Circulation Program

NAKANO Takanori | Program Director

What is circulation and how does it relate to global environmental problems? Two concepts of circulation are considered in this program. One is the circulation of energy and matter at the earth's surface. Matter includes air, water, chemical components and the living organisms they contain. Such circulations of energy and matter are caused by solar radiation absorbed by the earth's surface systems. In a broad view, the migration of humans around the planet can be considered as a kind of circulation, as can the great amount of material people move from place to place. Circulation describes large-scale spatial and temporal movements that in small-scale may look like flows. The critical issue in regards to global environmental problems is that current change in the biogeochemical circulations that sustain the biosphere is so sudden; it may be irreversible, though this is dif cult to predict, as it depends in part on human thought, action and culture.

The recurrent interaction between humanity and nature can also be considered as a kind of circulation. Through economic and technological development, and through its sheer numbers, humankind has gradually transformed the surface of the planet. It has altered existing environments and created wholly new environments, which have in turn become new sites of human-environmental interaction in which new societies have emerged.

Individual research projects in the RIHN Circulation Program are conceptualized and carried out within the above conceptual framework. They cumulatively improve human understanding of the ceaseless motion that composes the biosphere.

Completed Research	Leader	Title
C-05	TANIGUCHI Makoto	Human Impacts on Urban Subsurface Environments
C-06	KAWABATA Zen'ichiro	Effects of Environmental Change on the Interactions between Pathogens and Humans
Full Research	**Leader**	**Title**
C-07	HIYAMA Tetsuya	Global Warming and the Human-Nature Dimension in Siberia
C-08	MURAMATSU Shin	Megacities and the Global Environment

Human Impacts on Urban Subsurface Environments

Project Leader **TANIGUCHI Makoto** RIHN

The great coastal cities of Asia place substantial burdens on subsurface environments, but little is known of the impact or its environmental or potential social significance. Subsurface conditions merit particular attention in Asian coastal cities where population numbers, urban density and use of subsurface environments have expanded rapidly. The goals of this project were to evaluate the subsurface environments of seven Asian coastal cities for such problems as subsidence, groundwater contamination and subsurface warming, and to suggest how they can be addressed or avoided. This project was therefore designed to reveal the groundwater recharge rate, storage, redox and other natural subsurface capacities in Tokyo, Osaka, Seoul, Taipei, Bangkok, Jakarta and Manila, and to measure the pace and scale of human disturbance of subsurface environments in these cities in the past century.

Summary of research findings

Cumulative human impacts on subsurface environments were documented at depths of up to 200–300 meters. Groundwater circulation was accelerated by more than 10 times in the past century. Subsurface thermal storage due to surface warming, such as by the urban 'heat island effect', is two to six times that attributable to global warming. Numerical modelling of the subsurface environment in Tokyo, Osaka, Bangkok, and Jakarta allowed evaluation of groundwater recharge rate and area, residence time, and exchange of fresh/salt water between land and ocean. GRACE satellite data was scaled down to the Chaopraya basin, Thailand, allowing comparison with basin models. Creation of a 0.5km grid GIS database based on nine categories of land cover/use in three different historical periods (1930s, 1970s, and 2000s) allowed evaluation of water, materials, and heat exchange between surface and subsurface environments in each city.

Establishment of consortium on water management in Asian megacities
The consortium is a network of national working groups and a platform for sharing international knowledge on monitoring, modeling, and policy making.

Research significance

Natural resource capacity and social and environmental development indices allowed integration of findings. In total, the indices in our five-stage urban development and DPSIR (Driving force, Pressure, State, Impact, and Response) models described patterns of land subsidence, groundwater contamination, and subsurface warming, and allowed us to suggest a range of suitable policy approaches, taking account of latecomer's benefits, patterns of development, and natural resource capacities.

In total, project findings highlight the importance of careful public cross-boundary surface-subsurface environmental management. We conclude that subsurface environmental processes can be successfully managed, especially in their critical capacity in providing water, if policies correspond to actual material flows across surface-subsurface and land-marine boundaries. In regard to water quality, human societies should pay closer attention to the subsurface accumulation of contaminants and heat, especially as these loads can often be controlled or managed from the surface. Designing such policies, however, depends on accurate assessment of the stage of urban growth in relation to natural capacities and social capabilities.

