Japan's focus on water sector research

Japan's Core Research for Evolutionary Science and Technology (CREST) programme includes projects spanning the entire water cycle from the impact of forest plantation management on watershed runoff to urban water use and sewage treatment. **BILL McCANN** spoke to scientists leading the research in this area about why the country is investing billions of yen in furthering knowledge in the water sector.

Urayama Reservoir on the Aarakwa River, one of the main rivers flowing through Tokyo.

A massive water sector research and development project in Japan's national CREST (Core Research for Evolutionary Science and Technology) programme is currently in the fifth year of an eight-year plan that will conclude at the end of 2016.

Conducted by the Japan Science and Technology Agency (JST) the project has an overall budget of around five billion yen (about $50 million) and follows an earlier eight-year effort which looked in detail at global water circulation through studies and modelling of hydrological and water resource systems. Completed in 2008, this earlier phase in effect provided the base information for the current work.

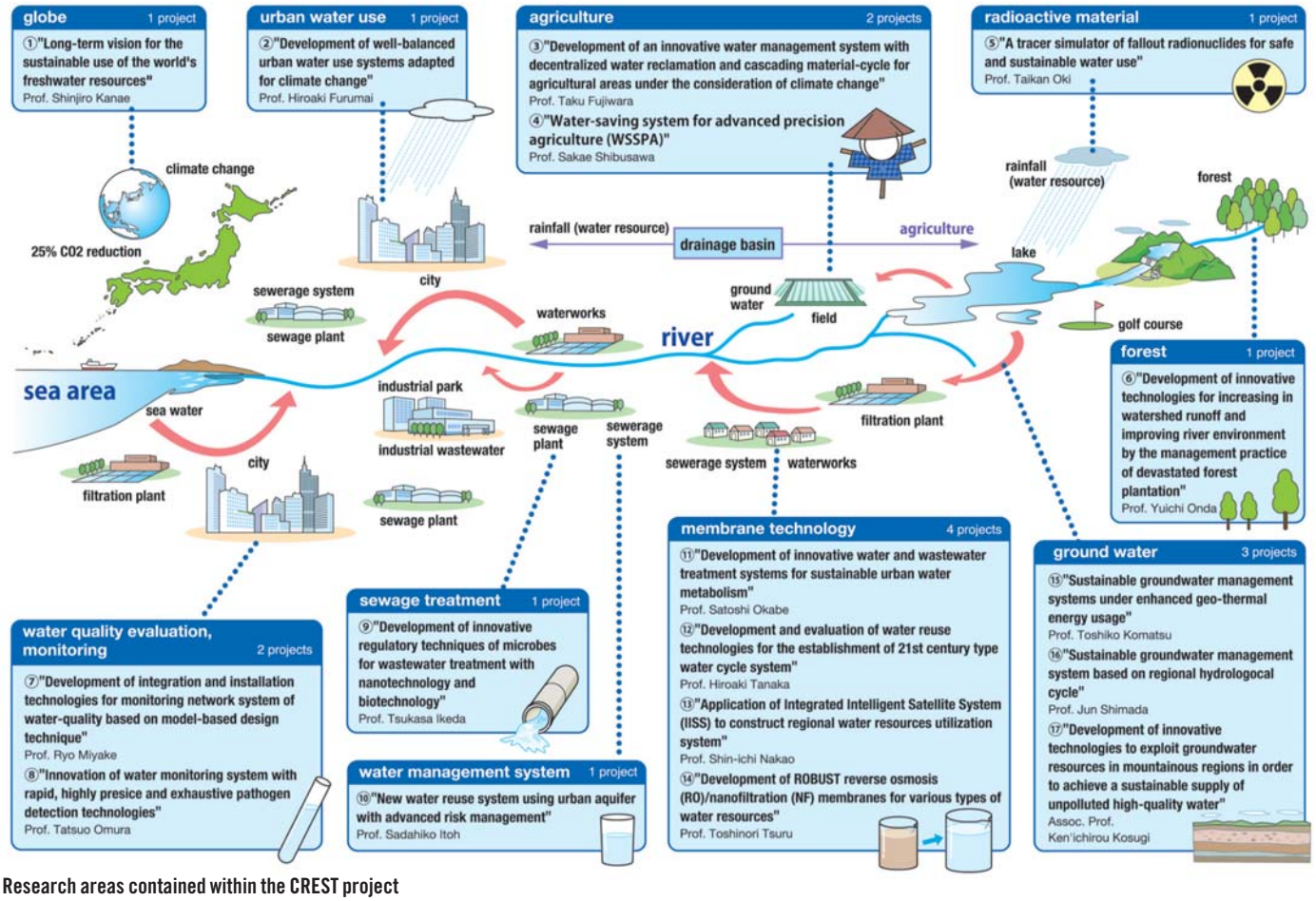
Now the focus is on sustainable water use, with the CREST-defined research area being Innovative Technologies and Systems for Sustainable Water Use.

