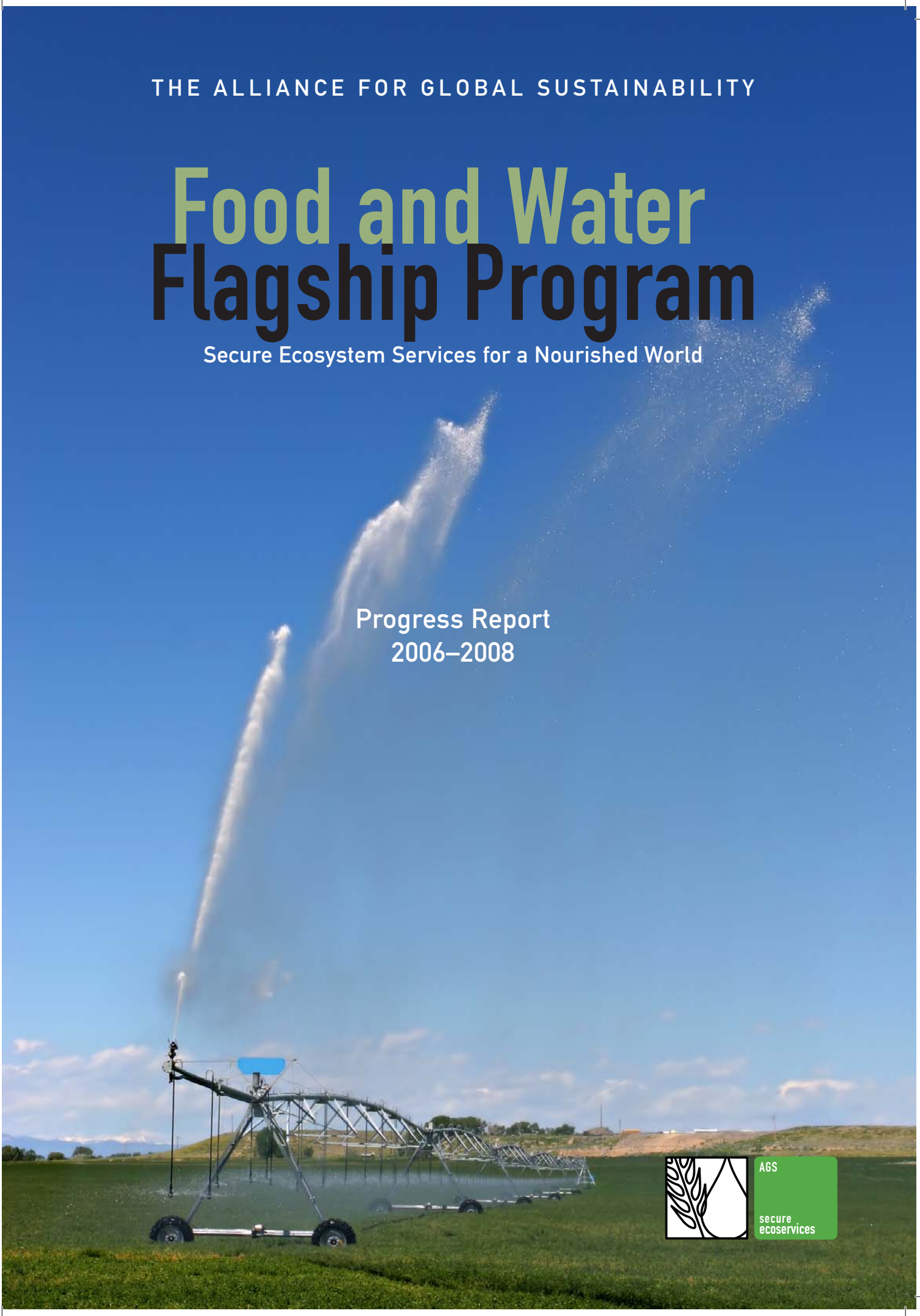
THE ALLIANCE FOR GLOBAL SUSTAINABILITY

Food and Water Flagship Program

Secure Ecosystem Services for a Nourished World



Progress Report
2006–2008

AGS
secure ecoservices

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Overview

In 2005 the AGS inaugurated its first flagship program on "Near-Term Pathways to a Sustainable Energy Future". This first flagship focuses on near-term options that will enable a long-term transition to more sustainable energy systems. As the global population is expected to reach 8 billion by 2030, the increasing demand for food and water catalysed by economic growth has led to raised concern over the long-term use of provisioning ecosystems and there is a need for near-term actions. Similar to the Energy Flagship program, the second AGS flagship program, which was inaugurated at the AGS Annual Meeting in Bangkok in March 2006, aims at investigating near-term options for a sustainable provision of food and water.