Research communication

Project research findings have been disseminated widely in a variety of fora. The project has convened five international symposia, a side event of COP13 and collaboration with UNESCO-International Hydrological Programme. Project researchers have published more than 120 peer-reviewed scientific papers, five books (three in Japanese and two in English), a special issue of the journal STOTEN, and a CD-Book with multilayer contents for beginners to experts. Feedback seminars were organized to discuss project findings with local administrators and policy makers in Manila, Jakarta, and Bangkok. The utility of such seminars, and perceived value of comparative discussion of subsurface urban issues, now inspires the creation of a consortium concerned with urban water management in Asia.

Effects of Environmental Change on the Interactions between Pathogens and Humans

Project Leader **KAWABATA Zen'ichiro** RIHN

There is an important environmental component to infectious disease. The rapid spread of emerging infectious diseases is not only threatening humans, wildlife, and livestock worldwide, but also inducing economical loss and collapse of ecosystems. While pathological studies inform effective disease treatment, study of *disease ecology*—the interactions between pathogen, host and human actions that may create or alleviate 'fertile' disease environments—is necessary for prediction and prevention of new disease outbreaks. This project developed a model of environment–pathogen–human interactions, based on intensive examination of the ecological and social causes and effects of Koi Herpes Virus disease (Photo 1) in Lake Biwa, Japan. This model will allow us to suggest ways to prevent or minimize the emergence and communication of infectious diseases.

Project achievements

Project researchers invented a new method to quantitatively detect the pathogen KHV and its host carp in natural environments. This method can also be used to establish presence of other pathogens and can therefore be of great utility to studies of environment–pathogen–human linkages.

Analysis of the links between lakeshore degradation, KHV, and human activity, allowed partial verification of the hypothesis that anthropogenic alterations of the environment facilitate outbreaks and spread of infectious diseases.

We established that the conceptual model of the environment–pathogen–human linkage derived from KHV disease in Lake Biwa was applicable to other cases of infectious disease, such as schistosomiasis in Kenya (Photo 2), fish diseases in the Pin River at Chaing Mai, Thailand, and Legionella disease, MRSA, Norovirus disease, and nontuberculous mycobacteria disease in Japan.

Photo 1 Carp killed by KHV disease, Lake Biwa, 2004
by Masatomi Matsuoka [2010] In: *The RIHN Encyclopedia of Global Environmental Studies*, Koubundou, p. 284.

New concepts of infectious disease

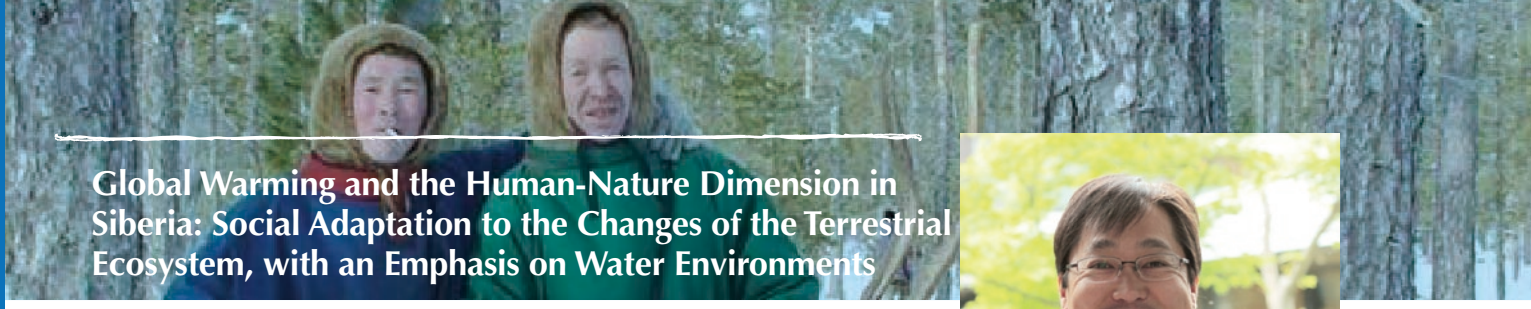
We found that since the outbreak of KHV disease in Lake Biwa was fist documented, KHV is now found throughout the lake ecosystem, including in plankton and sediment, in many lagoons and ponds, as well as in almost all the rivers of Japan. This finding indicates that it is impossible to eliminate KHV directly, and that instead it is necessary to practice precautionary environmental management to eliminate 'fertile' disease environments. In order to reduce future outbreaks of infectious disease, it is necessary to understand links between environments, pathogen, host, and humans in addition to the 'natural' behaviors of pathogen and host.

