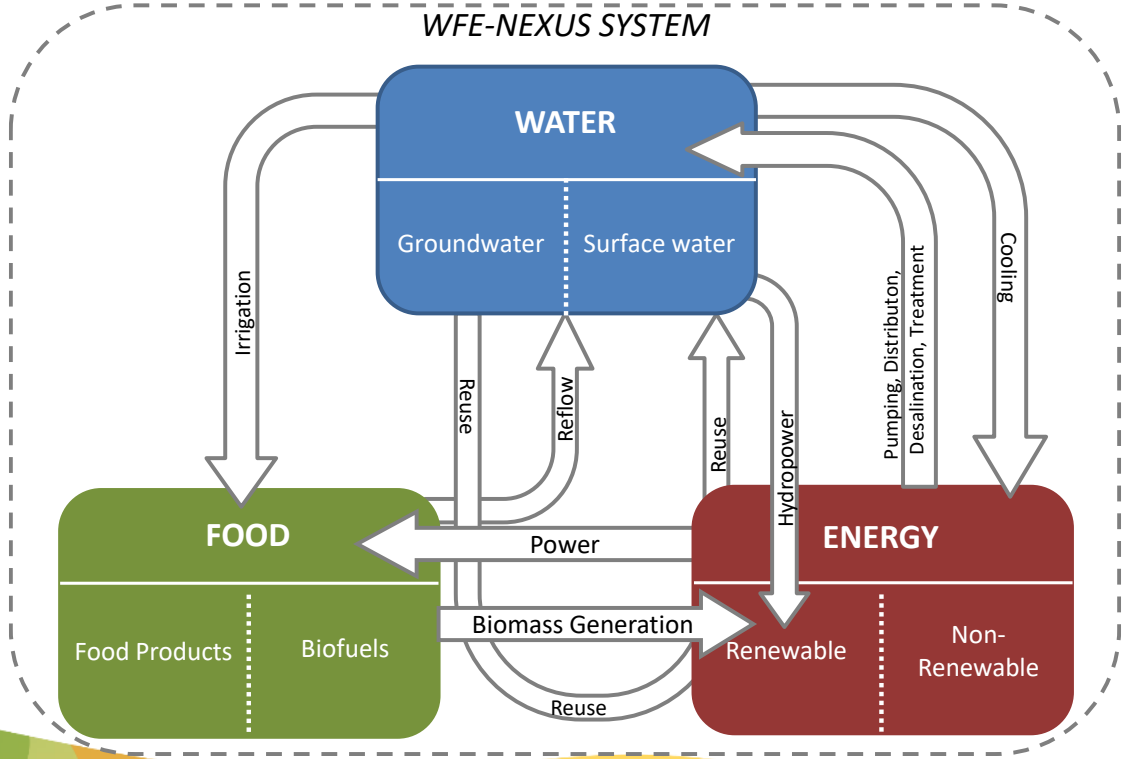
Source: wefnexusindex.org

Examples of cross-sectoral indicators

Need to be adapted to context and scope of analysis

- Total fossil energy consumption in agriculture/ agriculture gross production value
- Area under agricultural water management as a % of irrigation potential
- Share of monitoring sites in agriculture areas that exceed recommended drinking water limits for nitrates, phosphorous and pesiticides in surface water and groundwater
- Agricultural water productivity
- Water use efficiency in different sectors

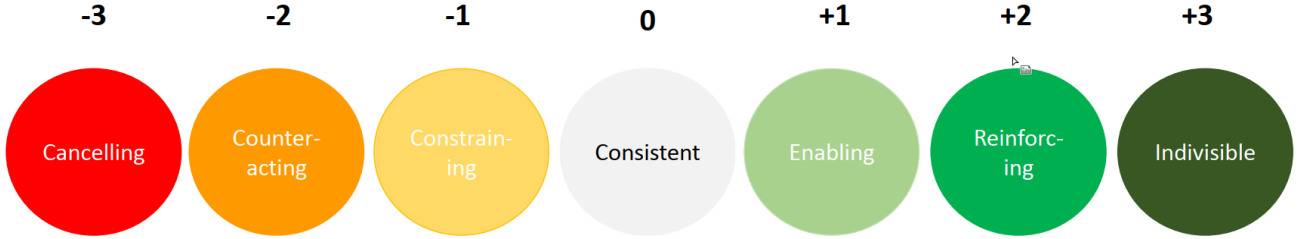
Visualisation Tool Nexus Interconnections Diagram



Meza et al., 2015

Assessing policy coherence

Scoring system for assessing the interaction of policy objectives (Nilsson et al. 2012)



