

Concepts, Tools/Methods, and Practices of Water-Energy-Food Nexus

**Human-Environmental Security in the Asia-Pacific Ring of Fire :
Water-Energy-Food Nexus**



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□ Social impacts & climate change

Population growth	7 billion (2013)⇒8 billion (2025)⇒10 billion (2050) ⇒11 billion (2100)	1
Globalization	Traded percentage of food produced has grown globally from about 10% in 1970 to 15% in 2000	2
Economic (GDP) growth	2.4% (2013)⇒3.2% (2014)⇒3.4% (2015)⇒3.5% (2016)	3
Urbanization	<ul style="list-style-type: none">-Half of the global population lives in urban areas-70% of the global population is expected to live in the cities in 2050-Cities produce 75% of economic output	4
Climate change	<ul style="list-style-type: none">-Global water cycle change in response to the warming will be uneven between areas and seasons with exceptions.-Global sea level is expected to rise due to the increased ocean warming and melting of glaciers and ice sheets-The increase of CO₂ in the atmosphere will promote ocean acidification due to the uptake of carbon by the ocean	5

□ Access to water, energy & food

Water	- 1.1 billion poor people have no adequate access to water	6
	- 2.6 billion people lack access to adequate sanitation	6
	- Two-third of the world's population lives in areas of high water stress	7
Food	-Close to 1 billion people are facing extreme hunger	6
	-Approximately 2 billion people lack food security	8

□ Resources of water-energy-food

Water	Demand for water will exceed global availability by 40% in 2030	9
Food	Global food demand will increase up to 70% by 2050	
Energy	Primary energy needs will rise to 50% by 2035	

Groundwater
Spring water
Surface water

Fig. Dynamics of Water-Energy-Food Nexus

-transporting water (virtual water)
 -withdrawing water
 -heating water

Social changes

Climate changes

-hydro electric power
 -thermo electric generation
 -power plant cooling
 -fracking

-agricultural irrigation
 -rainwater harvesting (water footprint)

Geothermal
Micro-hydro
Shale gas

Human Environmental Security (Risk, Resilience)

Fishery productions
Aquaculture
Agricultural productions

Human Well-being
Global Sustainability

biofuel

-food production
 -transporting food
 -groundwater pumping

- ✓ Considering complex and interrelated challenges of sustainable development, NEXUS stresses to promote the cooperation with various sectors and provides the opportunity to open up the disciplinary divides (Allan 2003).
- ✓ There is no fixed concept of NEXUS and the concept could vary depending on short, middle and long term goals at the particular region and sector (Ringler et al. 2013).
- ✓ Though unauthorized, it seems that “**Virtual water**” deals with production, “**Water Footprint**” deals with consumption, “Integrated Water Resource Management (**IWRM**)” deals with entire life cycle of water, and “NEXUS” deals with lifecycle of water and other related processes including energy and food.

- ✓ Water-Energy-Food Nexus has emerged as a useful concept to describe and address the complex and interrelated nature of our global resource systems, on which we depend to achieve different social, economic and environmental goals. It is about balancing different resource user goals and interests – while maintaining the integrity of ecosystems (FAO 2014)
- ✓ Nexus approach can enhance water, energy and food security by increasing efficiency, reducing trade-offs, building synergies and improving governance across sectors (“Understanding NEXUS” by Hoff at SEI, 2011)
- ✓ The nexus is fundamentally about resource recovery, closing the loop and capturing true efficiency gains instead of simply displacing or masking increased resource use (Lankford 2013; Scott et al. 2014)

Historical review of nexus study and practices

1983	Research	UNU launched the Food-Energy Nexus Programme ←Nexus terminology appears!
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 conducted 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 study 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 , Background paper “Understanding NEXUS” by Hoff at SEI
	Platform	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 2 nd 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 Papers	“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 study 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
	Conference	The International Conference on the Sustainability of the Water-Energy-Food NEXUS in Bonn by GWSP
	Conference	2014 World Water Week – Energy and Water by SIWI
	Platform	Future Earth published “Future Earth 2025 Vision” and Nexus is one of 8 challenges
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
	Workshop	Future Earth Nexus Cluster WS initiated by GWSP, Future Earth and others supported by Belmont Forum

