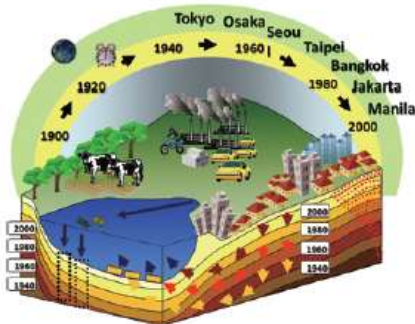


## Human Impacts on Urban Subsurface Environments

This project assessed the effects of human activities on the urban subsurface environment in Asian coastal cities. The primary goal of this project is to evaluate the relationships between the developmental stage of cities and various subsurface environmental problems, including extreme subsidence, groundwater contamination, and subsurface thermal anomalies. We address the sustainable use of groundwater and subsurface environments to provide for better future development and human well-being.



Schematic diagram of subsurface environment project in seven Asian cities

We evaluated "natural capacity indices" and "changing society and environmental indices" for seven target cities during the last 100 years.

We found that human impacts on subsurface environment reached to a few hundred meters depth during the last 100 years. The turnover time of groundwater was more than 10 times than natural condition, and thermal storage was 2-3 times higher compared with the average increased by global warming during the last 100 years.

Groundwater storage and material load to subsurface environment are manageable, however we need monitoring of material and heat accumulation in subsurface environment.

Integral management beyond the boundaries of surface-subsurface and land-ocean are necessary based on natural capacity and use of social capability such as late comers benefit.



Francis & Taylor 2008



Elsevier 2009



Gakuho-sha 2010



Shinsen-sha 2011



Springer 2011

<Project Title> Human Impacts on Urban Subsurface Environments  
 <Project Period> Apr.2005~Mar.2011  
 <Project Leader> Makoto Taniguchi (RIHN)

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RIHN Research Project on  
 Human Impacts on Urban Subsurface Environments  
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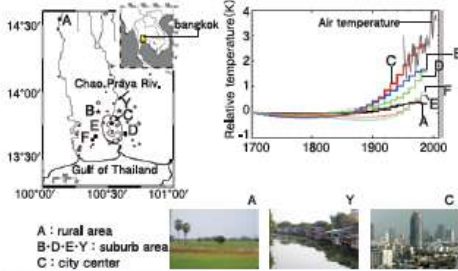
# RIHN Research Project Human Impacts on Urban Subsurface Environments



Research Institute for Humanity and Nature (RIHN)

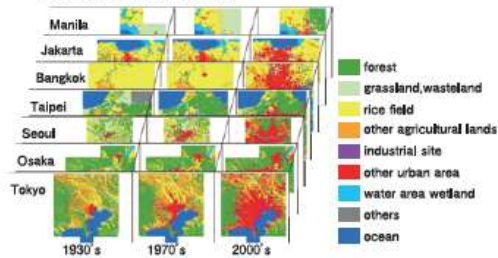
## Reconstruction of surface warming -Results from Bangkok-

Groundwater temperature profiles were measured on 2004,2006,2008, and 2010 in Bangkok. Surface warming histories were reconstructed from 6 boreholes.



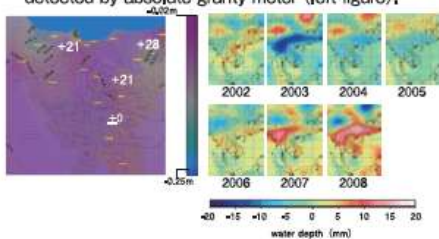
## Historical changes in land use/cover in the seven cities. (1930's 1970's 2000's)

Residential areas have expanded along with urban development.



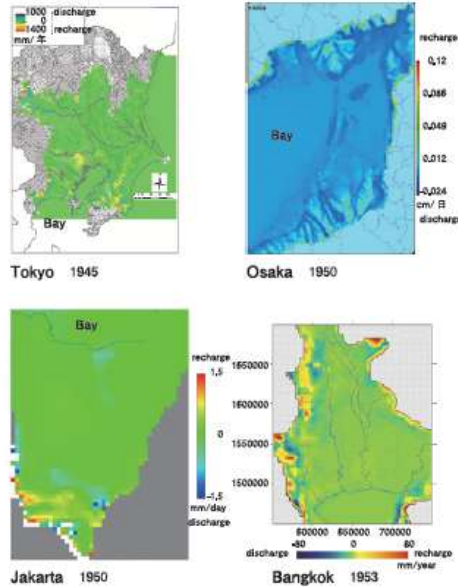
## Changes in land water storage obtained from satellite GRACE

Decrease in land water storage in Chao Praya River basin (right figures), and changes in mass detected by absolute gravity meter (left figure).



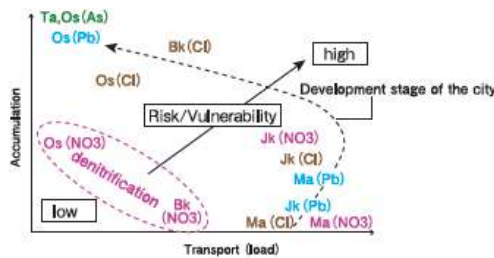
## Groundwater recharge rates calculated by 3D-groundwater model at 4 cities

Groundwater recharge rate has been changed depending on the amount and location of pumping.

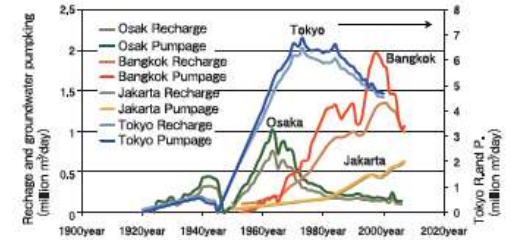


## Vulnerability of coastal megacities to different pollutants.

Load and accumulation have been changed depending on development stage of city. Denitrification is found in Osaka and Bangkok.

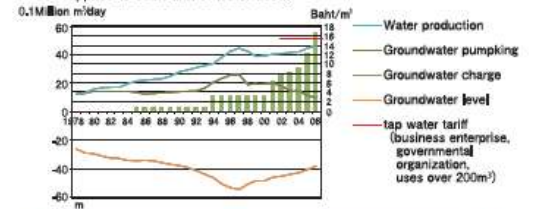


## Changes in groundwater recharge rates and pumping obtained from 3D-groundwater model at 4 cities.



## Law and institution for groundwater management

Excessive groundwater pumping led to land subsidence in the late 1970s in Bangkok. The problem was solved through expansion of surface water infrastructure and the imposition of a charge for use of groundwater, which is now more costly than tap water. Beyond 200m<sup>3</sup>/month, a special tariff of 15.31 Baht applies to each unit of water used.



## Stage model depending on DPSIR

Observed and statistical data are compared in seven cities based on five stages of urban development. The bar figure shows the stages of land subsidence at each city in comparison with Tokyo.

