AGS Future Cities -
Guangzhou:
A Partnership for
Urban Sustainability

Representatives from the Alliance for Global Sustainability (AGS) have been meeting with officials from the city of Guangzhou (formerly Canton), China—a city with more than 7 million inhabitants—to develop a set of projects for capacity-building in sustainable development. Guangzhou, a city with a long history of international trade, is one of China’s largest centers for the manufacture of exports. Rapid industrial and urban growth bring with them a host of problems familiar to municipal and environmental planners—in particular, adequate water supply, efficient transport, industrial air and water pollution, and sanitation. The city’s leadership is interested in seeing the city develop sustainably, ensuring a healthy environment in which to live and work, and in supporting further growth unconstrained by environmental degradation.

Four municipal administrative groups are working with AGS researchers: the Guangzhou Planning Commission, the Guangzhou Municipal Administration Bureau and Gardens Bureau, the Guangzhou Urban Planning Bureau, and the Guangzhou Environmental Protection Bureau. The project is actively supported by Li Zhuobin, the Vice-Mayor of Guangzhou. The project also involves a cooperation with faculty and students from the South China University of Technology.

At the Swiss Federal Institute of Technology in Zürich (ETH), principal investigators (PI) are Prof. Dietmar Eberle, Prof. Em. Alexander Henz, and Dr. Margrit Hugentobler, ETH Wohnforum (Center for Housing and Sustainable Urban Development), Faculty of Architecture. At MIT, the PI is Professor Fred Moavenzadeh, Director of the Technology and Development Program, Center for Technology, Policy, and Industrial Development, and at the University of Tokyo, the PI is Professor Keisuke Hanaki, Department of Urban Engineering. Professor Jia Beisi, Department of Architecture at the University of Hong Kong has been a project partner from the beginning and has been instrumental in helping to set up the project.

The overarching objectives of the project are twofold: (1) To support the city of Guangzhou in addressing problems related to urban transportation policy, housing, and water and land use management through the application and adaptation of technical, social and policy analysis tools and methodologies developed in conjunction with the AGS project “Future Cities: Toward Sustainable Cities”; and (2) to develop a model for research part-

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nnerships between developed and developing countries aimed at capacity- and institution-building. In addition to its focus on the exchange and enhancement of knowledge and improved decision-making, the project partners stress the need to effectively implement changes that support sustainable urban development. The project seeks to apply tools and methods developed by the AGS Future Cities research teams to “real world” challenges faced by Guangzhou.

After preparatory meetings, the first AGS Future Cities Partnership Conference was held in Guangzhou in November 2000. At the conclusion of the conference, Memoranda of Understanding for three interrelated sub-projects were signed between the AGS group representatives and decision-makers of the Guangzhou Municipal Government: Subproject 1: “Developing Sustainable Urban Transportation Systems and Policies,” focused on identifying urban transportation policies, technologies, and strategies to cope with the increasing traffic congestion plaguing Guangzhou; Subproject 2: “Sustainable Water Environmental Resource Management,” addressing pollution control and the sustainable management of water resources in Guangzhou; and Subproject 3: “Improvement of the Residential Environment in Zhu Village,” aimed at developing a model for sustainable urban renewal of older villages (so-called “villages in the city”) which have become part of the Guangzhou metropolitan area.

In May/June 2001, a delegation consisting of the leaders of the AGS Guangzhou Partnership Project from Guangzhou visited MIT and ETH. The main goal of the visit was to create closer links between the three subprojects. This goal was reached by providing an integrated perspective on urban development in Boston and Zürich, including issues of transportation, water management, housing, landscape and ecosystems management, and neighborhood development. During 2001, two additional Chinese delegations with experts and policy-makers involved in the respective sub-projects visited Zürich and Tokyo. The presence of Chinese research partners allowed for an exchange of knowledge and information in conjunction with visiting and discussing “best practice”. In return, members of the AGS university teams met with their counterparts in Guangzhou at various times during 2001 in order to exchange information and jointly work on the specific topic areas identified for cooperation. Building mutual trust and a common understanding of the research and development agenda has resulted in the involvement of the various partners in a way that effectively addresses the pressing sustainability problems in Guangzhou.

Impact
In the pre-meetings held in May 2001 and a conference in November 2001 as well as during subsequent research work, commitment to the project has continued to grow. Decision-makers in Guangzhou have expressed their interest in a continuation of the collaboration in a next project with the AGS. The

All events are held at MIT unless otherwise noted. For the most current listings, see the LFEE website:
http://lfee.mit.edu/

Please send MIT sponsored event listings to Dr. Richard St. Clair, stclair@mit.edu, phone 617-253-9871.
Guangzhou Planning Commission has a clear understanding of the roles to be assumed by the different project partners and has, itself, formulated the collaborative research topics, goals and programs.

