Nexus Challenges for Promoting Green Technologies

Aiko Endo, Research Institute for Humanity and Nature (RIHN)

UN ESCAP International Conference on Green Technologies for Achieving SDGs
November 28 in Manila

Outline of my talk

1. Background of Nexus studies
2. Nexus challenges by regions
3. Understanding the complexity of WEF nexus system

Water-Energy-Food nexus : Water for Energy? or Water for Food?

Jatiluhur Dam, Purwakarta, Indonesia

◆ Water for Energy

Water use for hydropower

◆ Water for Food

aquaculture in the dam using Floating Fish Net

→contribute to the deterioration of its water quality

→efficiency of energy production using contaminated water has become worse

✔Tradeoffs

Water for energy？VS water for food？

✔Conflicts

Energy developer VS aquaculture

Groundwater-Food-Environment nexus
Groundwater for Food?
or Groundwater for Environment?

Pajaro Valley in CA, USA

◆ Groundwater for Food

Use groundwater and recycle water treated household wastewater in San Francisco for agricultural productions

◆ Groundwater for Environment

- ・Serious water scarcity because of drought since 2012
- ・Decrease in groundwater storage and salination caused by overdraft
- ・Use energy for pumping, wastewater treatment, and allocate recycled water

✔Tradeoff

Groundwater resource for food production vs for environment

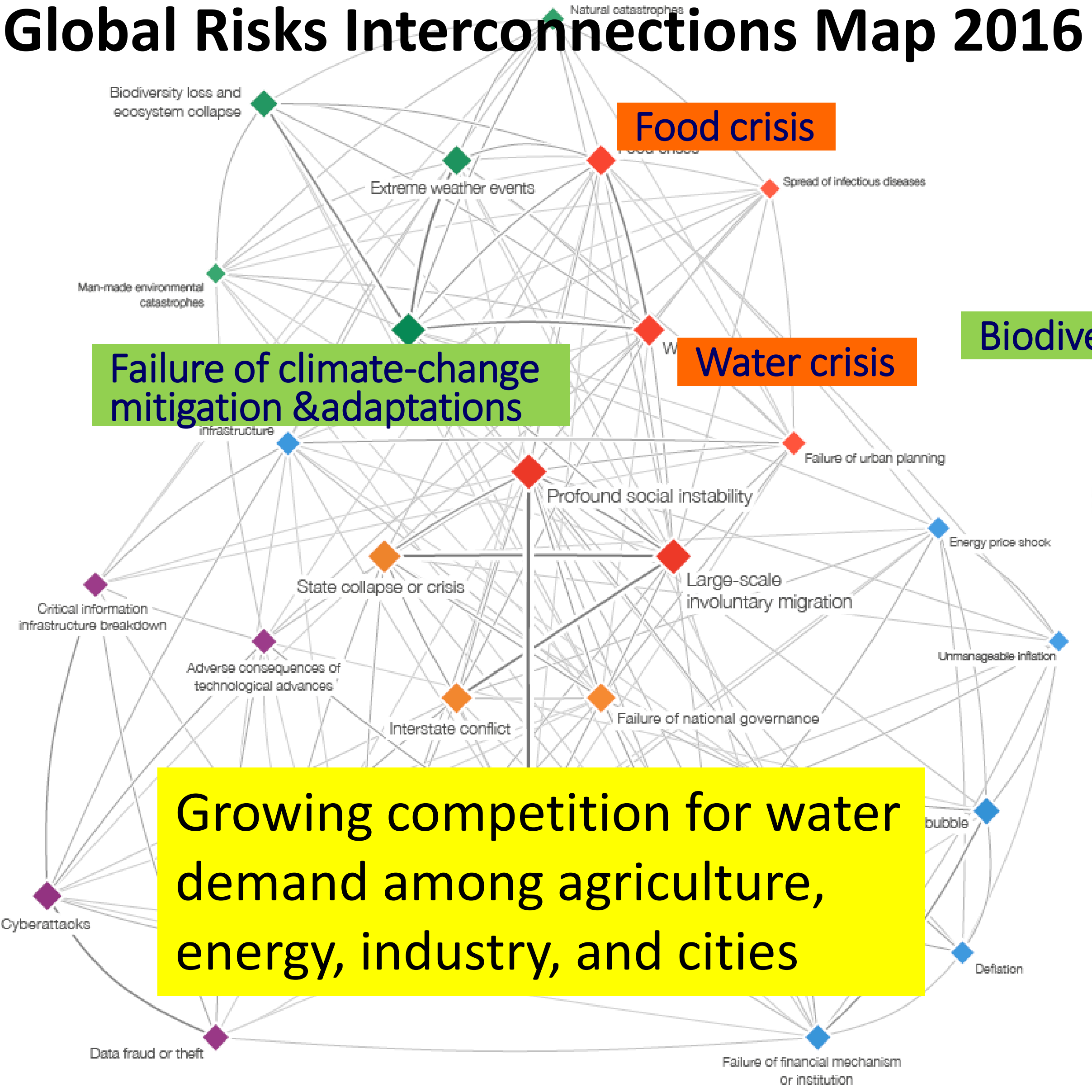
Background of Nexus studies

"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 is interconnected and interdependent in hybrid methods, among goals
- ✔ Identify the tradeoffs and synergies among the various goals
- ✔ Develop indicators/tools to evaluate/generate integration from holistic and systemic perspective to alleviate poverty & hunger, which are all related to the 17 goals