The finding that anthropogenic environmental changes mediate disease outbreaks and spread led us to consider how interactions between pathogens and humans can be modified for long-term societal benefit. From the view point of human ethics, we suggest that humans often have responsibility for outbreaks and spread of infectious disease.

Dissemination of the research results

We shared our research results with international and national academic communities and society. The concept of 'environmental disease' was introduced to academic communities in a general paper and more than 30 papers on specific environment–pathogen–human linkages, as well as through 10 edited special articles, and five project-organized international conferences. These activities formed the base of an international alliance of researchers to study environmental disease and promoted activities that can help alleviate infectious disease worldwide.

Photo 2 Field survey in Kenya (Photo: Zen'ichiro Kawabata)



Global Warming and the Human-Nature Dimension in Siberia: Social Adaptation to the Changes of the Terrestrial Ecosystem, with an Emphasis on Water Environments

Project Leader **HIYAMA Tetsuya** RIHN

Professor Hiyama's specialties are ecohydrology and hydrometeorology. He is interested in vulnerability assessment of shallow groundwater, especially in permafrost regions affected by global warming. He is also interested in atmospheric boundary layer (ABL) meteorology and terrestrial-climate interactions, especially energy/water/carbon exchanges. Eastern Siberia is the most important region for his field research, and he has conducted field observations of the ABL over several regions including Eastern Siberia for around twenty years.

Global warming will likely transform Siberian environments. Early evidence indicates that water and carbon cycles are undergoing rapid change, with potentially grave impact on Siberian flora and fauna. Human inhabitants, who have adapted to great changes in social structure and environment in the past, will be forced to adapt again, but to a cascading series of environmental changes whose dimensions are understood only in outline. This project uses multiple satellite and surface systems to track changes in water and carbon cycles and the cryosphere, and assesses their likely interactions and significance for human inhabitants of the region. The project is jointly conducted by Japanese and Russian universities and research institutes.

Regional climate predictions in Siberia are based on description of energy and water cycles and changes in surface reflectance due to snow, ice and vegetation coverage. The Lena River Basin in Eastern Siberia is covered in larch forest but receives little precipitation. The area is an ideal setting in which to study the effects of climate warming, as the forest-permafrost symbiosis is extremely susceptible to abnormal variations in temperature and precipitation. Local inhabitants depend on agriculture, stockbreeding and on fragile transport, building and water infrastructure. Human survival skills and adaptive capacity to environmental changes depend on unique social structures, history and culture, which have undergone Russian socialistic modernization.

This research project takes natural and social science perspectives on three aspects of climate-associated environmental change. It is designed to: 1) describe current variation in water and carbon cycles and predict likely variation in the near future; 2) make field observations of the effect of carbon and hydrologic variability in Eastern Siberian landscapes, and identify key exchanges or driving forces; and 3) examine the capability of the multi-ethnic Siberian peoples, and their distinct social economies, to adapt to predicted change in their climate and terrestrial ecosystems.

Three research groups are organized in order to realize these goals (Fig. 1). They are the Siberia bird's-eye group (Group 1), the Water cycle and ecosystem interaction group (Group 2), and the Human ecology group (Group 3).

Project research has emphasized five main research areas

1) **Permafrost–ecosystem modeling**

We have been revising our model of surface soil freezing–thawing processes in order to better represent heat, water, and carbon fluxes in permafrost ecosystems. Here we were particularly concerned with the surface permafrost layer, in which we now see increased thawing depth and surface soil moisture, and an increase of net primary production. Additionally, it was detected that annual maximum thawing depth gradually increased (deepened) on a decadal scale. Based on climatological analyses of atmospheric water circulation over the region (Fig. 2), recent increases in precipitation seem to be related to increases in soil moisture and annual maximum thawing depth.