The subproject “Developing Sustainable Urban Transportation Systems and Policies” has bolstered the effectiveness of the Guangzhou Transportation Research Institute by reaffirming the need to explore pricing as a mechanism to curb demand for private vehicles. It has reinvigorated the long-standing debate in Guangzhou regarding the applicability and affordability of Bus Rapid Transit systems versus costly subways. And it has also contributed to a new perception regarding pedestrian walk-ways and cycle transit as viable complements to modern mass transit. The work of the AGS team from MIT focused on supporting local research and policy development efforts by demonstrating the effectiveness of relevant programs implemented around the world. By drawing on real-world examples to show political feasibility, cost/benefit analysis, and possible implementation pitfalls, the goal was to encourage Guangzhou to avoid repeating the mistakes made by other large cities.

The research and discussion between the project partners of the subproject “Sustainable Water Environmental Resource Management” led to a clear understanding of what issues around water management should be prioritized, and initiated a plan for policy development of water management in large, new urban districts like Panyu.

The subproject “Improvement of the Residential Environment in Zhu Village” created an inter-disciplinary collaboration between different universities, private industry and municipal bureaus in Guangzhou, bringing together know-how from different disciplines and institutions. This allowed for the development of an encompassing approach to the analysis of urban renewal issues. As a result of the joint work, the local Guangzhou research team developed a proposal for the renewal of Zhu Village, which was selected as a demonstration project. At the conference in December 2001, the Vice-Mayor emphasized the commitment of the city to use this as a model project for the 138 other villages in the city involving a population of 1-2 million previous villagers. Subsequently, a steering committee involving all relevant municipal departments (i.e. planning, transportation, land use and green space, education, etc.) was formed to assist the project group with further planning and especially with the implementation of renewal strategies. The Zürich AGS team focused its role on providing information and consultation on the development of interdisciplinary concepts and successful planning and project management processes.

**Insights**

Establishing a meaningful, productive cooperation across different cultures and disciplines is a challenge. In addition to the geographical distance, language limitations and cultural differences in working styles, planning horizons, etc. require patience as well as persistence in order to build trust and develop a common understanding of the problems to be addressed. The interest expressed and the active role taken by project partners in Guangzhou, both at decision-making levels of the municipal government as well as at local universities, has exceeded expectations, making it possible very quickly to define the specific research topics considered of importance to the city of Guangzhou. Additionally, the cooperative efforts among the AGS partners has been exceptional and productive.

During the course of the research, it became increasingly apparent that some of the issues faced by Guangzhou were regional in scope. Problems relating to traffic congestion, air pollution, and water pollution could not be effectively segregated or resolved within the city’s administrative and territorial boundaries. Guangzhou’s integral role in the Pearl River Delta Region (PRDR) economy and environment predicated that effective solutions will have to involve all the major urban centers in the delta. Environmental issues facing Guangzhou are to a great extent caused by the rapid economic growth of the PRDR. This growth was mostly propelled by the economic integration of Hong Kong. In order to understand the scope and extent of the interaction of environmental issues between Guangzhou and the PRDR, a limited study was undertaken by the members of the MIT research team. This study identified the need for a comprehensive program focused on sustainable development of the PRDR.

**Outlook**

A final report describing the process and the major outcomes of the project following the second Guangzhou conference in December 2001 will be published this month in...
the AGS Book Series on Science and Technology: Tools for Sustainable Development. The book, edited by Peter Baccini (ETH), Keisuke Hanaki (UT), and Fred Moavenzadeh (MIT), is titled Future Cities: Dynamics and Sustainability (Kluwer Academic Publishers, 2002).

During the meetings held between the different project partners in 2001, the decision-makers in Guangzhou expressed their interest in a future commitment and collaboration with the AGS. The AGS Future Cities team submitted a new AGS project (for 2002-2003) that will build on the cooperation established during the past two years. It is titled “AGS Future Cities — Guangzhou: A Partnership for Sustainable Urban and Regional Development in the Pearl River Delta”. It entails a new focus of outreach and multi-disciplinary, cross-cultural as well as transdisciplinary cooperation at different levels, local and regional. The project components address different topic areas and levels, but are interrelated in that know-how developed through research can be linked to know-how gained from implementation practices and evaluation, thus allowing movement from research to action and vice versa. For further information, contact Dr. Margrit Hugentobler, ETH Zürich, Co-Director of ETH Wohnforum, email: hugentobler@arch.ethz.ch.

