AGS RESEARCH PORTFOLIO

1997-2003

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The Alliance for Global Sustainability
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AGS Research Portfolio 1997-2003
The Alliance for Global Sustainability (AGS)
research summary from 1997-2003

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The Alliance for Global Sustainability
an International Partnership

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ALLIANCE FOR GLOBAL SUSTAINABILITY

PREFACE

The issues surrounding global sustainability – energy efficiency, clean and adequate water, fresh air, and sufficient food for an expanding population – are among the most challenging problems facing the world today. With strengths in science, technology, and social sciences, the AGS partner universities have joined forces to commit substantial academic and research resources to meeting these challenges in an attempt to achieve three objectives:

- Improving the scientific understanding of global environmental challenges
- The development of technology and policy tools to help societies reconcile ecological and economic concerns
- The education of a new generation of leaders committed to meeting the challenges of sustainable development

It is the mission of the AGS to support policy-ready research that contributes to changing patterns of behaviour and to improving policy-making and decision-making for sustainable development. The AGS focuses on the scientific, technological and social issues that lie at the intersection of environmental and economic goals.

Central to the aim of advancing research into sustainable development are successful research partnerships. The AGS is working hard to promote successful and mutually beneficial “Research Partnerships” between the academic world and industry. The aim of this new research category in the AGS research portfolio is to establish teams with representation from industrial stakeholders. These partnerships provide a rare opportunity for academics and representatives from industry to jointly develop new approaches in order to overcome barriers to sustainable development in specific areas.

Since its inception, the AGS has supported more than 75 research projects at the partner institutes.

Please feel free to contact us!

PROJECTS

CLEANER TECHNOLOGIES

Technology plays an important role in moving towards sustainable development. The interest in ensuring that new technologies are developed to meet the needs of society coupled with environmental concern is increasing. The AGS has been working to introduce environmentally sound technologies for sustainable development.

Bringing Forth Sustainable Practices: an institutional strategic investigation

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Since the Rio Summit, the private sector has begun to emerge as the most critical institution in producing a sustainable world. Sustainability is the latest in a sequence of environmental management themes that now stretch over almost three decades. Sustainability requires new practices – new ways of thinking and acting that depart significantly from those that have evolved and have become embedded in present-day routines. Such new practices increasingly need to incorporate information and concern for the whole life cycle of products and services.

This project is aimed at accelerating the learning and embedding process that is presently evolving at a small number of leading companies. There are necessary changes that play a major role in this process, such as:

- Accelerating the learning and embedding process at a small number of leading companies to bring sustainability issues to the fore
- Exploring the new phenomenon of sustainable business practices and studying the institutional framework in which they are emerging
- Increasing the theoretical and practical understanding of how and why leading companies are moving towards sustainability

Decision Support for Planning an Eco-Effective Product System

This research was initiated to develop methodology and tools for planning an environmental product system based on life-cycle modelling. The method was developed by moving back to the product planning and pre-design phase prior to the point where the product designer determines 90-95% of all the costs plus the environmental impact of activities, products and services. Results and findings should cause a shift in the industry paradigm.

Expected deliverables from this research are:

- A formal, well-structured product system requirements model to form the basis for product development
- Ways of assessing environmental and business aspects simultaneously
- A direct behavioural change among practising designers throughout research will bring about a corresponding exchange of information
- A change in the education of designers and mechanical engineers
- Broad dissemination of results by developing on-line, computer-aided education modules
- Possibility to reach LDCs by establishing links with other projects

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AGS Book Series:
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Website:
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Framework for a Holistic Life-Cycle Design

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Technological and political systems have had a profound impact on behaviour and the consumption pattern in society. Consequently, the design needs to be adjusted to environmental and sustainability implications. The systems are all intended to fulfil a number of needs and consequently sustainability cannot be considered in isolation. Consumer, economic, social and sustainability needs must therefore be weighed together.

This project is aimed at developing a powerful analytical toolbox for concurrent consideration of classical engineering performance measures, manufacturing costs and environmental metrics within a standard design context. It adapts a study related to the automotive industry in order to apply a holistic design framework aimed at creating an integrated design and decision-making tool.

