Designing Local Frameworks for Integrated Water Resources Management

Project Leader **KUBOTA Jumpei** RIHN

Professor Kubota earned a doctorate in forest hydrology from Kyoto University (1987). He has served as assistant professor at Kyoto University (1987-1989), and assistant professor (1989-1996) and associate professor (1997-2002) at Tokyo University of Agriculture and Technology. He joined RIHN in 2002, and now directs the Center for Research Development and the RIHN-China initiative. His major research fields are hydrology, water issues in arid regions, and human adaptation to societal and environmental changes.

Co-Project Leader **Dorotea RAMPISELA** RIHN

Dorotea Rampisela earned a doctorate in forest hydrology from Kyoto University (1992). She was previously senior lecturer at Hasanuddin University (1982-2013). She joined RIHN in Jan 2014. Her major research fields are hydrology, focusing on watershed management and relocation of people related to dam construction. She established an NGO and for the last ten years has conducted participatory research with water users association for irrigation water management.

Background and objectives

The concept of Integrated Water Resources Management (IWRM) was first proposed in the 1990s in order to recognize and coordinate the many stakeholders and sectors involved in effective water resources management. Despite several decades of development, there are still difficulties implementing IWRM in local communities and in effectively assessing the influence of human activities on water resources. While IWRM has focused on integrating the sectors and organizations governing water resources, it has not typically been able to incorporate demands from local water users or taken account of their cultural or historical backgrounds. This has resulted in a lack of flexibility from the supply side. As a consequence, new frameworks or guidelines have been requested in the field of local-to-regional water resources management.

The objective of this project is to propose knowledge structures and functions of water resources management to local-level stakeholders who play the essential role in adapting IWRM into society. The research therefore involves considerable exchange between the scientific evidence of water cycles in particular places and the wide range of stakeholders involved in water management and use. The project's goals are to develop cooperation between science and society in order to stimulate the co-creation of desirable local water resource management.

Research areas and methods

In order to accomplish the goals of the project, we have established several study sites in Indonesia, Turkey, Egypt and Japan. Cases in Indonesia and Turkey give us a geographical and hydrological contrast between humid and semiarid to arid regions experiencing increasing demand of water resources associated with rapid economic growth. The Japanese case presents interesting contrast as it shows steady or decreasing demand for water resources. Project researchers have surveyed the management structures reflecting the relationship between water users in each area and observed important background hydrological and socio-economic dynamics.

Project research puts special emphasis on the sites in Indonesia and Turkey as they present a simple hydrological contrast between humid and arid regions, while their historical and cultural differences offer comparative examples of water management structures.

We have been developing a GIS system to analyze land-use change indicated by satellite observations in relation to other important conditions such as areas affected by flooding and drought. We held stakeholder meetings and conducted action research in field study areas in order to promote mutual understanding of how different actors perceive water-related problems and seek new ways of establishing proper water resources management. Both the hydrological model and GIS system are utilized as information-sharing tools in stakeholder workshops.

Progress to date

In Indonesia, field surveys in Subak, Bali have indicated a recent organizational transition as public policies have shifted water management from autonomous to cooperative unions. Furthermore, we confirmed recent changes in the societal functions and roles of Subak related to globalization and mass tourism. A stakeholder meeting was held in Bali in 2013. Most of the participants reported problems that have recently arisen between Subak members and outsiders, such as water pollution caused by illegal waste dumping and illegal constructions on irrigation canals. Because the Subak population is made up of farmers, it is difficult to handle these problems and participants realized the necessity of communication beyond the normal scale of Subak governance. In the second meeting in 2014, we decided to establish a new "Forum DAS"(river committee) to address these problems. Two preparatory meetings were held in December 2014 and February 2015 including Subak representatives, officials and engineers in local governments, scientists, and NGO workers. In South Sulawesi, a lack of communication among water managers was clearly identified in the stakeholders meeting in January 2014, in which almost a hundred of leaders of farmers, water managers, and governmental supervisors participated. After this meeting, we have supported further autonomous discussion among water managers by utilizing the traditional "apalili" meeting. Through these meetings, a detailed schedule of water allocation was established and shared with water managers and farmers, improving the performance of water allocation and, consequently, rice production in 2014. We are planning to have another series of action-meetings in collaboration with stakeholders, expanding to other irrigation districts in 2015.

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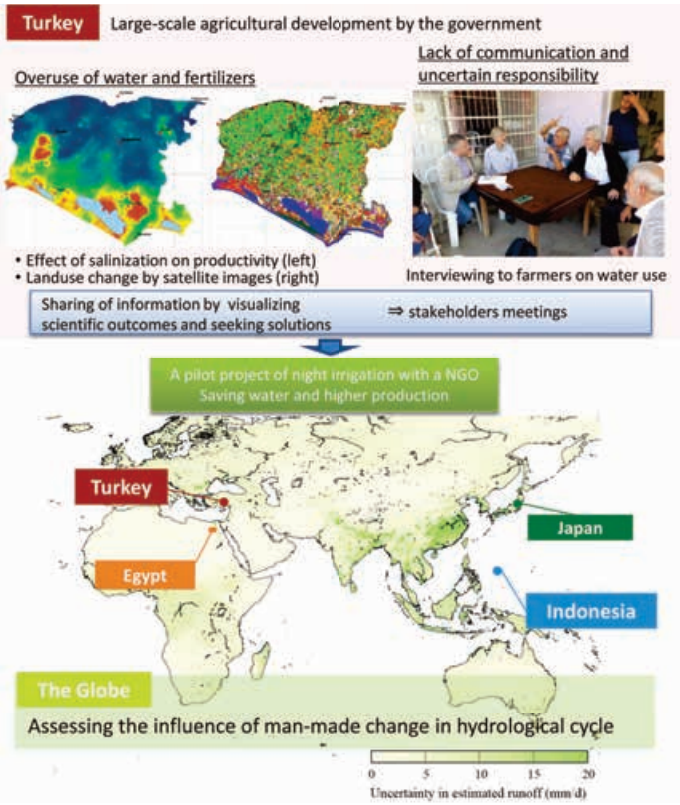

Figure 1 **Progress of the project at a glance. The map in the center features indicates the uncertainty indicated by a model predicting water runoff, on which the key elements of research problems and findings in the case study sites on water resources management are featured. Deeper green color signifies higher uncertainty, i.e. difficultly in estimating water resources; it allows us to consider how uncertainty can be included in model development. Local-level co-creation of knowledge between science and society in the context of global freshwater use will be realized so as to develop transdisciplinary integration of water resources management.**

In Turkey, we have identified similar problems in water management, such as information disparities and unclear responsibilities in spite of privatization. At the same time, surveys on river flow status, drainage water quality, and land use have revealed that excessive use of irrigation water and chemical fertilizer was responsible for degradation of watershed environment and land productivity. Two stakeholder meetings were held in March 2014 in order to enhance communication and mutual understanding among stakeholders. After the meeting, a local water users' association (WUA) consulted us on how to avoid over-irrigation and a resulting decrease in production. We proposed a night irrigation system. The WUA conducted a pilot project with governmental financing and the support of an NGO, which was very successful in that it reduced water used for irrigation while improving production by 30%. This pilot study was reported in the second stakeholders' meeting in October 2014 and we expect that more WUAs will employ the night irrigation system. These meetings, in addition to providing important opportunities for stakeholders to jointly address key problems in local water management, also allow project researchers to analyze changes in stakeholder behavior and decision-making processes as we further develop the methodologies of transdisciplinary investigation.

Figure 2 **The results of stakeholders meetings in Indonesia**

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Coastal Area Capability Enhancement in Southeast Asia

Project Leader **ISHIKAWA Satoshi** RIHN

Satoshi Ishikawa investigates population genetics and population dynamics of aquatic animals, and has participated in several rural development programs focused on improving fisheries and human capacity building in Southeast Asia. His current interest is how to harmonize conservation of coastal ecosystems and community-based management of fisheries resources. He received his baccalaureate from the National Fisheries University Japan, M.A. from Hiroshima University, and doctoral degree from the University of Tokyo.

Background

Coastal area ecosystem services are indispensable for rural people, but are also easily damaged by human use. Many coastal areas with high biodiversity and biological productivity are located in tropical zones of developing countries, as is the case in Southeast Asia. In such areas, ecosystem services, local livelihood and culture are closely related. Conservation and resource management strategies, however, are often derived from those of temperate regions, and usually target particular species or commercial resources with little consideration of how multiple ecologies and livelihood strategies overlap in culturally diverse contexts. In addition, in many cases, resource management and conservation activity are individually conducted by several different actors.