Global Risks Interconnections Map 2016

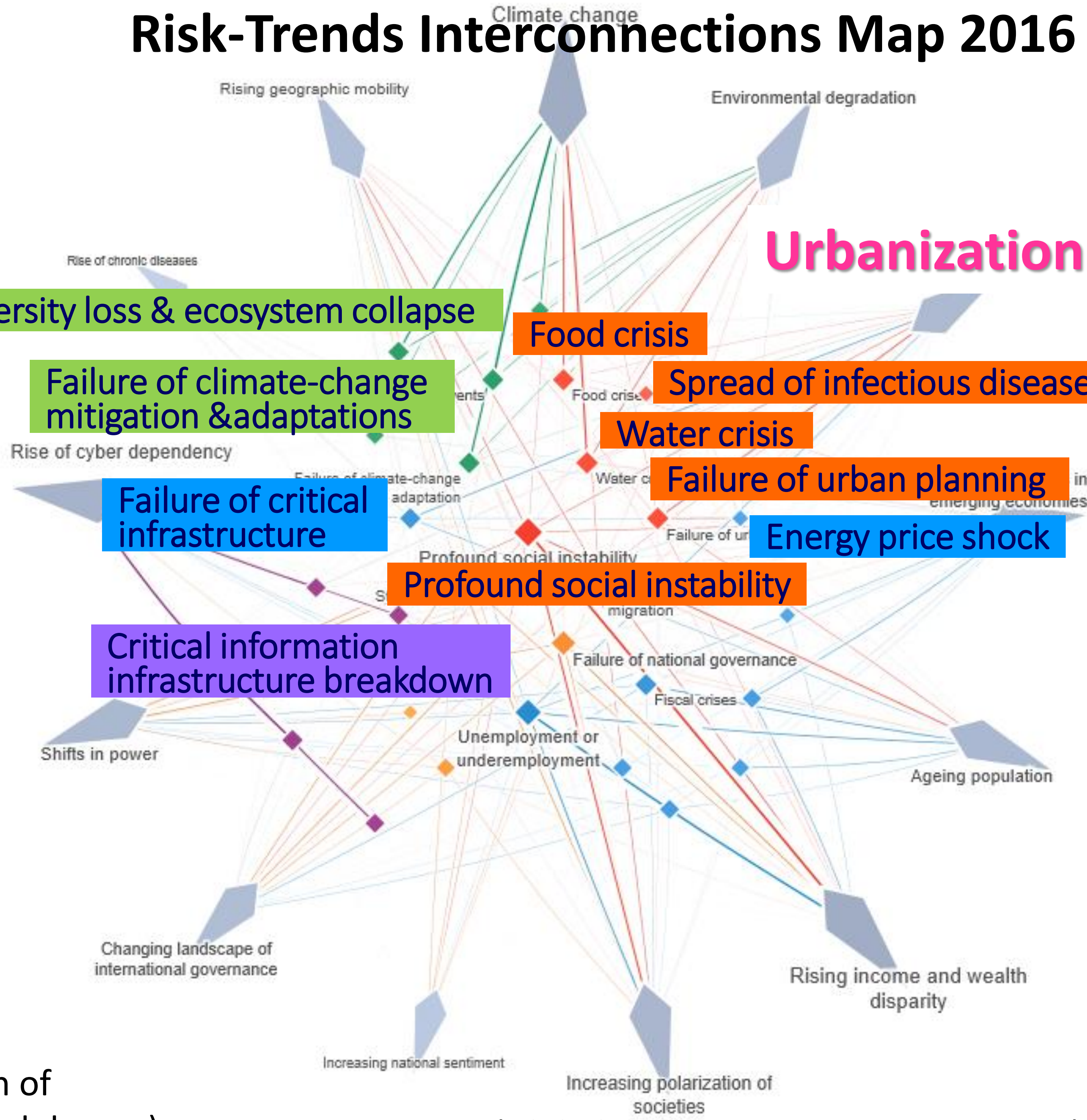


Growing competition for water demand among agriculture, energy, industry, and cities

- Economic risks
- Geopolitical Risks
- Technological Risks
- Environmental risks
- Societal Risks

Number and strength of connections (weighted degree)

Risk-Trends Interconnections Map 2016



(Global Risks Report 2016: WEF 2016)

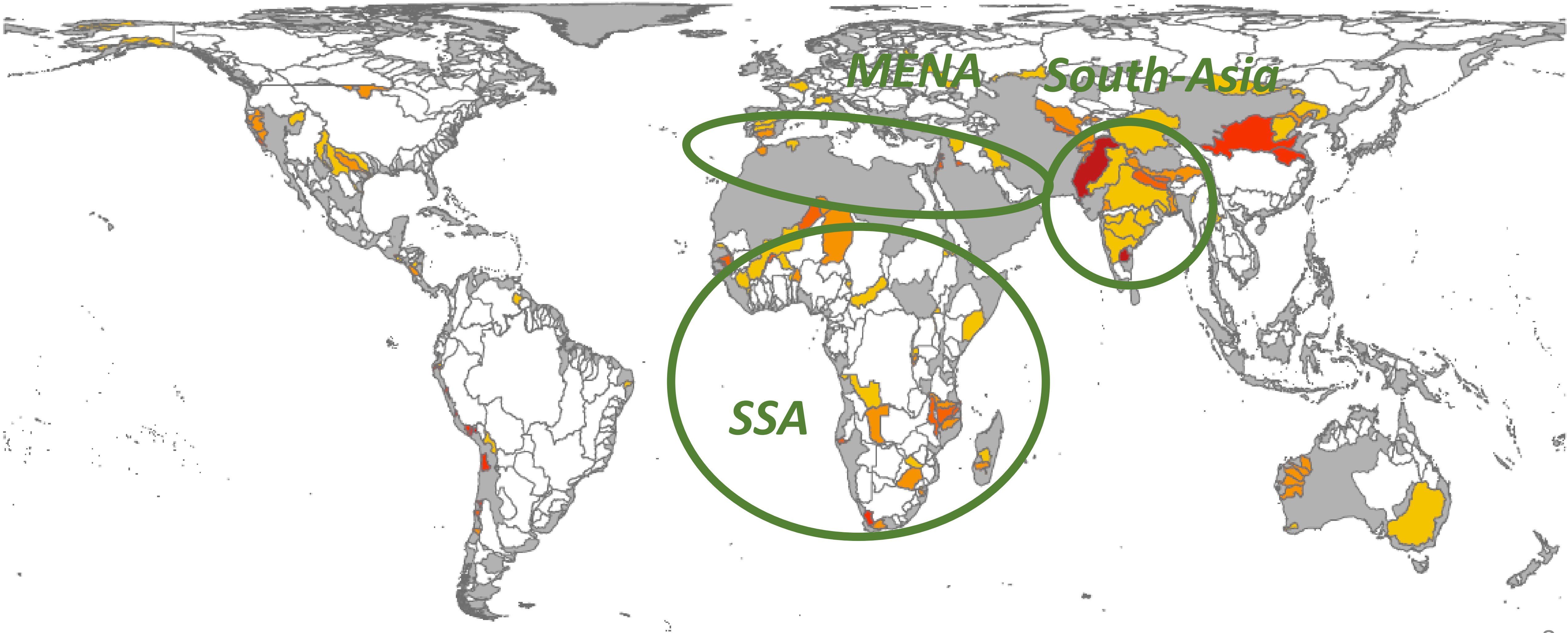
✓Social and climate change put pressure on water, energy, food resources

✔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 (Hoff 2011)

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 1000m^3/capita/year, 1,700m^3/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

<table>
<tr><th></th><th>South-Asia</th><th>MENA</th><th>Europe</th><th>SSA</th></tr>
<tr><td>Biofuels</td><td colspan="3">･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</td><td>Lack of laws and guidelines on biofuel cultivation
⇒Poverty and threat to energy security</td></tr>
<tr><td>Food loss & waste</td><td colspan="4">Diversity on diet change impacts on blue and green water footprints</td></tr>
<tr><td>Electricity production</td><td colspan="3">【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</td><td>90% of South Africa's power is generated from coal power plants which are located in (semi-)arid areas, will lack sufficient water</td></tr>
</table>