Parties of nexus activities

Region	Institution	Region	Institution	Region	Institution
UN Agency	UN General Assembly	International groups, institutes, and NGOs	WRI	Europe	Government of Germany
	WB		WPP		BMZ, Germany
	UNDP		GWP		GIZ, Germany
	UNEP		IAH		University of Lüneberg, Germany
	FAO		IWA		PIK, Germany
	UNIDO		IFPRI		Natural Environment Research Council, The Royal Society, UK
	UN-HABITAT		AVRDC		Imperial College London, UK
	UNESCO-IHP		IAEE		SEI
	UNU		IRENA		SRI
	WWAP		IGBP		SIWI
	UN-Water		WFEO		Ministry of Foreign Affairs, Norway
	UN-ESCAP		OECD		University of Life Sciences, Norway
	WMO		WBCSD		Erasmus University of Rotterdam, Netherlands
	GEF		WEF		Ministry of the Environment, Estonia
	IPCC		IFC		EC
UNCCD	WWF	EU			
Private Company	McKinsey & Co.	IUCN	EIB		
	Philips	IISD			
	Shell	Christian Aid			
	Nestlé	World Vision			
	The Guardian	ICLEI			
		Ellen MacArthur Foundation			

Parties of nexus activities

Region	Institution	Region	Institution
North America	USAID	Asia & Oceania	Government of Nepal
			Government of India
			Government Policy, Thailand
			Use, Kazakhstan
			ology Lahore
Latin America			izations
Africa			

✓ More than 53,000 hits from keyword nexus searches using Google scholar and other forms of search engine, **37 nexus practices (including 137 organizations)** that have linkages with the 2011 Bonn Nexus Conference were selected

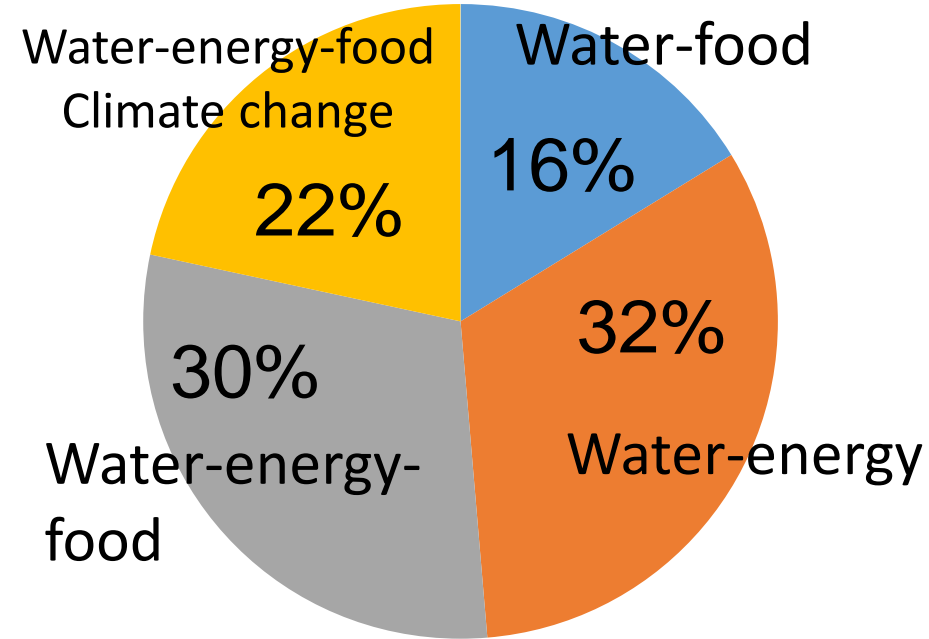
✓ We identify

- nexus type
- region
- key words
- stakeholders
- funding implementing agency
- objective