Platinum Group Elements from Automobile Emission to Global Distribution

Automobile catalysts were introduced in the 1970s to reduce exhaust emissions and the environmental load in urban areas. They are now in use in most developed countries and are being introduced in developing countries. Three of the platinum group elements (PGEs) – platinum, palladium and rhodium – are the main active components in automobile catalysts and it has recently been shown that PGEs are released into the environment during vehicle operation.

It was previously thought that PGE emissions would lead to relatively local contamination with deposition within 10 metres from the road. Previous studies have therefore focused exclusively on urban areas. But this belief is changing and there is now increasing evidence for long-distance transport and global contamination by PGEs from automobile catalysts.

This project is the first investigation into the global distribution of PGEs. The scope of the project is not to define trajectories for global transport or investigate health effects but rather to focus on the occurrence and source of PGEs, both locally and globally.

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Sustainable construction and operation of buildings in developing countries has become an important issue due to the rapid growth in the population and the ensuing high level of demand in the building sector.

Higher demand for living space and greater comfort means that new construction will adapt to a consumerism lifestyle in household appliances. Energy demand is certain to increase, which raises serious concern for the future.

In China, future buildings are planned to consume about one-third of the total energy. Decisions in the residential sector in China will therefore have a major impact on the world's sustainability. The largest obstacle to the improvement in building energy effectiveness is the lack of means to encourage the widespread adoption of efficient measures.

This project is a collaborative venture with Chinese policy-makers to develop "green guidelines" and to formulate simple computer-based tools that Chinese buildings can use to compare the energy efficiency of design options.

The aim is to identify new technologies and applications of existing technologies that will significantly increase the efficiency of new and renovated Chinese buildings. The focus is on the design, prototype testing and evaluation of several residential projects. It is also essential that the approach to energy efficiency appeals to Chinese buildings and users.

Tools for Integrated Decision Making in the Chemical Industry

In chemical processes, design time to market is crucial. In the light of this, time-consuming consideration of sustainability issues is typically put aside. This project is aimed at providing computer-supported tools that enable chemical engineers to consider sustainability issues in the design process without any significant loss of time.

The aim of this project is to create more sustainable chemical processes by improving the tools for decision-making in the chemical industry and to ensure that the tools take environmental and safety issues into account as well as economic considerations.

The approach is divided into three stages:

- The definition and measurement of design objective functions
- The development of the design and the integration of tools into a decision-making method
- The collection of case studies to establish a design and verify decision tools

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Implications for GHG of Technological Learning in the Transport Sector

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The contribution of the transportation sector to total greenhouse gas emissions increases in line with economic development. The sector already accounts for one-third of the total CO2 emissions in the US, with no saturation in sight. This sector thus deserves special attention in studies of climate policy.

This research is devoted to gaining a better understanding of the role of technological learning (or learning by doing) in models for assessing the impact of global warming policies in the transportation sector. Models have been prepared to calculate the technology changes required to satisfy transportation demand and to estimate the total travel and freight demands and the fuel process, while minimising the total cumulative system costs.

ENERGY AND CLIMATE CHANGE

Energy production and consumption lie at the very heart of economic development. While ensuring that energy demand meets the needs of the world’s population, all the countries in the world today are concerned with achieving the “3 E’s”, i.e. Environmental protection, Energy security, and Economic development. The AGS portfolio aims to shed light on sustainable ways of meeting the goals of the “3 E’s”

Technology-Energy-Environment-Health (TEEH) Chain

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Project 1: Energy-Efficient, Low-Pollution Technologies for China's Township and Village and State-Owned Enterprises

This project is focused on energy-efficient, low-pollution technology options for China's township and village (TVE) and state-owned (SOE) enterprises.

The aims of this research include:

- Extending the collection of information on technological variations in energy-intensity and pollution among different types of coke-producing ovens to include both SOE and the latest TVE technologies
- Testing for coarse and fine particles and gas pollution at coke-producing plants in the Shanxi Province
- Studying regional variations in energy intensity and pollution generation in TVE and SOE coke-producing plants
- Determining the macroeconomic impact of particular policy changes

Project 2: Multidisciplinary Research on Energy-Efficient and Low-Pollution Technologies in China

This research is an expansion study of energy use and environmental pollution, focusing on the coke-producing sector in the Shanxi Province in China.