Additionally, an initial concept for the formation of an Institute for Sustainable Development (ISD) for the Pearl River Delta Region has been developed. The partners believe that an emphasis on the regional context of the research will result in a better understanding of the viable long-term options and solutions. For further information, contact Prof. Fred Moavenzadeh, MIT, moaven@mit.edu.

Defining a Pathway to Future Sustainable Mobility: Options and Challenges

How can we help to create the institutional capacity to address complex, long-term issues such as sustainable mobility so that the technological progress that will be necessary in the future can proceed more effectively?

In 2000, several member firms of the World Business Council for Sustainable Development (WBCSD), MIT, and Charles River Associates assembled a research team to examine the prospects of ‘sustainable mobility.’ In their report, Mobility 2001, issued last October, the team concluded that several ‘grand challenges’ must be addressed if the worldwide community hopes to improve the outlook for sustainable mobility.

The report was commissioned by the WBCSD on behalf of 11 major mobility industry stakeholders: Daimler-Chrysler, Volkswagen, Ford, General Motors, Renault, Honda, Toyota, Shell, Norsk-Hydro, Michelin, and British Petroleum. The purpose was to establish a baseline which assesses the state of the world’s mobility at the end of the 20th century and threats to its prospects for sustainability. For the purposes of the report, sustainability was defined as "continued economic development while meeting environmental and social concerns".

Preparing the report was a team of researchers from MIT led by Professor David H. Marks, Director of MIT’s Laboratory For Energy and the Environment (LFEE), Professor John Heywood, Director of the Sloan Automotive Lab, and Project Director George Eads of Charles River Associates, along with MIT Professors Daniel Roos (Associate Dean and Director of Engineering Systems Division), Joseph Sussman (Department of Civil and Environmental Engineering), and Ian Waitz (Department of Aeronautics and Astronautics); Dr. Carl Martland, Senior Research Associate in MIT’s Department of Civil and Environmental Engineering; and Research Associate Chris Zegras of LFEE. The project looked at both the developed and the developing nations, with a focus on their urbanized areas. It includes all transportation modes and looks at freight mobility as well as personal mobility. The report assesses multiple dimensions of sustainability.

The nature of mobility has an important impact on patterns of human settlement. Shaping these patterns are urbanization—“the most powerful anthropogenic force on earth”—and “suburbanization,” or the reduction in population density of urbanized areas through outward spread. Both have important implications for the sustainability of mobility, and neither could be occurring to the extent they are without the mobility improvements of the post-World War II era.

The share of population living in urbanized areas is increasing. Currently, the world’s urban population, at 2.9 billion, represents 47% of the total population, 6.1 billion. It is estimated that in 30 years the urban population will jump to 60% of the total population, or 4.9 billion out of 8 billion people. Estimates of population increase in Asian megacities from 1995 to 2025 show Shanghai growing from 15.1 million to 26.8 million, or nearly the size of present-day Tokyo. The populations of Bombay, Beijing, Calcutta, Jakarta, New Delhi, Karachi, Bangkok, and Dhaka are all expected to exceed 20 million by 2025.
As people’s incomes grow, they travel more and they travel further, usually by substituting faster means of travel for slower ones. Transportation is an enormous user of energy, overwhelmingly using fuels based on petroleum. Further, transport is in an environmental dilemma. It cannot avoid the climate change issue, as virtually all transport systems produce carbon dioxide. And emissions such as SO2, NOX, hydrocarbons and particulates from transport have been rising. There has been progress in the developed world over the last quarter century in efforts to reduce these emissions, but this is not true in the developing world.

The developing world is urbanizing at a spectacular, if frightening, rate. As in the developed world, the twin forces of urbanization and motorization in the developing world feed one another. Both forces are threatening to overwhelm whatever improvements in mobility a number of developing countries have begun to enjoy in recent decades. Air transport’s impact on the global environment is disproportional: It is responsible for about 12% of all CO2 emissions, and it makes an unexpectedly large contribution to global warming because emissions at high altitude have much greater impact than emissions at the surface. The Intergovernmental Panel on Climate Change (IPCC) estimates that the impact of burning fossil fuels at high altitudes is approximately double the impact of burning the same fuels at ground level. Can the significant environmental challenges of air transport be successfully met?

“Overarching Challenges” that transcend any one mode or region include improving institutional capability to identify, build consensus about how to solve, and implement approaches that promote sustainable mobility, and ensuring that our transportation systems continue to play their essential role in economic development and—through the mobility they provide—serve essential human needs and enhance the quality of life.