- public/private
- budget
- method/strategy
- outcome
- source
- year

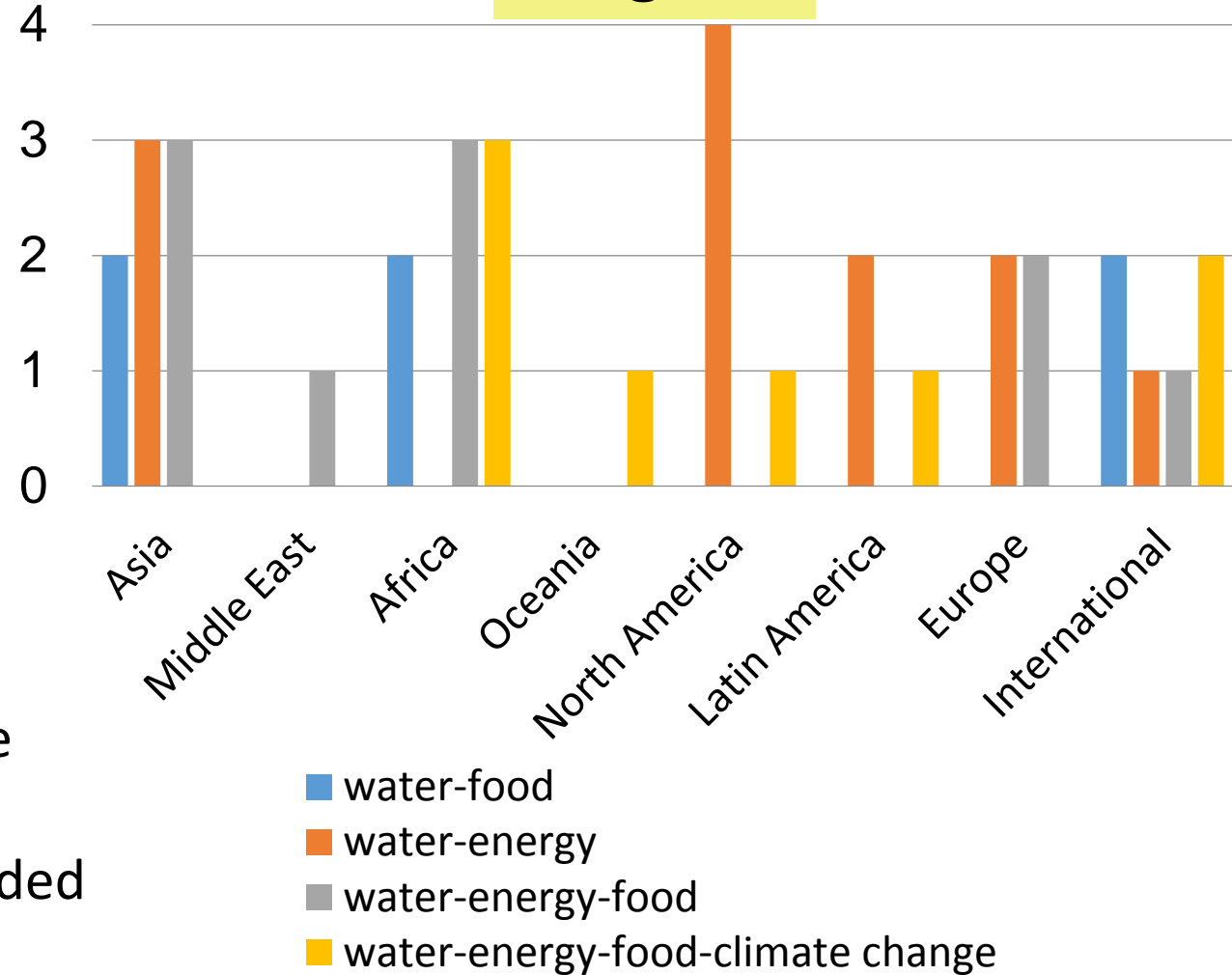
Nexus type and region

NEXUS Type



Source: I.Tsurita, A. Endo

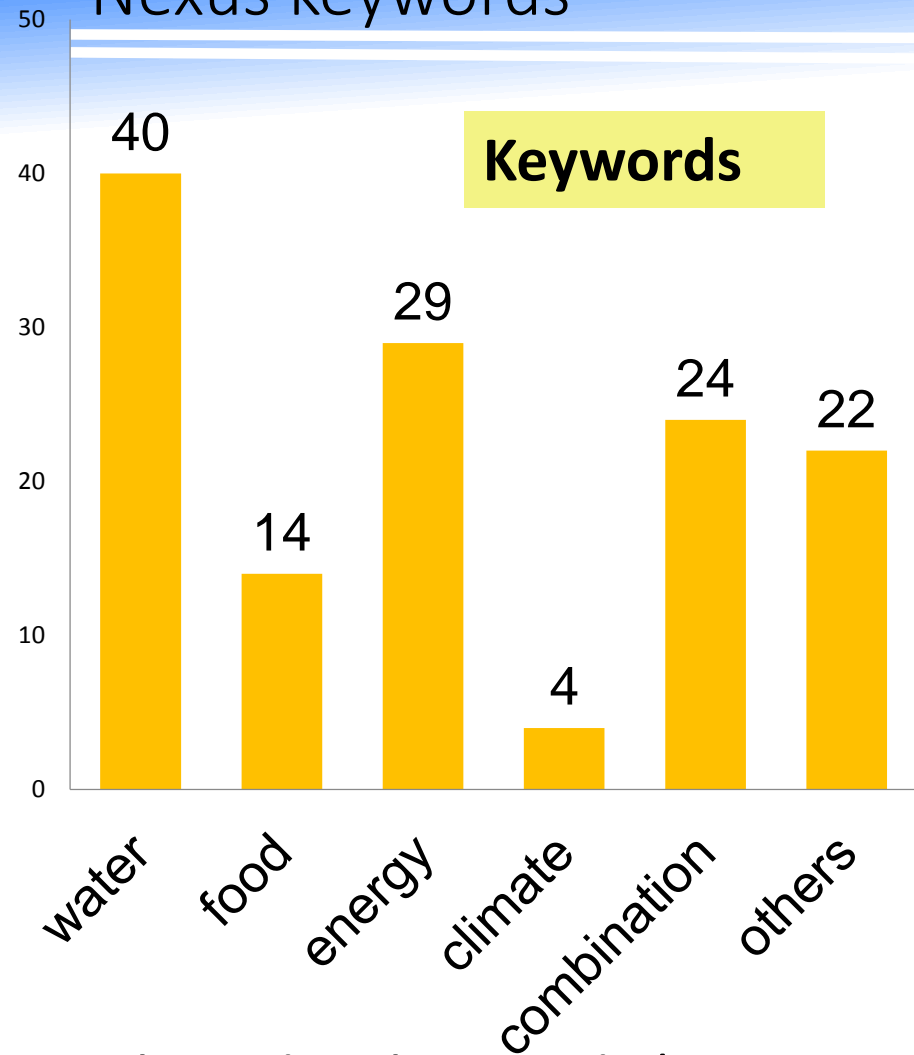
Region



- Four types of NEXUS (W-F, W-E, W-E-F-Climate change) are categorized
- Food for energy or energy for food is not provided due to the limited information
- Largest number of NEXUS type is W-E followed by W-E-F

