Challenges on Water-Energy-Food Nexus by Regions

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UNESCAP REGIONAL CONSULTATION ON INNOVATION STRATEGIES FOR SUSTAINABLE DEVELOPMENT THROUGH WATER-ENERGY-FOOD NEXUS
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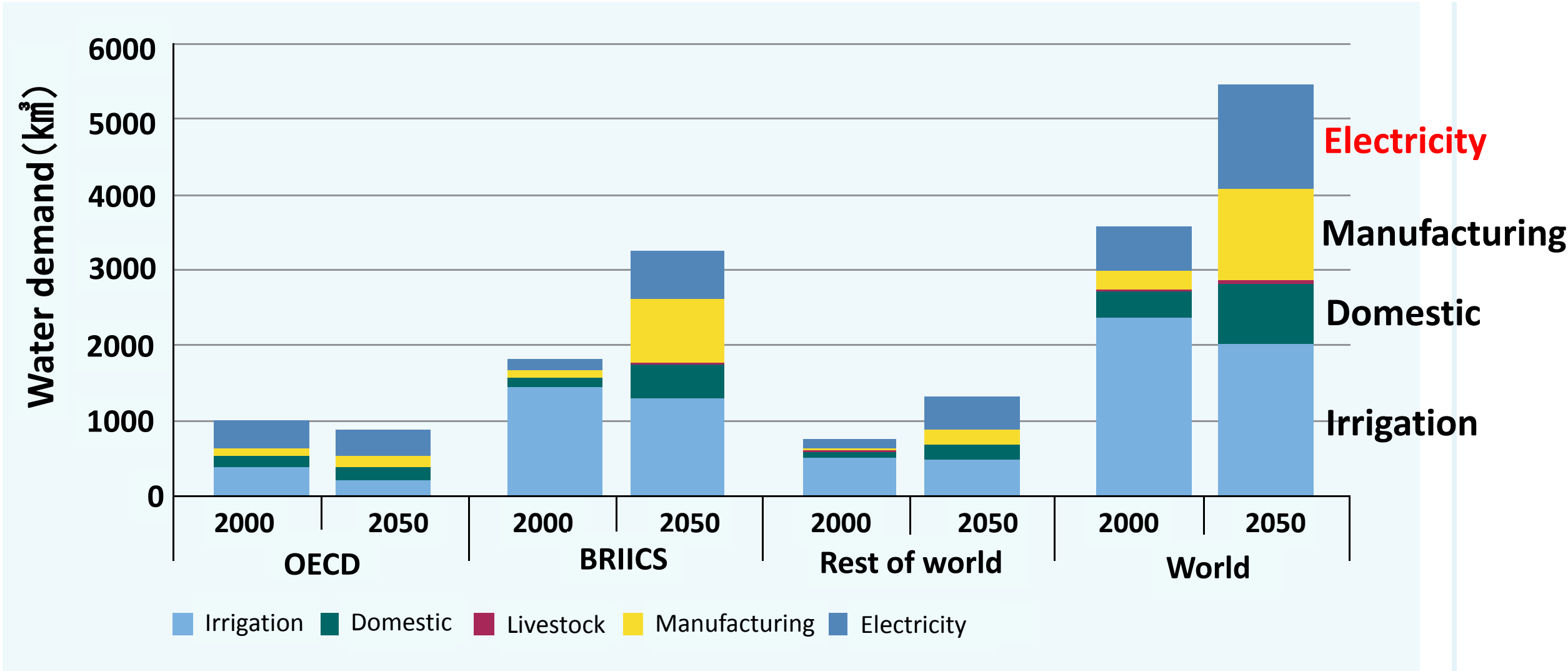
Outline of my talk

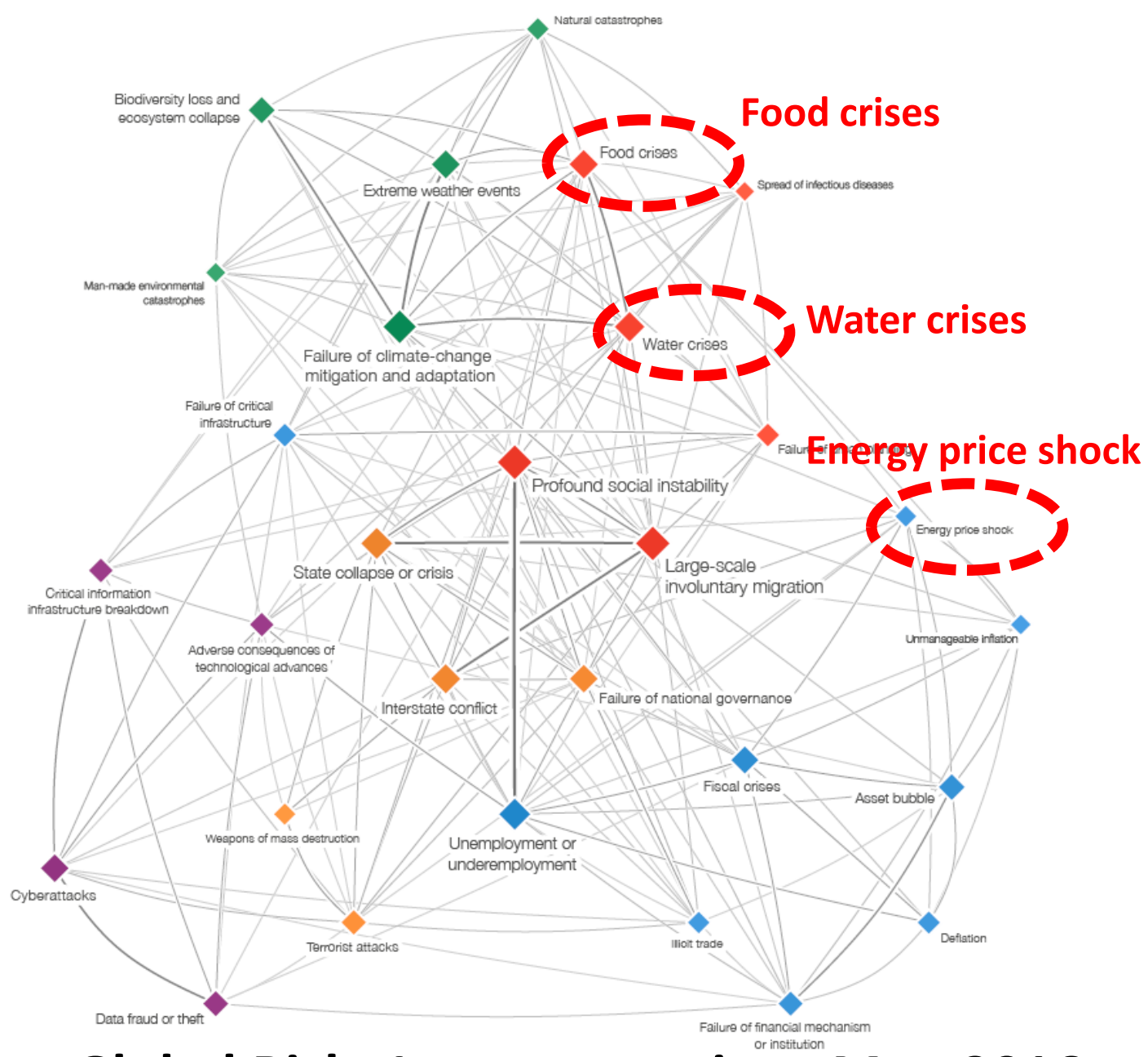
1. Background of Nexus studies
2. A current state of research on the WEF Nexus
3. Nexus challenges by regions
4. The role of the Nexus in the implementation of the SDGs

