Research Organization for Trans-disciplinary Research: The Experiences from RIHN Watershed Projects

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1. Introduction

The importance for consilience among different disciplines for solving global environmental issues has long been discussed among researchers and decision makers. As the problem becomes more complex in the real world, the society calls for trans-disciplinary approach for analyzing and solving environmental problems. Watershed is a geographical boundary of ecosystem that supports social and economic activities in the regional scale. The problem of watershed is considered to have multi-faceted aspects such as spatial and temporal aspects of material flow and balance, present and future climate conditions, resource use, hierarchical structure of social and cultural organizations and ownership. Thus sustainability of watershed requires "synthesis of knowledge from different specialized fields of human endeavor" (Wilson, 1998).

This chapter tries to review some trans-disciplinary research projects for watershed management and to consider effective research organization for achieving their goals. Particular focus is placed on how the project is integrating scientific knowledge/findings into policy formulations or providing recommendations for watershed resource management.

The organization of the chapter is as follows. First we try to identify the possibility of consilience in trans-disciplinary research. Stages of trans-disciplinary project and types of integration are explored. Second section briefly explains history, mission and organization of the Research Institute for Humanity and Nature. The third section describes experiences from three RIHN Watershed projects. The fourth section considers the evolution of research organization for trans-disciplinary research. The next section shows possible tools for integration. The last section concludes this chapter with some implications for resource management.

2. Consilience and Trans-disciplinary Research

In a path-breaking book, *Consilience: The Unity of Knowledge*, a biologist Edward O. Wilson mentioned that it is possible to unite the sciences with the humanities, and to synthesize knowledge from different disciplines. William Whelwell, in his 1840 book *The Philosophy of the Inductive Sciences*, first introduced the *consilience* and it meant:

> "literally a "jumping together" of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork for explanation."
> (Wilson, 1998)

According to Wilson, the "new synthesis" of knowledge among natural and social sciences, as an example of consilience, is the unification of Darwin's theory of evolution with new information of genetics. The evolution theory was empirically tested by the new knowledge of genetics as the advancement of science. In case of environmental issues, Wilson asserts that political decision makers can not solve most of the problems "without integrating knowledge from the natural sciences with that of the social sciences and humanities." There is a need to link together knowledge from environmental policy, ethics, biology and social science since the most real world problems arises in the intersection of above domains (Wilson, 1998).

Then how is it possible to realize consilience? The rest of the section describes the types of project-type research and directions that is to realize consilience. Three stages of area studies are described in Tachimoto (2003, 2004). Those are multidisciplinary, comprehensive and integrated area studies. Although Tachimoto used these criteria for describing stages of area studies, we try to use them for stages of integrated project-type research for an analogy. The first stage is multidisciplinary project-type research. In this stage, members from different disciplines work together in the same project but they simply consider project as an arena for their own individual study. However, members are like vegetables in the salad bowl and there is almost no influence among each other for the outcome of the research. This may be true for the initial stage of so-called trans-disciplinary project. The second stage is comprehensive project-type research. In this stage, the project focuses more on comprehensive outputs and each members are somewhat influenced by other members in the project. The third stage is integrated project-type research that creates new arena for trans-disciplinary research. Ideally in this stage, a project serves as a melting pot for integrated study across disciplines with a wholistic approach to tackle issues and to realize consilience.

In addition, there are three typical directions of integrated research. One direction is to integrate through common concepts and missions for environmental issues to share among researchers from various disciplines. Thematic concepts such as *sustainability* and *resilience* may be examples for this venue. Another direction is to integrate through a method of analysis. An effort to integrate various field of science with a unified method or a model may be one example. The last direction is to integrate through studying the same geographical area. The area study that has developed particularly after the Second World War has this typical integration method.

3. **RIHN as a ground for Trans-disciplinary Research**

i) History

In 1995, the Japan Science Council proposed, "it is necessary to examine the founding of a central research organization that will promote integrated cooperative research toward the solution of global environmental problems." The Preparation Committee of the Institute proposed in March 2000 the foundation of the "Research Institute for the Global Environmental Sciences" to be established for promoting integrated research projects, by

amalgamating various broad disciplines from humanity and social sciences to natural sciences and build networks among university researchers within and outside of the country. The Research Institute for Humanity and Nature (RIHN) was founded in 2001 as one of the inter-university research institutes of the Ministry of Education, Culture, Sports, Science and Technology, the Government of Japan. In 2004, the Inter-University Research Institute Corporation, National Institute for the Humanities (NIHU) was established, based on the National University Cooperation Law. RIHN became one of the five member institutes of the NIHU. Other members are the National Museum of Japanese History, the National Institute of Japanese Literature, the International Research Center for Japanese Studies, and the National Museum of Ethnology (RIHN, 2007).

ii) Mission

Environmental issues, such as global warming, loss of biodiversity, and depletion of water resources are said to be the consequences of human-nature interactions and these consequences are now manifesting themselves in various parts of the world. It is fundamentally a problem of human lifestyle, or "human culture" in the broadest sense of the word (RIHN, 2007). It is an important mission for RIHN to achieve consilience in the area of global environmental problems. The true nature of global environmental problems becomes apparent through consilience, presenting a new paradigm to view problems. It will then become possible to draw up a plan for building a futurable society. In summay, RIHN's mission is to construct an integral wisdom as consilience and to solve global environmental issues, which it sees as deeply rooted in human culture (RIHN, 2007).

iii) Organization

In order to achieve RIHN's mission, RIHN carries out trans-disciplinary and integrated project-based research. The RIHN was originally designed to have a capacity of accommodating fifteen trans-disciplinary research projects. At the time of establishment in 2001, five RIHN projects were inaugurated under five research axes and approaches. Those were:

Axis 1: Environmental Change Impact Assessment;
Axis 2: Human Activity Impact Assessment;
Axis 3: Spatial Scale;
Axis 4: History and Time Scale;
Axis 5: Conceptual Framework for Global Environmental Issues.