Secure ecosystem services for a nourished world

The provision of food and water is a key aspect in the survival of mankind and the development of a sustainable society. Therefore, food and water are two provisioning ecosystem services featured in the UN Millennium Ecosystem Assessment and the Millennium Development Goals. Ecosystem services interface with social and technical systems, which in turn are driven by human needs. Central factors affecting the demand for ecosystem services include the development of global population, the growth of the global economy and changes in the Earth's climate. Global population has increased to the present 6.5 billion and, despite a recent slowing of growth, will likely reach 8 billion by 2030. Food demand, catalyzed by recent economic development in highly populated regions such as India and China, is projected to increase at a greater rate than population growth to reach an average over 3000 kcal person^{-1} day^{-1}, raising concern over the availability of food. Additional pressure on ecosystems and food provision include deterioration of arable land and changes in land use, such as bioenergy production on agricultural land.

Today, there is a need to address critical issues of food and water, and it is increasingly evident that these critical issues require an understanding of the interface between the provisioning ecosystem services (food and water), society and technology. The AGS Food and Water Flagship Program addresses these issues and looks at probable global development paths during the near-term future, while still considering long-term projections.

The pathways approach

The identification of pathways is a unique feature of the AGS flagship programs 'Energy Pathways' and 'Food & Water'. The term 'pathway' originally relates to a trail in a rural setting but for the AGS isdefined as a succession of past-dependant alternatives leading to a specific point in the future.

The UN Millennium Ecosystem Assessment points to the need for a transition to a more sustainable food and water system, from provisioning ecosystems to the consumption of food and water. Balancing human needs and demands for food and water with the necessary care for the ecosystems that provide these services is one of the main challenges for mankind. The Food and Water Flagship aims at defining pathways for this transition through the study of near term options and their long term impacts. The final aim of the program is to propose options leading to an improved level of global nourishment (Figure 1). Tools for investigating pathways cover the range of systems approaches that attempt to look into the future and include scenarios, adaptive strategies, trend analysis, etc. When considering development paths it is important to identify safe food and water supply through realistic risk evaluations. Spatial aspects such as the uneven global distribution of food and water are at least as important as changes into the near-term future.

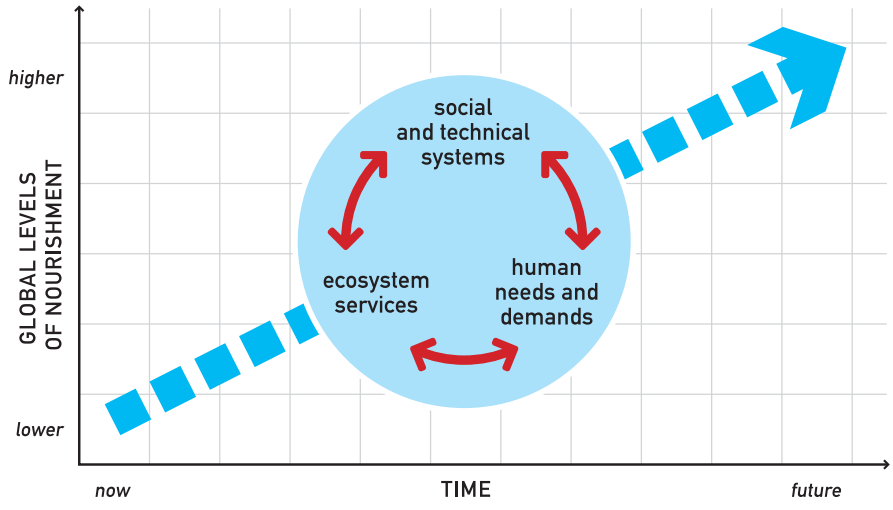

Figure 1. The basis for the program is the identification of development paths towards global nourishment. This requires an understanding of the links between social/technical systems and ecosystem services, as well as risks and safety aspects of the ecosystem services food and water.