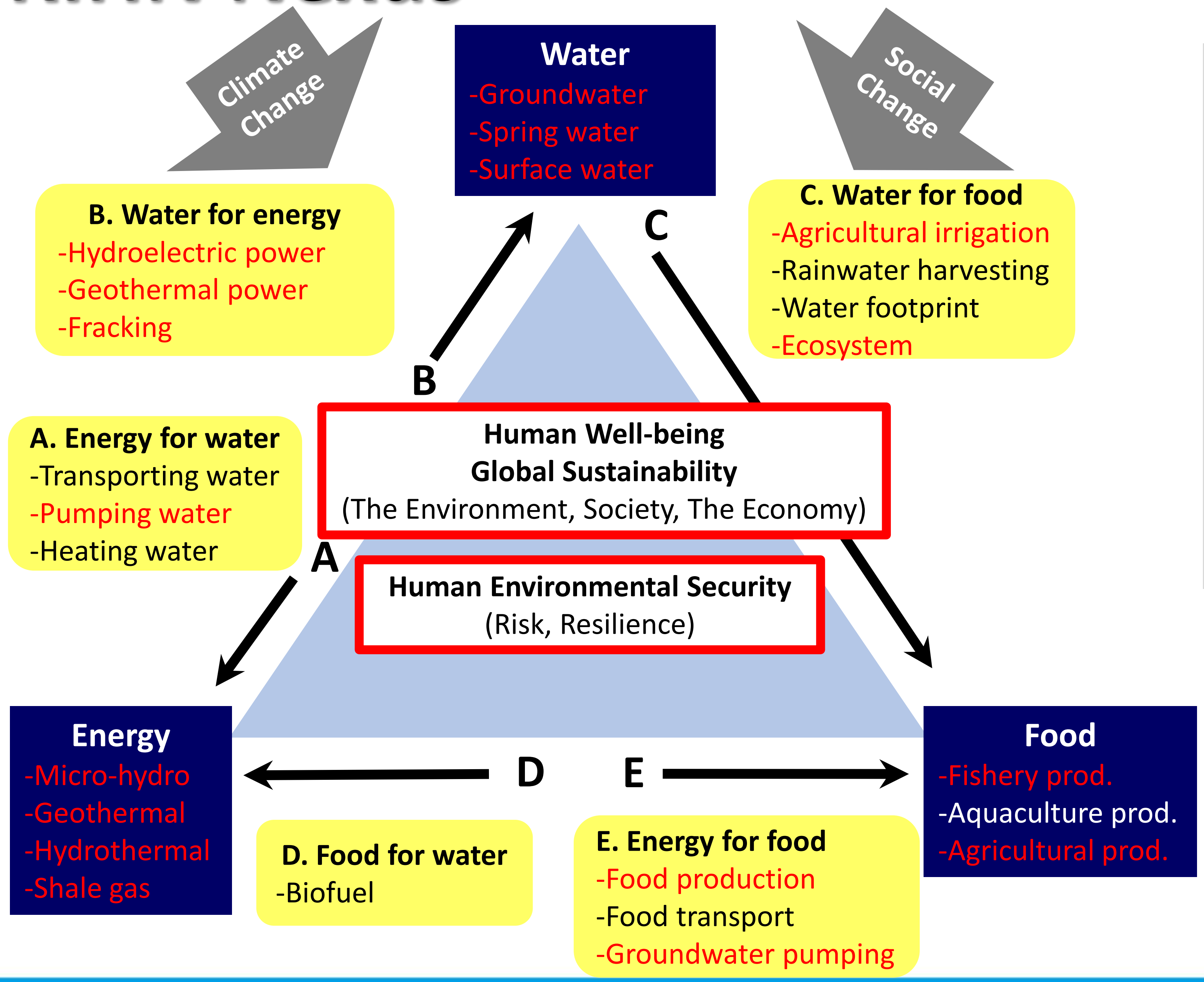
Source: Sandrine Paillard, Sebastian Heinz, Cliven Njekete, Renee Obregon-Gonzalez

<table>
<tr><th></th><th>South-Asia</th><th>MENA</th><th>Europe</th><th>SSA</th></tr>
<tr><td>Coastal environment</td><td></td><td></td><td>Dominant coastal sitting of power plants is threatening the marine environment due to the high temperature of discharged water. (The Mediterranean)</td><td></td></tr>
<tr><td>Agriculture</td><td></td><td></td><td>Phosphorus, nitrogen, pesticides impact on water quality (Europe and North America)</td><td></td></tr>
<tr><td>Urbanisation</td><td colspan="4">▪ 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)</td></tr>
</table>

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

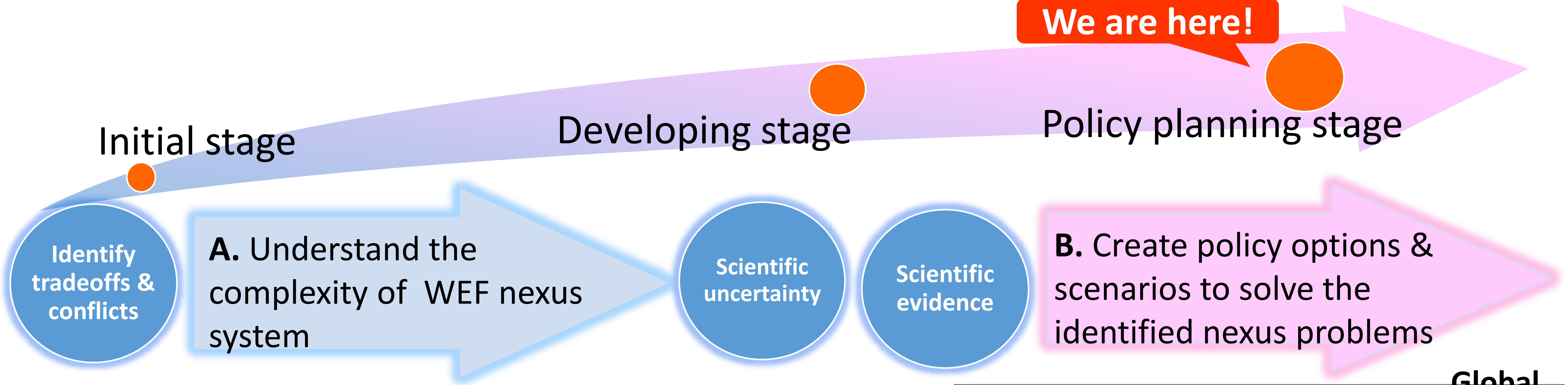
Understanding the complexity of WEF nexus system