Although the five research axes aimed at directing programs in the group, the trans-disciplinary interactions among projects in each axis were not very effectively organized. The trans-disciplinary integration was largely left with each project members although there were a great deal of interactions among researchers. As of 2007, five programs/domains were organized at RIHN to lead trans-disciplinary interactions and generating consilience among

domains. Five research programs/domains include circulation, diversity, resources, environmental history of civilizations, and global ecosophy.

Circulation Domain: Dealing with various kinds of problems as to the circulation of substances such as water, oxygen, carbon, and nitrogen in the human sphere and their imbalance and inappropriate uses.

Diversity Domain: Dealing with global environmental problems derived from the loss and degradation of genetic-specific and ecological biodiversity, as well as cultural diversity related to language, social structure, religion, and cosmology.

Resources Domain: Dealing with global environmental problems associated with food and energy resources and with the relevant economic activities (agriculture, forestry, fishery, and animal husbandry).

Environmental History of Civilizations Domain: Dealing with historical consequences of human-nature interactions, particularly of civilization as global environmental history.

Global Ecosophy Domain: Dealing with environmental issues in a particular regions/areas and to seek new approaches and methodologies to study global environmental problems.

RIHN project members are invited to participate more than one program meetings to seek common ground for trans-disciplinary research. Although research domains are purposed to represent integral perspectives of global environmental problems, trans-disciplinary organization and research has mostly been practiced and realized in each research projects. Therefore, the following session describes outlines and research focuses of three watershed projects at RIHN.

4. **Experiences from RIHN Watershed projects**

The initial five RIHN projects were studying on water issues, i.e., Seyhan River Basin, Oasis Region in Inner Mongolia, the Lake Biwa-Yodo River Watershed, and Global Virtual Water. Here, we show experiences from three watershed projects. First two are the completed projects. One is "Impact of Climate Changes on Agricultural Production System in the Arid Areas (ICCAP) (2002-2006)"; the second project is "Multi-Disciplinary Research for Understanding Interactions between Humans and Nature in the Lake Biwa-Yodo River Watershed (2002-2006)." The third project is "Human Impacts on Urban Subsurface Environments (2006-2010)" that is to be completed in 2010.

4-1. Impact of Climate Changes on Agricultural Production System in the Arid Areas (ICCAP) (2002-2006)

a. Outline

ICCAP project was one of five research projects that started as the first phase of research

activities at RIHN in 2002. Their study site was the Seyhan River Basin that is located in the central south of Turkey. The Seyhan river extends to Adana City and flows into Mediterranean Sea. The total watershed area of Seyhan River Basin is 21,734 km^2 and the land cover class in upper and middle basin are dominated by rain-fed wheat and barley (22.2%), pasture (31.8%) and forest (19.4%). Along the downstream of the Seyhan River, the Lower Seyhan Irrigation Project (LSIP) in Adana was initiated by the Turkish government as one of the most important irrigation projects located in southern Turkey. The Government constructed the Seyhan Dam in 1956 for the purposes of irrigation, power generation and flood protection. The reservoir can store 1.2 billion cubic meters that supply irrigation water to LSIP. There is a concern among local authorities as well as farmers that how the future climate changes will affect the local agricultural production. The project was to answer this question by focusing on local impacts of climate changes in 2070's.

b. Objectives

The objective of the ICCAP was first to assess the impacts of climate changes during the 2070s and possible adaptations for it on agricultural production system in Seyhan River Basin. For this purpose, the main tasks were development of the methodology or model for the assessment, including the improvement of Regional Climate Model (RCM), for generating future regional climate scenarios. The second objective was to assess the vulnerability of agricultural production systems from natural changes and to suggest measures for enhancing sustainability of agriculture, through integrated impact and adaptive assessment of climate changes (ICCAP, 2007).

c. Research Organization

The project leader of ICCAP was Dr. Tsugihiro Watanabe, an irrigation engineer. The group consisted of more than one hundred researchers mainly from Japan and Turkey. The major collaborating institution was the Scientific and Technological Research Council of Turkey (TÜBITAK) and Cukurova University in Adana. Figure 1 indicates the research organization of ICCAP. The project researchers are grouped into six sub-groups based on conventional disciplines, climate, hydrology and water resources, irrigation and drainage, crop production, vegetation and socio-economics (Figure 1). The climate group provided the regional climate conditions during the 2070's using the RCM. Other groups assessed the impacts of climate changes in various aspects such as river flow, crop growth, vegetation changes, irrigation water and agricultural production of farm households.

d. Integration

The member of each sub-group was quite stable from the start to the end of the project although there were some integral transformation at the later stage. At the same time the RIHN researchers including post-doctoral fellows provided integral drives across disciplines

of six sub-groups. The integration activity and trans-disciplinary communication was most realized in the process of scenario formation for climate change (Figure 2). For making climate change scenarios, many researchers participated and discussed the possibilities in the future (Nagano et al., 2007). One of the integration efforts was made through various modeling exercises. The RCM developed by ICCAP utilizes the output from Global Circulation Model (GCM) and provides future climate conditions such as precipitation, temperature, radiation, wind speed and humidity. One of the integrated models of ICCAP is SiBUC (Simple Biosphere including Urban Canopy) land surface model that utilizes climate information from RCM for calculating river water flow. Also the output of SiBUC, water availability for LSIP, was used for analyzing cropping patterns that farmers may choose under the water constraints given by the scenarios (Figure 3). The ICCAP provided final output to the local authority General Directorate of State Hydraulic Works and the members of water users associations in LSIP for discussing and recommending strategies against possible future climate changes.