Importance of social and technical systems

Importantly, ecosystem services interface with the social and technical systems, which in turn are driven by human needs and demands (Figure 2). Social and technical systems can therefore play a major role in balancing provisions and human need and demands.

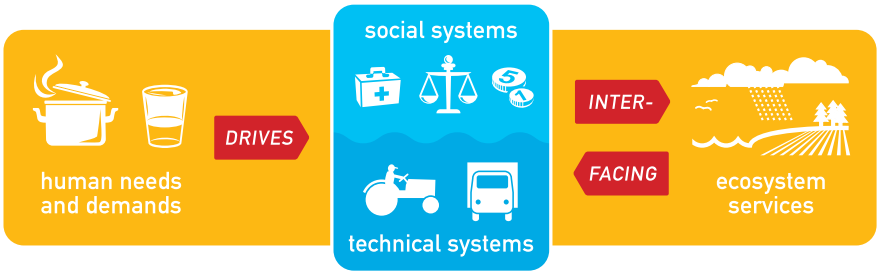

Figure 2. Representation of the food and water system. Ecosystem services interface with social and technical systems, which in turn are driven by human needs and demands.

Four important scientific aspects have been identified for food and water as provisioning ecosystem services:

1. There are no substitutes available for food and water per se, however there are considerable differences between different diets and the way they are produced, which do contain possibilities for substitutions both regarding diets and production systems. The wider context for food and water is therefore related to social, and more slowly changing cultural, aspects where preferences and values influence the framing of the problem.
2. A significant aspect of food and water is their uneven distribution, the uneven means of production of food and uneven distribution of wealth. The identification and analysis of these uneven distributions should focus on the links between social/technical systems and ecosystems services.
3. In the long-term the final outcome of human development is closely dependent on innovations. In focus are the social and technical systems where both institutional/ organisational and purely technical aspects need to be considered, but again the links between the anthropogenic systems and ecosystem services are critical.
4. One of the difficult challenges is related to the scales humanity is now operating on and the lack of feed-back loops between distant and future possible impacts and recent activities and policy making. We need to identify how we can integrate distant concerns into the here and now management of public and private organizations on a global scale.

Achievements in 2006–2008

The first two years of the Flagship program were focused on project development, team building and fundraising, while performing research in specific areas of food and water.

The following achievements are described in subsequent sections.

- identification of project partners and integration
- definition of key questions for food and water
- building of the Food & Water platform
- fundraising efforts
- identification of strategic areas within food and water
- on-going research

Identification of project partners and integration

During 2006-2008, representatives and researchers at AGS universities were contacted to participate in the F&W programme. The contribution of MIT will be discussed at the AGS meeting at MIT in January 2008. Members of the core teams are listed below; additional researchers were involved in discussion and program development.

Coordination group

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Meetings

Meetings have provided opportunities for team building and program development. During 2006-2008, 3 meetings (Zurich, October 2006; Macau, January 2007; Barcelona, March 2007) were organized and a further meeting is planned for AGS Annual Meeting 2008 at MIT.

Figure 3. The Food and Water team at a meeting in Zurich in October 2006.

In addition, the International Symposium on Food and Water Sustainability in China 2007 was held in Macau, China on January 2007. Approximately 20 of Chinese researchers with various academic backgrounds reported on their studies on sustainability of food and water in China, such as water resource management in North China, aquatic food production, agriculture in water stressed areas, food trade, etc. Through vigorous discussions about these issues among the participants, the symposium successfully contributed to establishment of relationship among the participants from China and other nations, and among those with different academic background. Participants from AGS universities involved in the Food and Water Flagship also attended. The second International Symposium on Food and Water Sustainability in China 2008 will be held in September 2008 to further develop the academic network with Chinese researchers who are engaged in studies related to food and water sustainability in China.

Key Questions for a nourished world

Three key areas of questions proposed in the initial programme writings have been developed by the Food and Water team. These questions are central to the programme as they reflect the aim of the AGS Food and Water Flagship and form a starting point for the integration of the whole programme. Each study will in turn identify a series of key questions to guide the research, but with careful attention to following the key questions for the whole flagship.