North America: water-energy

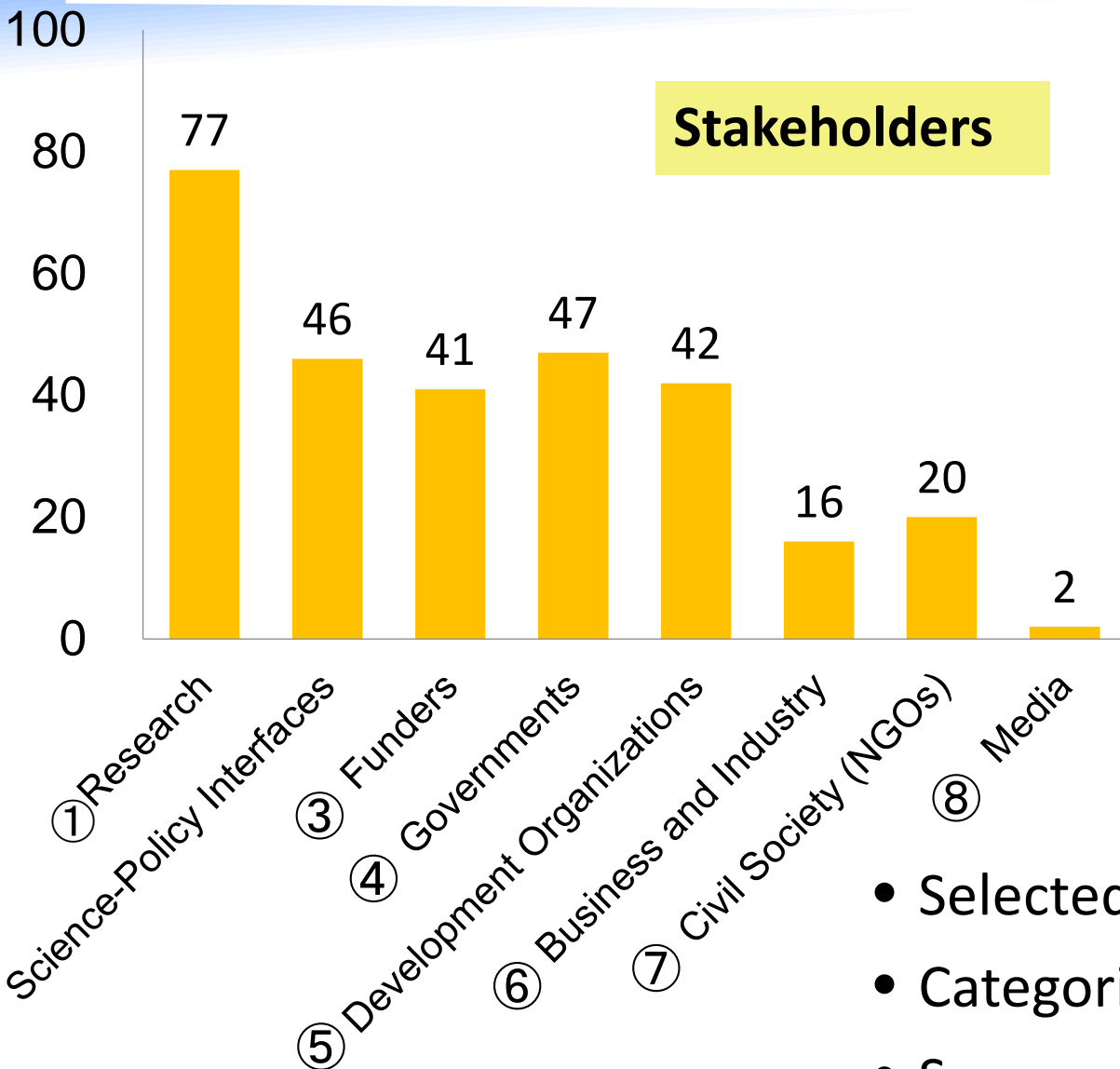
Nexus keywords



	water	food	energy	climate	combinations	others
Irrigation scheduling	✓	✓			✓	
Water reuse	✓		✓		✓	
Water transportation	✓		✓		✓	
Waste water management	✓		✓		✓	
Sea water desalination	✓		✓		✓	
⋮	⋮	⋮	⋮	⋮	⋮	⋮
84 in total	40	14	29	4	24	22

- Selected **84** keywords (e.g. irrigation, etc.) from 37 NEXUS practices
- Categorized into water, food, energy, climate, combination, and others in subjective way
- Most of the keywords have more than double categories.
- 40 out of 84 keywords were linked with water followed by energy

Parties of nexus activities



	①	②	③	④	⑤	⑥	⑦	⑧
World Bank		✓	✓		✓			
Pepsi						✓		
Japan International Cooperation Agency (JICA)	✓	✓	✓	✓	✓			
World Vision			✓		✓		✓	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
137 in total	77	46	41	47	42	16	20	2

- Selected **137** organizations from 37 NEXUS practices
- Categorized stakeholders under the framework of the FE
- Some organizations have more than double roles
- Research are largest followed by governments

Integrated Tools for Water-Energy-Food NEXUS

*Human-Environmental Security in the Asia-Pacific Ring of Fire :
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□ Project purpose

To maximize human-environmental security (minimize the risk) by choosing policies and management structures that optimize water-energy-food connections in the Asia-Pacific region

Human Environmental Security = (Resilience, Risk)

□ Primary Challenge

to analyze the interlinkages between groundwater and fisheries production, regarding the hypothesis that the flow of nutrients from land to ocean affects the coastal ecosystem.