4-2. Multi-Disciplinary Research for Understanding Interactions between Humans and Nature in the Lake Biwa-Yodo River Watershed (2002-2006)

a. Outline

The Lake Biwa-Yodo River Project was also the one of the first phase projects of RIHN. The Lake Biwa-Yodo River watershed is one of the most intensively human-dominated watersheds in Japan. Since the water quality of this area began to deteriorate in the 1970's, Shiga Prefecture has worked on reducing the human load inflow by establishing laws and by promoting the development of sewage plants. Currently, the control of non-point sources, including agricultural drainage, has become an urgent issue, including turbid water flowing out from the paddy fields through medium and small rivers and finally into Lake Biwa (Yachi, 2006).

In General, a watershed has a "nested" structure that encompasses the human the human activities that develop within it (Figure 4). The project particularly focused on ways of viewing the problems occurring in the watershed at each level, because differing views can cause conflicts of interest between levels and thus obstruct watershed management. They consider the reason why watershed management is not working well is that active communication aimed at balancing competing interests is blocked, leaving a variety of stakeholders dispersed over the different levels. Thus the Lake Biwa watershed was chosen as an example of this kind of nested structure defined as a hierarchy consisting of three spatial levels: macroscale (the entire watershed), mesoscale (the regional community), and microscale (the local community) (Yachi, 2006).

b. Objectives

The four objectives were designed to be achieved through interdisciplinary partnership and local execution in each hierarchy: (1) clarification of the entire problem; (2) development of environmental diagnostic indices for each hierarchy and research on a method to support adaptive management; (3) establishment of a methodology for the promotion of inter-hierarchical communication; and (4) for the Yodo River watershed, which constitutes the downriver reaches of Lake Biwa, the identification of important problems related to the water environmental problem, based on the research activities related to the Lake Biwa watershed. Based on these case studies, the project intended to provide appropriate recommendations for the watershed management of the Lake Biwa-Yodo River watershed and to contribute to the establishment of global *environmentology*, i.e., a new synthesis of global environmental studies.

c. Research Organization

The Lake Biwa-Yodo River watershed project was led by Dr. Shigeo Yachi, a theoretical ecologist. The total number of project members was forty-eight including eight RIHN researchers. Figure 5 shows the research groups of the Lake Biwa-Yodo River Project. The project consisted of four working groups (WGs), Material Cycling WG, Ecosystem WG, Social & Cultural WG, and Watershed Information System WG. The number of project member increased from 19 in 2002 to 48 in 2007. Along the project implementation, various working groups were organized during the project period to support the research activities (Tanaka, 2007a). The Integrated WG, seven core members and other members who like to participate, discussed detailed research plans by sharing the concept of "watershed management model". Also, other working groups not shown in Figure 5 are formed to meet their research needs. Those working groups included Extended Material Cycling WG, Social Psychology WG, Paddy Field WG, Environmental Economics WG, Yodo-River Downstream WG. The meetings of those working groups accelerated trans-disciplinary communication among researchers.

d. Integration

Practical methods of watershed diagnosis for hierarchical watershed management include two important aspects. One is the use of indices, models and geographic information systems (GIS) and the other is stakeholder communication. Those two aspects also represent naturally integrating methods for the Lake Biwa-Yodo River Project.

They found that small to medium sized rivers, in the farming area east of the Lake Biwa, are responsible for discharging acid and minerals, such as sulfuric acid, nitric acids, bicarbonates, calcium, and magnesium. These acids are produced by farming activities and have eluted minerals from the soil and caused changes in the water quality of the lake. They utilized GIS so that the scientific information, such as turbid water discharge and water quality (stable isotope compositions) is mapped onto GIS for visualization and

communication with stakeholders.

Another important aspect of integration is placed on stakeholder communication by performing interviews, conducting questionnaire-based surveys and holding various workshops/meetings with stakeholders. They interviewed residents from 35 communities in the region on water management and use, and integrated the data, along with detailed data on the region and on the Lake Biwa watershed, into the GIS database. Based on the results, workshops were held in three communities, at which the residents themselves discussed the locations of beautiful and comfortable waterside areas using maps. The workshops were and attempt to encourage residents to notice the actual regional waterside environment and form desired future visions.

The integrated efforts are delivered by project proposal on "hierarchical watershed management system" based on 1) adaptive management appropriate for each level, and 2) communication between levels. In Figure 4, hierarchical watershed management means that communities and stakeholders at each level undertake specific functions and perform diverse activities related to the watershed at their level. Actions in each unit involve drawing up a plan (P), monitoring the process (D and C), analyzing and assessing the results of monitoring (A), and making necessary revisions.

4-3. Human Impacts on Urban Subsurface Environments (2006-2010)

a. Outline

Securing water resources and preventing contamination of water caused by human activities in urban areas are global environmental issues in the 21st century. Heat island phoenomena caused by human activities is also a big environmental problem in addition to global environmental warming. These global environmental issues which are caused by urbanization, should be addressed strongly and prevented as population and density increases occur rapidly in urban areas.

Most global environmental studies have long been focused on the environmental issues above ground, such as air pollution, global warming, seawater pollution, and decreases in biodiversity. Subsurface environmental issues are also important for human life in the present and future, but have been largely ignored because of the invisibility of the phenomena and difficulty of evaluations.