Global water demand (Freshwater withdrawals):



BRIICS : Brazil, Russia, India, Indonesia, China, South Africa)

The United Nations World Water Development Report 2016



Global Risks Interconnections Map 2016

(WEF2016)

✔Food crises, water crises, and energy price shock were identified as interconnected global risks（WEF2016)

✔Social and climate change put pressure on water, energy, food resources

✔Demands for water, energy and food are estimated to increase by 40%, 50%, 30% by 2030（USNIC 2012）

✔Increase in number of tradeoffs and potential conflicts among these resources that have complex interactions

✔**Nexus approach** can enhance water, energy and food security by increasing efficiency, reducing trade-offs, building synergies and improving governance across sectors

A current state of research on the WEF Nexus

Historical review of nexus studies and projects

1983	Research	UNU launched the Food-Energy Nexus Programme to acknowledge the important interconnectedness between the issues of food and energy
1984	Conference	Conferences on "Food, Energy, and Ecosystems", was held in Brasilia, Brazil by UNU
1986	Conference	Second International Symposium on "the Food-Energy Nexus and Ecosystems" was held in New Delhi, India by UNU
Mid-1980s	Research	Western United States water for electricity concerns
1990s	Practice	Term "nexus" to link water, food, and trade was used by the World Bank
Mid-to-late 1990s - early 2000s	Research	India W-E-Agriculture Nexus studied by Columbia Water Center, Earth Institute, Columbia University
2003	Research	The electricity for water nexus was applied to Jordan by Scott, C.A
2004	Research	The electricity for water nexus was extended to Mexico by Scott, C.A & Shah
2006	Workshop	Hyderabad (India) workshop on groundwater irrigation (electricity nexus) by IWMI, ICRISAT, Wageningen Univ., others
2009	Research	WEF nexus in climate adaptation by Lopez-Gunn
2010	Research	Resource dependencies by Lazarus

Historical review of nexus studies and practices

2011	Research	The Water – Energy – Climate Nexus by Scott, C.A
	Conference	W-E-F NEXUS was officially announced at 2011 Bonn Nexus Conference organized by German Federal Government
	Pratform	Water, Energy, and Food Security Nexus Resource Platform was established by German Federal Government
2012	Conference	"Green Economy" at Rio+20 (United Nations Conference on Sustainable Development) The Water, Energy and Food Security NEXUS in Practice - Make it happen!
	Programme	UNU-FLORES Dresden was established for integrated management of environmental resources: water, waste and soil
2013	Documents for 2nd APWS	"The Status of the Water-Food-Energy Nexus in Asia and the Pacific" prepared by UN-ESCAP
	Research	GIZ-funded FAO-NRC project "The Nexus between Energy, Food, Land Use, and Water: Application of a Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM)"
	Working Paper	"An Innovative Accounting Framework for the Food-Energy-Water Nexus: Application of the MuSIASEM approach to three case studies" prepared by FAO
	Report	"The Water–Energy–Food Security Nexus: Towards a practical planning and decision-support framework for landscape investment and risk management" by IISD

Historical review of nexus studies and practices

2013	Kick-off workshop	Advancing a Nexus Approach to the Sustainable management of Water, Soil and Waste by UNU-FLORES
2014	Discussion brief	"Cross-sectoral integration in the Sustainable Development Goals: a nexus approach" published by SEI
	Conference	"NEXUS 2014: Water, Food, Climate and Energy Conference" by Water Institute, UNC
	Conferer	od NEXUS
	Conferer	
	Platform	allenges
2015	Book	"Governing the NEXUS" base on international kick-off workshop by UNU-FLORES in 2013
	Conference	Water, Soil & Wastes Dresden Nexus Conference 2015 "Global Change, SDGs & the NEXUS Approach" by UNU-FLORES Dresden & others
	Book	Walking the Nexus Talk: Assessing the Water-Energy-Food Nexus in the context of the Sustainable Energy for All Initiative by FAO
	Program	Food-energy-water-climate linkages among the topics for its Horizon 2020 research and innovation programme by EU

"The Water, Energy & Food Security Platform"

(https://www.water-energy-food.org/start/)

Nexus types

Water-food (6, 16%)

Environment:
- examining food import and virtual water nexus
- improving the efficiency of utilization of green water or the rainwater
- preventing depletion of the residual soil moisture
- reducing the use of water through a shift to low water consuming crops

Social & Governance:
- promoting - design of extension and training programs
  - public-private partnership

Economic:
- microfinance funding model
- pro rata pricing system of electricity

Method: climate prediction model

Water-energy-food (11, 30%)

Environment:
- analyzing the sugar for producing energy as alternative energy
- concentrated solar power and woody biomass for producing electricity
- investigating the land and water requirements for producing bioethanol from maize
- developing trench system to recharge underground aquifers
- reduction in irrigation application can result in decline in energy consumption and carbon emission of groundwater use

Economic, Social & Governance:
- hydropower investment
- power market development
- irrigation reform
- regional public goods awareness building

Method:
- Multi-scale Integrated Analysis of Social and Ecosystem Metabolism
- SWAP model
- Soil Conservation Service Cerrc Number method
- economic calculation (land and water footprints of biofuel)
- crop model called CropSyst
- integrated Analytical Model

Water-energy (12, 32%)

Environment:
- assessment of biofuel (micro-alges)
- use of abandoned mines for water storage
- use of solar pumps and quench systems for water pumping and billing
- waste water treatment plant including shale gas development from a life cycle perspective
- promoting well-regulated on-site treatment technologies

Social & Governance:
- improvement of accurate, fine-scale, site-specific data
- stakeholder engagement

Economic: Multiple market management approaches
-tariffs and investments
-further investigation on life cycle of products
-evaluating scenario of carbon and water prices

Method: website

Water-energy-food climate change (8, 22%)