The tasks of this research are:

- Extension of the research focus to other sectors along the coke-producing supply chain (coal mines, iron and steel plants) and to other regions in China
- To study the transportation of coal and coke in order to determine the impact it may have on final energy use and pollution

A long-term goal of these research results is to have a concrete effect in this region, to ensure that plant managers and local officials can continue working on this issue on their

Technology-Energy-Environment-Health (TEEH) Chain

own after the AGS project has ended, and to develop the tools and techniques from this project in ways that make them accessible and functional to people in other sectors and in other areas of the world.

Project 3: Training for Energy-Efficient and Low Pollution Technologies in China

China has been affected by a significant reduction in energy intensity and subsequent environmental effects. The coke-producing sector has proved to be the area with the highest energy use and this is the focus of this research.

This project is focused mainly on training and outreach. Goals include increasing the training of the local population in scientific activities, e.g. surveying and monitoring and developing technologies such as geographic information systems that can identify the factors for energy use, the cost and pollution arising for different methods of coal and coke transport. Programmes are proposed to raise public awareness of energy and environmental issues and to educate the coke plant workers on how to recognise the quality and characteristics of coal and coke.

The research group is also conducting a survey of state-owned coke-producing enterprises versus less energy-efficient township and village enterprises to allow techniques to be compared and transferred.

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SESAMS: Strategic Energy Sector Assessment Methodology under Sustainability Conditions

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The identification, design and implementation of “sustainable energy systems” is a key element in the success approach to “sustainable development”. SESAMS seeks to develop the fundamental strategic and analytical capabilities necessary to identify sustainable production and use of electricity over the next several decades, primarily via the integration of existing and innovative models and analytical approaches as well as those currently under development.

SESAMS comprises three core analytical elements: horizontal electric sector simulation, vertical life cycle assessment and decision support analysis

The main aim of this research is to assist the overall decision-making process through the identification of innovative technologies and policies. To address long-term sustainability-related issues, portfolios of energy options and policy initiatives will be examined over several decades. Although initially exercised for Switzerland and North-Eastern USA, the proposed analytical framework has now been expanded to Ukraine.

Leverage and enhanced additional educational and research activities via the dissemination of the knowledge and analytical tools developed within SESAMS, beyond the advisory groups and participating AGS institutions, to the community at large.

Energy Consumption Indicators as Indicators of Sustainability

Indicators help to quantify, simplify and monitor events, states and developments. They are used to communicate findings to the general public, facilitate political decisions and/or help in the evaluation of policies. The targeted use of improved, meaningful indicators can enhance communication processes and also improve decision support for sustainability policies.

The aims and objectives of this project are:

- Quality criteria for the selection of the energy consumption and energy efficiency indicators that are most relevant to the description of the eco-efficiency of technologies, national economies and lifestyles
- Identification of policy indicators describing policy measures and bundles of measures with the aim of identifying interdependency between the efficiency/ energy indicators and the policy indicators
- Development of an information base dealing with the potential of efficient climate change policies (sectorial, national and multinational) that could support the decisions in climate change policy on the regional, national and multinational level

The results and findings from this project are:

- Effective indicators are much more situation-specific than was previously thought
- Knowledge of the importance of socio-economic and infrastructure factors which influence total energy consumption on the household level

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Biomass and Waste as Renewable Fuels for Process and Transportation

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Biomass and Waste (B&W) are readily available, ubiquitous resources. If managed and used sustainably, they are renewable and can contribute to a global reduction strategy for CO_2 emissions. Sustainable use of B&W for the efficient substitution of fossil fuels requires advanced technologies.

This research addresses primarily the technology challenge in the utilisation of B&W as energy and/or carbon sequestration. Gasification is often referred to as a complex and expensive technology, which on the economical level cannot beat the much more straightforward direct combustion.

The aims of the projects are:

- To assess the potential of gasification technologies
- To analyse the technical and non-technical reasons for the limited success of gasification in the energy technology market
- To identify the research needed to help advanced technologies find broader applications

Mobility and Pollution Control

Different forms of economic and engineering-based models have been applied to an analysis of GHG policies. Although each of these efforts attempts to integrate aspects related to energy, the economy, and the environment, they differ from one another in certain key aspects. As a result, these models are subject to one of two criticisms: “Top down” are said to concentrate too strongly on economic aggregates and trade flows and associated economic interactions, and they fail to capture the important micro-level details of energy technologies; “Bottom Up” are seen as being too weighed down by detailed descriptions of specific technologies, and thus are unable to account for general equilibrium adjustment that occurs in an economy or on a world level through international trade.