CREST research

CREST research programmes began in 1996 in support of the Science and Technology Basic Plan, also initiated in 1996 following the 1995 enactment of Japan's Science and Technology Basic Policy Law. The Basic Plans are determined by government every five years and cover promotion of science and technology across the spectrum of national research activities. The water sector was not targeted directly until 2001, but now attracts a significant portion of the total CREST budget, currently running at about $300 million /year and covering research in 36 areas.

Generally, a CREST research area attracts the expertise of a large number of scientists, typically divided into 15 or more sub-teams. In this current 'Water Use' research programme 17 sub-teams began work on individual projects between 2009 and 2011. According to Research Supervisor Professor Shinichiro Ohgaki, over 600 engineers and scientists are involved, meaning, he says, that 'the whole system works essentially as a virtual institute'.

Along with Deputy Research Supervisor Mikio Yoda, Professor Ohgaki is responsible for assembling the research teams and guiding the overall direction of research. Mikio Yoda is the Senior Chief Engineer at Hitachi Information and Control Systems Ltd., while Professor Ohgaki, a former Vice President of IWA,



Research areas contained within the CREST project

is board chairman of Japan's Water Research Centre and an Emeritus Professor at the University of Tokyo. The Supervisors are in turn advised by a panel of nine of Japan's most eminent water experts, including Takashi Asano, a Professor Emeritus at the University of California and past winner of the Stockholm Water Prize.

Professor Ohgaki explains that the background to the current research goes back several years, covering a period when the impacts of climate change have become more obvious, manifested in the form of unpredictable events such as the disastrous 2011 Tohoku earthquake in Japan or the equally unprecedented and ferocious Philippines typhoon of recent months. At the same time it has been increasingly recognised that the pressures of the man-made environment, not least in the burgeoning cities of Asia, demand more research into water quality and the effects of emerging contaminants and other environmental factors on human health.

Professor Ohgaki cites a declaration arising from the 1999 World Science Forum as influencing a shift in Japanese governmental thinking on the manner in which these changing impacts and trends should be addressed. That declaration, he says, referred to the concept of 'science in society and science for society' and, in his view, was the catalyst to recognition of 'sustainable water use' as one of the specific emerging social problems demanding attention within CREST research.

While adaptive measures have to be sought to combat unpredictability, the more structured trends, due to rising populations and rapid urbanization, give rise to a variety of social issues that demand a new look at water infrastructure and its management; a revision that takes fully into account the importance of energy and resource conservation.

CREST research therefore includes a strong component of basic science and an additional driver in this direction, says Professor Ohgaki, was the perception at the end of the 1990s that Japan was exploiting the basic research results of other developed countries to back new technologies for the export market. This, he says, was an affront to Japanese scientists and politicians and an important influence towards the subsequent increase of funding for basic research and problem solving in the social environment. Currently, while Japan is responsible for about 8% of the world's GDP it is said to carry out around 10% of global R&D.

In the search for new approaches towards sustainable water environments it is essential, says Mikio Yoda, that basic findings can be developed into new technologies and practical business applications. This is a strong theme within the CREST programme and, as Yoda notes, there is also an emphasis on team working, with each project combining inputs from different research institutions and academic bodies as well as from the private sector.

Ultimately there is an enticing export market in Asia, but a market with quite different demands. While developed countries like Japan face the problems of declining populations and ageing water and sanitation infrastructure, the more common situation is one of growing populations and movements to urban areas grossly lacking in adequate facilities.

Urban water adaptation to climate change

Amongst the 17 active projects the one that probably best encompasses the issues outlined above and the general thrust of the overall programme is being led by Professor Hiroaki Furumai of Tokyo University. Entitled 'Development of well-balanced urban water use systems adapted for climate change' the work is centred on river basins in Japan and Vietnam, each serving very large urban populations with current water infrastructure and systems at distinctly different stages of development. In Japan the Arakawa River basin serves Tokyo with the support of water introduced by the Tone River, while in Vietnam the capital, Hanoi City, is within the watershed of the Song Hong River.

Despite the differences a central feature for the future in both cases is that a metropolitan area should make best use of what Professor Furumai calls its 'self-owned' water resources – those more reliable resources that are

within the area. Wastewater for example is always there and can be reclaimed, rainwater can be harvested and these sources may be complemented with local groundwater and surface sources. Managers must then strive to balance these supplies with the various demands, taking account of both the quality and quantity required of the specific end use.

As well as saving on pumping energy and resource consumption of constructing pumping stations and pipelines associated with bringing in water from distant sources this type of system is an adaptation to possible climate change impacts. It removes some of the effects arising from impacts on remote sources, for example from the increased fluctuation of rainfall across watersheds that is being seen as climate changes.

In this work it has not been easy to pinpoint climate change as the culprit in such impacts as have been seen, especially in the Vietnam study where extensions to the dry season low flow period in the Song Hong river have been recorded. It is felt that this could just as easily result from increased abstractions or other controls in the higher reaches of the river, across the Chinese border.