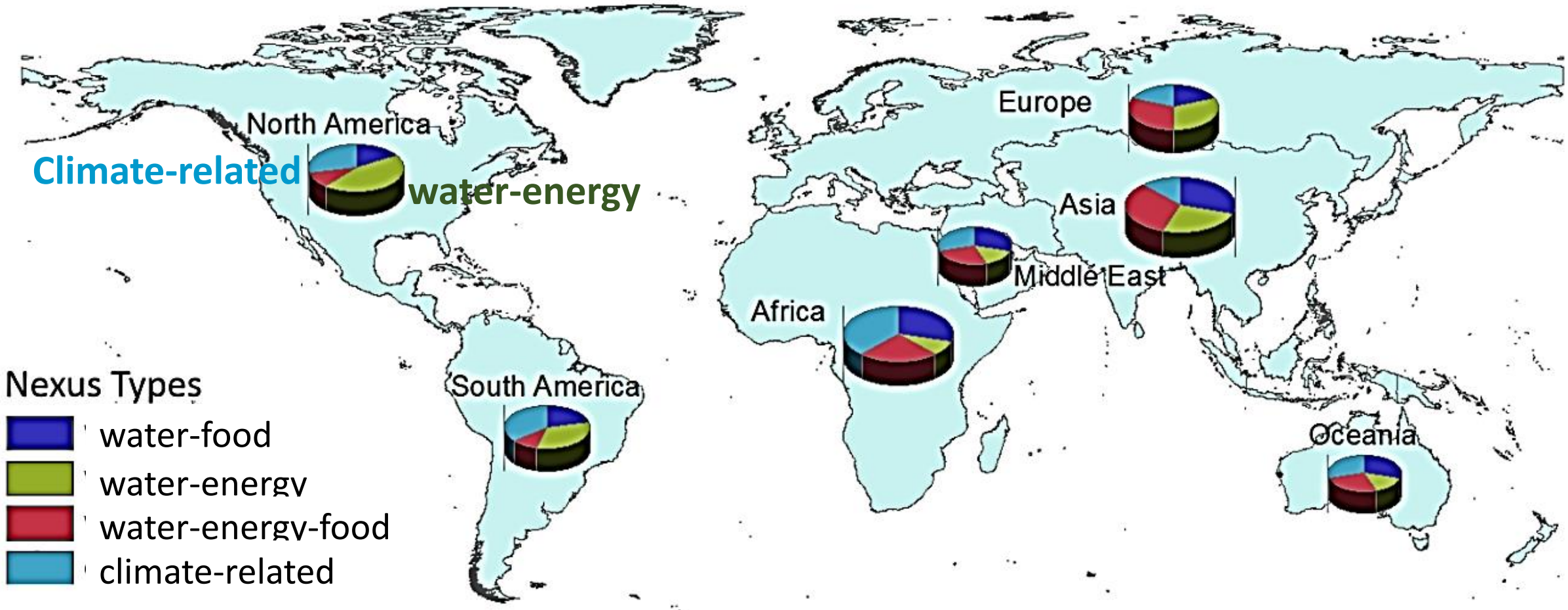
Environment:
- reduce vulnerability to climate change induced disaster and environmental degradation taking a longer term
- analyzing specific data such as 280 aquifers including precipitations and temperature in Mexico

Social & Governance:
- development strategies with climate benefits and increase the capability of developing countries
- using meteorology and historical data to anchor the relationship of climate change and poverty nexus in Nigeria
- addressing the issues of energy use and GHG emissions to associate with water management

Method: NDI & NDC

NEXUS RIHN

Nexus regions Graphical presentation of nexus types in different regions



✔**North America**: water-energy (46%) and climate related (43%)

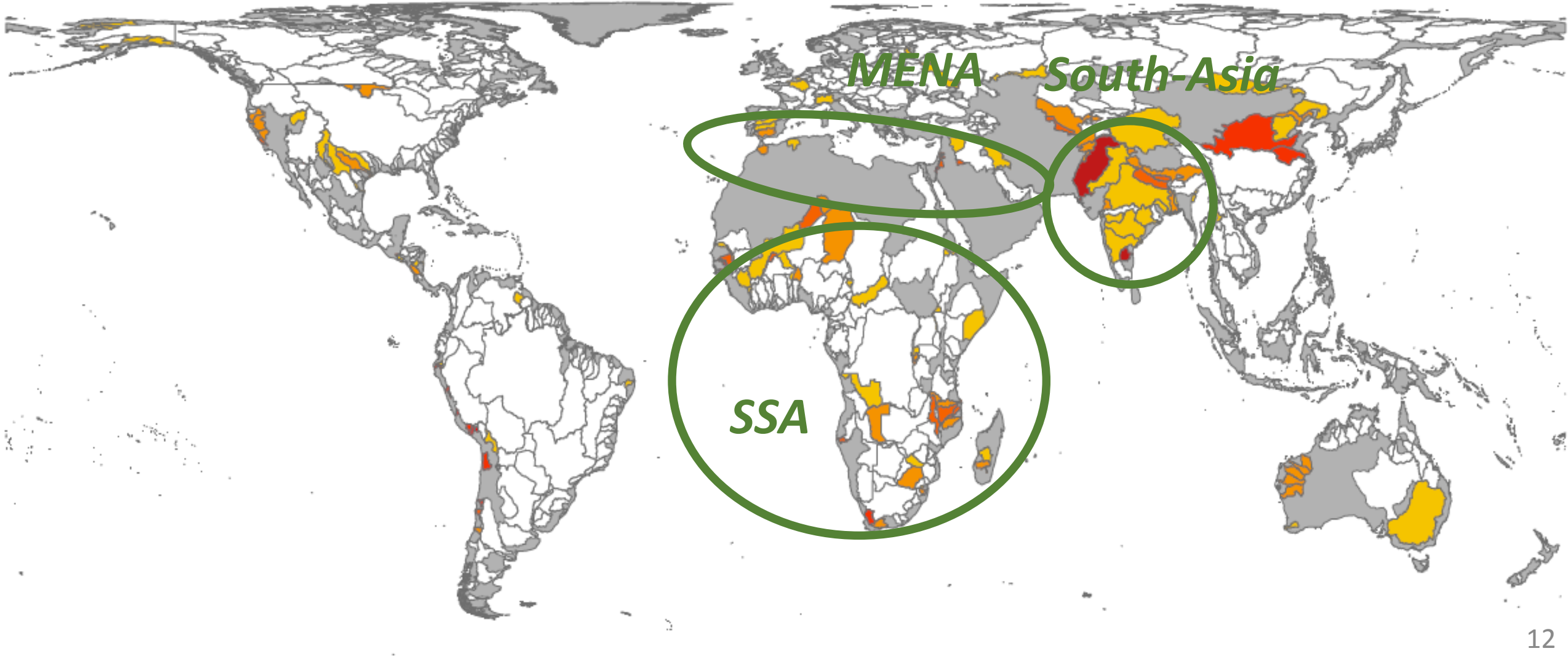
✔**Africa**: climate-related (36%)

✔**The other regions**: balanced interest in each nexus type

Challenges of WEF Nexus research

- ✔ Understanding of the interrelationships between resources and the subsequent complexity of **nexus systems** is limited
- ✔ Nexus is likely to be recognized at the research level, but is **not fully acknowledged on the ground**
- ✔ Ways to connect local nexus issues within a community to broader national and **global environmental issues** were often missing from site-specific case studies
- ✔ Differences and/or changes in tradeoff relationships between **different spatial and/or temporal scales** are poorly analyzed
- ✔ Definition of **synergy effects** in nexus case studies is still unclear
- ✔ **Academic concept** of the “WEF Nexus” has not been clearly defined as a result of the above five reasons.