Key Questions

- What are the needs and demands of the global population for food and water over the next 50 years? How do these determine the pathways which we need to choose in a near-term perspective (5-15 years)?
- What are the potential capacities to supply sustainable food and water services?
- How will we ensure a balance between the secure provision of food and water (and other ecosystem services) and human needs and demands?

The project platform

The Food and Water flagship program structure is presented in Figure 4. The program will be underpinned by a conceptual project which outlines development paths through the near-term future (5-15 years). The central focus will be the social and technical systems for food and water and how these are affected when in balance with the respective ecosystem services.

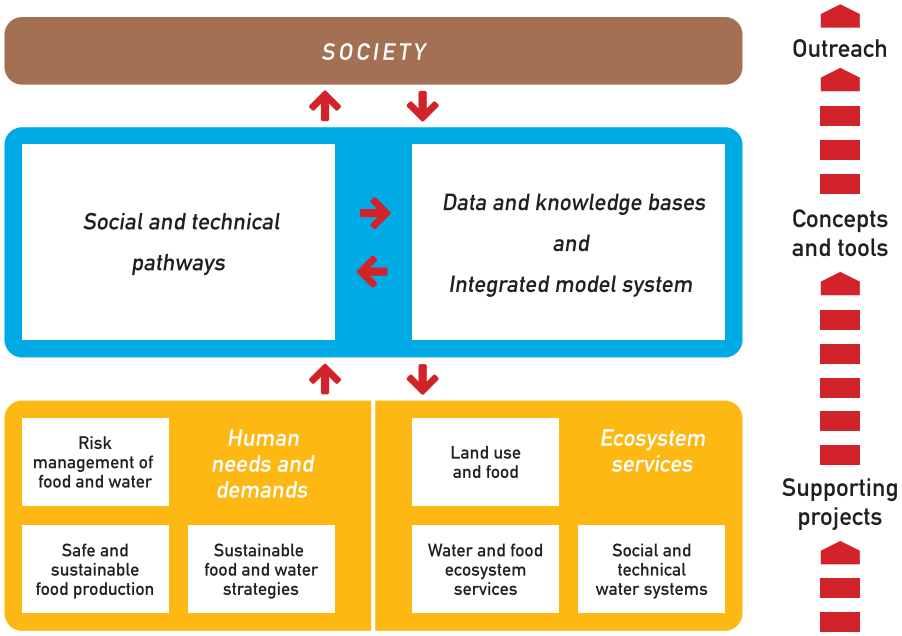

Figure 4. The structure of the Food and Water Flagship. The development paths and databases and modeling components are central to the program and are fed by the supporting projects.

Because of the complexity of food and water program and the exten t of included research, integrating all studied aspects is a major challenge. Here, we propose that the investigation of pathways and related modeling work are central to the program. A series of specific supporting projects will provide information that can be used for the development of pathways and/or the models. These supporting projects will focus on human needs and demands, and ecosystems services. Another difficulty is the complexity of the model required for a comprehensive study of the food ands water system. Hence, a number of models (Figure 5) will be used and their integration is a challenge for the modeling team.