The research is designed to secure the advantages of the different model structures in a common study. The three linked models used are: the multi-sector, multi-region MIT Emissions Prediction and Policy Analysis Model (EPPA); a version of the MARKAL model, which is focused on the transport sector; a transportation model which projects an aggregated traffic volume and model split over several-decade time horizons.

The aim of this work is to illuminate transport issues in greenhouse gas control policy and to support a study of the joint application of these different models to a common analysis task. The three models are used to formulate consistent scenarios of regional and global transportation demand; examine how the transportation sector would be affected by energy sector CO_2 reduction targets and to study how transportation sector emission targets can be achieved at minimum cost in the light of the projected demand.

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A Spectroscopic Approach towards Local and Global Management

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Atmospheric trace gases play an increasingly important role in the earth's environment, largely as a result of increased human activity. Globally, they have a crucial impact on the earth's climate and chemical reaction networks in the atmosphere, and locally they have an impact on the health of the biosphere. It is therefore necessary to develop approaches for managing the trace gas content of the atmosphere on both the local and global scales.

The aim of this project is focused on the development and implementation of spectroscopic approaches to the management of the earth's atmosphere.

Substantial progress has been made in the demonstration of novel techniques and in selected applications to key atmospheric molecular species. Testing was done on several atmospheric species. A mobile system for field monitoring is currently being implemented in a measurement campaign for road traffic monitoring at a freeway tunnel near Zurich. The emphasis is on on-line ammonia recording and comparison measurement with other instrumentation.

The Lidar group at LPAS is developing the next generation of mid-IR laser absorption spectrometers for the creation of compact and highly adaptable devices for routine field deployment. Theoretical studies of interlayer dielectrics suggest a possibility for replacing high-GWP PFC compounds in the semiconductor industry.

A prototype DOAS system has been build and tested in Shanghai. A second prototype, based on Chinese components, is being developed, and provision for the production and training of operators in China has been initiated.

Development of Urban Air Monitoring Network in China – “China Sky”

Urban air pollution is a serious cause for concern in China and there is a need for qualified measurements of a range of compounds on a nationwide basis. The project aims to set up a network of high-quality air monitoring stations in China at an affordable cost. China Sky is ambitious, aiming for 500 instruments in operation within five years. It will provide sophisticated air quality data on the degree and temporal and seasonal variations of air pollution, it will facilitate the development of indices for information to the general public on air quality in the media and it will develop the measurement technology to a widespread commercial product.

The technology, DOAS (Differential Optical Absorption Spectroscopy), is available but at a price that hampers widespread use in developing countries. This difficulty will be overcome by bringing a DOAS pioneer (Professor Ulrich Platt) into the project team and by taking into account commercialisation aspects at an early stage in co-operation with the end-users.

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Regional Climate and Air Quality

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Recent research has made it clear that atmospheric pollution in the form of gaseous and aerosol constituents can substantially influence regional and global climate. Policy decisions regarding climate thus need to be taken into account in air pollution policies and vice versa. The interaction between the meteorological and the chemical components of the system is through regional circulation. Cloud and precipitation patterns determine the transport and wash-out of the chemical species, while the atmospheric pollutants feed back to the regional climate through radiative and cloud-microphysical processes.

This study found a slow, heterogeneous chemical reaction that may be of importance in areas of intense agriculture or where ammonia emissions are important. Soot from combustion sources when interacting with NO_2 may result in the formation of HONO, which is a trigger of photochemical smog formation. Hydrological feedback processes between the soil and the atmosphere, and in particular between soil moisture and precipitation are studied in order to assess the predictability of regional climate and to evaluate the impact of the climate change of water resources. Results show that precipitation in summertime mid-latitude climates rely heavily on the soil-moisture content.

Other important findings are: characterisation of the ice surface of cirrus clouds and contrail particles formed in the upper troposphere, where the greenhouse effect is the greatest; investigation of the mechanism of atmospheric oxidation of aromatic compounds, particularly toluene; investigation of chemical properties of soot particles, in particular their susceptibility to oxidisation by the hydroxil radical; characterisation of regional climate predictability.