Subsurface environmental problems such as subsidence due to excessive pumping and groundwater contamination have occurred repeatedly in Asian major cities with a time lag depending on the development stage of urbanization. Therefore, the project is to assess future scenarios if we can evaluate the relationships between subsurface environmental problems and the development stage of the city (RIHN, 2007).

b. Objectives

The project address the sustainable use of groundwater and subsurface environments to provide for better future development and human well-being. The primary goal of the project is to evaluate the relationships between the development stage of cities and various subsurface environmental problems, including extreme subsidence, groundwater contamination, and subsurface thermal anomalies. The project targeted the following four research topics: (1) relationship between the development stages of the cities and subsurface environmental problems which will be assessed by socio-economic analysis and reconstruction of urban areas using historical records; (2) serious problems in subsurface environments and changes in reliable water resources which will be studied after evaluations of groundwater flow systems and changes in groundwater storage using hydrogeochemical data and in-situ/satellite-GRACE (Gravity, Recovery and Climate Experiments) gravity data; (3) evaluation of accumulation of materials (contaminants) in subsurface and their transport from land to ocean including groundwater pathways using chemical analyses of subsurface water, sediments and tracers; and (4) subsurface thermal contamination due to the "heat island" effect in urban area by reconstruction of surface temperature history and urban meteorological analysis (RIHN, 2007; Taniguchi, 2007).

In order to pursue above objectives and research targets, Tokyo, Osaka, Bangkok, and Jakarta are targeted as main study cities, and Taipei, Manila and Seoul are selected as secondary study cities, depending on the four sub-themes. The project focuses on the urban subsurface environments and treats the problems on a basin scale, because subsurface water, heat, and material transports are interconnected on this scale. We will assess the relationships between subsurface environmental changes and human activities during the past 100 years.

c. Research Organization

The project leader of Urban Subsurface Environments is Dr. Makoto Taniguchi, hydrologist. The project has six research groups as shown in Figure 7. "Social economic group" and "urban geography group" is organized to study the first research topic, "water group" and "gravity group" for the second research topic. Material group and heat group is to study the third and fourth research topic respectively. Based on the field surveys in targeted cities and assessments of natural and social data in each city from six research groups, they are to built project database/platform on GIS for further analysis.

d. Integration

The project is still in the process of developing methods of integration. One of the integration methods of this project is to focus on historical changes of four research targets from 1900 to 2000 and to use GIS for mapping historical data. Then this database/platforms is to be utilized for visualization and analysis of urban subsurface environments in target cities. Preliminary models such as GRACE, groundwater flow, and DPSIR (Driving force, Pressure, State, Impact, Response) have been established in each sub theme for providing

scientific information on urban environments. In order to evaluate the origin and process of material loads to the subsurface, isotopes and chemical analyses of water samples with new tracers techniques using CFC, Kr are introduced. In addition to GIS, integrated models and indicators natural and social science information will be developed to provide recommendations for sustainable groundwater management and subsurface environment of cities.

5. Evolution of Research Organization for Trans-disciplinary Research

Different type of research organization has evolved in RIHN projects since the establishment. The project leader chooses a type of research organization for his/her project depending on the mission and the methodologies to approach important issues of the project. The most common research organization of project-type research can be categorized into three types; discipline, target and issue/theme oriented research organization. Although the mission of the each project is different, there are various reasons to adopt a particular type of research organization for a project. Research organization is particularly important to achieve the mission and goals of the project.

a. Discipline Oriented Research Organization (first phase)

Most of the initial RIHN projects had this type of research organization. In this research organization, the project is grouped into sub-groups based on conventional academic disciplines, such as climatology, hydrology, agronomy, socio-economics as you can find in university departments. The benefit of this research organization is that it is easy to form and communicate/work among members since the members of the sub-group is mostly from the same discipline, same academic society, and sometimes from the same department of the same university. However the problem of this research organization is that it is difficult to integrate with other group with different disciplines. The ICCAP was the typical example of project that formed this type of research organization.

b. Target Oriented Research Organization (second phase)

The another research organization, target oriented research organization, appeared as the second phase of RIHN projects. Not like discipline oriented research organization, this research organization has a particular target object of research. In this way, researchers from different discipline can possibly work together focusing on a target of research. For example, the Lake Biwa-Yodo River watershed project had a group targeted to “material cycling” and “esosystem” and “social and cultural issues”. The Urban Subsurface project has a research organization that target research on water, heat, contamination and a city. The advantage of this research organization is that it is easy to focus research topic but difficult to make a wholistic view.

c. Issue/Theme Oriented Research Organization (third phase)

The pursuit of more trans-disciplinarity made another type of research organization, i.e., issue/theme oriented research organization. Based on the experience that discipline oriented and target oriented research organizations are not enough for trans-disciplinarity, issue/theme oriented research organization aims at tackling particular working hypothesis/issues with a trans-disciplinary group from the beginning. Urban subsurface project is considered a combination of target oriented and issue oriented research organization since each sub-group has a particular target as well as issues to focus on. In this way, it will make easier to focus on issues for trans-disciplinary output from the earlier stage with relatively small number of researchers that required pursuing each goals. For establishing this type of research organization, trans-disciplinary leadership is essential.