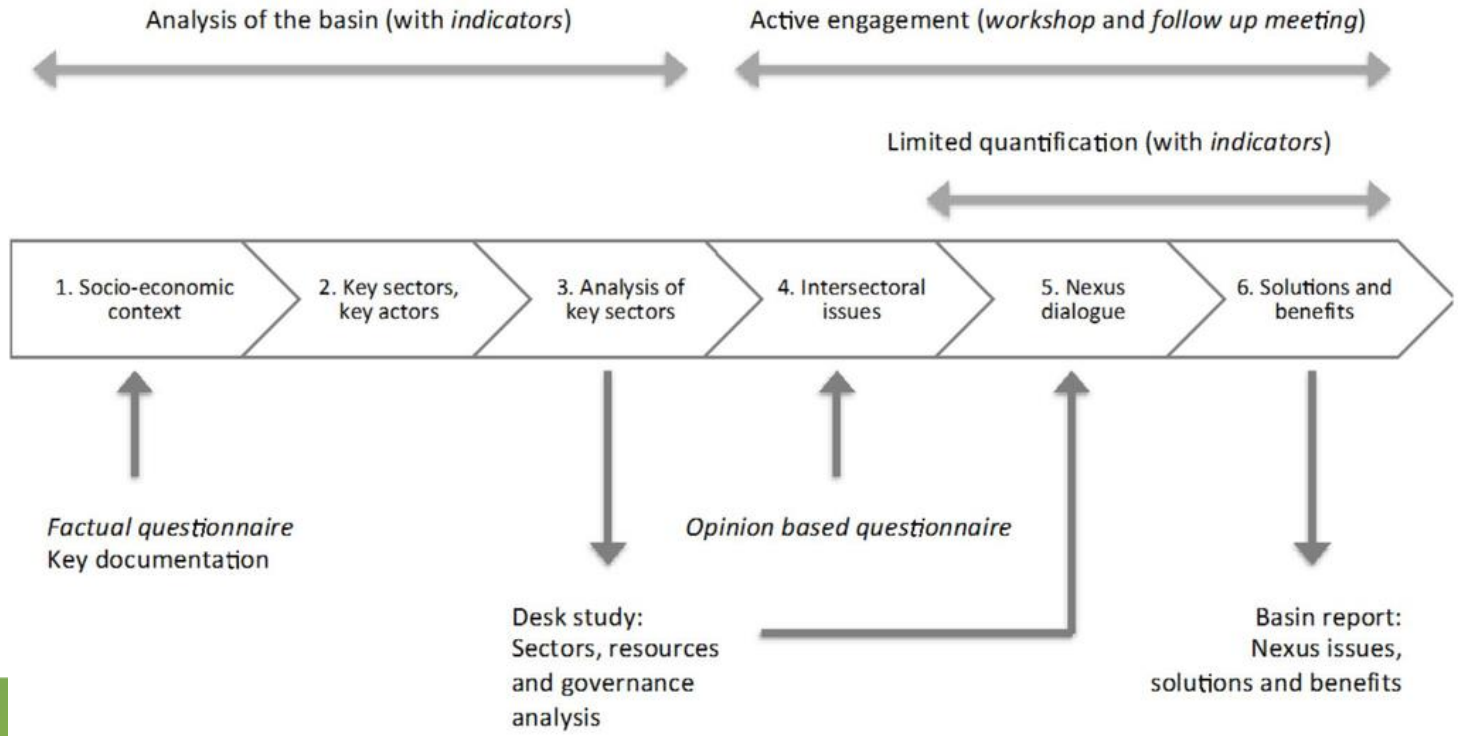
Screening matrix of coherence among policy objectives in the water-land-food-energy-climate (WLEFC)-nexus domains (SIM4NEXUS)

	W1	W2	W3	W4	W5	W6	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	L1	L2	L3	L4	F1	F2	F3	F4	F5	F6	F7	C1	C2	C3	C4	C5	C6
W1		+2	0	-1/0	+1	+1	-1/+1	0	0	0	-1/+1	0	0	0	0	0	+1	+1	+1	0	-1/+1	-1/+1	+2	-1/+2	0	0	0	0	0	0	0	0	0
W2	+2		-1	-1	0	+3	-1/+2	0	0	0	+3	0	0	-1/+1	0	+2	+1	+1	+1	-1	-1/+2	-1/+2	+2	-1/+2	-1/+1	0	0	0	0	0	0	0	+1
W3	0	0		+3	0	+2	+1	0	0	0	0	0	-1/+1	-1/+1	0	0	0	0	0	0	+1	+2	0	0	+3	0	0	0	0	0	0	0	+3
W4	+1	+3	+2		0	+2	-1/+1	0	0	0	-1/+1	0	-1/+1	+2	0	0	+1	+1	0	0	1/+1	1/+1	+1	0	+2	0	0	0	0	0	0	0	+1
W5	-1/+1	-1/+1	0	0		0/+1	-1/+1	0	0	0	0	0	0	0	0	+2	+1	+1															
W6	+1	+3	+2	+3	0		-1/+1	0	0	0	+1	0	0	-1/+1	0	+2	+1	+1															
E1	-1	-1	0	-2	-1	-1		+3	0	0	0	0	0	0	0	+1	-1	-1															