Modelling Atmospheric/Ocean Variability on the Decadal Time Scale

Over the past decade, the societal need for more accurate prediction of climate has emerged as one of the greatest challenges in natural sciences. The need is driven in part by the increasing vulnerability of modern civilisation to fluctuations in climate, which have always been present, and in part by the growing evidence that anthropological activities may cause changes in the environment and climate.

The challenge in predicting climate arises from the enormous complexity of the climate system, which encompasses a range of space and time scales far broader than can be handled by even the fastest computers. The result is that even the most sophisticated models must make serious compromises in how they represent the climate system.

The aim of this research is to build a high-resolution atmosphere/ocean-linked model that can reproduce a different climate from the present one in a high spatial resolution.

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Predicting Sea Level Changes over the Next Century

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Over the centuries, global mean temperatures and sea levels have been rising. The rise in sea level is generally projected to continue and to accelerate over the next century. Sea level changes are recognised as being one of the major potential effects of climate change in society.

There is considerable uncertainty in the projection of the rise in the sea level. Making accurate projections of the rise in the sea level requires good knowledge and models of all the different components in the climate system that determine temperature, precipitation and how the land-ice components of the system respond to changes in these quantities.

The aim of this project is to calculate the “best estimate” of the rise in the global sea level during the 21st century by forcing the land-ice and ocean thermal expansion models with output from the new MIT-linked AOGCM, taken from a simulation using a global warming scenario.

Origin and Potential Control of Air Pollution in the Kathmandu Valley

Urban air pollution is a growing threat to sustainability in many developing countries. It affects not only human health but also pollution and climate on a global scale. Governments in developing countries have far fewer resources at their disposal to address these problems than those in developed countries. At the same time, the climate, emission patterns and socio-political systems in many of these developing countries are sufficiently different that a direct “transfer” of knowledge and “solutions” from elsewhere is not possible.

Better research and understanding is a key requirement for improvements in this area of sustainability. The aim of this project is to carry out an initial study of the processes that control air pollution in the Kathmandu Valley in Nepal. This valley is enclosed by mountains and is home to a rapidly growing city situated in a developing country with very few resources and little previous scientific data.

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AGS Book Series:
"Integrated Assessment of Sustainable Energy Systems in China"

The identification, design and implementation of "sustainable energy systems" is a key element in sustainable development. Recent reviews of the current state of long-range integrated energy system modelling have concluded that there is a lack of integrated energy assessment activity, with sufficient technological specificity, to educate decision-makers of the longer-term implications of policy decisions, particularly in a joint fact-finding and decision-making environment involving multiple stakeholders.

The project is focused on two main objectives:

- To develop a global methodology for analysing the true cost of electricity, taking energy technologies and their environmental impact into account and using China (Shandong Province) as a case study to demonstrate its effectiveness.
- To identify robust portfolios of energy options to assist the decision-making process among stakeholders through database development, risk assessment, demand forecasting, energy system modelling, life cycle assessment, environmental impact assessment and decision support analysis.

Energy Use and Well-Being in India

The reason for this project stems from the limited knowledge of the relationship between energy consumption and development and an insufficient understanding of which components in household consumption contribute the most to increasing energy use in developing countries.

Low energy consumption is not a cause of poverty and energy itself is not a basic human need. However, energy has for a long time been seen as being closely linked to a better standard of living and a lack of energy has been shown to correlate closely with many poverty indicators and general economic well being. At the same time, the pattern of energy consumption has several implications that are significant to general development and sustainable development in particular.

By determining the direct and indirect energy profiles of various groups of households, i.e. the sources of energy consumed, the energy consumption patterns, as well as the quantity of energy consumed by the different groups, can be evaluated. The research is aimed at developing a bottom-up energy model for the development of India.

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Isolated Rural Distribution Networks with a Large Penetration of Renewable Sources

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The principle scientific aim of this research is the development of a method to assess the performance of rural electricity distribution networks with a large penetration of renewable sources of energy (e.g. wind, sun and river flow). Performance is defined as the ability of the system to supply the customers with electric power of sufficient quality.

The research concentrates on the development of models for a reliability analysis of the supply. Some of the models can also be used in voltage quality assessment studies. The reliability, availability and quality of the supply are important criteria for social acceptance of the large-scale use of renewable energy. Additional results of the project are expected on the development of techniques for improving the performance and/or reducing the costs.