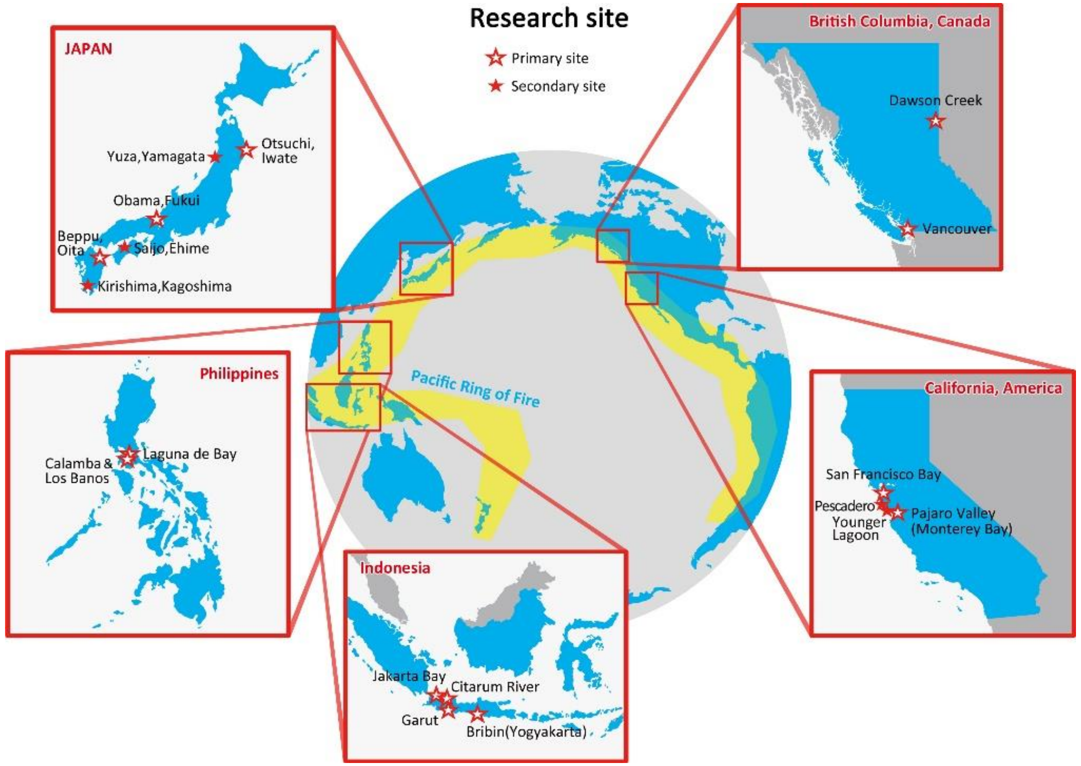
RIHN Nexus

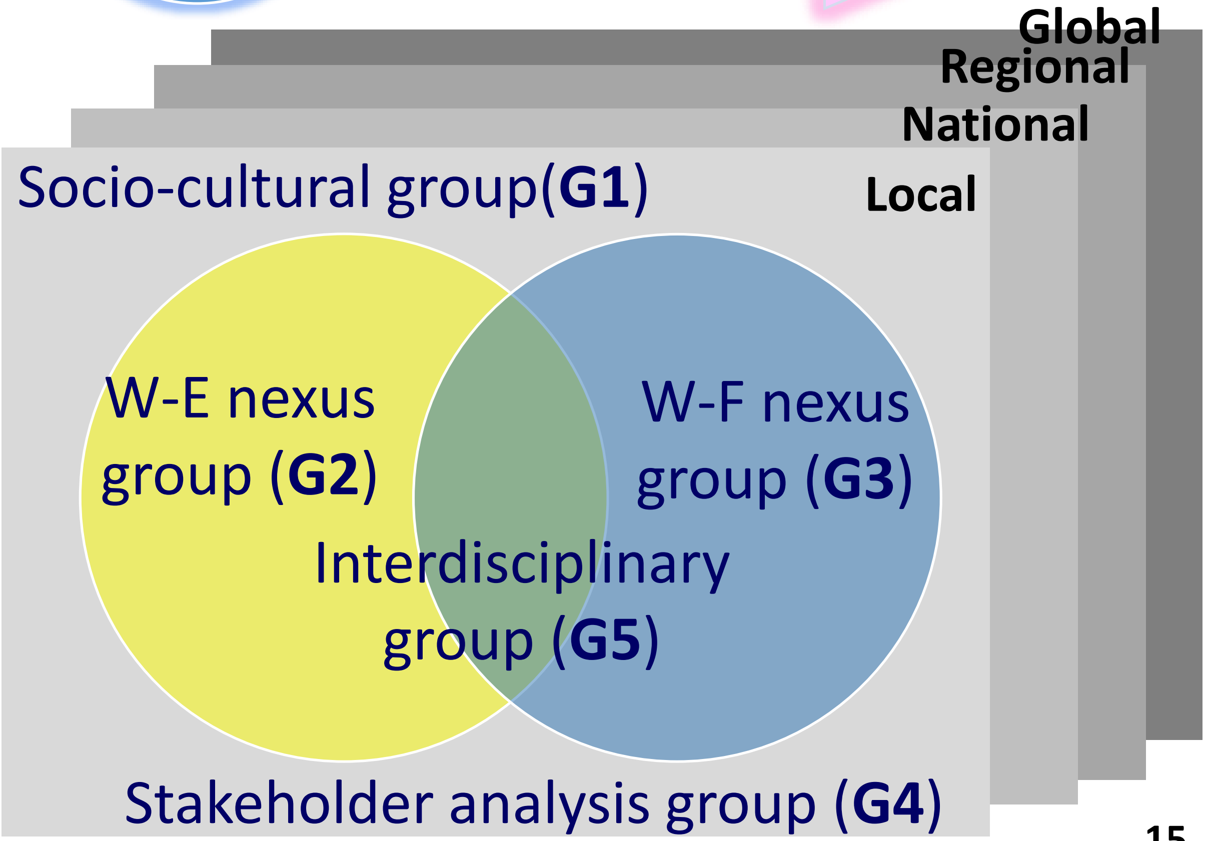


Purpose

Understand the complexity of WEF nexus system, and to create policy options to reduce tradeoffs among resources and to solve the conflicts of resource users, under scientific evidence and uncertainty


We are here!
Initial stage
Developing stage
Policy planning stage
Identify tradeoffs & conflicts
A. Understand the complexity of WEF nexus system
Scientific uncertainty
Scientific evidence
B. Create policy options & scenarios to solve the identified nexus problems


Research site
Primary site
Secondary site
JAPAN
Yuza,Yamagata
Otsuchi, Iwate
Obama,Fukui
Beppu, Oita
Saijo,Ehime
Kirishima,Kagoshima
British Columbia, Canada
Dawson Creek
Vancouver
Philippines
Calamba & Los Banos
Laguna de Bay
Pacific Ring of Fire
California, America
San Francisco Bay
Pescadero
Younger Lagoon
Pajaro Valley (Monterey Bay)
Indonesia
Jakarta Bay
Citarum River
Garut
Bribin(Yogyakarta)


Global
Regional
National
Local
Socio-cultural group(G1)
W-E nexus group (G2)
W-F nexus group (G3)
Interdisciplinary group (G5)
Stakeholder analysis group (G4)