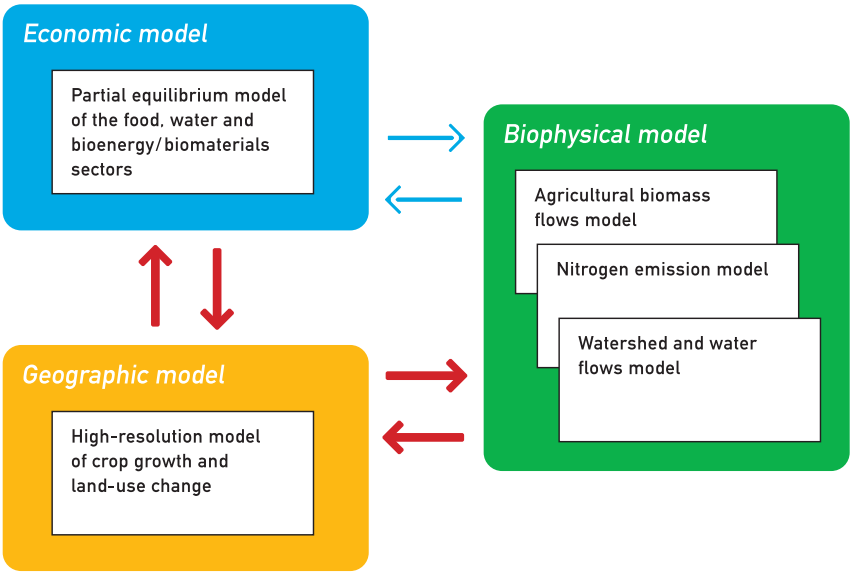

Figure 5. Different components in the modeling system, which includes biophysical, economic and geographic models.

Fundraising efforts

Fundraising has been a key activity in 2007. Over 20 international and 25 Swedish companies or organizations dealing with food/water were identified. Companies in Sweden/Scandinavia have been approached. While there is a general interest in the proposed research, not all companies have the possibility or commitment to fund research. To date, 4 companies/organizations who have indicated a strong interest and the possibility to support at least part of the program were met. Discussion and funding applications are in progress. More recently, fundraising efforts have included the identification of international companies and organizations.

Identification of strategic areas

Five key areas have been identified through contact with companies. It is important to note that some of these areas may reflect the European situation rather than global issues.

Land use constraints – food, biofuel, multiple services

The increasing use of agricultural land for energy production is a current concern in many countries. This increase means either the use of previously unused land (and possible deforestation) or the conversion of agricultural land used for food production. The production of bio-energy is therefore linked to food production.

Changes in diets and food/water demands

Economic growth and globalization of dietary habits are causing a shift in food demand and the global transport of food and water. It is believed that global food demand will continue to increase and strategies need to be developed to support regional and global food demands.

Organic and ecological farming and products in a global perspective

Organic and ecological products have slowly increased in importance during the last decade and this is a trend which is seen to increase rapidly in the near-term future.

Packaging and food safety

Concern over health issues in food and water is leading to an increasing demand for sterile packaging and proven safety guidelines. This development is seen to increase with expanding global markets.

Climate labeling

The threat of climate change has made individuals consider their impact on the climate. Climate labels are an alternative to enable people to choose consumer products with a low impact on the climate. The establishment of such a label requires a systems analysis of each product, including emissions during production, transport, use and eventually disposal. There is also a clear need a labeling system that is easy for consumers to understand.

On-Going research

This section features examples of on-going projects by members of the Food and Water team.

Modeling the impacts of up- and downstream water reallocation on rural communities and social equity in the Chaobai watershed in China

Yuan Zhou and Hong Yang, EAWAG

During the past two decades, irrigated agriculture in northern China has been expanded rapidly and contributed greatly to the national growth in grain production. However, water stress has intensified water use conflicts between upstream and downstream areas and also between agriculture and the municipal and industrial sectors. As irrigation is by far the largest water consumer and often regarded as a low-value use of water, there has been a tendency to reallocate water from agriculture to meet industrial and domestic needs.

Our study area in the Chaobai watershed, located in the upstream Miyun Reservoir, has been undergoing agricultural water transfers to downstream municipal uses in Beijing. This paper examines the impacts of water reallocation on crop production and farmers' income and identifies the gaps between current compensation levels and the real loss of farmers' income. The analyses are based on a survey of 349 farm households and their farm plots in the study area and used both descriptive statistics and regression models. The results show that water reallocation from upstream to down stream has led to a reduction in agricultural water supply and irrigation areas, consequently, household incomes. Plots deprived of irrigation maize yield decreases by 21% and crop revenue drops by 32%. On average converting a plot from irrigated to rainfed land would decrease the net crop income by 162 yuan/mu. It is also found that irrigation has spell over effect on farm income. The reduction in irrigation leads to a loss of total household income by 227 yuan/mu.