The associations may be stronger in Japan's Arakawa watershed where the Tone river input depends on snow melt in the higher reaches of the basin, possibly affecting the flow regime in two ways. It is anticipated that a warming climate will bring earlier melting and also reduce flows as snowfall is reduced. Abstractions for upstream paddy field irrigation will therefore be impacted, in turn reducing water availability for the Tokyo urban area.

Developing methods for predicting such changes in impacts and trends is just one part of this study and is being achieved through the downscaling of global experimental data on warming. The overall work of the study is in the hands of five groups respectively focussed on watershed water resources, urban rainwater management and use, urban groundwater management and use, water quality assurance and urban water use design.

A lot of emphasis in the study is being placed on the quality of these local resources. Data is being collected on rooftop rainwater harvesting systems and on rainwater reservoirs. Runoff from roads is also important in this context as quality is assessed for appropriate end use in a new management system. Work is in hand on drafting a quality management indicator for both types of runoff.

Similar assessments of quality are being made on surface and groundwater in both watersheds. Identification of possible pollution sources is a focus for attention here through a detailed analysis of viruses, the disinfection by-product NDMA, and bromide ions – a precursor for brominated disinfection by-products in ozone disinfected water. Professor Furumai says an important outcome of this part of the study is that the efficacy of AiV (Aichi virus) and PMMoV (pepper mild mottle virus) as new virus indicators for water safety has been proved. They can be used, he says, to assess safety and stability of all the source waters at issue here – ground and surface waters, roofwater and reclaimed water.

Looking towards the conclusion of the study, when outputs from the five sub-groups can be integrated into a management system for new well-balanced urban water use, workshops have been proposed where concrete policy recommendations can be presented and discussed with stakeholders in the respective watersheds. In the case of Hanoi Professor Furumai feels that the findings of his groundwater group could be quite quickly incorporated into the city's water management plan because of the close collaboration that has been ongoing between his team, the Hanoi City government and national institutions and universities.

'Water management and quality control are on the verge of a revolution'
Professor Shinichiro Ohgaki

Water reuse technologies

Of course this is just one component of the thrust towards sustainable supplies through 'innovative technologies and systems', but it gives some credence to Professor Ohgaki's contention that 'water management and quality control are on the verge of a revolution'. The focus there is on new systems, but another of the projects gives a flavour of the advances being sought through innovative technologies.

Led by Professor Hiroaki Tanaka of Kyoto University, this project – Development and evaluation of water reuse technologies for the establishment of 21st century water cycle systems – is seeking optimal treatment systems for water reclamation, using ozone with various combinations of organic and inorganic membranes in micro, ultra, nano and reverse osmosis filters. The combinations are being assessed for removal of enteric viruses such as norovirus, and against a range of chemicals and medications, including fluorine-based organic matter, endocrine disrupters, Tamiflu and ecotoxic substances. Energy efficiency as well as treatment capability is part of the assessments. The project began in late 2009 and is due for completion in March 2015 when it is envisaged that optimal systems can be proposed for the rural and urban locations on which the project's several case studies have been based. These include a reclaimed wastewater system for agricultural use in Southern Okinawa, Japan, improved treatment systems for Shenzhen and other cities in Southern China and new treatment systems for Da-Nang, Vietnam.

These illustrations of the scope of the CREST project are no more than an outline of a truly comprehensive effort (see figure for overall content) to exploit technical advances within new systems essential to a future of sustainable water supply. Successful outcomes here can have wide application in the Asia region and throughout the World. ●

For further information on JST's CREST water related projects, see: www.water.jst.go.jp/en/index.html

Wildfire risk for drinking water utilities

The Water Research Foundation (WRF) has just completed a new study looking at the effects of wildfire on drinking water utilities, and best practices for wildfire risk reduction and mitigation.

The project collated information from a survey of drinking water utilities that had experienced, or were at risk from, the effects of wildfires, as well as feedback from a Denver workshop that examined related topics and a literature review of relevant industry, academic and scientific publications.

Participants in the survey reported that collaboration with other drinking water systems and stakeholders such as landowners, non-profit organisations and local, state and federal government agencies was critical to effectively mitigating wildfire risk. Such collaboration helped the utilities to increase their knowledge base and leverage finance.

Best practices identified through the survey included undertaking strategic fuel reduction efforts such as burning, mechanical removal and grazing in the watershed and areas immediately around reservoirs.

Other ideas include developing partnerships and cooperation with other organisations to ensure that upstream reservoirs have the capacity to contain sediment, and wildfire preparations such as diversifying water intakes and creating redundancy of both treatment plants and raw water supplies. ●

The study, 'Effects of Wildfire on Drinking Water Utilities and Best Practices for Wildfire Risk Reduction and Mitigation' (project #4482), by Chi Ho Sham, Mary Ellen Tuccillo, and Jaime Rooke, can be accessed at: www.waterrf.org.