Water-Energy Nexus

A1 Analyze underground environmental system

A2 Effective potential energy production using water

A3 Diversify renewable energy sources

A4 Climate × Water × Energy model

A5 Mapping water security vulnerability

Water-Food Nexus

B1 Interlinkages between GW & fishery production

Water-Energy-Food Nexus

C1 Hydrothermal energy development × ecosystems

C2 CBA for hydrothermal energy cascade use

C3 CBA for land use for food production

Socio-culture

D1 Study socio-cultural history of GW use

D2 Review institution for GW management

D3 Evaluate Economic value of local resources

Stakeholder analysis

E1 Online survey for energy development

E2 governance for hot spring energy development

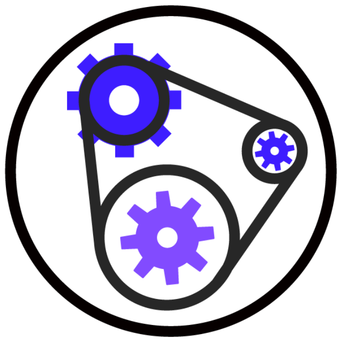
E3 Visualize social network of hot spring SHs

E4 Social acceptability on energy development

Interdisciplinary tools

F1 Develop integrated methods for ID & TD

F2 Design and visualize nexus system



Integrated approach

G1 Integrated models

G2 Future scenarios

Co-production

H1 Accountability

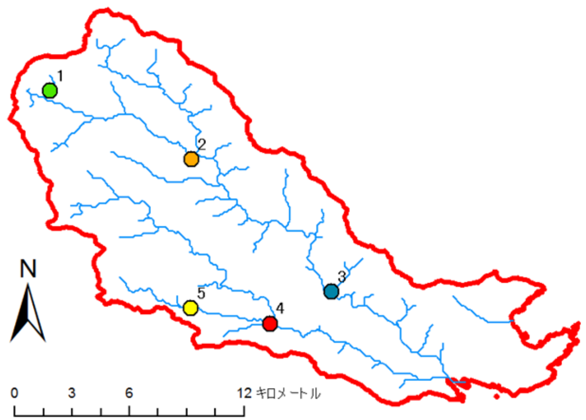
H2 Impact

H3 Humility

Water-Energy Nexus

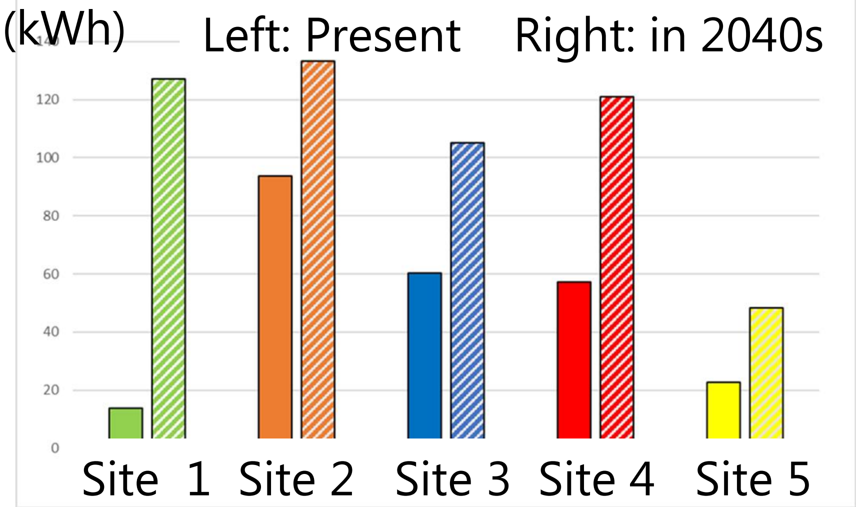
A3 Diversify renewable energy sources

Small-hydropower



Source: Sawadate, T., Fujii, M.

Annual potential SHP in 2040s



■Potential electricity of SHP

・2,171 MWh: Possibly cover 4% of total demand in the town

・Possibly reduce CO2 emission of 2,026 t

✔**Climate change：More precipitation in 2040s than present**

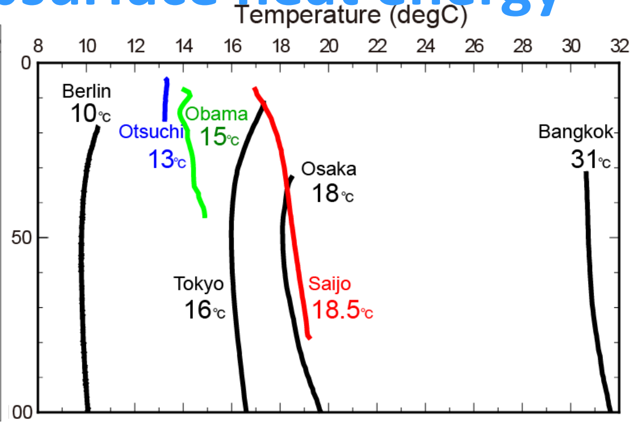
✔**Social change：**

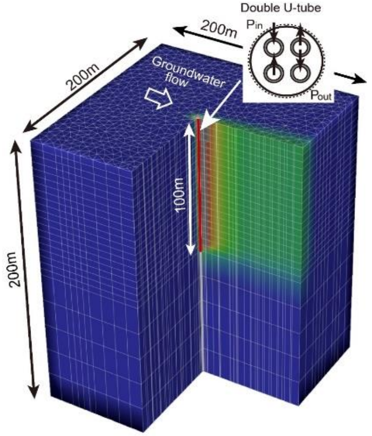
Population: Decrease by 53% in 2040 than present

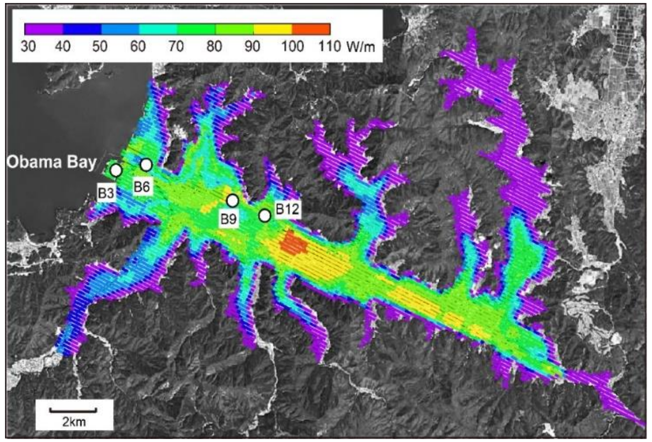
Land-use pattern: from forest to artificial land with higher water penetration by developing wind power facilities

→ more streamflow→promising→irrigation rights, electricity prices, river ecosystem and fisheries

Shallow subsurface heat energy







・Construction of shallow geothermal potential map

・Utilize the energy from ground heat for application of heat pump

Source: Hamamoto, H., Miyashita, Y.