Table 1. Impact of irrigation on crop revenue for poor and rich households

	Crop revenue (yuan/mu)	Crop revenue for irrigated plots (yuan/mu)	Crop revenue for unirrigated plots (yuan/mu)	Percentage increase in revenue	Per capita household income (yuan)	Share of crop income in total income
All samples in survey area	464	597	377	0,58	2840	0,25
Poor households	406	525	345	0,52	895	0,57
Rich households	525	659	412	0,6	5681	0,18

Current compensation arrangements are discussed for three major policies implemented and in all the cases we found that proper mechanism of compensation is far from established to assure social equity in water sharing and reallocation. The current compensation received by farmers is generally lower than the loss incurred due to the deprivation of irrigation. Based on our calculations the appropriate levels of compensation are suggested for policy considerations.

Soil and Water Safety in North China

Ken Fukushi, UT

Sustainable supply of safe food is a great concern in Asia, which has large increasing population. However, food production in most Asian countries is not always based on secure foundations. In North China, which is one of the largest food production sites for China and Japan, water shortage and contamination of soil threatens sustainability of safe food production. The study aims to reveal the factors that threaten sustainability of safe food production, and to evaluate measures to secure its sustainability.

In North China, a part of irrigation water is contaminated with heavy metals, because wastewater is discharged to surface water channels. Since the contaminated water had been used for irrigation due to severe shortage of water, serious soil contamination with heavy metals is found in many agricultural fields.

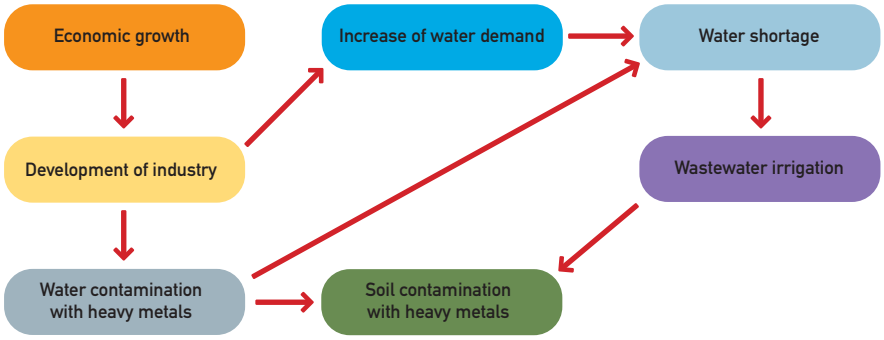

Figure 6. Relationship among the factors causing soil contamination with heavy metals in North China

Targeting on agricultural fields in North China, we investigated heavy metal concentration of soil and water. Of 12 soil samples taken from agricultural fields irrigated with wastewater, 10 samples exceeded Chinese standards on heavy metals in soil. Analysis of correlation among elements suggested wastewater as a source of contamination in wide area, as well as implication of small specific source of cadmium and mercury. Soil in the area where wastewater had been irrigated for long had severe contamination with cadmium.

Remediation methods should be chosen carefully according to the level of contamination and situations of the target agricultural fields.

Water Resource Management for Sustainable Food Production

Taikan Oki, UT

Future demand of water was estimated based on forecast of population and GDP. According to the estimation, water demand will remarkably increase in a large area in Asia. In order to ensure a stable water supply for food production in a century predicted to experience global warming, a dynamic quantification of water resource status will be developed for early warnings of drought risk. Quantifying the vulnerability of water resources will also contribute to long-range agricultural and land-use planning.

Impacts of Land-use Change on Nutrients Flow in Peri-urban Area in Thailand

Ryo Honda, Yuji Hara, Ai Hiramatsu and Makiko Sekiyama, UT

Expansion of Asian mega-cities brings about rapid population growth in peri-urban area. The population growth induces land-use change from agricultural fields to residential area. In Nonthaburi Province, which is located next to Bangkok, new residential houses are being constructed in many places, by developers expecting large demand of migrants from Bangkok for residences. In this area, canal network has been used as an irrigation water source of agriculture fields. However, nutrients loadings from these new residences are expected to increase remarkably and to threaten sustainable use of canal water for irrigation.

Figure 7. Land-use change in a target area in Nonthaburi, Thailand from 2003 (left) until 2007 (right). Red-circle shows newly developed residential area.