Nexus challenges by regions



Nexus challenges by regions

Source: Sandrine Paillard, Sebastian Heinz, Cliven Njekete, Renee Obregon-Gonzalez

	South-Asia	MENA	Europe	SSA
Irrigation	・Share of agriculture in total water consumption reaching 90% (70%) ・Groundwater accounts for 3/5 of all irrigation water ・Soaring use of electricity and diesel for groundwater pumping for irrigation has made agriculture more energy-intensive ・Low irrigation efficiency 20% (45%) ⇒Excessive irrigation entails declining soil fertility caused by water erosion, water logging, contamination, soil salinization ⇒Land degradation	・Largest water deficit in the world (water availability under 1000㎥/capita/year, 1,700㎥/capita/year) ・Two major water sources in the MENA region, groundwater (65%) and desalinated water (5%) is highly energy intensive ・Low irrigation efficiency 30% (45%)		

	South-Asia	MENA	Europe	SSA
Land	Insufficient access to electricity and other energy sources ⇒Reliance on biomass for cooking and heating ⇒Affects soil fertility ⇒Crop productivity to considerable extent			▪ Insufficient access to electricity and other energy sources ⇒Reliance on biomass for cooking and lighting ⇒Deforestation and affects soil fertility ⇒Crop productivity to considerable extent ▪ insufficient access of households to food and income ⇒Reliance on common natural resource pools like wetlands and woodlands ⇒Land degradation⇒Soil productivity (**Zimbabwe** and other Southern African countries) ▪ Large-scale dam projects for hydropower and agricultural development ⇒Adverse effects of land degradation for potential food & energy production (**Ethiopia**)

Source: Sandrine Paillard, Sebastian Heinz, Cliven Njekete, Renee Obregon-Gonzalez

	South-Asia	MENA	Europe	SSA
Biofuels	▪Potentially affect biodiversity, water and soil quality, food security and land rights ▪Indirect land-use change/ convert forest and grassland to new cropland⇒potentially significant emissions of GHG ▪European palm oil imports from Malaysia and Indonesia (biodiesel) ⇒High deforestation rates and large carbon emissions in **Malaysia** and **Indonesia** ⇒Losses of habitat and threats to biodiversity			Lack of laws and guidelines on biofuel cultivation ⇒Poverty and threat to energy security
Food loss & waste	Diversity on diet change impacts on blue and green water footprints			
Electricity production	【US & Europe】 ▪91% (**US**) and 78% (**Europe**) of the total electricity is produced by thermoelectric (nuclear and fossil-fuelled) power plants ⇒Directly depend on the availability and temperature of water resources for cooling ⇒Vulnerable to climate change owing to the combined impacts of lower summer river flows and higher river water temperatures			90% of South Africa's power is generated from coal power plants which are located in (semi-)arid areas, will lack sufficient water

Source: Sandrine Paillard, Sebastian Heinz, Cliven Njekete, Renee Obregon-Gonzalez

	South-Asia	MENA	Europe	SSA
Coastal environment			Dominant coastal sitting of power plants is threatening the marine environment due to the high temperature of discharged water. (**The Mediterranean**)	
Agriculture			Phosphorus, nitrogen, pesticides impact on water quality (**Europe and North America**)	
Urbanisation	▪ High relevance for low- and middle-income countries since their urban population is high ▪ Effects of urban agriculture on food security and water quality ▪ Demand for agricultural products, due to quantity increase and change in diets ▪ A change in lifestyle and diets in **Asia** will increase demand for water-intensive products such as meat and dairy products (FAO 2013)			

Source: Sandrine Paillard, Sebastian Heinz, Cliven Njekete, Renee Obregon-Gonzalez

WEF Nexus challenges in South-Asia

WEF Nexus challenges in South-Asia

Overview on South Asia

-Afghanistan, Bangladesh, Pakistan, Bhutan, India, Nepal, Sri Lanka and the Maldives
-monsoonal climate with dry and wet seasons
-Himalaya-fed river systems such as the Ganges, Indus and Brahmaputra
-world's most densely populated region with a total of 1.8bn people (UN 2015), a number is expected to increase to 2.2bn people by 2050 (Rasul 2016)
-large parts of South Asia have enjoyed economic growth in the last decade

Access to water, food, energy

-around 63% of the population are not connected to the grid (Rasul and Sharma 2015)
-236 million **Indians** are still left in the dark
-134 million still have no access to drinking water (Unicef 2015)
-336 million people (almost 20% of the population) still go hungry regularly and much more face severe nutrition deficiencies (World Bank 2016)

WEF Nexus challenges

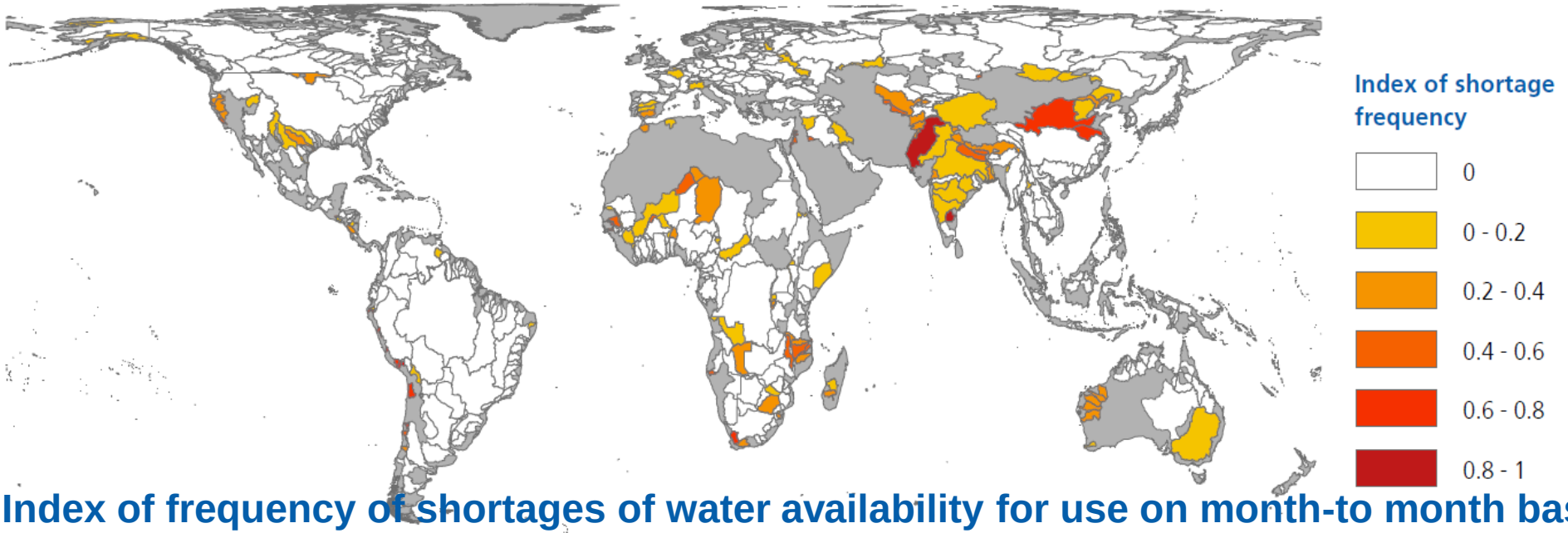
1. Low water availability

-risks of monthly water shortages are most severe in South Asia

-**Pakistan**'s per capita annual water availability decreased from 5000 m^3 in 1951 to 1000 m^3 in 2010 (Gupta and Deshpande 2004)

-**India**'s annual per capita water availability, at around 1500m^3 in 2011, is expected to fall to 1140m^3 by 2050 (Biemans et al. 2013)

-water stress becomes more severe due to the rising impact of climate change, which causes severe impact on agriculture and energy production



Source: Sadoff et al. (2015, Fig. 8, p. 77).