Water-Energy-Food Nexus

C2 CBA for enhancing multistage utilization of hydrothermal energy for food production

Full cascade uses of hot spring water and hot spring drainage water at different temperature & quality profiles

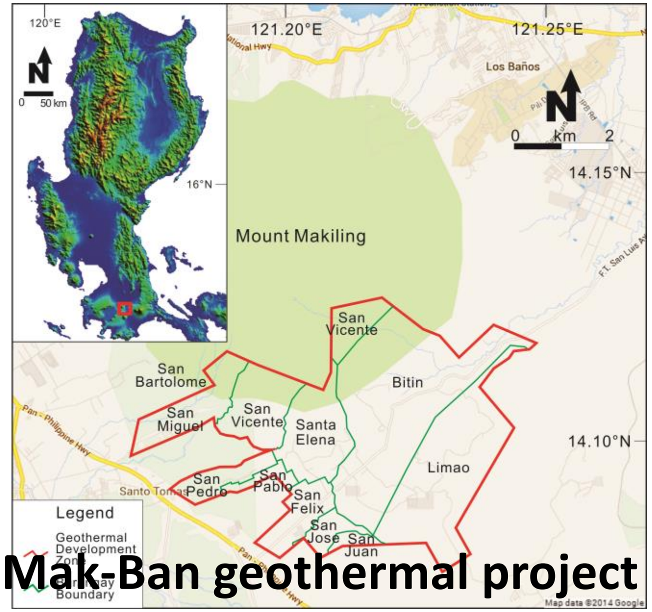
Temperature	Quality (chemical components)	Quality profiles	Cascade use
100°C	Hot spring water	Steam	-Hot spring energy development: W-E -Cooking: W-E-F
80°C	ditto	Heat energy Water	??⇐Agriculture productions: W-E-F
60°C	ditto	Heat energy	-Heat pump for heating room: W-E -Grow berry (testing): W-E-F
40°C	ditto	Heat energy Water	Spa: W-E
35°C	Hot spring drainage water (chemical components)	Heat energy	?? ⇐Agriculture productions: W-E-F

Policies and/or regulations for sustainable use of hot spring water and wastewater management should be addressed

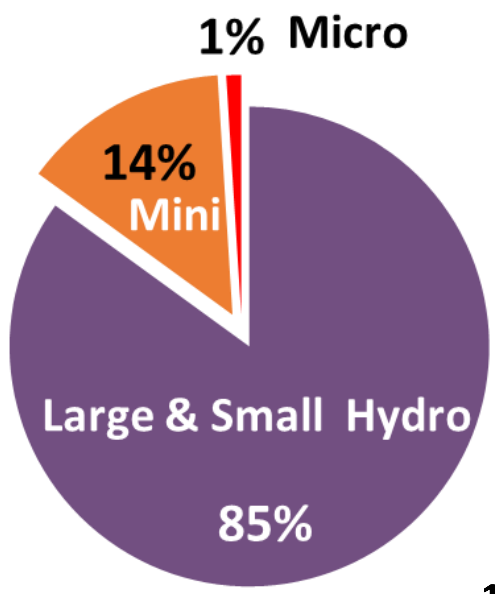
Stakeholder analysis

E4 Social acceptability study on energy development

	Geothermal Energy	Micro-hydro power generation
Background	New RE laws, Feed-in-tariff scheme	Off-grid areas for decentralized electrification
Targets/methods	Semi-structured interview （7 barangays, 268 households）	Semi-structured interview （4 barangays, 400 rsidents）
Results	Supporters: males, Residence in barangays with geothermal facilities, Illegal settlers on public land Opposers: Residence with higher education	Those who don’t know micro hydropower as a source of energy : 49% Expect to reduce electricity costs: 78% Increase general welfare of the community：95%
Co-production	Workshop（88 participants）: deepen the understanding regarding geothermal energy	Stakeholder Consultation（20 participants）: Institutional, Funding source, Reduce electric costs



Mak-Ban geothermal project

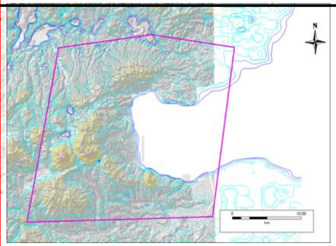


Integrated Approach

G1 Integrated model
G2 Future scenarios

Integrated approach

G1 Integrated models

	Obama	Beppu	Peace River Region	Pajaro Valley
Type of Model	Nexus Physical Model	**Integrated Water Cycle Analysis & Hydrothermal Model**	Snowmelt Hydrological Model	USGS MODFLOW-2005 and Farm Process (FMP2)
Target area		 Beppu Bay	Graham WS Blueberry WS 	Pajaro Valley 
Code	Water Balance Model (SHER)＋3D GW Model (MODFLOW, SEAWAT)	GETFLOWS	Cold Regions Hydrological Model (CRHM)	Pajaro Valley Hydrologic Model (PVHM)
Integrated W-E-F-Climate	Integrated model -surface, river runoff/ groundwater -GW temperature -rainfall and snowfall	Integrated model -rainfall runoff and surface water flow (field survey) -GW flow -water use -thermal energy	Integrated model -shale gas water use projections -climate change projection (temperature＋precipitation) -focus on drought/low flows	Integrated model -surface/ groundwater -water supply-and-demand accounting -crops types -drought and climate change
Other data	-land use -land elevation -climate -geological structure	-geological structure -land use -land elevation -submarine topography	-land use -land elevation -climate -dugouts (water storage detention ponds)	-land use -climate -hydrogeologic data -land elevation

Integrated approach

G1 Integrated models/G2 Future scenarios

1. Integrated model

1) Existing data provided by Geospatial Information Authority of Japan：Ishii
2) Monitoring data collected by local ：Endo
3) Observation data collected by the project (verification data)

Data	Researchers	Methods
River flow observation	Fujii, Yamada	Water gauge
Groundwater pumping model	Osawa	Hot spring data collected by Oita prefecture
3D geological model/Groundwater flow model	Miyashita	Microtremor array measurements
Hot spring water flow simulation	Nishijima, Narutomi, Ota	Gravity Measurement

2. Future scenarios: Quantitative scenarios

・4 different scenarios based on **quantitative models** for sustainable use of hot spring resources (quantity, temperature, quality of HSW)

・How much does groundwater contribute to biological production?