Ecosystem services have different significance for different peoples, depending on their interests and contexts. Although overuse and/or abuse of ecosystem services should be avoided, conservation actions should take careful account of the close relationship of local livelihoods and culture to local ecosystems, especially in rural areas lacking other livelihood opportunities. Addressing solutions to environmental problems in such contexts therefore requires linking people and policies engaged in both conservation and resource utilization.

This project attempts to examine several good ecosystem management practices based on local community participation in order to assess the conditions and functions of each actor in creating "Area-Capability". We expect that an action contributing to Area-Capability can link utilization and conservation and facilitate appropriate ecosystem utilizations, improve local life, cultivate ecosystem health, and foster hope for local society.

Project framework

In Nishio City and Ishigaki Island in Japan, environmental education links several actors having different jobs and interests in new utilization and conservation activities. Around Hamana Lake (Japan), stock enhancement of Kuruma shrimp enhanced social capital among seven villages, facilitated smart fishery management, and stimulated fishermen to care for ecosystems. In Rayong, Thailand, a new community of fishermen was created based on set-net fishery installation, and they collected detailed fishery data and promoted zoning of fishing ground. In Batan Bay, Philippines, shrimp stock enhancement increased local peoples' interest in ecosystem health. Project research conducts field surveys in these areas to collect detailed data and information about social and environmental changes regarding each event. Scientific and social analyses are conducted in order to examine the impacts of each event on both ecosystem health and quality of life. Further, we collaborate with key stakeholders, including local communities, governments and scientists, in order to identify key factors and conditions for local

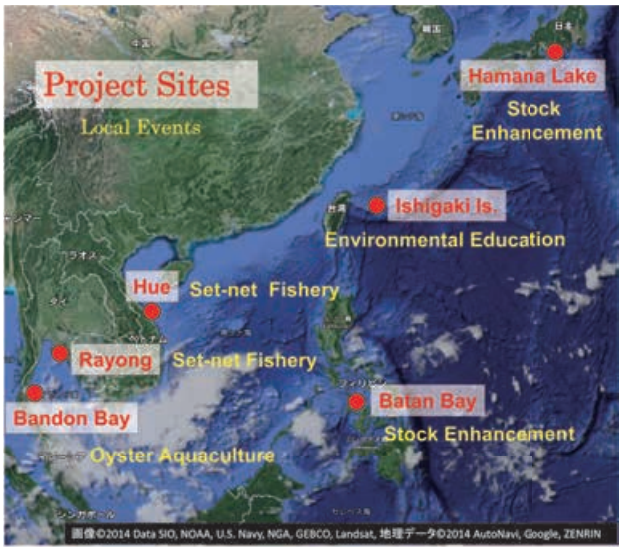

Figure 1 Research sites and characters of each area

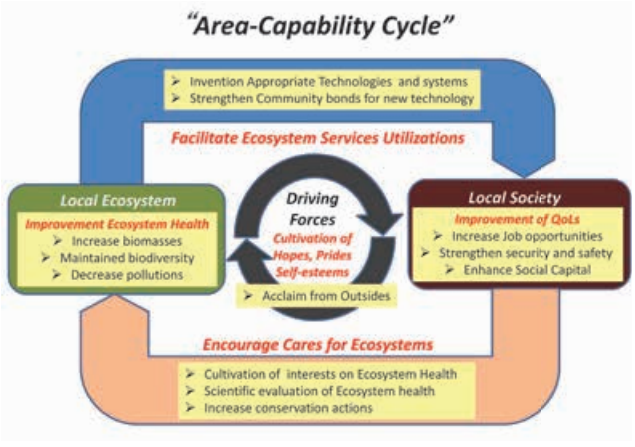

Figure 2 Conceptual model of the "Area-Capability Cycle"

Figure 3 ACC for shrimp stock enhancement in Hamana Lake, Japan

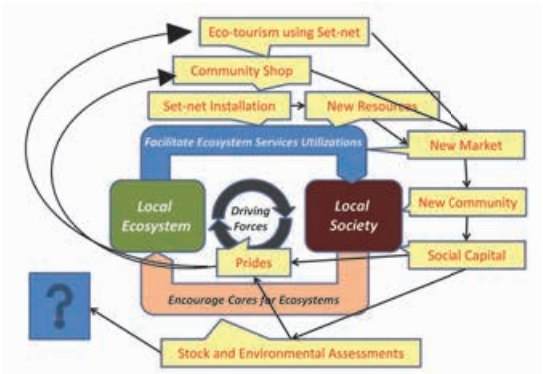

Figure 4 ACC for set-net in Rayong, Thailand. Weakness of impact survey on environments is suggested by ACC. Researchers should try to make an impact survey with the local community, and its results should be taken into account by the set-net fishery operation. The ACC should further clarify other improvements as well.

- Human development for invention new appropriate technologies and systems
- Strengthen (or Creation) of community bonds for the technology and system
- Rediscovery of local ecosystem services
- Scientific evaluation of new technology (or system) impact on ecosystem health
- Collaboration among local community, scientist, and government
- Fortify of hope for local life

Figure 5 Current hypothesis of 6 target items for rural development based on AC concept

Photo 1 Community-based set-net fishery in Rayong, Thailand

Photo 2 Group photo from the international joint seminar held in Philippines 2014

community-based ecosystem management and rural development, examining the functions of each actor in the transformation of society.

This project is based on the joint research efforts of Southeast Asian Fisheries Development Center (SEAFDEC), Eastern Marine Fisheries Research and Development Center of Department Fishery, Thailand, Faculty of Fisheries of Kasetsart University, the University of the Philippines, Visayas (UPV), Aklan State University, and researchers from ten universities and one research organization in Japan.

Future tasks

The Area-Capability Cycle (ACC) was proposed as one model of sequential change in harmonization of natural resource conservation and management. ACC would be comprised of :1) invention of appropriate technologies and improvement of the social and economic systems related to ecosystem service utilization; 2) enhance capability of community members; 3) improved concern for ecosystem health; 4) increased biomasses and maintained biodiversity or decreased pollution; 5) increased self-esteem and hope in local life. Several factors are important to the development of ACC, including: people who can create new technologies related to utilization of ecosystem services; communities that can legally utilize new technologies; collaboration between scientists, government and local communities to evaluate the impact of the technology and prevent overuse; new conservation actions, and; wider appreciation of the need for new relationships with nature. Project research will apply the ACC model to many cases in order to examine its validity and refine understanding of how to harmonize conservation and management of natural resources. We will also compile all experience and information of ACC in order to make a manual useful to evaluation of rural development.

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Desertification and Livelihood in Semi-Arid Afro-Eurasia

Project Leader **TANAKA Ueru** RIHN

Ueru TANAKA obtained a Doctorate in Agriculture from Kyoto University (1997). He has previously worked as lecturer of Jomo Kenyatta Collage of Agriculture and Technology, Kenya (1983–1987), assistant professor in the Faculty of Agriculture, Kyoto University (1990–1999), associate professor in the Graduate School of Agriculture, Kyoto University (1999–2002), associate professor in the Graduate School of Global Environmental Studies, Kyoto University (2002–2011), and since 2012 is honorary professor of Hue University (Vietnam). His major fields of interests are agronomy, indigenous livelihood systems, desertification, and rural development support in West Africa, Southern Africa, India and Southeast Asia.

Research backgrounds, objectives and study areas

Desertification is a complex phenomenon related to land degradation and poverty, especially in sub-humid, semi-arid and arid areas. With increasing population, desertification is primarily caused by activities related to basic human survival and daily livelihood, such as cropping, animal husbandry, and gathering of fuel wood. Efforts to mitigate or solve desertification do not often take account of such causes. This may be one of the major reasons why desertification remains a serious problem despite commitments from the international community, including the United Nations Convention to Combat Desertification (1994), to address it.

This project's objectives are: 1) to deepen understanding of the social, cultural and ecological characteristics of targeted areas in semi-arid Afro-Eurasia; 2) to design and verify some practical techniques or approaches effective for desertification control in the context of rural development support; and 3) to propose and implement some techniques and approaches to desertification control and rural development, paying special attention to vulnerable people.