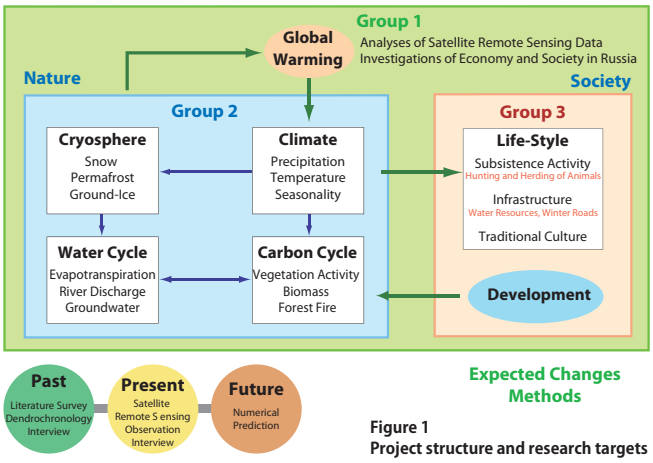


Figure 1
Project structure and research targets

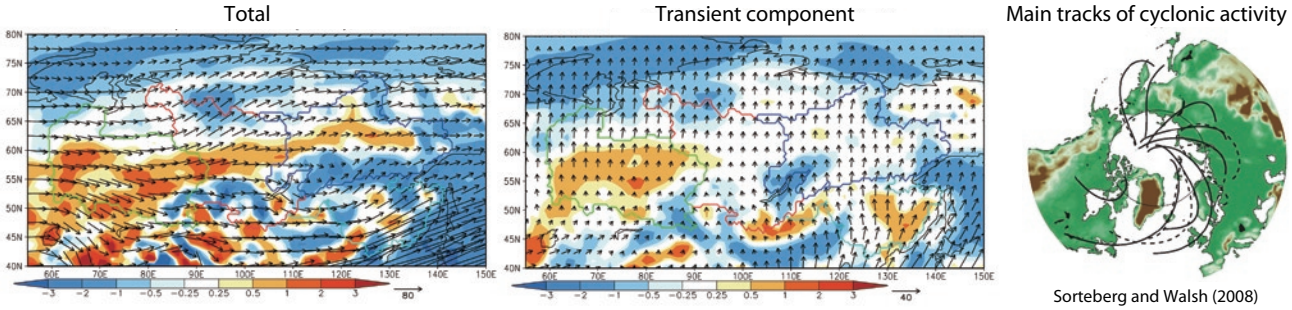


Figure 2 Atmospheric water circulation in summer (from June to August) over the Siberia
Main tracks of cyclonic activities (Sorteberg and Walsh, 2008) are also shown.

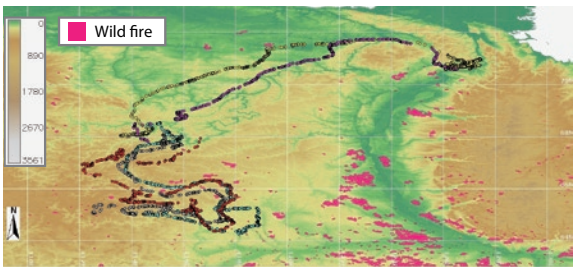


Figure 3 Tracking routes of eight wild reindeer detected using ARGOS satellite system from August 2010 to February 2011
The routes are drawn on a topographical map. Areas of wild fire are also shown in the figure.

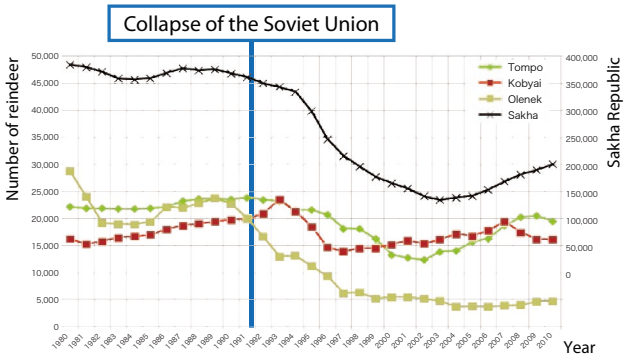


Figure 4 Interanual change in numbers of domestic reindeer in the Sakha Republic (right axis) and the three sub-regions (left axis) from 1980 to 2010