Integrated approach

G1 Integrated model in Beppu

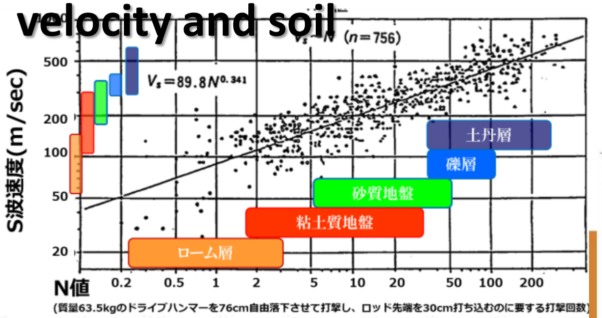
Source: Miyashita, Y

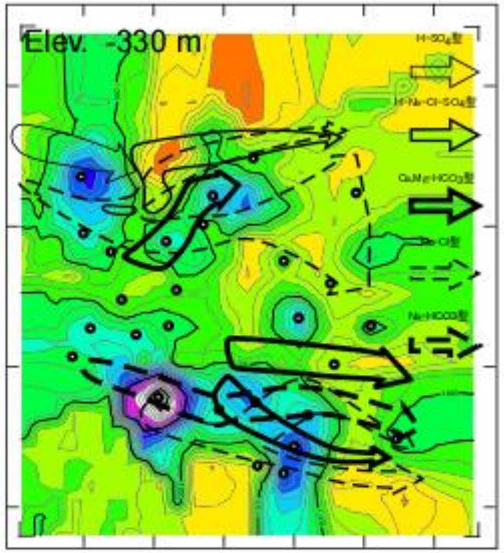
Geology, HSW flow

Microtremor array measurements

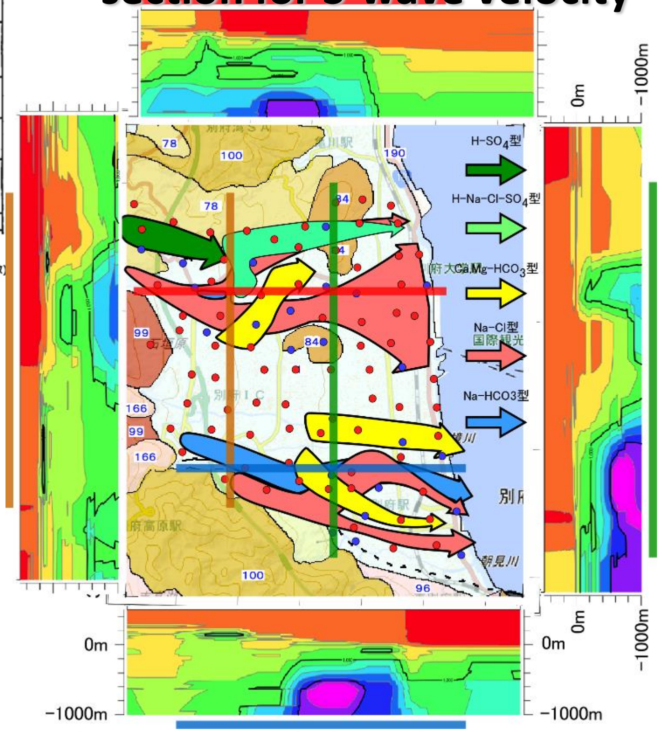
3D geological model/ groundwater flow model

Relationship between S-wave velocity and soil





Second-dimensional cross section for S-wave velocity



Three-dimensional distribution for S-wave velocity

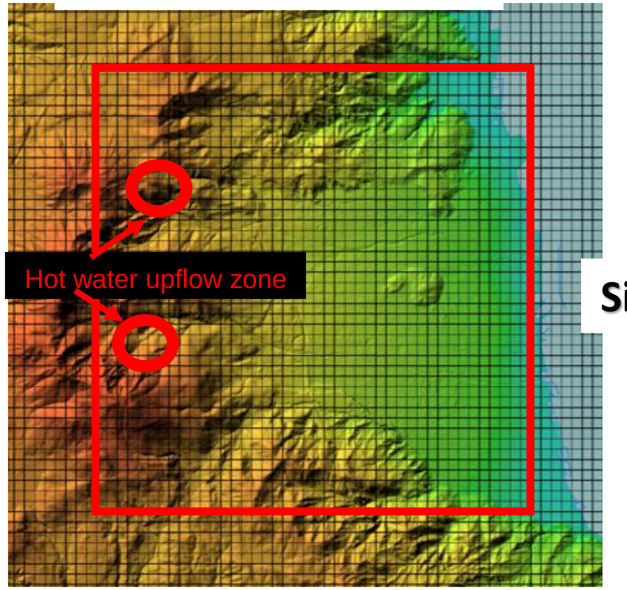
Source: Nishijima, J., Ota, K

HSW flow simulation：
Changes in temperature and pressure 1950-2030 (80 years)/ 50,000 tonnage/year

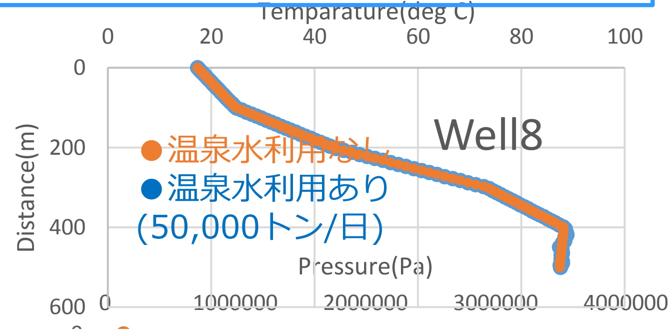
Temperature distribution of HSW wells at 100-meter elevation

Not sustainable to consume 50,000t/day in 80 years
- temperature: no change
- Pressure: will decline

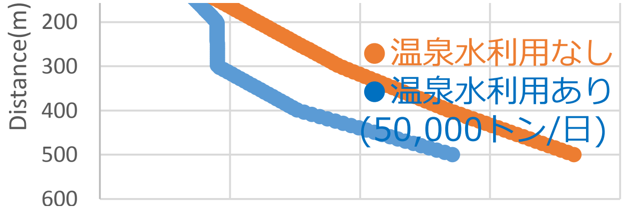
HSW flow simulation



Area for modeling with 2 upwelling points



Simulation of temperature variation



Simulation of pressure variation

Integrated approach

G2 Future scenarios

	Beppu: Baba	Peace River Region	Pajaro valley	Citarum River-Jakarta B	Laguna de bay
Scenarios	①4 scenarios based on model ②Draft of 72 stories -SH meeting -Delphi method	Pembina Institute projections for water demand Global climate model output data	En- Drought, climate variability, future climate change - change in crop type, best management practice	3 scenarios 1) BAU, 2) Conservation, 3) Zero FFC -CBA	2 scenario for developing micro-/small hydro power generation -climate model
Target year	2040	2020-2050 "near future" period; showing statistical variability	2040	2040	2020, 2050
Policy options	-set the quota/limit of HP -Identify or expand restricted areas -charging HSW use -waste water management -collective management	Improve water management for shale gas development - Restrict water use during dry periods.	Set quota/limit of GW use Optimize water management for wet and dry periods	-Benefits from conservation are highest -institutional arrangement -decentralization -financing -stakeholder involvement	-implementing micro hydro -Policy for groundwater use -guideline for hot spring water resource utilization at national level
Recommendations	○ To Beppu city gov.	○ To BC Oil & Gas Commission	○To Pajaro Valley Water Management Agency To California department for water resources	○ -Ministry of Public Work -Regional authority (BAPPEDAS) -Ministry of Fishery	-National water resource board -Local government unit of Los Banos and Calamba
Implementation		Ongoing	PVHM is built, but we are on-going in terms of modifying for future simulations.	Pilot implementation (2017)	