Index of frequency of shortages of water availability for use on month-to month basis

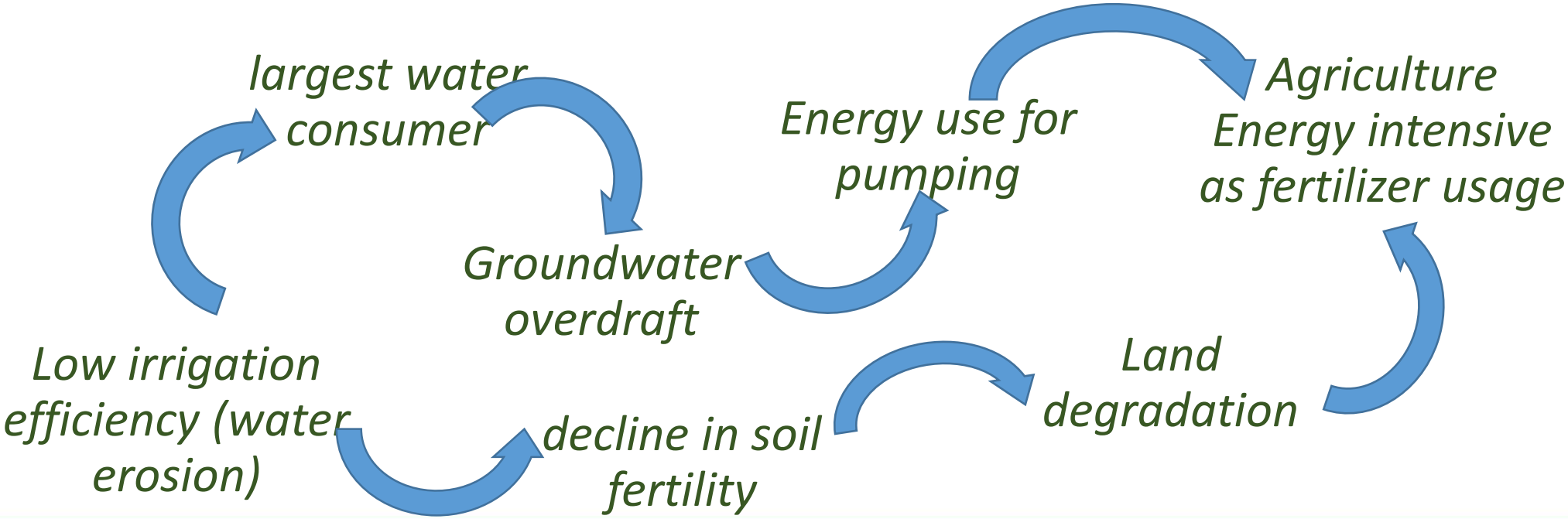
WEF Nexus challenges

2. Water-intensity of the agriculture

-agriculture is the largest water consumer reaching 90% (Rasul 2014; Rasul 2015)

-groundwater accounts for 3/5 of all irrigation water, low irrigation efficiency 20%

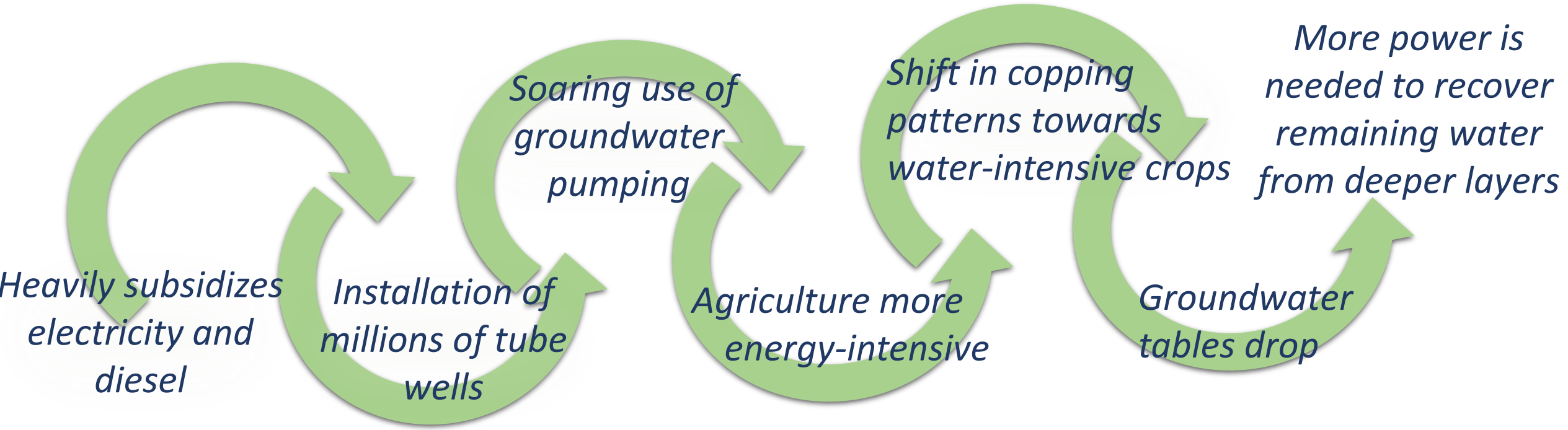
-groundwater usage is highly unsustainable, especially in **Northwest India**, **Northeast Pakistan, Bangladesh**, threatening long-term food security



WEF Nexus challenges

3. Energy policy that heavily subsidizes electricity and diesel

-subsidized electricity and diesel has led to the installation of millions of tube wells



4. Reliance on biomass for cooking and heating affects soil fertility

-11 million farmland across South Asia are impacted by nutrient depletion which has resulted in stagnating or declining agricultural productivity (Lal 2007)

5. Rise in severe social ramifications

- small-scale farmers are bereft their income, give up their lands, migrate to urban centers where there is increase pressure on local labor markets and public services (Schneider 2016)

☐ Policy recommendations

-planning and coordination across sectors

-concrete implementation of policy changes in connection with nexus issues

-involving the social sciences in order to investigate the conditions necessary for planning and implementation of nexus solutions to succeed (dominance of natural & engineering sciences in the nexus research)