From our survey in target areas in Nonthaburi, built-up area increased 20~40% from 2003 until 2007. Larger increase of built-up area was found in nearer area to Bangkok city. A large part of nutrients loadings to canals was estimated to originate from residential areas. Generation of organic solid waste and demand for fertilizers was estimated from land-use change expectation provoked by population growth. The estimation suggested that supply potential of compost made from organic solid waste matched demand in agricultural fields when residential area accounted for 16~18% of total area.

In order to realize sustainable water environment management and control of nutrients pollution in peri-urban area in Asia, profiling of development and measures dependent on its development stage will be proposed.

Balancing ecosystem services with technical and social systems

Greg Morrison and Mark Bost, Chalmers University of Technology

This study analyzes specific aspects of an urban water system in the context of the Millennium Ecosystem Assessment. The concept of ecosystem services and their valuation is considered with a focus on revealed preference methods. A combined contingent valuation and choice experiment survey was developed and sent to 500 households in Gothenburg in order to value water related ecosystem services as respondent's willingness to pay (WTP). However, attributes were first identified through stakeholder interviews. This included a provisioning service (Goods produced or provided by ecosystems) in terms of tap water healthiness, a regulating service (Benefits obtained from regulation of ecosystem processes) in terms of climate impacts through CO_2 emissions related to tap water supply, and a recreational service (Non-material benefits from ecosystems) in terms of a bathing site which also serves as raw water reservoir.

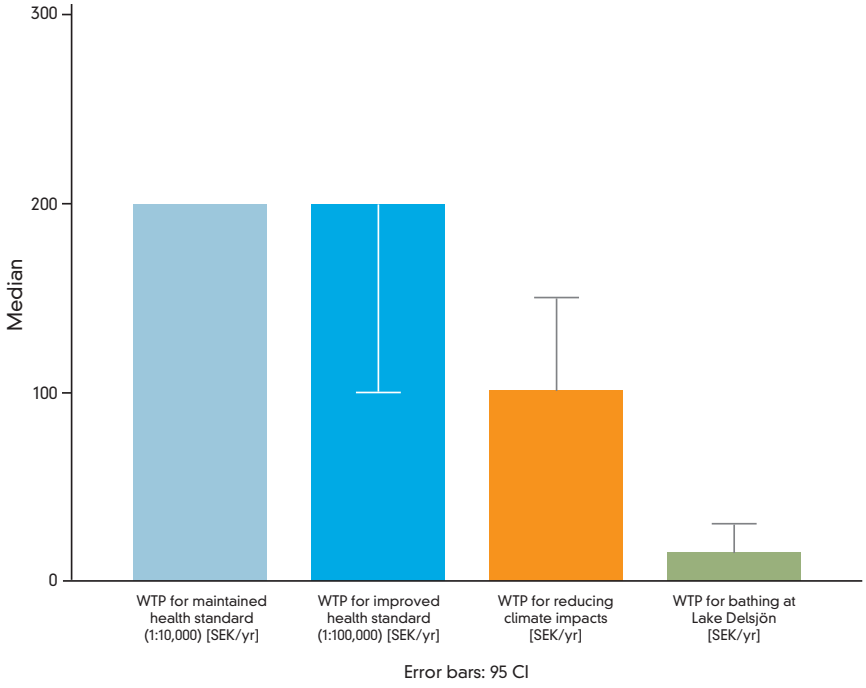

Figure 8. Willingness to pay for water ecosystem services in terms of stakeholder identified provisioning, regulating and recreational attributes.

It was revealed that healthy tap water is most important for all respondents, followed by environmental impacts, good taste, and few supply interruptions. WTP for maintaining today's health standard (Figure 8) does not significantly differ from a hypothetical 'improved' standard, indicating that people are satisfied with the current health standard. Median WTP is measured as annual fee additional to current charges per person and is highest for health (200 SEK/yr), followed by reduction of climate impacts (100 SEK/yr), and maintaining the possibility of bathing at Lake Delsjön (15 SEK/yr).

WTP were then compared to real costs for water system improvements. The WTP for maintaining the present health standard was one order of magnitude greater than the costs for raising health standards through the introduction of ultrafiltration (protection against Giardia and Cryptosporidium). The WTP for climate impacts were one to two orders of magnitude higher than climate mitigation costs which might be within the catchment area such as reforestation in the watershed or construction of wetlands.

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