Table 1 shows the characteristics of various research organizations. For facilitating easy communication among sub-group members, discipline oriented research organization has an advantage over other research groups. On the other hand, research focus is better made through target oriented research organization. Furthermore, trans-disciplinary integration becomes easier when we make issue/theme oriented research organization. For example, ICCAP started with discipline oriented research organization. Through the course of project implementation, the group members transformed more towards target and issue oriented research organization at the later stage of the project. The Lake Biwa-Yodo River project and the Urban Subsurface project are geared to target/issue oriented research organization compared to ICCAP. Nevertheless, the success or failure of the project output is not only depends on how the research groups are organized but also depends on the inter-disciplinary communication among project members to pursue particular goals.

6. **Tools for integration**

For integration of the project output, there may be many practical ways and tools to consider. Table 2 indicates examples of tools for integrating outputs from different disciplines. The x shows the relative focus of each tool within the project and they not comparable across projects. One way is to map spatial changes and try to overlay of various parameters and variables for comparison. Also, similarly we can map historical changes and try to trace various parameters and variables. This gives us an easy exposition and visualization of target indices across space and time. The above two methods are often realized by using GIS techniques. The third method is to show some indicators for new insight. The indicator can be both for quantity and quality, or totally new composite indicator for indicating things from different perspectives. Modeling also is one of important tools for integration. The forth method is so called “coupled models” which has a component of social and natural science at the same time in one model. In the field of ecological economics, there is a strong tradition of coupled models. Especially mathematical biologists/ecologists are the pioneers of explaining human behaviors using ecological modeling. This is the natural science approach to integrate

social science. Also, social science modeling can embrace information from natural science for integrated analysis. The fifth method is communication among researchers. Project can be better integrated through smooth communication among researchers from different disciplines. This is not always easy because each discipline has their own technical languages, definitions, models, a way of approaching issues, i.e., induction or deduction. The sixth method is communication among stakeholders. Through communicating stakeholders, the output of the project is getting more integrated for communicating with community and the society.

The above-mentioned methods are sometimes combined. For example, all three RIHN watershed projects utilized GIS methods for showing spatial and temporal changes for communication. For ICCAP project, GIS is particularly useful for visualizing the impacts of future climate changes on water resources and agricultural production system in the region. The results were shared with local water authorities and water users associations in addition to university researchers (Nagano et al., 2007). In the Lake Biwa-Yodo River project, trans-disciplinary communication was very intense through holding various integrated working group meetings and publishing working paper series for dissemination (Tanaka, 2007a, 2007b). Also they focused on communication among stakeholders for showing their research output using GIS database. For the Urban Subsurface project, their focus is more on generating various indicators by intensive field observations and historical overlay for a long period of time.

7. **Conclusion**

We tried to consider research organization for trans-disciplinary research projects. In early stage of trans-disciplinary project, interactions among researchers may be minimal. As the problems of the real world become more complex, a need of both researchers and decision makers for comprehensive and integrative research becomes high for providing solutions to the environmental problems.

The experiences from three watershed projects revealed that different research organization was formed by each project as a result of their efforts for pursuing goals of the project and to implement a variety of research agendas. Through a pursuit of consilience, research organization evolved at the same time so as to focus more on trans-disciplinary output and solutions for environmental problems. In order to synthesize knowledge from different specialized fields of science, tools they adopted varied across projects depending on their focus of the project including mapping spatial and temporal indicators using GIS and stakeholder communications. There seem no golden rules for trans-disciplinary research since the research organization is selected for their particular research goals and needs of the project. Especially visualizing scientific knowledge using GIS is useful for communication among researchers as well as stakeholders concerned. Recent developments in a unified models for natural science and social science, for example in a study field of social-ecological systems, may possibly provide a common ground for explanation for consilience.

Reference

ICCAP. 2007. *The Final Report of ICCAP-The Research Project on the Impact of Climate Changes on Agricultural Production System in Arid Areas (ICCAP).*

The Lake Biwa-Yodo River Project. 2007. *Multi-Disciplinary Research for Understanding Interactions between Humans and Nature in the Lake Biwa-Yodo River Watershed, Final Report.* RIHN, Kyoto.

Nagano, T., Y. Fujihara, K. Tanaka, C. Umetsu, K. Hoshikawa, T. Kume, F. Kimura and T. Watanabe. 2007. "Generated Social Scenario and Basin Condition for the Final Integration." *The Final Report of ICCAP-The Research Project on the Impact of Climate Changes on Agricultural Production System in Arid Areas (ICCAP).* RIHN, 15-18.

RIHN. 2006. *RIHN Annual Report 2005*.

RIHN. 2007. *RIHN Annual Report 2006*.

Tachimoto, Narifumi. 2003. "Methodological Issues for the Area Studies in the 21st Century" *Kokusai Kenkyu* 19: 148-156. Chubu University. (in Japanese)

Tachimoto, Narifumi Maeda. 2004. "Global Area Studies and Fieldwork." Discussion Paper No. 129. Graduate School of International Development, Nagoya University, Nagoya.

Tanaka, Takuya. 2007a. "Collaboration among Researchers in the Lake Biwa-Yodo River Project." Multi-Disciplinary Research for Understanding Interactions between Humans and Nature in the Lake Biwa-Yodo River Watershed, Final Report. RIHN, Kyoto. 581-587. (in Japanese)