What happens to objective x → (affected)
If we make progress on objective y ↓(affecting)

Munaretto et al 2017

The Transboundary River Basin Nexus Approach (TRBNA)



de Strasser et al., 2016

Various scopes of assessment

Context analysis – what is the current situation in the Nexus sectors and how are they interlinked

Assessing impacts of changes: develop development/policy scenarios and analyse/quantify impacts on sectors and sustainability

Assessment of specific interventions in terms of their efficiency in resource use, social, economic and envi. impacts

Comparison of interventions

Modelling Tools to Assess the WEF Nexus

- Models are used to simulate complex socio-ecological systems
- They help us understand interconnections between drivers (e.g. climate, socioeconomic development) and the individual elements of the WEF Nexus
- Models can simulate future scenarios as decision support for planning
- Uncertainties need to be considered!

Approaches of Modelling Tools to assess the WEF Nexus

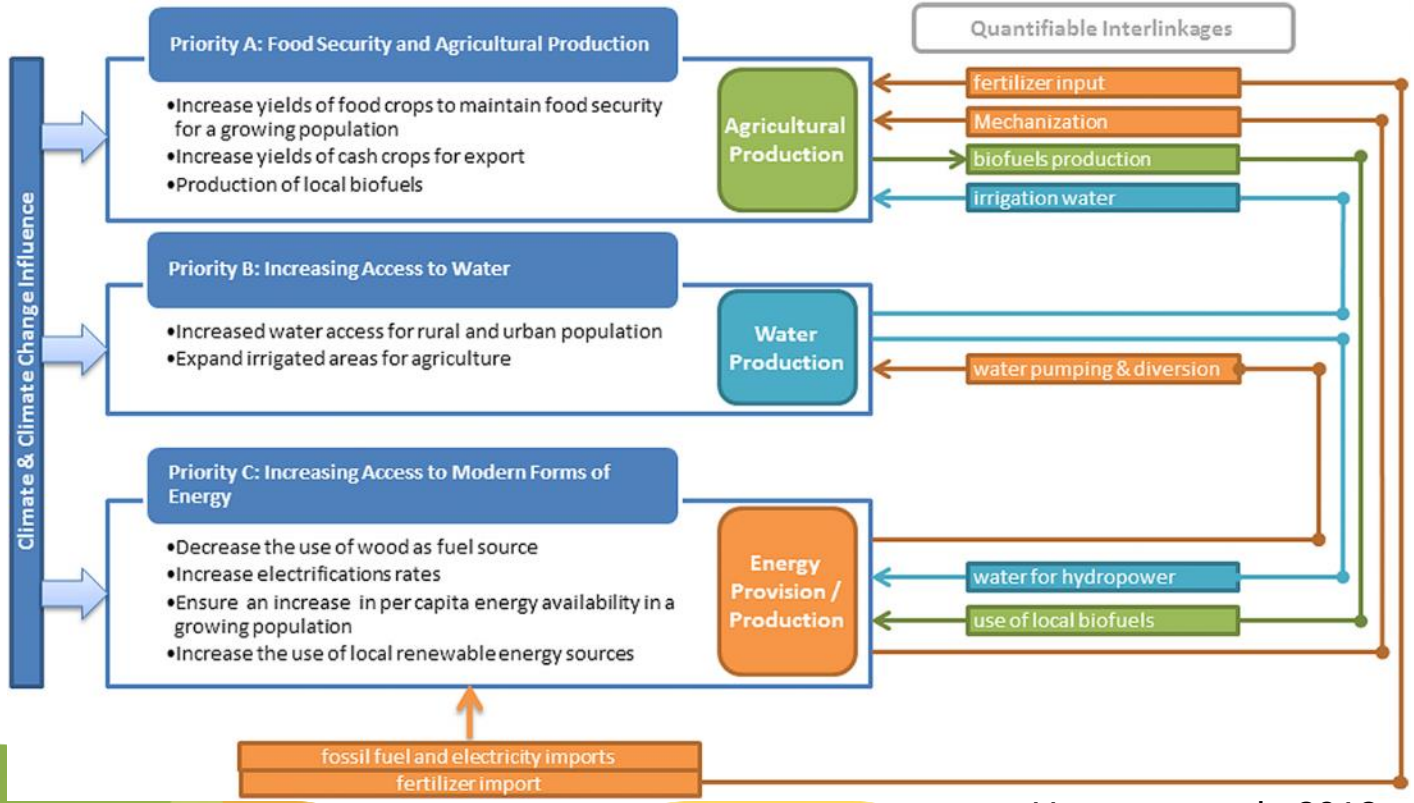
- fully integrated, multi-resource modelling tools in which interlinkages can be investigated with the use of only a single software
- extended (single system) models
- single models that are combined through soft-linking
  - different models are available for different sectors (e.g., WEAP, LEAP, GAEZ, OSeMOSYS, CropWat, Agent-based models, etc.)