Project research takes place in the Sahel of West Africa (Burkina Faso, Niger and Senegal), Northeast Africa (Sudan), East Africa (Tanzania), Southern Africa (Namibia and Zambia), South Asia (India) and East Asia (Mongolia and China), as shown in Figure 1, where ecological conditions and land resources are degraded due to demographic pressure and uncertain socio-economic conditions, and extreme weather.

Research activities

UNCCD has already set the framework for action to address desertification. We focus on 'scientific knowledge' and 'techniques' which may be associated with some shortcomings in the framework (Figure 2). Many techniques employed to control desertification to date, however scientifically sound and rational they may be, unfortunately are often not matched to the needs and situations of local people if, for example, they are too expensive or require too much time or labor. Some techniques are highly dependent on materials and machinery that may not be locally available.

Our project modifies such shortcomings and adds more knowledge and techniques through the activities in West Africa (Figure 3), Southern Africa (Figure 4) and South and East Asia (Figure 5). In West Africa the major focus of project work is on collaborating with local people in the innovation of practical desertification control techniques and extension methods, especially related to the livelihoods of vulnerable people. In Southern Africa, basic studies are being developed to describe agro-ecosystems, local livelihood systems, and adaptation strategies under demographic pressure and environmental fluctuation. In South Asia, we have inventoried local knowledge (e.g. indigenous knowledge, techniques and tools), in order to identify pastoralist peoples' adaptation strategies in high population areas experiencing fluctuating social and agro-climatic conditions. In East Asia, we re-appraise indigenous knowledge in the traditional upland farming systems. Comparative studies within Africa and between

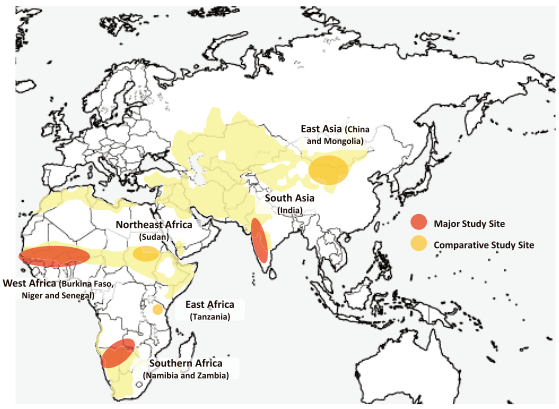

Figure 1 Study sites

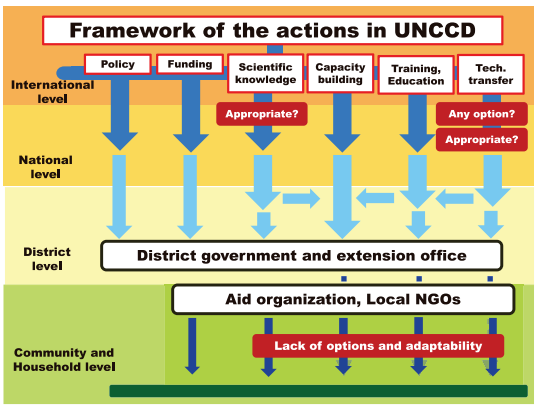

Figure 2 Focusing points and shortcomings in the framework of the actions in UNCCD

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http://www.kazehitotsuchi.com/ (in Japanese)

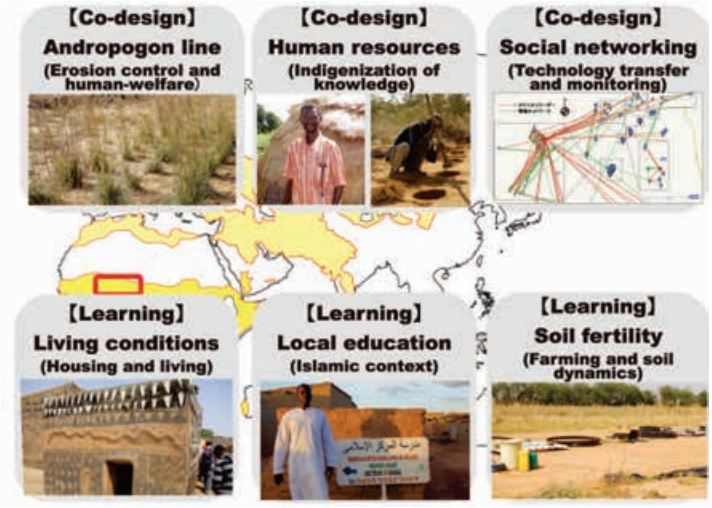

Figure 3 Activities in West Africa

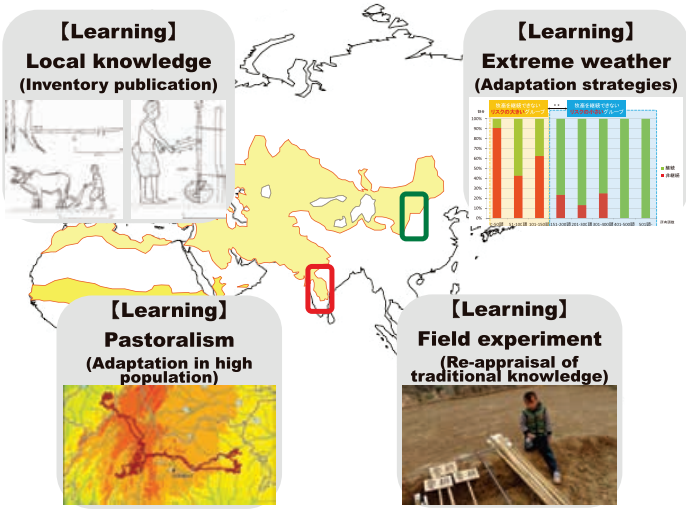

Figure 5 Activities in South and East Asia

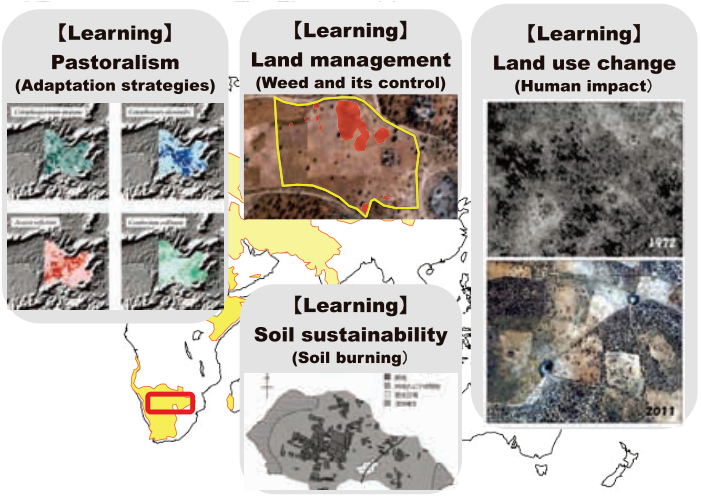

Figure 4 Activities in Southern Africa

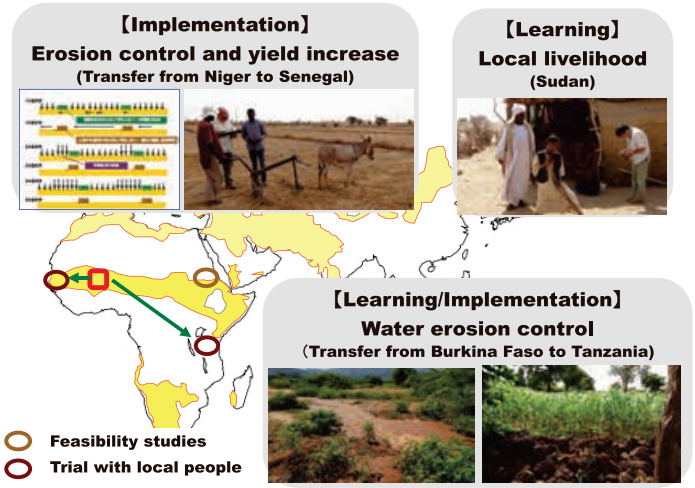

Figure 6 Implementation and feasibility studies on technology transfer in Africa

Africa and Asia are also underway in order to evaluate the possibility of horizontal technology transfer.