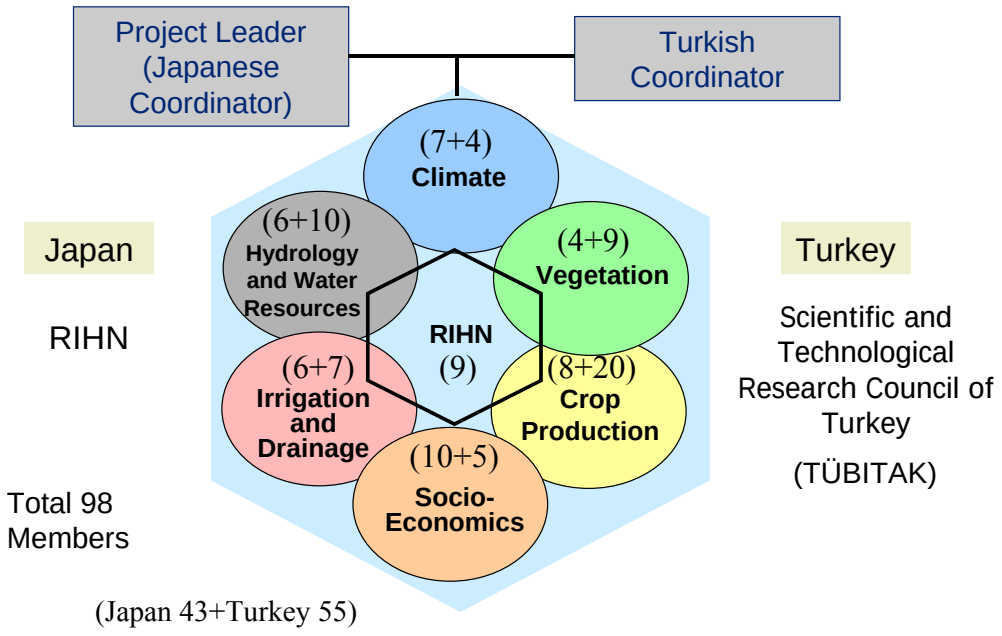
Tanaka, Takuya. 2007b. "Collaboration with the Local Community in the Project: The Case of the Lake Biwa-Yodo River Project and Inae Region." *Multi-Disciplinary Research for Understanding Interactions between Humans and Nature in the Lake Biwa-Yodo River Watershed, Final Report.* RIHN, Kyoto. 588-594. (in Japanese)

Taniguchi, Makoto. 2007. *Progress Report 2007: Human Impacts on Urban Subsurface Environments. No.4.* Research Institute for Humanity and Nature, Kyoto, Japan.

Umetsu, Chieko, K. Palanisami, Ziya Coşkun, Sevgi Donma, Takanori Nagano, Yoichi Fujihara, Kenji Tanaka. 2007. "Climate Change and Alternative Cropping Patterns in Lower Seyhan Irrigation Project: A Simulation Analysis with MRI-GCM and CCSR-GCM" *The Final Report of the Research Project on the Impact of Climate Change on Agricultural Production System in Arid Areas (ICCAP).* 2007. 227-239. RIHN, Kyoto Japan.

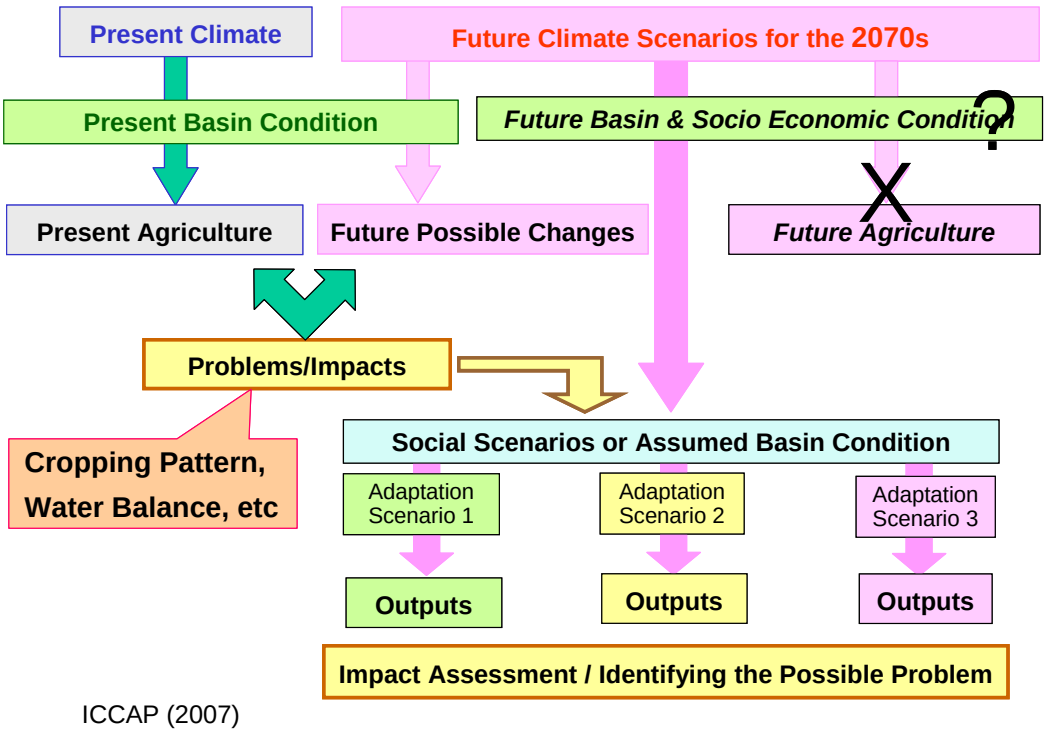
Wilson, Edward O. 1998. *Consilience: The Unity of Knowledge*. New York: Alfred A. Knopf, Inc.

Yachi, Shigeo. 2006. "A Hierarchy-based approach to the problem of agricultural water turbidity in the Lake Biwa Watershed." *RIHN 1st International Symposium Proceedings – Water and Better Human Life in the Future* -. November 6-8, 2006, Kyoto International Conference Hall, Kyoto. 81-87.