Climate, Land Use, Energy and Water Systems (CLEWs) framework

- Integrated system approach to assess Nexus interconnections with the aim to:
  - Understand the systems within their natural or organizational boundaries
  - Assess interconnections between different resource sectors to attain insights into trade-offs and potential synergic solutions
  - Provide policy relevant information
  - Highlights the need for a collaborative approach incl stakeholders

- considerable number of applications, spanning different spatial and temporal scales and political contexts, discussing two or more resource interactions with different purposes

CLEWs: Nexus Challenges in Burkina Faso



Hermann et al., 2012

Various scopes of assessment

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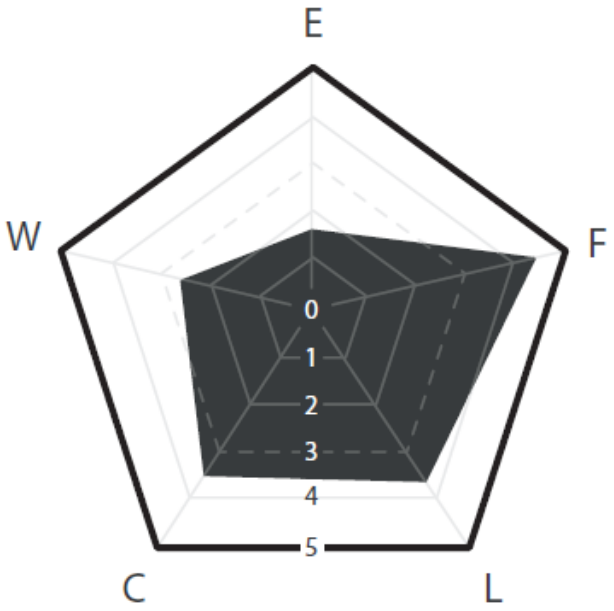
FAO Nexus Rapid Appraisal Tool: Example

Intervention: On-grid wind energy for water desalination for agriculture

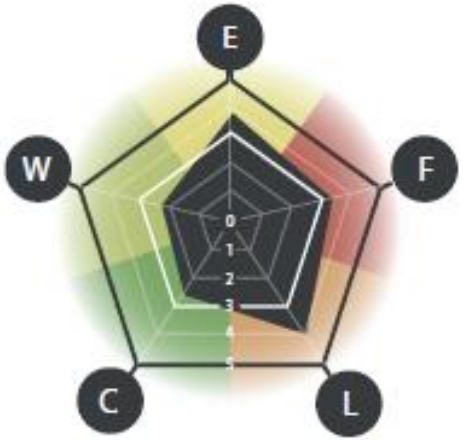
NEXUS ASPECT	OVERALL PERFORMANCE SCORE
Water (W)	2.76
Energy (E)	1.68
Food/land (F)	4.5
Labour (L)	3.67
Capital (C)	3.56



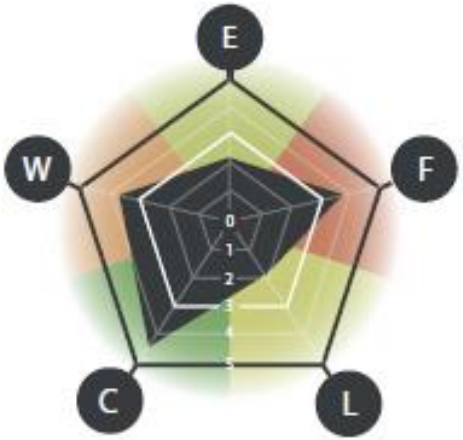
Flammini et al., 2014

Nexus Rapid Appraisal Tool: Comparison

A. SOLAR IRRIGATION IN REGION a



B. HYBRID DIESEL-SOLAR IRRIGATION IN REGION a



C. MINI-HYDRO IN REGION a

Flammini et al., 2014

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DEUTSCHE ZUSAMMENARBEIT

nexus

Thank you for your time!

Global Nexus Secretariat

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