Progress to date

Practical innovations with local people

Together with volunteer villagers in Niger and Burkina Faso, we designed a 'fallow-band system' and 'andropogon line', both techniques based on use of local materials and indigenous knowledge, in order to control soil erosion and increase household income. In Niger, though the security situation makes collaboration difficult, we have found one local NGO working in extension and monitoring. In Burkina Faso, we pay special attention to some pioneer villagers who continue to modify or innovate practical techniques through their own efforts after our commitment.

As shown in Figure 6, together with an NGO established within an Islamic community in Senegal, we began an implementation trial of the 'fallow-band system' and 'andropogon line'. The indigenous technique known as *'diguette'* (or *stone line)* commonly practiced in Burkina Faso to control soil erosion has been introduced to Tanzania.

Future tasks

We intend to make comparative studies on adaptation strategies utilized by people in agro-pastoral systems in relation to several key variables, including population areas, tropical/temperate climate regions, and cultivation/pastoral system. We also will explore the possibility of technology transfer, e.g. land use systems, restoration of degraded land, farming tools and soil management practices between Africa and Asia. In order to share such experiences and findings, we will increase the frequency of academic workshops and open seminars held domestically and internationally.

Sub Leader

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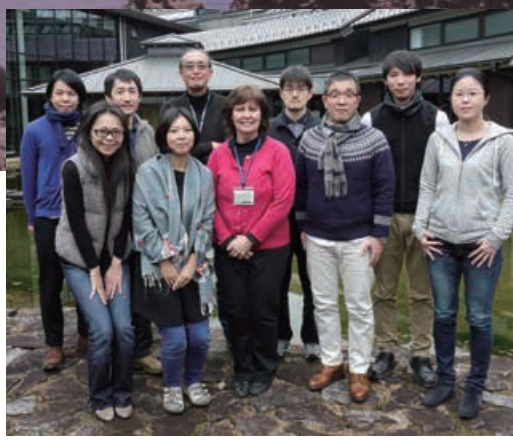
Creation and Sustainable Governance of New Commons through Formation of Integrated Local Environmental Knowledge (ILEK project)



Project Leader **SATO Tetsu** RIHN

Professor Tetsu Sato studied the ecology of cichlid fishes of African lakes for 20 years. Throughout his career, including as Conservation Director of WWF Japan and professor of Nagano University, he focused on creating knowledge bases for community-based management of natural resources. He also led a project to create a network of local scientists producing Integrated Local Environmental Knowledge.

Co-Project Leader **KIKUCHI Naoki** RIHN

Associate professor Naoki Kikuchi has been working at the Hyogo Prefectural Homeland for Oriental White Stork as a residential researcher on environmental sociology regarding restoration of the Oriental White Stork. His transdisciplinary research focuses on solutions of environmental problems from the perspectives of local stakeholders.

Research objectives

Local ecosystem services have deteriorated all over the world for various reasons. Ecosystem services should be managed as new commons by collaboration of various stakeholders, both within and from outside the communities. In order to create and sustainably manage such commons, the formation and circulation of local knowledge systems deeply embedded in real local settings is desperately needed. Integrated Local Environmental Knowledge (ILEK, Fig. 1), a novel concept of local knowledge blending scientific as well as various types of knowledge systems among stakeholders, is produced, circulated and utilized in diverse cases of local research and actions to support adaptive changes toward sustainability of local communities.

Our project aims to clarify mechanisms to facilitate production and circulation of ILEK and dynamic changes of social systems to propose ILEK-based adaptive governance mechanisms of local communities. We also seek mechanisms for cross-scale governance of global environment problems, primarily by analyzing formation of cross-scale knowledge bases created as knowledge flows and is mediated by bilateral translators who promote the circulation of knowledge between knowledge producers and users, both within local communities and across global, regional and local scales (Fig. 2). Through the transdisciplinary integration of these research results, we aim to design "science for/with society" and "society making full use of science" for bottom-up solutions of global environmental problems.

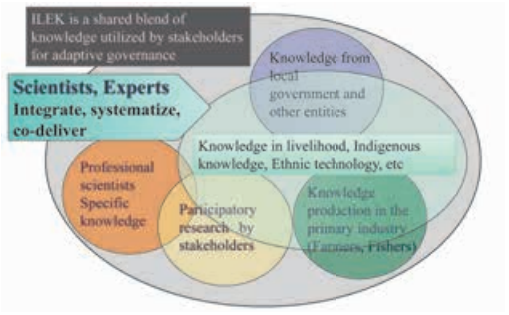


Figure 1 Structure of ILEK
Production and circulation of ILEK is not exclusively performed by professional scientists. Rather, it is often produced and circulated by diverse actors in local communities, including skilled workers in primary industries, local government officials, local companies and NGOs, most of them being knowledge users at the same time. ILEK is formed and utilized through dynamic interactions among different actors/stakeholders in local communities, integrating scientific and local knowledge in daily livelihood and practices among local stakeholders. In this process of ILEK production, scientists and experts are assuming new roles to reorganize and integrate various knowledge systems from the viewpoints of knowledge users and co-deliver ILEK to promote collaboration among diverse stakeholders for solutions of local environmental problems

Main results to date

We have selected 61 case study sites from past and ongoing RIHN projects as well as other examples of diverse production of local knowledge in order to accumulate and analyze ILEK production mechanisms (Fig. 3). Project members belonging to the case study group are deeply involved in each local community and conduct participatory research. These researchers also conduct meta-analysis in order to integrate diverse case study results in collaboration with the Theory and Modeling group and various task forces to understand ILEK production and adaptive governance mechanisms leveraged by ILEK. Fifteen cases of Action-based Verification have been selected among case study sites and cases of cross-scale translators to verify focused hypotheses concerning ILEK-based adaptive governance, including the Shiraho community in Ishigaki Island (Japan), Nishibetsu River Watershed (Japan), Sarasota Bay in Florida (USA), Karapinar area (Turkey), Lake Malawi National Park (Malawi), and the Japan Biosphere Reserve Network.

Residential researchers live in local communities, and in contrast to visiting researchers from outside the communities, they conduct transdisciplinary research as local stakeholders and also are involved in producing ILEK. Bilateral knowledge translators promote circulation of ILEK among scientists and diverse knowledge users by evaluating and transforming scientific knowledge from the viewpoints of knowledge

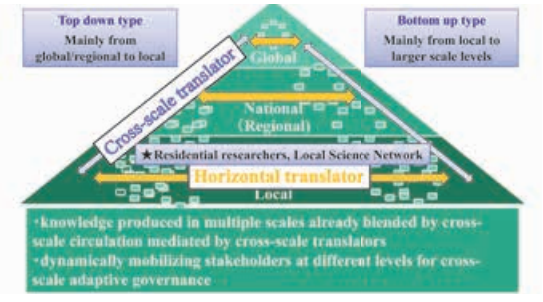


Figure 2 Roles of bilateral knowledge translators
Bilateral translators connecting various scale levels from local to global promote intensive knowledge flows across different scale levels. Diversity and multiplicity of bilateral translators were found to play crucial roles in promoting cross-scale knowledge circulations. We aim to understand and utilize this processes to clarify mechanisms of cross-scale adaptive governance supported by knowledge bases emerging from integration of various knowledge types at different scale levels.

Figure 3 Case study sites of the ILEK project
Sixty one project case study sites are grouped into East Asia (32), EU and North America (12), and Developing Countries (17) teams. Project members are embedded in each case study site as residential/visiting researchers or bilateral translators to collaborate with various local stakeholders in producing and utilizing ILEK. Web GIS and other techniques are currently developed to categorize case study sites using natural and social-ecological indices for meta-analysis and integration.

users, and by translating knowledge among stakeholders into scientific language.

We constructed a conceptual model of ILEK-based adaptive governance focusing on functions of these important actors of local communities (ILEK Triangle, Fig. 4), and identified five hypothetical categories of important drivers of adaptive societal changes promoted by ILEK production and circulation, namely "create and visualize values", "create nexus among actors (local and cross-scale)", "provide options and opportunities", "emergence of collaborative actions" and "appropriate translation". Participatory observations in case studies from the world and in-depth interviews with various actors playing important roles in knowledge production, circulation and utilization opened a new research approach to understand interactive functions of these driver categories in the ILEK Triangle, resulted in identification of diversity and multiplicity of bilateral knowledge translations as an important factor of cross-scale governance. The findings will be integrated in the theoretical models together with outcomes from the action-based verification processes to understand elaborate mechanisms of ILEK-based adaptive governance.