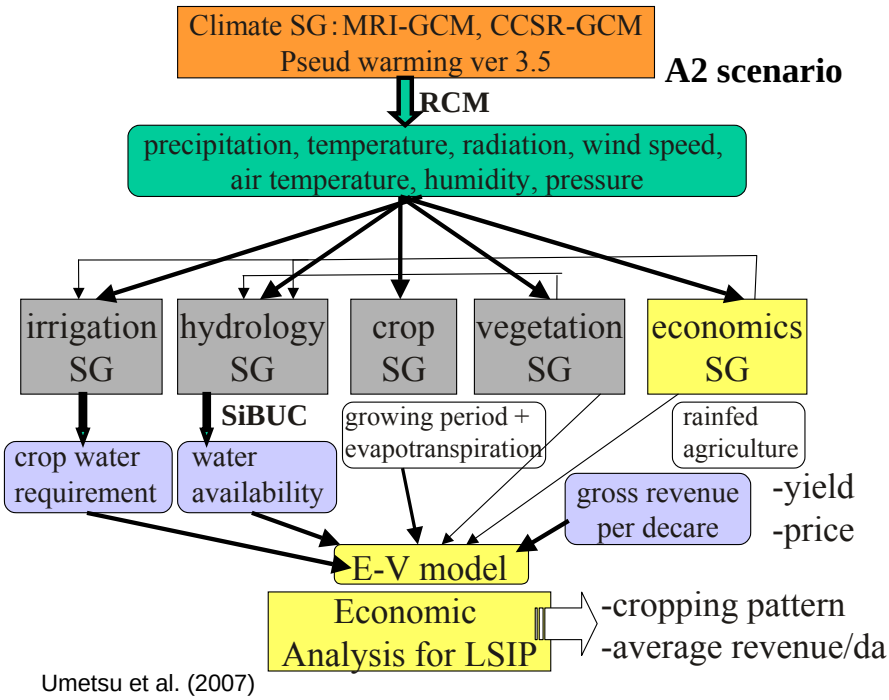
ICCAP (2007)

Figure 1. Six Research Groups of ICCAP



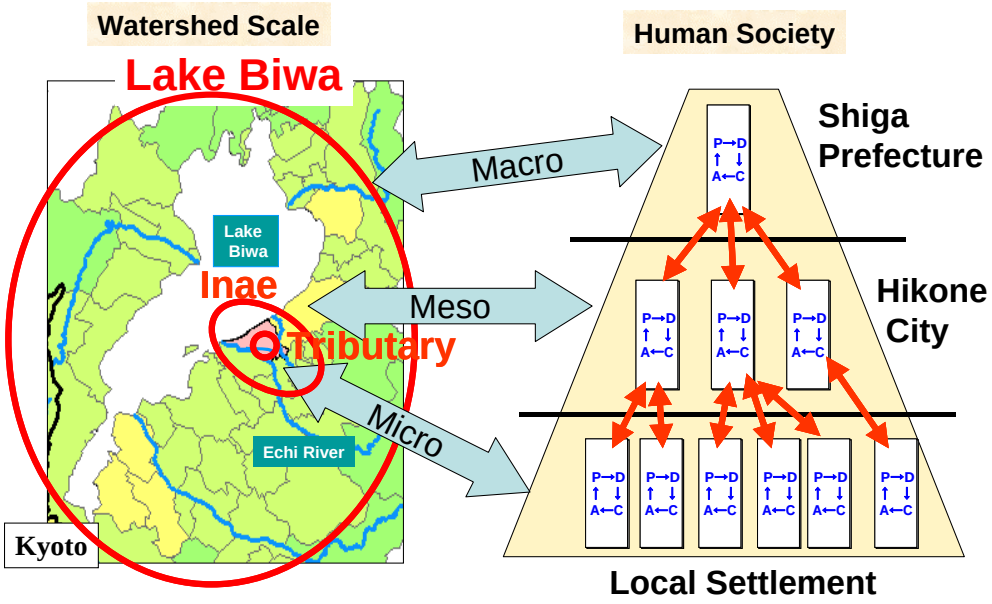
ICCAP (2007)

Figure 2. Impact Assessment Flow and Scenarios in ICCAP



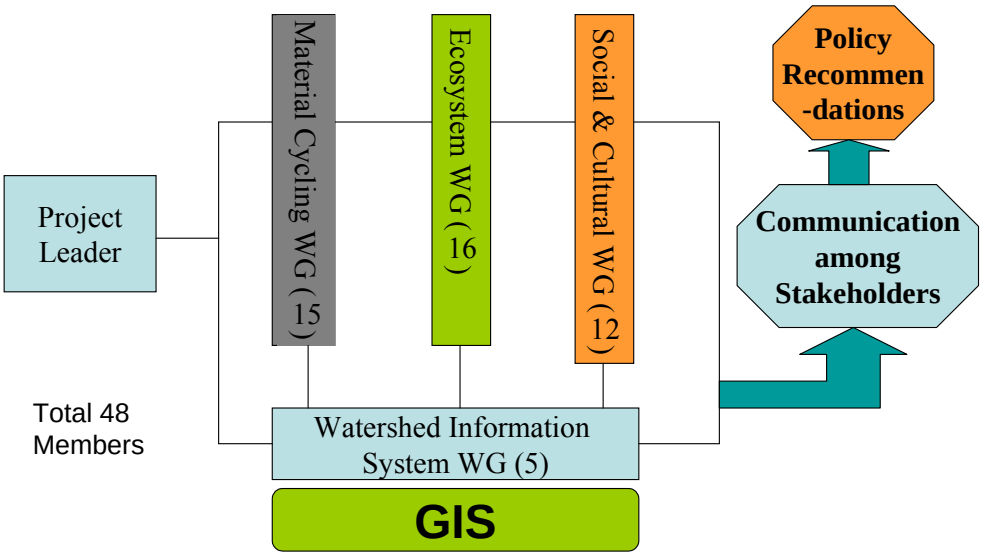
Umetsu et al. (2007)