How can the personal-use motor vehicle be adapted to the future accessibility needs and requirements of the developed and developing worlds alike? Variables in addressing this challenge include vehicle capacity, performance, emissions, fuel use, safety, materials requirements, waste, ownership structure—all with the objective of drastically reducing carbon emissions from the transportation sector. This may require virtually phasing carbon out by transitioning from petroleum-based fuels to a portfolio of other energy sources.

Challenges to sustainable mobility cannot be credibly addressed without the significant involvement of other modes of transport. Sustainable transportation options must be found which provide accessibility in both developing and developed nations to people who are unlikely to afford a personal auto. Further, it should simultaneously provide a reasonable alternative for those who do have access to personal motor vehicles. Sustainable mobility must also resolve the competition for resources and access to infrastructure between personal and freight transportation in the urbanized areas of the developed and developing worlds. If future mobility is to be sustainable it must anticipate congestion in inter-city transportation and develop a portfolio of mobility options for people and freight.

The report suggests that a major goal is to focus initially on sustainability issues created by the dominant role played by light-duty vehicles in providing personal mobility in the developed world and in developing world urban areas. This would mean making the automobile a sustainable transportation mode. In the developed world this implies completing the task of removing the automobile from the list of major conventional emissions sources and, over the longer run, preparing for the transition to fuels containing less or no carbon. It also implies devoting increased attention to safety-related aspects of vehicle design and construction, and examining the potential for different auto usage strategies, as well as examining alternative roles for the automobile as a component of a balanced transportation system.

Enhancing knowledge of mobility needs, options, and expected future changes can be approached by raising the awareness of the vital role that infrastructure plays in enabling mobility, raising our awareness of significant mobility-related issues in freight and air transportation, and improving understanding of transport’s role in global warming and of alternative actions to reduce this role. This means investigating just how realistic it might be to replace elements of ‘actual’ mobility with ‘virtual’ mobility and exploring how
Mobility 2001 defines a number of grand challenges for mobility in the 21st century which, if successfully addressed, would dramatically increase the sustainability of mobility:

> Ensure that our transportation systems continue to play their essential role in economic development and, through the mobility they provide, serve essential human needs, and enhance the quality of life;
> Adapt the personal-use motor vehicle to the future accessibility needs/requirements of the populations of the developed and developing worlds (capacity, performance, emissions, fuel use, materials requirements, ownership structure, etc.);
> Reinvent the concept of public transport—provide accessibility for those lacking personal motor vehicles in both the developed and developing worlds;
> Provide a reasonable alternative choice for those who do have access to personal motor vehicles;
> Reinvent the process of planning, developing, and managing mobility infrastructure;
> Drastically reduce carbon emissions from the transportation sector, which may require phasing carbon out of transportation fuels by transitioning from petroleum-based fuels to a portfolio of other energy sources;
> Resolve the competition for resources and access to infrastructure between personal and freight transportation in the urbanized areas of the developed and developing world; and
> Anticipate congestion in intercity transportation and develop a portfolio of mobility options for people and freight.

Water Budgets: A New Measure of Sustainability?

Dennis McLaughlin is H. M. King Bhumibol Professor of Water Resource Management at the Massachusetts Institute of Technology. His research group at MIT works on improved ways to characterize and manage water resources. Current activities include research on remote sensing and environmental data assimilation and investigations of the sustainability of irrigated agriculture. Prof. McLaughlin is Principal Investigator for the Alliance for Global Sustainability (AGS) project on Population, Food, and Water, which is examining man’s ability to satisfy food needs in critical arid and semi-arid regions of Asia. Additional support for his group’s research comes from the US National Aeronautics and Space Administration and the National Science Foundation.

Initiatives in Energy and the Environment: What do you see is the main problem with water supply looking ahead, and how does that impact food production?

Dennis McLaughlin: The UN estimates that the population of the world will grow from about 6 billion now to about 9 billion sometime around the middle of the century. Almost all of this growth will be in an area stretching from North Africa through the Middle East, Iraq, Iran, Northern India and Central Asia. This is an arid region with large populations of poor subsistence farmers who do not have access to the same resources as American farmers. Production and living standards can be increased only if inputs are increased. That means better hybrids, more fertilizer, and more water. But the question is whether or not this is sustainable.
It's possible that enough food could be grown in North America to feed the Earth's extra 3 billion people by 2050, but that brings up all kinds of trade issues. Where are subsistence farmers in countries like Bangladesh going to get enough money to pay for Canadian grain, even accounting for the fact that the price of food has gone down in the last 20 or 30 years globally? Most of the people we’re talking about don’t buy their food in the grocery store; they grow it locally. They’re very vulnerable to climatic fluctuation and to drought. Their population is growing. So even though they’ve been able to feed themselves with locally grown food up to now, if the population increases too much that will no longer be possible. And they don’t have the money to buy food on the global market.