→ This suggests that water use for producing and/or consuming food and/or energy on land might affect fisheries production in coastal areas

Integrated tools for water-energy-food nexus

Quantitative approach

Data		Functions Integrated tools	Interdisciplinary				Trans disciplinary
primary	secondary		Unification	Visualization	Evaluation	Simulation	
✓	✓	Index	✓	✓	✓	✓*1	✓
✓		Model -water/dissolved material balance	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓
✓	✓	Cost-benefit analysis	✓	✓	✓		✓
✓	✓	Economic optimization	✓	✓	✓	✓	✓
✓		Text-mining	✓	✓	✓		✓
✓		Network analysis -social network	✓	✓	✓		

Qualitative approach

*1 making options

✓	✓	Map	✓	✓	✓	✓*1	✓
	Definition	Ontology	✓	✓	✓	✓*2	✓*3
✓		Reviewing/Interviewing	✓	✓	✓		✓

*2 Qualitative simulation

*3 Potential

Integrated tools for water-energy-food nexus

□ Multistakeholder involvement & Transdisciplinary approaches

Index	-selecting indicators in AHP(Analytic Hierarchy Process) -setting security policy options, recommending security policy, implementing/evaluating the policies
Model	-making future scenario for setting security policy options and/or recommending security policy
Cost-benefit analysis	-setting security policy options, recommending security policy, implementing/evaluating policies
Map	-visualizing/building capacity/raising awareness at stakeholders participation events or etc. -setting security policy options, recommending security policy, implementing/evaluating the policies
Text-mining	-visualizing discussion contents at stakeholders participation events
Ontology	-identifying discussion contents at stakeholders participation events

Summary of nexus

- ✓ Nexus activities are currently shared among different stakeholders through various modes, led by **researchers** and **governments**
- ✓ The number of **water-energy** practices in **North America** is the largest
- ✓ UNU and Federal Government in Germany, Arizona State University, Columbia Water Center, SEI would be originally leading parties for nexus study and practices
- ✓ Nexus concept, theory, policy, tools, methods, and practices are diverse, to develop **interdisciplinary and transdisciplinary tools to integrate and synthesize sectoral administration and monodisciplinary approaches** would be necessary
- ✓ It is a challenge **to make connections between local nexus issues within a community and broader national and global nexus issues** and themes
- ✓ So far, the Nexus activities shared around the international communities are mainly linked to the terrestrial activity
- ✓ RIHN Nexus cases on fishery and marine related activity are unique among the international Nexus projects

- *1: UN Department of Economic and Social Affairs, Population Division “World Population Prospects The 2012 Revision”
- *2: Andersson 2010
- *3: WB (<http://www.worldbank.org/ja/news/press-release/2014/01/14/global-economy-turning-point-world-bank>)
- *4: Working documents for NEXUS Conference in NC NEXUS 2014
- *5: IPCC
- *6: Human Development Report 2006
- *7: Bonn2011 Conference Programme
- *8: Bazilian et al. 2011
- *9: UNC Water Institute (<http://nexus.unc.edu/what-is-the-nexus/>)
- *10: FAO 2009 Medical Fact Sheet “Growing more food-using less water”
- *11: C.A.Scott and et al 2015. The Water Energy-Food Nexus: Enhancing Adaptive Capacity to Complex Global Challenges, M.Kurian and R. Ardakanian eds: *Governing the NEXUS*: Switzerland, Springer
UNU-FLORES 2013 Advancing a Nexus Approach to the Sustainable management of Water, Soil and Waste
I. Tsurita & A. Endo