-**energy subsidies for irrigation should be reconsidered**

WEF Nexus challenges in MENA

WEF Nexus challenges in MENA

Overview on MENA

-6 GCC (Gulf Cooperation Council) countries (UAE, Oman, Qatar, Kuwait, Saudi Arabia, Bahrain), Lebanon, Syria, Egypt, Iraq, Iran, Israel, Palestine, Jordan, Yemen, Algeria, Tunisia, Morocco, Libya

-population is 381 million, increasing

-mostly rich in conventional energy resources such as **oil and gas** (60% of the world's oil reserves and 45% of the world's natural gas reserves)

-the most **water scarce** and **food import dependent** regions in the world

-**civil war** is ongoing in Syria, the largest refugee population in the world

-**climate change** will increase in temperature & number of dry days in countries on the Mediterranean and some parts of the Arab Peninsula

Access to water, food, energy

Water scarcity threshold level

【Water】

-GCC countries: **100 m³**/capita/year of total renewable water resources

-Lebanon, Syria and Egypt: closer to **1000 m³**/capita/year, Iraq: 2467 m3/capita/year

-tends to be highly dependent on **transboundary water** (the Tigris, the Euphrates)

-water availability is expected to **decrease by 50% by 2050**

【Food/land】

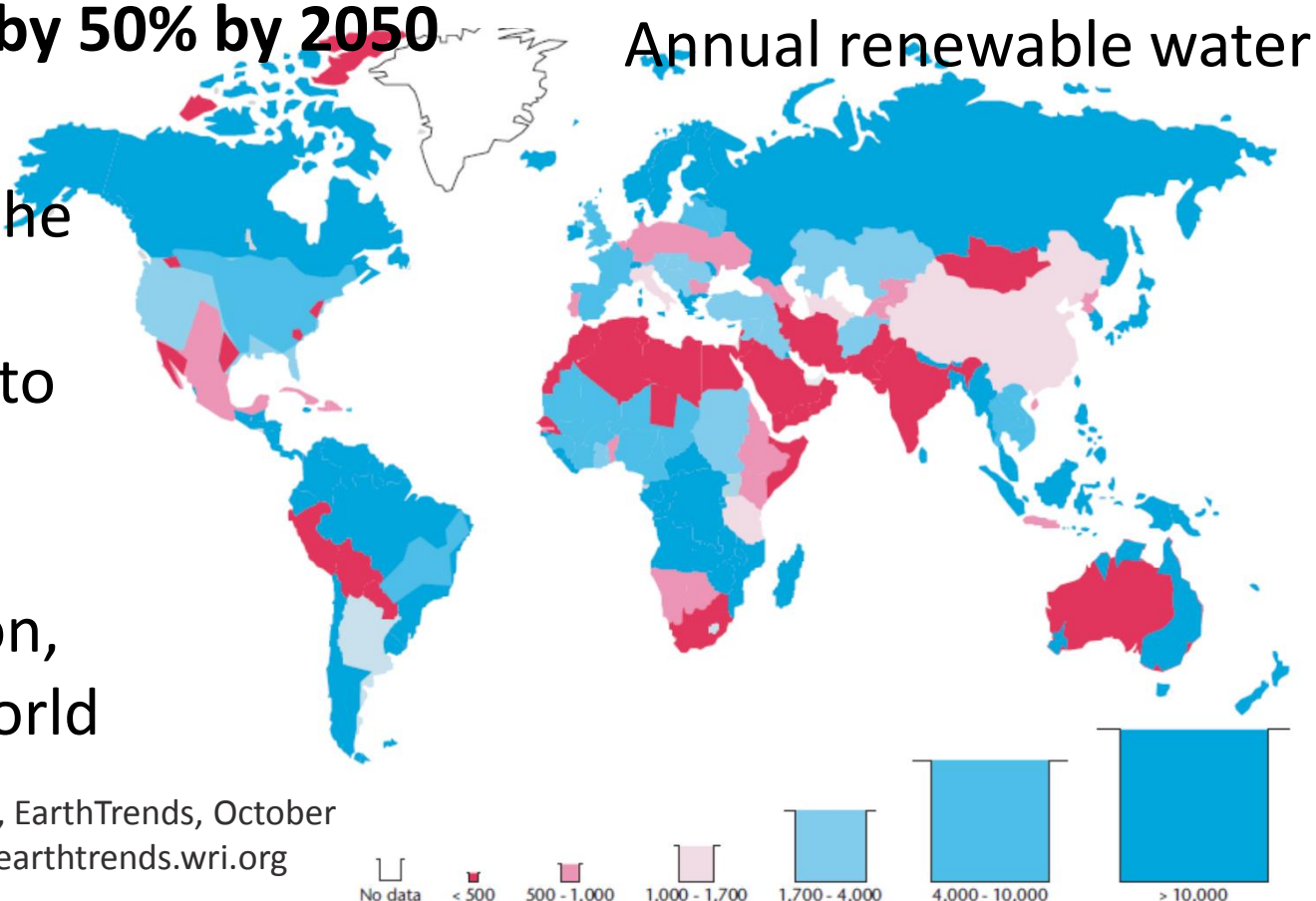
-**the largest importer of food** & cereals in the world

-**land availability is low**, which constraints to agricultural productivity

【Energy】

-average electric energy losses in generation, transmission and distribution is **19.4%** (world average: 8.3%)

Annual renewable water



Revenga, C., EarthTrends, October 2000,www.earthtrends.wri.org

WEF Nexus challenges

1. Water-intensity of the agriculture

-Agriculture consumes close to 90% of water in some Arab countries

2. Highly energy intensive for producing water

-Egypt: 25% of the electrical generation capacity is based on fresh water systems

-Desalination and re-use with highly energy intensive, are key sources of water

-Saudi Arabia and the United Arab Emirates: produce around a third of the desalinated water in the world

-Saudi Arabia: approximately 65 % of domestic oil use is for desalination

-Energy is also needed in food production at different stages, pumping, transportation of produce, refrigeration

3. Institutional

Arab Ministerial Water Council (AMWC), Arab Ministerial Council for Electricity (AMCE) , the General Assembly of Arab Ministers for Agriculture, Regional center for Renewable Energy and Energy Efficiency (RCREEE)….