IEE: So poverty is as important an issue as resource limitations?

DM: I believe so. We know that, on a global basis, there is enough water on Earth to feed 9 billion people, but all the surplus water in the Amazon doesn’t help the farmer in Pakistan. Even if you could grow food with the water in the Amazon, the farmer in Pakistan would have to buy it, which means he’s got to produce something other than food to get cash. It’s not to say that it can’t be done—people in Manhattan don’t grow their own food either—but you’ve got to have some other economic activity, and that’s why many economists have said that poverty, rather than resource scarcity, is the real issue.

IEE: You’ve said that if most of the billion or so people who now grow their own food will continue to do so, we’ve got to make sure that their consumption of natural resources is sustainable. Some say the market will resolve this, but a lot of people could starve to death in the process if it were left up to market conditions. What role can water markets realistically play in this?

DM: The concept of a water market is to give people the option to sell or rent water that they have the right to consume. This has been shown to increase efficiency, because the more productive farmers make more money and are more inclined to buy additional water. Less productive farmers can do better by selling their water than by struggling to survive from agriculture.

There’s no doubt that crops could be grown more efficiently in many areas of the world, although I think there’s a tendency for us to be patronizing toward subsistence farmers as if to say they don’t know what they’re doing and are wasting a lot of water. We probably waste a lot more water in our agribusiness in the US than they do. In the US, for example, water is very heavily subsidized by the state and there’s less inclination to conserve than there is for a poor farmer in India who knows that his water supply is limited.

There are areas in the US and Australia where water markets have been encouraged and it’s resulted in better yield with the same amount of water. But obviously, to run a water market takes a certain institutional infrastructure to make sure it works. You need to monitor the water and you need some central authority to make sure the water is going to the right place.

IEE: Would you explain sustainable water usage?

DM: Sustainable water use requires that the stock of water stored in a surface or subsurface reservoir be maintained over the long term. We really don’t know whether groundwater basins are being depleted unsustainably over large areas. There are anecdotal reports of particular locations where water levels have dropped substantially at supply wells, causing these wells to dry up. This appears to be occurring in parts of India, for example. In the North China coastal plain, well water has become saline because seawater has intruded inland where well pumping has drawn groundwater levels well below sea level. These are indications that local groundwater reservoirs are being unsustainably depleted. But we don’t have any quantitative sense of how extensive these problems are. My former Ph.D. student Julie Kiang used a water budget approach to assess large-scale groundwater depletion in Asia. She found that existing global data sets are too uncertain to support definitive conclusions about sustainable water use.

IEE: What is meant by a “water budget”?

DM: What we call a water budget is a lot like the budget you would use to monitor your personal savings account. A water budget is just an account sheet that keeps track of water inflows (income) and water outflows (expenditures). Water is stored in lakes and in permanent snow packs and glaciers. It is also stored underground in the soil and in porous rocks. Groundwater accounts for most of the liquid fresh water on the planet. If outflow exceeds inflow in a given region, we are running a deficit and will eventually deplete the regional reserve of stored water.

It is very difficult to measure changes in groundwater storage directly. But it is also difficult to obtain accurate measurements of the inflows (e.g. precipitation) and outflows (e.g. evapotranspiration) over large areas. It’s as if you could never check your account balance but would have to estimate it from inaccurate records of your income and expenditures. So we don’t know whether we are depleting our savings or not. Changes in groundwater reservoirs take
place over very long time scales because these reservoirs are very large and groundwater moves slowly. When a groundwater reservoir is depleted, recovery will take hundreds of years. Those are the kinds of time scales we are talking about.

**IEE:** What role does irrigation play in water budgets?

**DM:** When we irrigate, we divert water from runoff to evapotranspiration. Evapotranspiration includes all the water moving as vapor from the land to the atmosphere—evaporation from open water and transpiration from plants. For example, in California it doesn’t rain for 5 months of the year, and so the natural vegetation is dormant and transpiration is near zero. That’s why the grasses are all yellow in the summer. But if you go to the San Joaquin Valley [in California], where there’s a lot of irrigation, you see all this green in the summer. The Valley is transpiring much more water than is falling as rainfall. The extra water comes from ground and surface reservoirs. The water in these reservoirs is really spring runoff that has been trapped for use later in the year. So the runoff is stored for a few months, applied to the crops, and eventually transpired.