2) **Tracking reindeer migration**

We are interested in documenting the migration routes of wild reindeer and whether these are changing in relation to new environmental conditions. We successively tracked routes of eight wild reindeers using an ARGOS satellite system. MODIS satellite data showed that reindeer have moved along rivers and through zones of better vegetation, while avoiding increasingly common forest fires (Fig. 3). Migration distance was similar to those documented in North America and North Europe. Interviews with keepers of domestic reindeer revealed that current climate change has not severely damaged their operations. It appears that so far they have been able to successfully adapt to changes in climate, while, on the contrary, they were severely impacted by social changes following the collapse of the Soviet Union (Fig. 4).

3) **Flood impacts**

Using archival sources and remotely sensed data, we were able to make a detailed historical description of changes in annual spring ice-jam floods. We found that increased flooding disrupts cold-weather transport via ordinarily frozen rivers and warm-weather transport over land. As result we note that Northern communities are increasingly remote and difficult to access, and have begun to study disaster vulnerability, prevention and adaptation in such areas.

4) **Socio-cultural adaptations**

We are describing local minority peoples' social-cultural adaptations to environmental and social changes. It became clear that traditional knowledge, social networks, money, and (in the case of North America) technology, were key factors affecting adaptive capacity to climate change. In the case of Eastern Siberia, we found additional adaptations, such as 'working with what's available, and doing without what isn't'. Interestingly, in the case of Siberia, we found that public support systems, remnants of the Soviet era, are increasingly replaced by personal networks.

5) **Folklore**

We have begun to analyze the local folklore recorded between the 19th and early 20th century. Examination of local myths, legends and fairy tales allows us to elucidate folk beliefs and traditions related to environmental change. We detect that indigenous people might often consider a disaster to be the revenge of nature for human transgressions.

Future research issues

We will continue to investigate the five collaborative research topics described above, with particular emphasis on describing local peoples' vulnerability and adaptations to the documented changes in climate and environment. It is also necessary to work with local peoples and governments to develop new adaptation strategies and propose appropriate policies.

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Megacities and the Global Environment

Project Leader **MURAMATSU Shin** RIHN

Shin Muramatsu has studied Asian architectural and urban history and is now interested in developing new methods that can shed light on urban futures. His previous publications include *Shanghai: The City and Its Architecture*, *Addicted to China*, *Keeping an Elephant*, and *Asian Architectural Studies*. He is the founder of mAAN (http://www. maan.org), an NPO involved in the evaluation, conservation and revitalization of modern architecture in Asia.

As places that support half of the Earth's population, cities are becoming the most important spaces inhabited by human beings. To explore ways in which megacities with populations of 10 million or over can coexist in harmony with the global environment, this project adopted the following goals:

1) to determine methods for developing an integrated understanding of megacities from the perspective of different academic areas, history and culture
2) to propose integrated solutions for the mitigation of problems associated with megacities
3) to indicate images of how future cities that integrate the richness of their environments, economy and society should be

To achieve the above objectives, we decided to focus our research on the urban area surrounding the capital of Indonesia, known as Jabodetabek, which is located in a tropical monsoon area, and to study this urban area by comparing it with about 40 other megacities and megacapitals with populations of five million or over. For our project goals, we set four, two in the area of cognitive science and two in the area of design science respectively.

A. Cognitive Science

Goal 1 Identify historically restricting factors governing the manifestation of megacity mechanisms and environmental problems

Goal 2 Elucidate environmental problems and mechanisms associated with megacities and establish analytical methods for these

B. Design Science

Goal 3 Establish indices for evaluating the impact of cities on the global environment; integrate and make visible geographical data on urban spaces

Goal 4 Share project results from micro to macro aspects with the various stakeholders of local and international society