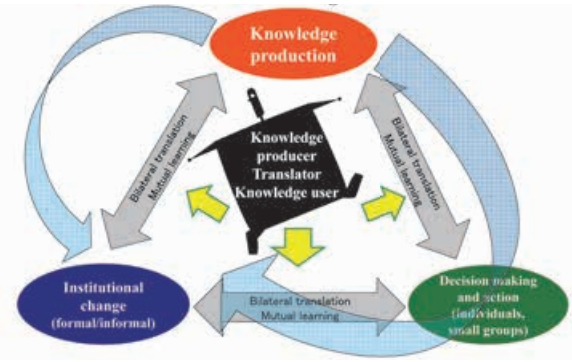


Figure 4 Conceptual model of adaptive governance (ILEK Triangle)
The ILEK Triangle model is composed of an interactive system of three important elements of ILEK-based adaptive governance (knowledge production, decision making and action, and formal/informal institutional change), driven by knowledge producers, knowledge users and translators. The pathways to achieve ILEK-based adaptive governance are postulated in this model with two different processes starting from knowledge production resulting in institutional changes via changes in individual decisions and actions, or directly influencing formal and informal institutions and human networks.

Future research plan

We are moving forward to elaborate the analytical framework of ILEK-based adaptive governance using the ILEK Triangle and the action-based verification processes to verify focused hypotheses derived from meta-analyses of diverse case studies from the world. In order to understand ILEK functions in the real-life adaptive governance systems in local communities, interactions between science and various types of local knowledge production must be incorporated to the research processes by co-design of research and co-production of knowledge with stakeholders.

This transdisciplinary approach to promote intensive interactions, feedbacks and mutual learning among residential/visiting researchers, bilateral translators, and diverse stakeholders is the core of the ILEK project. We will further strengthen the transdisciplinary approach both in local case studies and abstract meta-analysis processes by designing stakeholder workshops. Action-based verification processes and further development of meta-analyses and modeling methodologies will contribute to production of solution-oriented research outputs to support ILEK-based adaptive governance to tackle with the challenges of diverse global environmental problems.

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

Project Leader **TANIGUCHI Makoto** RIHN

Professor Makoto Taniguchi is a hydrologist. He has worked on global studies of groundwater as a leader of the UNESCO GRAPHIC Project "Groundwater Resources Assessment under the Pressures of Humanity and Climate Change", as Vice President (2007-2011) of the International Committee of Groundwater of IAHS under IUGG, and as national representative (2007-present) of IAHS. He is also an editor of the books "Subsurface Hydrological Responses to Land Cover/Use Changes", "Land and Marine Hydrogeology", "The Dilemma of Boundaries" and "Groundwater and Subsurface Environments".

Co-Project Leader **ENDO Aiko** RIHN

Associate professor Aiko Endo studies the economics of fisheries as well as coastal and marine policy. She has taken interdisciplinary and multi-sectoral approaches to Integrated Coastal Management (ICM) in coastal areas in Japan and has experience in projects which made national policy proposals. Her research theme is to find the proper governance structure linking local, national, regional, and global to solve the environmental issues through interdisciplinary and transdisciplinary research with co-design and co-production.

Research objectives and background

Climate change and economic development are causing increased pressure on water, energy and food resources, presenting communities with increased levels of tradeoffs and potential conflicts among these resources. Therefore, the water-energy-food nexus is one of the most important and fundamental global environmental issues facing the world. As water is the central matter within this cluster, we will focus on the inherent tradeoffs between water and food, and water and energy. For the purposes of this project, we define human-environmental security as the joint optimization between human and environmental security as well as the water-energy and water-food connections. To optimize the governance and management within these inter-connected needs, it is desirable to increase human-environmental security by improving social management for the water-energy-food nexus. In this research project, we intend to establish a method to manage and optimize the human-environmental security of the water-energy-food nexus. We base our approach on the viewpoint that it is important for a sustainable society to increase human-environmental security and decrease vulnerability by optimizing the connections within the critical water-energy and water-food clusters.

We will take a regional perspective to address these global environmental problems. The geological and geomorphological conditions in our proposed study area are heavily influenced by the so-called "Ring of Fire," around the Pacific Ocean. Within these areas including Japan and Southeast Asia, the hydro-meteorological conditions are dominated by the Asia monsoon. The populations that live under these natural conditions face elevated risk and potential disaster as negative impacts, while also benefitting from positive ecological goods and services. There are therefore tradeoffs and conflicts within the water-energy-food nexus, as well as among various stakeholders in the region.

The objective of this project is to maximize human-environmental security (minimize vulnerability) by choosing management structures and policies that optimize both the water-food and water-energy connections in Asia-Pacific coastal regions. We define a joint security approach as optimized policy for both critical water clusters. Optimal policies will develop joint security approaches for human-environmental security in the coastal region of the Ring of Fire, including stakeholders and decision-makers.

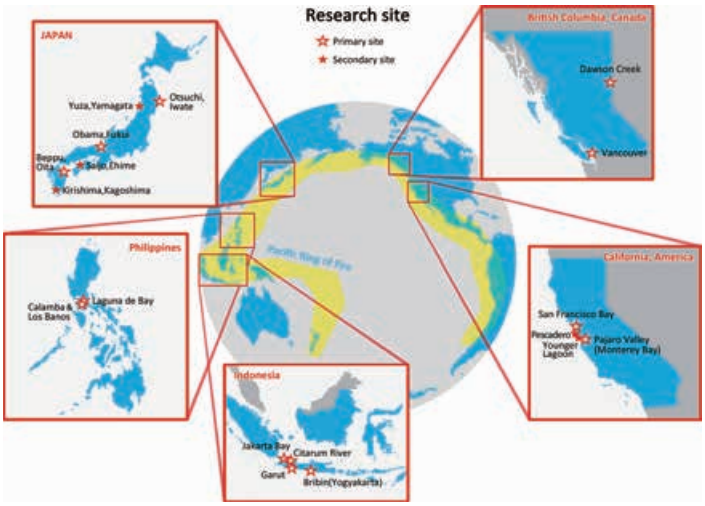
Research methods and structures

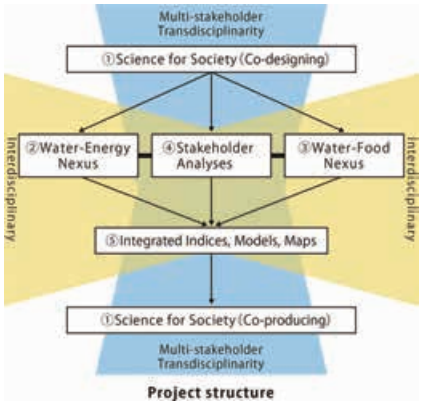
Five different interdisciplinary approaches, scales and clusters will be used in this investigation: (1) Environmental governance, science in/for society, and co-design/co-production approaches, in particular emphasizing integration of local-national scale stakeholders, and regional scale stakeholders such as GEC (Global Environmental Change) Asia/ Future Earth in Asia-Pacific Platform; (2) Biophysical measurements/ analyses of the water-energy nexus by using state-of-art space satellite, geothermic, and hydrogeological techniques to evaluate linkages between water and energy; (3) Biophysical measurements/analyses within the water-food (e.g., fisheries resources) nexus by using state-of-the-art geochemical, coastal oceanographic, geophysical, hydrologic, and ecological techniques including isotopic tracers to evaluate the linkages between land and ocean; (4) Social measurements/analyses of water-energy-food relationships by use of stakeholder analyses, social network analyses, and community surveys, based on sociology, economics, anthropology, psychology, and behaviour science methodologies; and (5) Development of integrated indicators/indices based on cost-benefit/efficiency analysis, environmental valuation, principal component analyses (PCA), and factors weights determined by feedback from stakeholder meeting/workshops, integrated physical models including water, nutrients for fishery resources, and temperature related to energy developments, integrated maps for the tools of policy option selections.

Research activities and findings

At the regional scale of the water-energy-food nexus among 32 Asia-Pacific countries, we found that: the US mostly consumed energy for water transportation in comparison with other countries; and the ratio of utilization of water and energy consumption for fisheries activities in Japan, the Philippines and Indonesia were higher than that of other countries.