**IEE:** How is your work different from that of other researchers?

**DM:** When other researchers construct water budgets they usually assume that the storage change is zero. So, for example, they measure the precipitation and the run-off and assume that the difference is evapotranspiration. But we don’t assume that the storage change is zero. The storage change is the difference between the inflow, which is precipitation, and the total outflow, which is runoff and evaporation. When we estimate all three quantities independently and take that difference, sometimes we get storage increases and we sometimes get storage decreases. But what we find is that the storage change value is nearly always smaller than the uncertainties, so the result is inconclusive.

**IEE:** What measurements do you use in a water budget analysis?

**DM:** There are a lot of datasets that have been compiled for global climate modeling. For example, you can divide the globe up into a grid, and you can get long-term precipitation estimates for each cell in the grid. These are usually a composite of rain-gauge measurements and satellite measurements [remote sensing]. Satellites don’t measure precipitation. They measure things like the temperature of cloud tops, and you then have to correlate that with precipitation.

**IEE:** What are some of the problems you’ve confronted?

**DM:** Evapotranspiration is difficult to measure over large areas and needs to be inferred from land use. In other words, an empirical formula is typically used to correlate evapotranspiration with measured precipitation and land use. Some of the quantities needed in water budget analyses are simulated in global climate models but they are also uncertain. Such models are notoriously poor at predicting precipitation or evaporation. One of the major things we’ve done is to recognize the uncertainty in our data sources and not just issue some kind of number without considering its accuracy. I have to admit that I was surprised how uncertain these hydrologic fluxes are. As far as I can see, there’s no way we’re going to reduce that uncertainty without getting better data, and we’re probably not going to get better data on the ground.

**IEE:** What is your new case study in the Sahara about?

**DM:** It has to do with the competition between Algeria, Tunisia, and Libya over the large aquifer that lies under all three countries. The focus of that work, from my point of view, is not so much the Sahara but the connection between remote sensing data and sustainability issues. Basically, available information is too uncertain to make a definitive conclusion about the sustainability of agriculture over large areas. We would like to make some scientific statements about sustainability, but we can’t because we don’t have enough information. What information we do have is too uncertain. So we need to get better information and more information, and one option for that is remote sensing.

**IEE:** You have also been examining rice production in Australia.

**DM:** The work we did in Australia had to do with sustainability of rice agriculture in a semi-arid environment. The research had an economic component because one of the
The particular problem of concern is salination, or the accumulation of salt which is present in the irrigation water but not transpired by the crops. If the fields are not drained sufficiently salt accumulates until agriculture becomes impossible. It seems better to anticipate degradation than to wait for it to have adverse economic consequences. Our conclusions in Australia were relatively optimistic. We believe that current practices are more or less sustainable, and the Australians are quite careful about monitoring conditions so they can detect adverse trends. But it would be unwise to expand production significantly above present levels.

**IEE:** What is the role of more sophisticated irrigation systems?

**DM:** The Israelis have led the way in that they grow high value crops very efficiently, but you can’t feed billions of people on kiwis and oranges. If you want to grow grain, and you want to grow significant amounts of grain, it’s not presently cost-effective to use the kind of micro-irrigation that they’ve developed in Israel. Often there’s another problem. If you don’t waste any water, if all the water goes to the plant, then every bit of salt stays in the soil. If you put in more water than the plant needs and it goes out to the ocean, then it carries the salt with it. So in Israel salination is a real problem with these drip irrigation systems.

**IEE:** What about desalinizing ocean water for irrigation?

**DM:** At some point, perhaps we could grow grain by desalinizing ocean water or salty groundwater, but it costs up to a dollar a cubic meter to desalinize water. That’s a lot less than it costs to buy bottled water in the supermarket, but you cannot afford to irrigate wheat with water that costs a dollar a cubic meter. Most farmers in the world, if they’re paying anything, are paying less than 10 cents a cubic meter for water for irrigation. So the price of grain would have to go up a lot to make it economically viable to grow grain with desalinized water, and I can’t think of any place where desalinized water is used for irrigation.

It’s not clear to me that the problems in the long term are going to be dealt with purely from technological improvements in the way we do agriculture. It certainly will help but we need to look at the larger picture. Perhaps we should not expect massive improvements in agricultural productivity in places where there’s not much water. We really should ask where we should be practicing agriculture and to what extent people should be self-sufficient in food production. That’s the basic problem, and all the others follow from it.

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**School Teachers Experiment with Water Pollution in MIT Labs**

Twelve science teachers from schools around Massachusetts were at the Massachusetts Institute of Technology January 9th and 16th, learning how pollution travels through groundwater and surface water and performing environmental science experiments they can adapt to suit their own classroom needs.