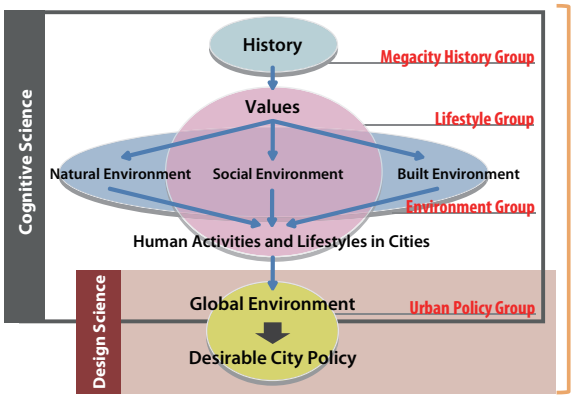
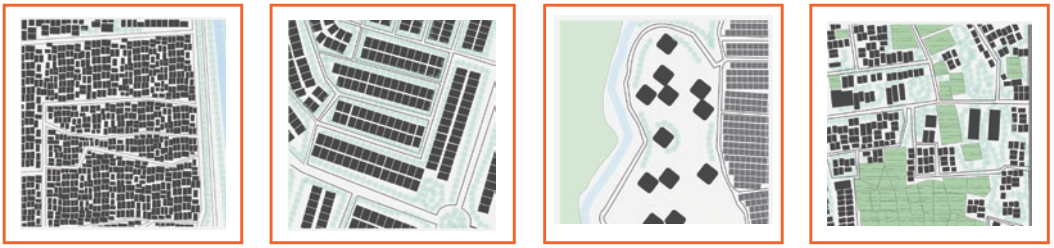


Figure 1 Project flow and research organization
The project is comprised of 5 groups.



	Urban village area	Planned residential area	High-rise residential area	Rural village area
Block planning	Unplanned	Planned	Planned	Unplanned
Land use	Buildings	Buildings	Buildings	Interspersed rice fields
Dwelling density	High density	Low density	Low density	Low density
Building height	Low height	Low height	High height	Low height

Figure 2 Four characteristics of the urban environment

Photo 1 With 40 Indonesian and Japanese university students participating, the Indonesian-Japanese Student Workshop took place from September 10–18, 2011

Photo 3
Presentation of project outcomes and sharing feedback with local residents

Photo 2 Urban village area (Cikini)

We also included the following five items in our final results:

1) to present megacity scenarios until the year 2050 for people who will live in the next generation
2) to construct a Megacity GIS network to facilitate grasping megacities
3) to develop educational and training programs for intervention in macro, meso and micro situations in megacities
4) to publish a series of Megacity Studies (English and Japanese) to introduce the results of our megacity research and the latest information
5) to assume an international role in cooperation with international organizations

Fiscal 2011 outcomes

1. Development of an 'index of land attributes' for analyzing cities at a micro level from the perspective of the built environment

In megacities of developing countries where changes are occurring rapidly, a variety of land uses and the built environment exist alongside each other. In this project, to get a deeper understanding of megacities, we categorized these mixed conditions of the built environment on 250m mesh scale graphic images from objective data on the four aspects of land use, district shape (either planned or unplanned), building height, and population density. As a result, we were able to grasp the distribution of the built environment of Jabodetabek by dividing it according to the four characteristics of the urban environment on individual 250m mesh scale graphic images: 1) urban village area, 2) rural village area, 3) high-rise residential area, and 4) planned residential area (Fig. 2).

2. Integrated survey of the environment and lifestyles in the urban village area (kampung type) and rural village area (rural type)

The groups of the project have up until now engaged in joint research on their respective topics in two areas of Jabodetabek: Cikini, an urban village area, and Tangerang, a rural village area. The groups undertook measurements and observations of environmental burden indices, indices relating to the local environment, and indices relating to people's awareness of the environment, and they compared the characteristics of the two urban environments. This resulted in some interesting indications. For example, although in the urban village area figures for indices on the natural environment such as heat environment and biodiversity were low in comparison with those for the rural village, values for the four awareness indicators were high. This implies that possibilities for alternative technologies and lifestyles may exist there.

3. Joint Indonesian-Japanese Student Workshop in Indonesia on an urban village area

Forty Indonesian and Japanese students came together for a joint student workshop in September 2011 to consider methods of analysis and intervention in the local environment (Photos 1 and 3). Held in the urban village area of Cikini where students engaged in fieldwork and discussions on the built environment, the natural environment, and lifestyle over a 10-day period, the workshop culminated in a presentation of the workshop results before the residents of Cikini (Photo 2). Initiatives like this are an effective means of improving cities through education and awareness raising of disparate urban stakeholders regarding their urban environment.

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