At the local scale of the water-energy nexus, the requisite amount of energy to raise the temperature of river water and the actual conditions of flows of hot spring water waste to rivers were obtained under the survey in Beppu, Japan. In addition the potential of geothermal energy was examined accurately by using an absolute gravimeter in Beppu and Kamojang Geothermal Field, Indonesia and the ground heat in Obama, Japan was also estimated.



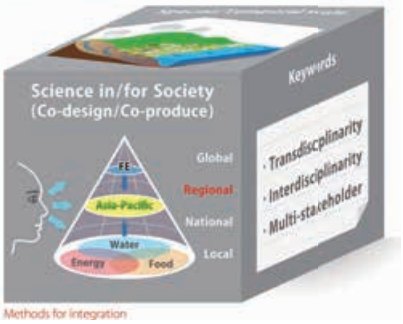


Project structure

RIHN initiative project
(1) Integration of RIHN projects results
(2) Co-design / co-production (design science)

Water-Energy-Food Nexus

Local people involved in groundwater survey



Integration(Contents,methods)

WEF Nexus meeting in San Francisco

At the local scale of the water-food nexus, physical, chemical and biological surveys were conducted at four sites in Japan (Otsuchi, Obama, Beppu, and Yuza), two sites in Indonesia (Citarum river and Jakarta bay), and in the Philippines (Laguna de Bay) with different spatial scales (inter-bay scale and within-bay scale). In Otsuchi, physical and biological surveys were conducted on submarine groundwater discharge (SGD) and collections of crustaceans/fishes. Biotic and abiotic data were compared between the two bays. Radon concentration, abundance and species diversity of fishes were higher in the bay with higher SGD. In Obama bay, physical and biological surveys were conducted, and higher fish abundance and species diversity were observed at the site with higher radon concentration.

Expected results

1. Suggested guidelines to increase environmental security and reduce conflicts related to the water-energy-food nexus.
2. Recommendations for decreasing coastal vulnerability related to the separate governance of land and oceans.
3. Policy and governance structure recommendations for improved water management.
4. Suggestions for sustainable environmental management of the water-energy-food nexus in the Asia-Pacific region.

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Long-term Sustainability through Place-Based, Small-scale Economies: Approaches from Historical Ecology

Project Leader **HABU Junko** RIHN

Born in Kawasaki City, Japan, Junko Habu received her BA (1982) and MA (1984) from Keio University in Tokyo and PhD (1996) from McGill University in Montreal. She is the project leader of the Small-Scale Economies Project and a Professor at RIHN, and also a Professor of Anthropology at the University of California, Berkeley. As an environmental archaeologist, she has excavated a number of prehistoric Jomon sites and historic Edo period sites in Japan and conducted fieldwork in North America. Her books include *Ancient Jomon of Japan* (Cambridge University Press, 2004) and *Evaluating Multiple Narratives* (Springer 2008, co-edited with Fawcett and Matsunaga).

Objectives and background

This project examines the importance of place-based, small-scale and diversified economies for the long-term sustainability of human societies. Our working hypothesis is that a highly specialized subsistence strategy can support a larger community for a short period, but a decrease in subsistence and food diversity makes the production system and its associated community more vulnerable in the long-run. Archaeological, historical and paleoenvironmental studies are used to test this hypothesis (*Longue-Durée* Group). Ethnographic and ecological studies of contemporary small-scale food systems and communities link these studies to ongoing academic and popular discussion of the scale and methods of alternative food systems (Contemporary Society Group). In combination, studies of the past and present point to the future, as the research process also involves the development of implementation and public outreach programs that promote place-based, small-scale, and diversified food production (Implementation, Outreach and Policy Proposal Group).

We realize that there are many additional factors that affect the dynamics among subsistence/food diversity, the scale of a food production system, and its long-term sustainability (see Figure 1). Correlations among these factors will also be examined when testing the main hypothesis.

Small-scale economies and global environmental challenges

For the purposes of this project, a "small-scale economy" is not defined solely on the basis of the absolute size of the economic unit, but rather in terms of the relative scale of food production within a given socioeconomic context. Our definition of small-scale economy addresses the range of networks that enable food production, distribution, and consumption in a given locality without precluding links to the outside economy. We are particularly interested in relatively small-scale food production with the following characteristics: 1) goals not limited to the pursuit of short-term efficiency and profits; 2) production for local markets rather than domination of the world market; and 3) readily available information about the producers.

Based on the premise that improved understanding of the operation of small-scale economies should inform contemporary approaches to global environmental challenges, our project conducts comparative and integrative field investigations at multiple present and past sites. In particular, this project aims to address vulnerability of food production systems caused by soil and water contamination, loss of food and biodiversity, and long-lasting damage to ecosystems. For example, the development of large-scale monoculture-based agriculture, which makes use of a large amount of chemical pesticides and fertilizers, has resulted in serious soil and water contamination and the destruction of ecosystems. The loss of biodiversity resulting from over-specialization has aroused concern about the vulnerability of global food production and other related environmental systems. We propose that smaller-scale and more place-based economies can provide an alternative model that reduces environmental damage and encourages food diversity, thereby improving the resilience of our food systems.

Geographic focus: North Pacific Rim

Northern Japan is the core research area because of its extensive archaeological record and its significance as a food-producing region in Japan. We draw key comparative case studies from the west coast of North America because of the abundance of ethnographic and ecological scholarship on the region, as well as the presence of active contemporary food/agriculture movements. The two regions share similar climates, vegetation, fauna, and levels of seismic activity. Historically, small-scale economies supported by marine food exploitation and intensive nut collecting thrived in both areas, and cultural ties

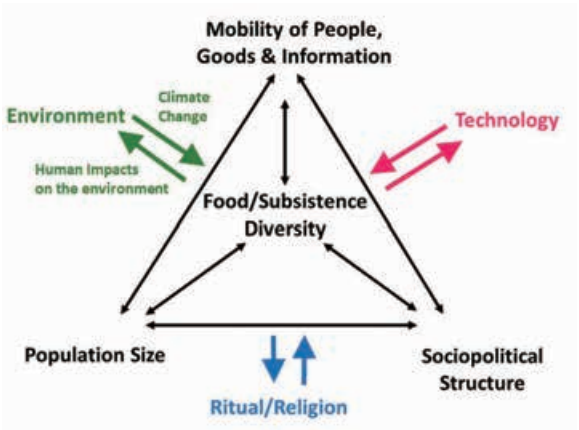

Figure 1 Mechanisms of Long-term Culture Change

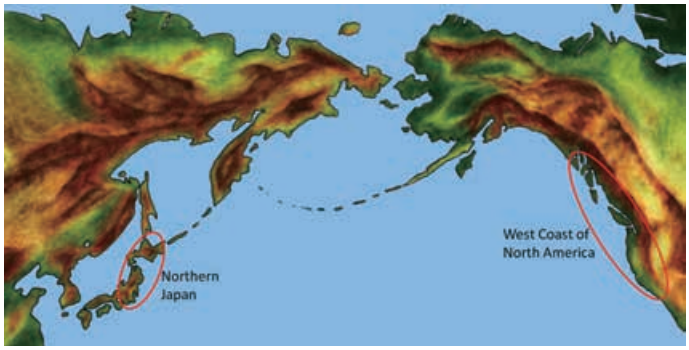

Figure 2 Main Research Areas

Photo1 Archaeological Excavation of a Middle Jomon Site in Aomori Prefecture

between them date back to the migration of anatomically modern humans from Asia to the Americas after the late Pleistocene.

Research activities and findings

***Longue-Durée* Group:** Results of our analyses of settlement patterns and food diversity in northern Japan are consistent with our hypothesis that over-specialization leads to the vulnerability of a socioeconomic system. These data also aid in the development of a new understanding of Early-Middle Jomon chronology and vegetation, which will be important in determining the role of climate change in the long-term shifts in Jomon subsistence patterns. Contrary to the Jomon data, comparative studies from the west coast of North America suggest that increased subsistence diversity correlates with long-term sustainability of complex hunter-gatherer societies. The role of social networks in system resilience is also being explored across multiple regions.