The teachers, who teach from kindergarten through high school, were participants in “Pollutant Transport in Natural Water Systems,” a two-day course taught by MIT Professors Heidi Nepf and Patricia Culligan of the Department of Civil and Environmental Engineering. The course was offered through Teachers as Scholars, a national teacher education program that draws on faculty from MIT and Harvard University.

By taking this course and others like it, public school teachers earn points toward recertification (required every five years in Massachusetts), refresh their knowledge, update their skills and recreate the experience of being on the other side of the desk.

Professors Nepf and Culligan volunteer their time and expertise out of a sense of professional responsibility, a love of teaching and also to satisfy the requirements of environmental research grants, many of which now require that up to 30 percent of funding be used for outreach purposes. As co-directors of educational outreach for the Center for Environmental Health Sciences at MIT, the two have spent countless hours creating a video-tape series for middle and high school students which has now been condensed into a single 33-minute tape with an accompanying curriculum guide. They also worked with a freshman seminar at MIT to create a web-based game called “Consumption Gumption,” which teaches people how to make environmentally sound choices at the supermarket. All these projects were funded by the National Institute for Environmental Health Sciences.

“I feel a responsibility to do what I can to improve education at all ages, and in particular in the area of environment, because it impacts everyone,” said Prof. Nepf. Using a single topic in environmental science and adapting it for different ages and audiences, she and Prof. Culligan have managed to create an outreach program that works for ages five upwards.

“I’m very passionate about education. I think the better educated everybody is, the better off we all are as a society,” said Culligan. “We wanted to try to excite school children about science and get them interested in problems they’ll inherit as adults. We need people who are motivated, interested and aware.”
Environmental experiments

On their first day at MIT, the public school teachers spent the morning in Prof. Nepf's classroom learning the movement of pollutants released into surface water such as lakes, rivers and wetlands. That afternoon, they experimented using a wetlands model in a 6-foot aquarium in Prof. Nepf's lab. Nepf used the model to describe the hydrodynamics, or water movement, through the shallow water of ponds and wetlands. The students manipulated the model to discover how different factors such as vegetation density affect water movement and how changes in the pattern of water movement affect the wetlands' capacity to absorb and dissipate runoff pollution before it makes its way into the open waters of lakes and oceans.

Their second day of the course was spent with Prof. Culligan in the Pierce Lab. In the morning, the teachers learned how water and contaminants move through groundwater systems. That afternoon in the lab, they first measured the hydraulic conductivities of different soils, then built a model of a cross-section of soils beneath a small farming town and watched as water moved through the different soils, carrying contaminants along with it.

“This was the most enthusiastic group of students I have taught,” said Prof. Nepf. “I enjoyed hearing how they would adapt material from the course for their own classes.” “It was a pleasure teaching these teachers,” said Culligan. “They were full of enthusiasm and asked many thought-provoking questions. I also enjoyed learning how they motivate students and teach science in their own classrooms.”

What's next?

The Teachers as Scholars program is now being launched nationally by the Woodrow Wilson National Fellowship Foundation. Approximately 16 MIT faculty participate by teaching seminars in the humanities, social sciences and sciences, helping teachers connect with leading-edge scholarship.

Professors Nepf and Culligan teach their course only once a year, but they plan to use a portion of the curriculum as a unit at MIT's Edgerton Center. Working with teachers from Cambridge Public Schools (Massachusetts), the two have prepared a four-hour instruction module for fifth graders that includes building the model of the groundwater system. The children will spend an afternoon at the Center working on the topic with their teachers.

MIT Wins Environmental Plaudits

The Massachusetts Institute of Technology has achieved national recognition for developing an environmentally sustainable campus, according to the first national survey of college and university environmental practices conducted by the National Wildlife Federation. “State of the Campus Environment: A National Report Card on Environmental Performance and Sustainability in Higher Education” says many schools are embracing sound environmental practices while others are due for environmental remediation.

The report, based on findings from 891 colleges and universities, provides green grades for more than 20 categories ranging from curriculum to transportation. MIT was recognized as a “leading school” for doing more with energy efficiency and conservation; recycling, solid waste and materials flow; and transportation programs.

“It is gratifying to receive this national recognition of MIT's past and present campus environmental efforts,” said Jamie Lewis Keith, MIT’s Senior Counsel and Managing Director for Environmental Programs and Risk Management. “However, even as we gratefully accept this recognition, we must acknowledge that we have much work to do to meet our own high standards. The continuing efforts of every constituency of our community are necessary to sustain our initial accomplishments and to make even more progress toward a greener campus.” The collaborative efforts of the task force and the Working Group on Recycling, which includes support staff from many MIT departments, “are key to the success of our expanded ‘green campus’ programs,” Keith said.
In cooperation with INCAE, scholars will collaborate to examine the AGS research and education portfolio and consider ways in which the academic community—in partnership with industry, government, and civil society—can help generate a clear and focussed agenda for the future. As the 10th anniversary of the Rio Conference on the Environment and Development draws near, participants in the Annual Meeting will look forward to building the future through enhanced leadership, improved technologies, and global citizenship. There will be presentations by the presidents of the AGS member institutions, by world class scholars, and by thought leaders from business and industry, governments, and civil society to address these issues and set the research agenda for their solution in the future.