→ remains mostly sectoral in structure

4. Policy challenges

The Arab strategy and action plan for water security in the Arab Region

-enhancing cooperation and exchange of experiences and information
-increasing efficiency of water use especially in agriculture
-expansion in the use of non-conventional water sources

The Arab Sustainable Agricultural Development Strategy 2005 to 2025

-investing in shared water basins
-developing conventional and non-conventional water resources
-using renewable energy sources in water desalination

The "Pan-Arab Strategy for the Development of Renewable Energy Applications: 2010 – 2030

-untapped renewable energy options including water desalination, small hydro and pumped storage options

The Arab Strategic Framework for Sustainable Development adopted by CAMRE in 2014

-integration among sectors and issues between Arab States

5. Financial challenges

-private sector see glowing business opportunities

-Green Climate Fund

6. Renewable energy development in North African countries

-potential for renewable energy, **solar & wind** energies is high, especially in North African (the Pan-Arab Strategy for the Development of Renewable Energy Applications 2010 – 2030)

☐ Policy recommendations

-developing a solid knowledge base, bridging the existing knowledge gap of the WEF nexus at the national and regional levels by understanding and **quantifying the interlinkages between WEF**

-focus on the **food supply chain** with its significant losses of WEF

-support **water subsidy reform**

-encouraging and promoting technology transfer and innovation to **reduce electric energy losses**

-information sharing within and between nations for improved management & planning

Policy recommendations

-capacity and institution building for enhanced coordination and collaboration
-mobilizing finance towards water, energy and food security projects in an integrated approach
-encouraging private sector participation by reducing capital risks
-data collection on the economic benefits of sustainability and collection of success stories of private sector investment
-**WEF-related success stories** in the region should be studied and disseminated towards up-scaling
-the interlinkages between WEF in **ecosystems and societies** should be understood
-**Providing decision making tools such as** Nexus approach **scenarios**
-The development of **policy dialogues** across sectors

WEF Nexus challenges in Southern Africa

WEF Nexus in Southern Africa

Overview on Southern Africa

-The region's population is projected to roughly double by 2050, mostly in urban area

-the Southern African Development Community (SADC, 14 countries) & Southern African Power Pool (SAPP, 12 countries)

-Most nexus studies for southern Africa have been motivated by climate change

✔climate variability has important consequences for resource management in the

-South Africa: experienced a decrease in GDP in the 1983 El Niño

-Malawi and Zambia: severe 1992 drought caused a drop in GDP

✔most southern African countries will warm up more than the global mean, with annual mean temperatures rising by 2 to 3 ℃ in most cases

✔annual precipitation, soil moisture and runoff are likely to decrease, while rising temperatures could increase evaporative demand in large parts of the region

Access to water, food, energy

【Electricity】

-SAPP electricity-generating mix in 2012–2013 was 54,923 MW, **dominated by coal** (72.9%)

-almost 100% of electricity production in the Democratic Republic of Congo, Lesotho, Malawi and Zambia is from **hydropower**, sharing Southern African Power Pool (SAPP) members

-South Africa: more than 90% of energy generation is coal-based

- wet cooling systems in coal-fired power plants consume far more water than most other energy technologies
- coal mining and energy generation from coal substantially impact water quality and availability
- Eskom has implemented a dry-cooling system in 2 existing and all new power stations, enabling a 15-fold reduction in water use

coal-fired power plants in South Africa

WEF Nexus in Southern Africa

- **Access to water, food, energy**

【Food】

-there are strong contrasts in food (5–90% of cereal food imported) self-sufficiency
-cereal import dependency ratio is high in Swaziland (79%), Lesotho (85%), Botswana (90%), Namibia (65%), Angola (55%)
-**chronic and episodic food insecurity** remain important problems at the household and individual level in the region dominated by **poverty, environmental stressors, & conflict**

【Water】

-**85 % of the SADC region's water resources is transboundary**
-South Africa, Swaziland, Zimbabwe: facing most water shortage
-intensity of freshwater use including groundwater

WEF Nexus challenges & Policy recommendations

1. Climate change will have considerable indirect impacts on electricity generation, region's food system, GDP per capita growth

-develop forecast skill and utility in guiding nexus-related decision making

-improve lower-carbon-emitting technologies in coal-fired power plants

-**biofuels** may reduce the region's imported fossil fuels and rural poverty, but have potential food security trade-offs

-**solar photovoltaic** and **wind energy** would be the most viable renewable options

2. Transboundary water allocation

-addresses how member countries sharing rivers might resolve water allocation priorities through protocols

-SAPP has the potential to serve as a buffering mechanism for climate-induced river-basin-scale electricity insecurity

2. Transboundary water allocation (cont.)

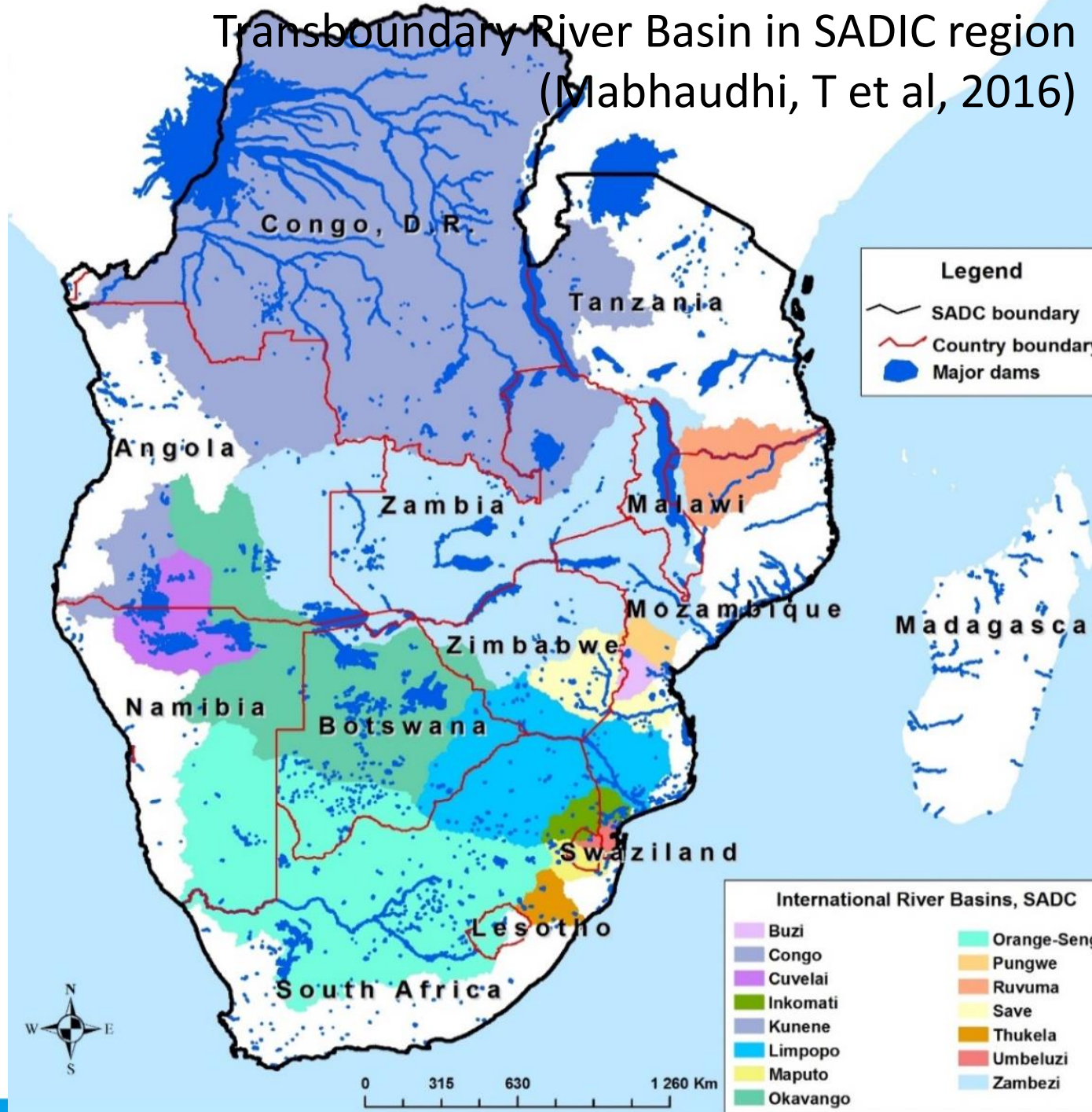
-efforts to increase stakeholder participation and decentralize water management