Contemporary Society Group: In northern Japan, interviews and participant observation are being conducted in order to understand the correlations between scale of economy, food diversity, and the resilience of food and environmental systems. These studies have revealed the importance of social networks in mitigating unexpected disruption and dislocation, including those caused by the 2011 Great East Japan Earthquake and the aftermath of the Fukushima nuclear accident. In North America, our research focuses on Native American/Alaskan harvest and distribution of diverse food resources, as well as on the significance of small-scale urban farming for local food security. We are also conducting ethnographic research on the traditional environmental knowledge of rural groups in Japan and indigenous groups in North America.

Photo 2 Urban Agriculture Initiative in California

Implementation, Outreach and Policy Proposal Group: Our implementation and outreach programs include: (1) an eco-literacy educational program focusing on cherry salmon in the Hei River Area of Iwate Prefecture, (2) an educational program about the traditional environmental knowledge of the Tlingit people of the Northwest Coast, (3) a TERM (Traditional Environmental and Resource Management) program in collaboration with the Amah Mutsun Tribe of California, (4) an urban agriculture initiative in collaboration with educational programs at UC Berkeley, and (5) a phytoremediation program using ferns to remediate soil contamination by arsenic.

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Societal Adaptation to Climate Change: Integrating Palaeoclimatological Data with Historical and Archaeological Evidences

Project Leader **NAKATSUKA Takeshi** RIHN

Professor Nakatsuka's specialties are palaeoclimatology and isotope biogeochemistry. Since his early career as a graduate student, he has been using nitrogen isotopes to study long-term variations of climate and its impacts on oceanic biogeochemical cycles. Recently, he changed his main research area from oceans to land and focused on using tree-ring oxygen isotopes to examine the relationship between climate change and human history. Investigating periodicity of climate during last two millennia in Japan and the world, he now hypothesizes that past human societies were often damaged by multi-decadal climate variations as they were caught in a cycle of over-adaptation and subsequent failure of adaptation.

Background and objectives

When global warming causes many difficulties in our society, how can we adapt to the change? Remarkable recent progress in palaeoclimatology has elucidated the fact that large climate variations often underlay epochs of human history. How did our ancestors address such change in the past? Human history must include many examples from which we can extract common lessons relevant to contemporary global environmental change. The research target of this project is Japanese history from the prehistorical Jomon era to the present. First, we reconstruct past climate variations in Japan and Asia at annual or seasonal time resolutions for last several millennia, using up-to-date palaeoclimatological methods to identify outstanding periods of climate variations. Then we use historical and archaeological approaches to investigate how local societies reacted to the climate variation in order to clarify common sociocultural characteristics of societies that are tolerant or vulnerable to changes in climate.

Research methods

In this project, past climate variations are reconstructed by various proxies, such as tree rings (Photo 1), coral rings (Photo 2), ice cores, lake and marine sediments, and historical weather records, and compared with historical documents (Photo 3) and archaeological archives (Photo 4). There are three reasons why we have chosen Japan as the main research area in this project. First, Japan is located at northeastern rim of the Asian summer monsoon, where small changes in monsoon dynamics might have significantly affected paddy rice cultivation on which Japanese sustenance has historically depended. Second, due to the historically high literacy rate and long-lasting family system in Japan, innumerable historical documents dating back to the 8th century are preserved in both private and governmental sectors. Third, rapid land developments during last several decades have provided us of precise archaeological records at numerous excavated sites all over Japan. In addition, a palaeoclimatological tool (tree-ring cellulose oxygen isotope ratio) particularly useful in the Asian monsoon region has been developed recently to reconstruct summer precipitation on which rice paddy cultivation in Japan depends and provide Japanese archaeologists with a reliable tool for annual resolved dating of numerous excavated woods.

Remarkable results

So far, we have been using many tree-ring samples from around Japan in order to analyze tree-ring oxygen isotope ratios during the last 4.3 thousand years in annual time resolution. Besides, we have collected many tree-ring width datasets all over Asia in the framework of international palaeo-climatological project (PAGES) and reconstructed inter-annual variations of averaged summer temperature in East Asia (Cook et al., 2013). Annual resolution of past climate data enable us to confirm whether there are direct relations between extreme climate conditions and special paleographic events, and to discuss how periodicity of climate variations influences people's livelihood. Figure 1 illustrates that multi-decadal (20-50 years) summer temperature variability might have often underlain major famines and political regime shifts during the medieval upheaval period in Japan. We are now investigating how people in the past from Jomon to Early Modern eras reacted to those large climate fluctuations, using various historical documents and archaeological archives.

Final goal

Because the relationship between climate and society is one of the most mysterious subjects remaining in history and archaeology, this project must have the potential to substantially improve our understanding of Japanese history. The most important hypothesis in this project is that society, vulnerable to climate variations, must be vulnerable to environmental changes, too. Although the sources of "past climate variations" are completely different from those of "present global environmental problems", both kinds of change might have the same structure in the context of societal adaptation. Therefore, the final goal of this project is to conduct detailed examinations of societal adaptation to past large-scale climate variations in order to propose adaptation strategies to environmental change in the present.

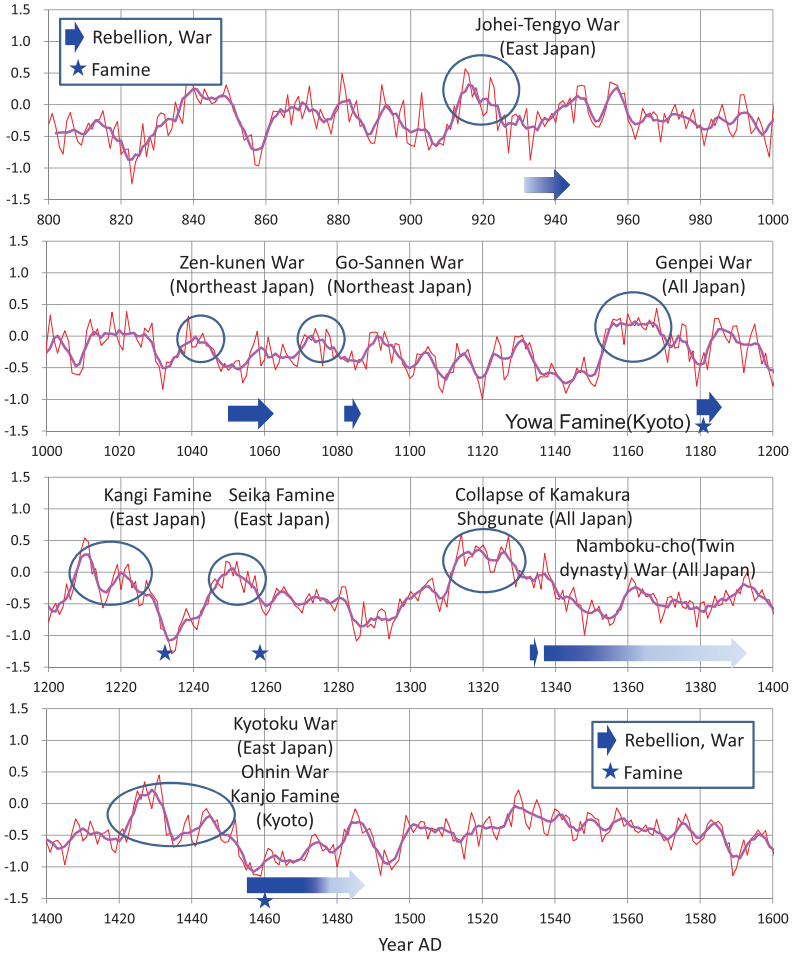

Figure 1 Apparent coincidences between annually resolved average summer temperature variations in East Asia (Cook et al., 2013) and major famines and warfare in Japan from the 9th to 16th centuries. Temperature is shown as the deviation from the average temperature between 1960 and 1990. Thin and thick lines indicate summer temperature in yearly resolution and its 5 years running mean, respectively.

Photo 1 Collection of a tree-ring core from a pine tree

Photo 3 Investigation of early modern documents in Iwate prefecture

Photo 2 Survey of coral reef in Southwest Japan

Photo 4 Watergate piles and pit-house pillars excavated from Aichi prefecture

Sub Leader

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MIZUNO Shoji	The University of Shiga Prefecture	**YOSHIMURA Kei**	The University of Tokyo
SATO Daisuke	Tohoku University		

Biodiversity-driven Nutrient Cycling and Human Well-being in Social-Ecological Systems

Project Leader **OKUDA Noboru** RIHN

My specialty is ecology, the field of study concerned with the relationships between biodiversity and ecosystem functioning. One of ecology's central questions is why we should conserve biodiversity. I have approached this question by integrating different research fields related to biodiversity, especially molecular biology and macro-ecology, while a member of the Center for Ecological Research at Kyoto University. At present, I am developing methods for adaptive watershed governance that can address environmental issues related to nutrient imbalances on both local and global scales. I also should say that I love nature and humanity and how they come together very much!