Integrated approach

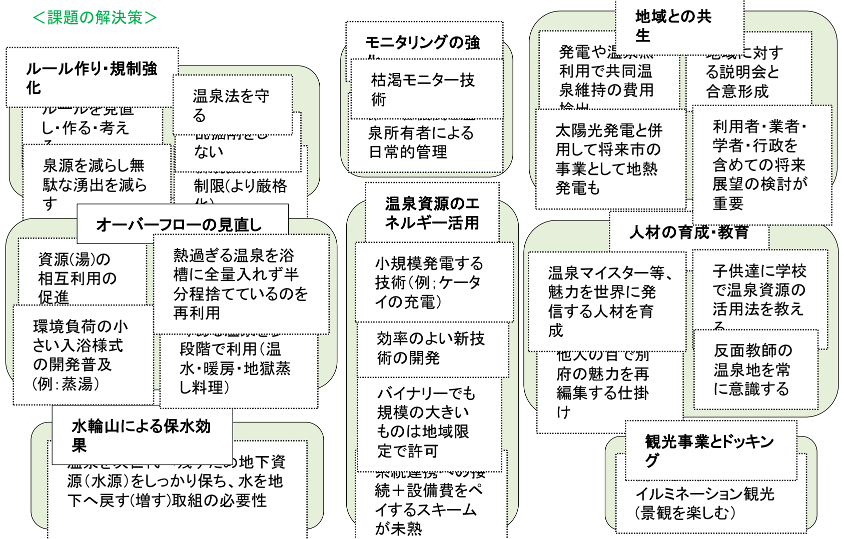
G2 Future scenarios: Descriptive scenarios

Stakeholder analysis (FY2013)
Interviewing and identifying interests of stakeholders such as local officials, farmer, distributors, plant nursery ✔

Stakeholder meetings (FY2014-15)
Sharing the results of stakeholder analysis and discussion
(Collecting local knowledge) ✔

	Interests to climate change	Negative effects of climate change				Positive effects of climate change
		disease and pest	Sunburned	Bird and animal damage	Freezing injury	
Local official	△	○	○	○	—	○
Farmer	○	△	○	○	—	△
栽培技術員	○	○	○	○	○	△
流通	○	○	○	—	○	—
種苗	○	—	○	—	○	△
農業資材	×	○	—	—	—	△

Results of SH analysis and discussion



Scenario development (FY2016-17)
Making future scenarios by experts using Delphi method
(Collecting expert knowledge) ✔

Scenario workshop (FY2017)
Providing scenarios and development of action plans by collaboration of stakeholders, general public and experts
(Integration of local knowledge and expert knowledge)

Future Challenges

Future challenges in nexus approach focusing on energy development:

✓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

-SDGs must be a big incentive

1) Establishing distributed energy systems with integrated small-scale renewable energy sources

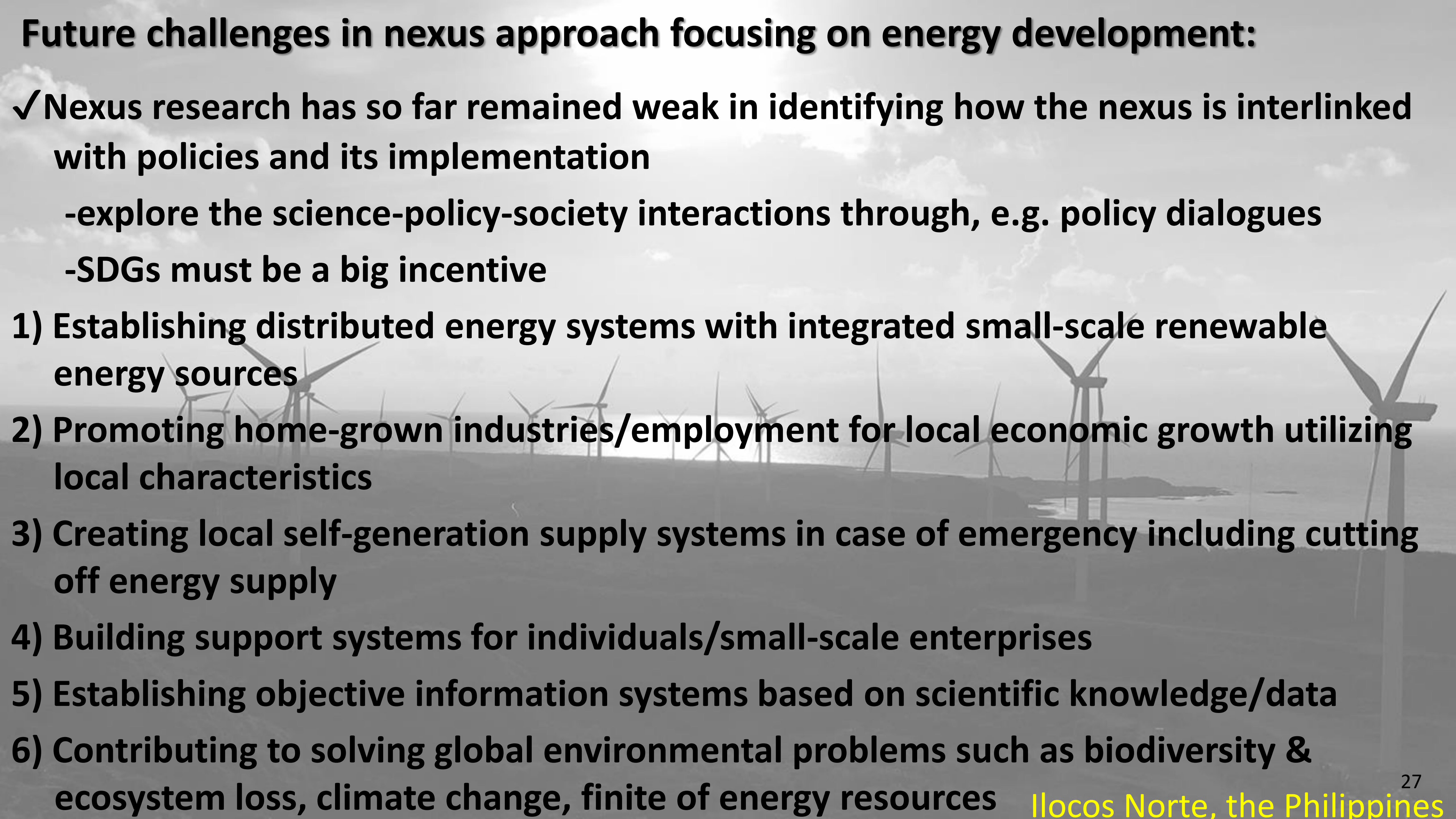
2) Promoting home-grown industries/employment for local economic growth utilizing local characteristics

3) Creating local self-generation supply systems in case of emergency including cutting off energy supply

4) Building support systems for individuals/small-scale enterprises

5) Establishing objective information systems based on scientific knowledge/data

6) Contributing to solving global environmental problems such as biodiversity & ecosystem loss, climate change, finite of energy resources



Ilocos Norte, the Philippines