Figure 3. Framework of Analysis for Integrating SG Outputs in ICCAP



Lake Biwa-Yodo River Project Final Report (2007)

Figure 4. Lake Biwa-Yodo River Project-Four Research Groups



RIHN Annual Report 2006 (2007)

Figure 5. Four Research Groups in Lake Biwa-Yodo River Project

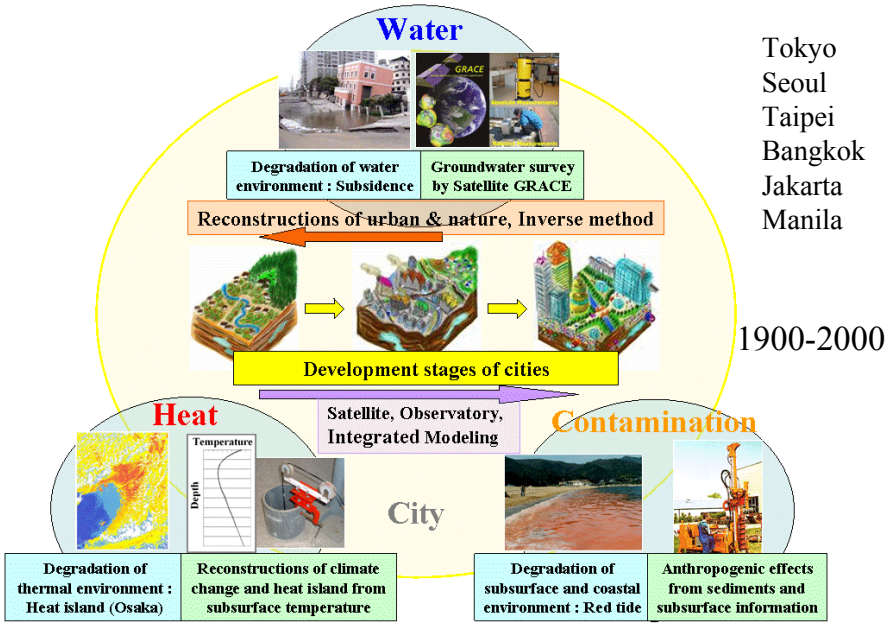


Figure 6. Human Activities on Urban Subsurface Environments

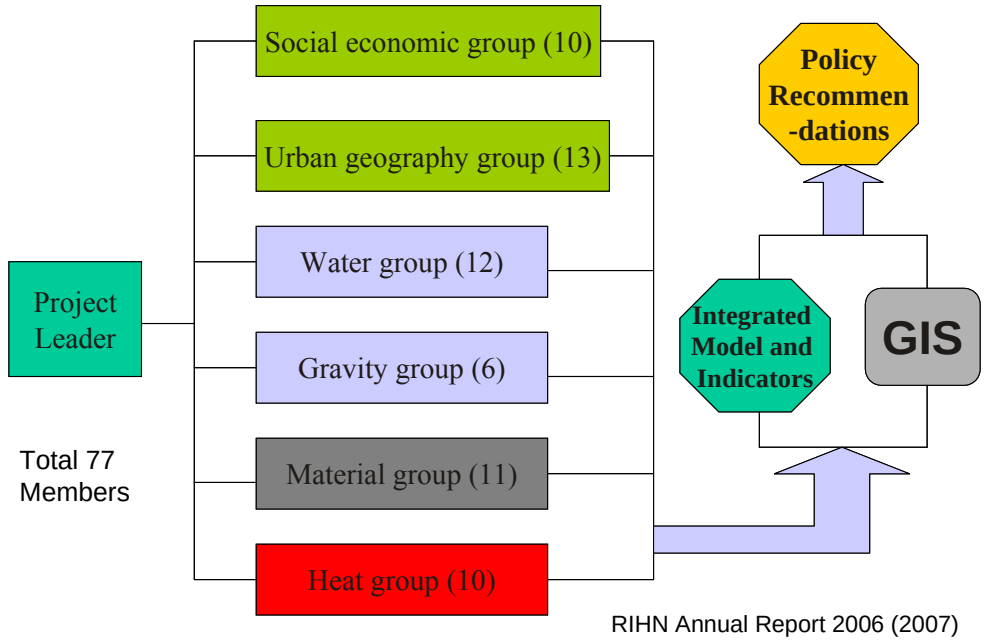


Figure 7. Six Research Groups of Urban Subsurface Environments Project

Table 1. Characteristics of Research Organizations

	Communication among Sub-group	Research Focus	Trans-disciplinary Integration	RIHN Projects		
				ICCAP	Lake Biwa-Yodo River	Urban Subsurface
Discipline Oriented RO	xxx	xx	x	xx		
Target Oriented RO	xx	xxx	xx	x	x	x
Issue/Theme Oriented RO	xx	xx	xxx		x	x

RO=Research Organization

Table 2. Tools for Integration

	Spatial changes	Historical changes	Indicators	Coupled models	Communication among researchers	Communication among stakeholders
ICCAP	xx	x	x	x	xx	xx
Lake Biwa-Yodo River	xx	xx	x	n.a.	xxx	xxx
Urban Subsurface	xx	xxx	xx	xx	xx	x

n.a.= not available