Research background and objectives

Technological innovations in the use of nutrients, such as nitrogen and phosphorus, to produce food are related to the great global increase in population, life expectancy, and economic prosperity experienced in the twentieth century. Overexploitation of nutrient resources leads to disturbance of natural biogeochemical cycles, however, contributing to significant eutrophication in almost all watersheds with densely populated areas (Photos 1, 2). Such nutrient imbalances are a main driver of biodiversity loss on a global scale. It is now recognized that nutrient imbalances and biodiversity loss are prevalent throughout the planet and pose a risk to sustainable human development. In order to solve these problems related to nutrient imbalances and to ultimately construct sustainable social-ecological systems, we have to enhance nutrient recycling on watershed scales.

Although many governments have adapted nutrient management practices, most are unsuccessful because top-down policy or scientific approaches often do not resonate with local community experience. We therefore need to develop governance practices based on exchange between stakeholders and the integration of local and scientific knowledge to solve social and environmental issues specific to local communities. Such community-based governance, if practiced in many places, may result in the solution of issues related to nutrient imbalances found on watershed scales. In this endeavor, project research aims to develop a framework for adaptive watershed governance that takes account of how biodiversity, nutrient recycling and human well-being are altered through community activities. In this way we hope to improve the strategies used to increase these response variables through the PDCA cycle, according to approaches of transdisciplinary science (Fig. 1).

Research methods

Our hypothesis is that human activities affect biodiversity through alteration of nutrient balances, while biodiversity affects human well-being through alteration of ecosystem functioning and services (Fig. 2). According to this hypothesis, we work in a transdisciplinary process with a variety of stakeholders to integrate local and scientific knowledge on adaptive watershed governance directed towards increasing biodiversity, ecosystem services and human well-being.

In order to empower citizens in watershed governance, we introduce some methods to visualize how nutrient recycling is enhanced through community activities. To motivate stakeholders, we also evaluate how numerous ecosystem services are derived from biodiversity. We will also develop a new method to evaluate human well-being in local communities, as it is closely associated with site-specific cultural services. We expect that such a context-dependent description of human well-being will enhance the sense of community created through collective recognition of locally unique values.

Research progress

A preliminary field survey was conducted in the catchment of Yasu River, the largest tributary of the Lake Biwa

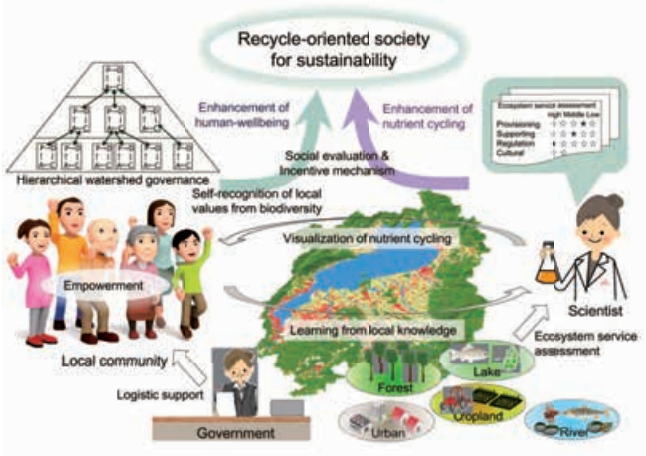


Figure 1 Conceptual schema of adaptive watershed governance

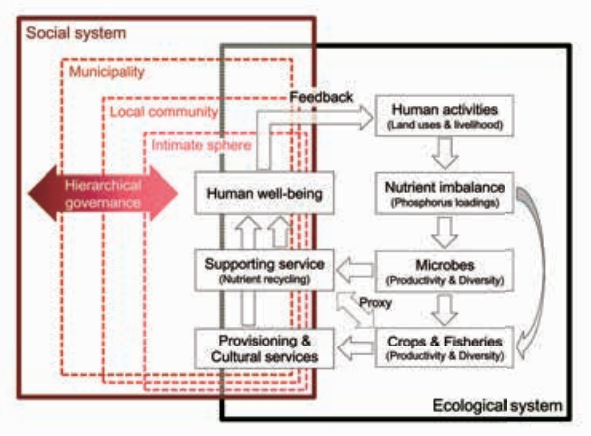
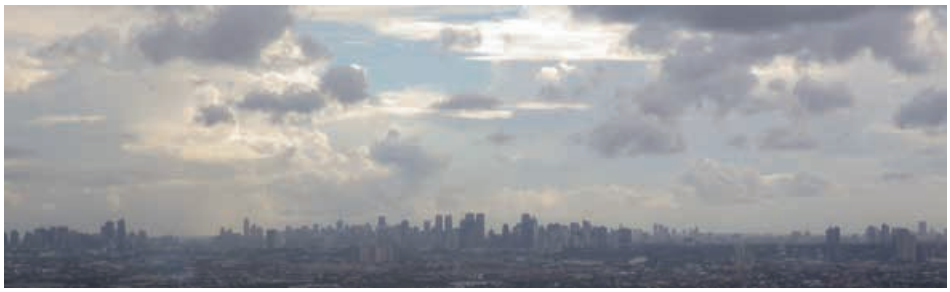


Figure 2 Nutrient-mediated human-nature interactions



Photos 1 and 2 Metro Manila. The zone of economic development (above) and surrounding slums (below) that confront serious issues such as overpopulation, eutrophication and poverty

Photos 3 and 4 Community-based governance in the Lake Biwa Watershed (left) and the Laguna de Bay Watershed (right)

Watershed (Japan). We selected four local communities as models for community-based governance from upstream, middle-stream, downstream, and coastal area of this sub-watershed. Through dialogue with local communities, we focused on local community activities which have the potential to enhance biodiversity and nutrient recycling. Preliminary observations and experimental studies demonstrated that local knowledge-based activities are indeed likely to be useful in enhancement of biodiversity and nutrient recycling.

We have also established three techniques to visualize biodiversity-driven nutrient recycling. The first is nutrient spiral metrics, which indicates how watershed ecosystems metabolize nutrients (Fig. 3). The second consists of phosphate oxygen isotope analysis in order to trace phosphate cycling in aquatic and terrestrial ecosystems. The third is a molecular technique to characterize microbial diversity and functions of nutrient recycling in ecosystems. So far, these techniques reveal that our hypothesis on nutrient-mediated human-nature interactions can be partly supported. They also allow us to do comparative studies in other ecosystems.

On entering the period of full-research, we organized seven discipline-oriented research units and twelve site-based or issue-based working groups, which are composed of a total of 83 collaborators.

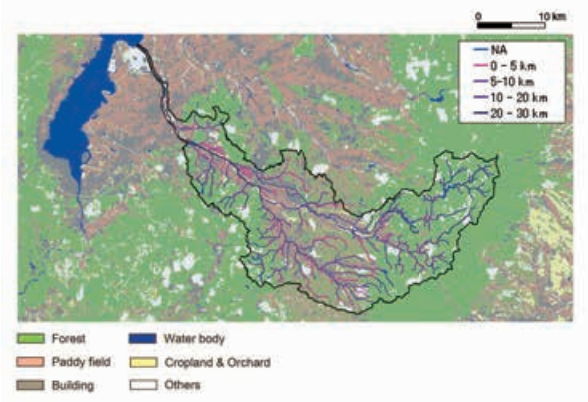


Figure 3 Map of phosphorus spiral length in the sub-watershed of Lake Biwa

Perspectives

Comparative examination of four other watershed systems in Monsoon Asia, three in Japan (Lake Shinji, Inba Marsh, and Hachiro Lagoon) and one in Laguna de Bay, Philippines, allows us to consider the generality and specificity of adaptive governance in relation to social, cultural and geographical features (Photos 3, 4). Disseminating our research outcomes, we also want to expand the research network related to nutrients and watershed governance, especially in other developing countries in Asia.

Sub Leader

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OSONO Takashi	Kyoto University	**SANTOS-BORJA, Adelina C.**	Laguna Lake Development Authority, Philippines