-coordination during flood events since the persistent 2010–2011 summer rainfall in the Zambezi raised downstream water levels, which increased flooding

3. Very little is know about aquifers

-geologic and hydrologic conditions of the aquifer, groundwater storage, level of water table should be studied

Transboundary River Basin in SADIC region (Mabhaudhi, T et al, 2016)



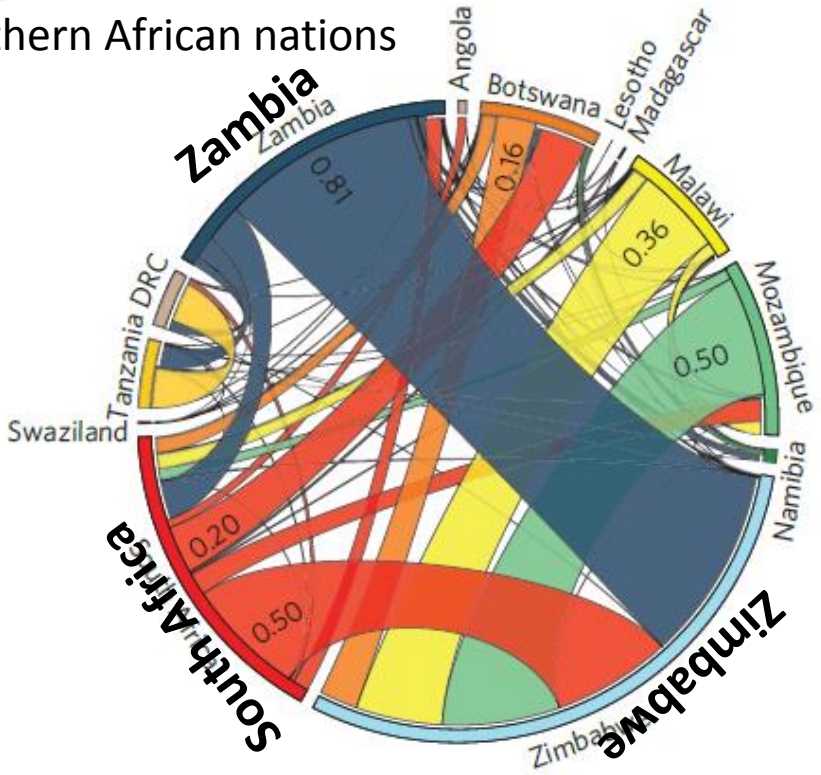
4. Virtual water trade embedded in intraregional flow of food exports

- from South Africa and Zambia to other nations account for 2/3 of the total intraregional flow

-virtual water trade embedded in intraregional flow of food require further investigation

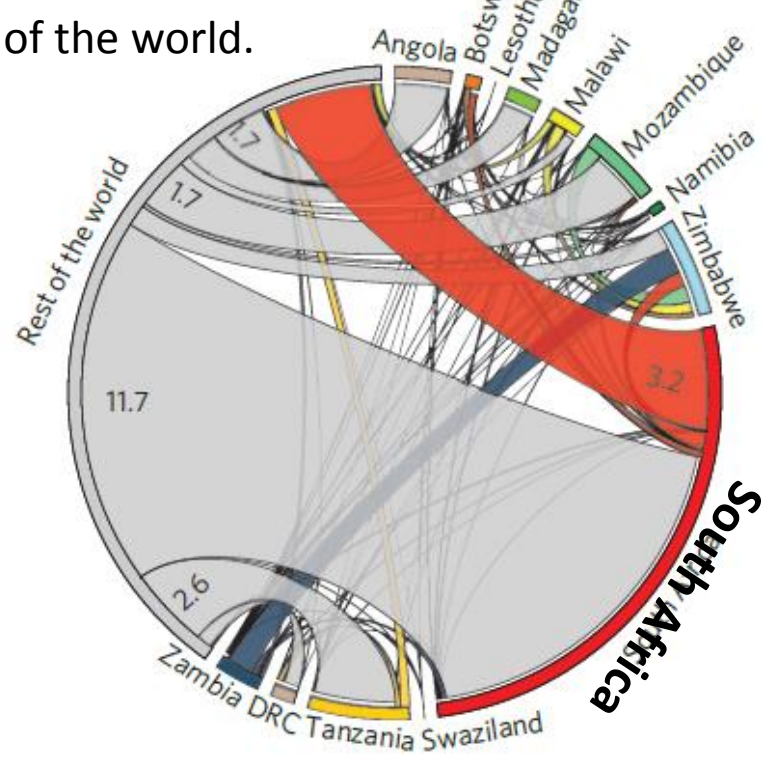
Water resources transfers (km3) through food trade in 2007(Conway D et al 2015)

A among southern African nations



Zimbabwe was the region's major virtual water importer in 2011

B the rest of the world.



Southern Africa is largely a net importer of virtual water

The role of the Nexus in the implementation of the SDGs

The role of the Nexus in the implementation of the SDGs

"a nexus perspective has not been adopted in their framing. The proposed SDG targets fail to take a nexus perspective, i.e. they fail to recognize there are inherent trade-offs but also potential synergies among the proposed SDGs and their targets"

(UN-DESA, 2015)

- ✔ identify how each goal are interconnected and interdependent from quantitative and qualitative approach, among not only 2, 6, 7, but also all 17 goals
- ✔ identify the tradeoffs and synergies among the various goals from a quantitative and qualitative approach

The role of the Nexus in the implementation of the SDGs

✔ Develop indicators/tools to evaluate/generate integration from holistic and systemic perspective to alleviate poverty & hunger, which are related to all 17 goals

1) cross-sectoral cooperation/coordination
2) Implementing multi-sector plans/programmes
3) stakeholder involvement
4) capacity building for nexus approach
5) cross-sectoral financial system including subsidies, research funds
6) standardizing data

Summary

✔Nexus research has so far remained weak in identifying how the nexus is interlinked with policies and its implementation

-explore the science-policy-society interactions through, e.g. policy dialogues

-SDG must be a big incentive

✔Regional alliances would not work well for nexus approach yet

-SAPP, SADC, Arab league, e.g. has the potential to serve as a buffering mechanism

✔Identify 1) nexus challenges, 2) drivers & stakeholders (mapping, network analysis) from multi-scales, 3) setting the clear goals, 4) solutions including tools for the achievement of the goals taking system approaches holistically and systemically


Thank you.