José María Figueres Olsen—Former President of Costa Rica and Honorary Chairman of the Meeting, as well as Member of the AGS International Advisory Board—will open the meeting followed by introductory remarks on the challenges and themes of the meeting by Göran Lindahl, Chairman of the AGS International Advisory Board. The Keynote Address will follow, “Prospects for Sustainable Development in the New Millennium,” by Jeffrey D. Sachs, Director of the Center for International Development at Harvard University.

The opening panel will address “Poverty, demography, economics and sustainable development: Perspectives from the developed and developing worlds.” The second panel on Thursday will consider “Managing risk and vulnerability with sustainability—Industry’s challenge: Where is the world turning now?” Issues will include the meaning of sustainability in the context of the present world divide: Does globalization have the same meaning today as it did on September 10th, and what are the implications for industry and academia? Friday panels will examine “Human Settlements and the Mega-Cities of the Future” and “Technology and the Future of Sustainable Development.”

Concurrent working groups will address the issue of “The development gap: Threat to sustainable development.” Tensions generated by the growing divide between affluent and poor people, nations, and regions threaten to undermine progress toward sustainable development. Working groups will consider the prospects and tools for bridging the divide within countries as well as between developed and developing countries. A second session of concurrent working groups will address the issue of “Technology that matters: Prospects for sustainable development.”

In 1994, the presidents of three of the world’s leading technical universities, with generous support from Swiss philanthropist Stephan Schmidheiny, created the AGS. Its purpose is to focus the best scientific and technical resources on the world’s pressing need for better understanding of threats and constraints to sustainable development, and to develop means to overcome them. Since its inception, the founding members of the AGS—the Massachusetts Institute of Technology, the Swiss Federal Institute of Technology (ETH-Zürich), and the University of Tokyo—have held an annual meeting to promote a better scientific understanding of global environmental challenges. Chalmers University of Technology in Sweden, which joined the AGS in 2001, will formally participate in the AGS annual meeting for the first time this March.

This year’s annual meeting of the Alliance for Global Sustainability (AGS) will consider a number of increasingly pressing world issues:

> Does globalization have the same meaning as it did on Sept. 10, 2001?
> What is the world likely to look like in 2025 if present trends persist?
> What is, or can be, the role of technology in altering current trends?
> What are the moral and ethical dimensions of the challenge of technology? and in this context,
> What are the responsibilities of academia, business, industry and civil society in meeting the challenge? and finally,
> Are we ready for the future?

The meeting will be held March 21-23 in San José, Costa Rica. This year’s host institution is the Instituto CentroAmericano de Administración de Empresas (INCAE).

Sobering realities in the world today challenge an overly optimistic view. With the present economic downturn, declining support for aid to developing countries, persistent poverty in the developing world, and increasing consumption and concomitant energy and materials intensity in the developed world, the question must be raised, what are the realistic prospects for sustainable development in the first decade of the new millennium? The events of September 11th and their aftermath pose challenges that cannot be ignored by thought leaders concerned with sustainable development.

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Concurrent working groups will be held on relevant topics to allow meeting participants the opportunity to explore in-depth issues that constrain or inhibit progress toward sustainable development. Each workshop will be chaired by an AGS principal investigator, and issues will be raised by experts from both developed and developing countries. These working groups are intended to promote provocative discussions that will inform future research, education and outreach activities of the AGS.

Guest speaker for the gala dinner will be former president of Costa Rica and Nobel laureate, Oscar Arias.

Towards the conclusion of the meeting, a panel will be presented on “The challenge to academia: Preparing the next generation of leaders,” featuring university presidents from MIT, ETH-Z, the University of Tokyo, INCAE and the Instituto Tecnológico y de Estudios Superiores de Monterrey, Mexico. Panelists will discuss ways in which universities can contribute to meeting the challenges of global sustainability and building the future for the next generation: Are there thresholds, and do we know what they are? The closing panel, “Are we ready for the future? Visions and voices from the next generation,” will be presented by representatives of the AGS World Student Community, Youth Environmental Summit, INCAE student leadership, and new student networks for sustainability.