The results of this project can be applied to large interconnected (urban) networks with renewable sources of energy.

The underlying long-term objective of this collaboration and related projects at the institutes is the propagation of a new way of thinking in the design of electric power systems, i.e. “the system should adapt itself to the sources of energy, not the other way around”. This long-term objective will be pursued through undergraduate and postgraduate teaching and through research on the integration of renewable energy sources in electric power systems

Clean and Efficient Use of Coal

The cleaner and more efficient use of coal by China may help sustain Chinese economic development and at the same time mitigate local and regional pollution problems and reduce the risk of global, regional and local interests, thus creating opportunities for international environmental co-operation.

Improved energy efficiency may ease one constraint on Chinese economic development. Over the past decade, the economy has grown while energy intensity has dropped. By reducing demand for energy per unit of output, improvements in energy efficiency may ease short-term energy bottlenecks and long-term energy dependency.

Aims/Objectives

- To conduct research into environmental aid and coal combustion in China in order to examine how the fit between local technical and economic conditions and international aid programmes affects the assimilation of coal combustion technologies
- To examine domestic Chinese programmes, bilateral Japanese programmes, Global Environment Facility (GEF), activities implemented jointly, and other environmental initiatives that promote the clean and efficient combustion of coal in China.

Results and findings from this project are shared with Chinese government officials, the World Bank and ABB.

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Large Scale Demonstration of Sustainable Buildings for Chinese Urban Housing

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The boost in the Chinese economy over the past years has led to a significant increase in energy use. Energy expenditure in the form of air conditioning systems has raised concerns about the large emissions of CO_2, SO_2, and CFCs into the environment.

A large amount of the architecture in China today is copied from the West despite differences in climate making air conditioning necessary and many buildings energy-inefficient. However, excellent traditional methods of controlling indoor air temperature and quality do exist in China.

In co-operation with Chinese researchers, architects, and developers, this project aims to plan, support, monitor and evaluate a demonstration building in a residential area of Beijing. This building is construct using many traditional, passive technologies, such as shading devices and natural ventilation to conserve energy and still offer the expected comforts to its inhabitants. It is anticipated that when the demonstration proves to be successful, similar designs will be used for subsequent buildings.

Improving Sustainability in Heavy-Polluting Sectors in China

This research is focused on regional analysis in the Shanxi and Liaoning Provinces.

The overall aim of this research is to determine the economic, environmental, technological and transportation factors that are affecting the provincial and industrial energy intensities, i.e. energy consumption per unit of output, and environmental pollution in the People's Republic of China (China), to improve the sustainability of development in China.

Now that some of the most important underlying factors affecting energy intensity and environmental pollution have been determined for that sector in the Shanxi Province, the team is shifting its focus to the Liaoning Province, which is the biggest energy consumer of all regions in China.

In 1999, the total energy consumption in the Liaoning province was 93.84 million tonnes (standard coal equivalent—sce). The Liaoning Province is a main producer of iron and steel, which is an energy-intensive sector. More specifically, the Chinese iron and steel-making sector is located in that province. The research team is also shifting its work on freight transportation in order to analyse the entire steel-making supply chain from the coal mines the coke plants, the steel plants and the major final users of steel, such as automobile manufacturers and exporters.

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EDUCATION

Being university-based, the AGS connects with the next generation, who will be called upon to address the challenges of sustainability during this century. Preparing the students of today to capably and successfully lead society in an increasingly sustainable relationship with the environment is a defining component of the AGS mission.

Education and Outreach for the Alliance for Global Sustainability

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The Task Force on Environmental Education originated at the Tokyo Annual Meeting of 1999 as a reaction to the abundance of AGS research results and the lack of outreach accomplished.

The focus of this project is to spread knowledge of environmental sustainability to the broadest audience possible, starting with the university education level at the partner institutions. The goal was to bring the results of the many AGS projects to the general public and decision-makers and to incorporate the knowledge acquired from these projects into the curricula of our three institutions.

This study will consist of examining what students are presently taught, what topics are essential, how multidisciplinary AGS projects can be immersed into the standard curriculum, and what must be done to make the faculty supportive of changes in teaching methods. Practical aids that will be used within the task force plan are surveys conducted with students, faculty and alumni, inventories, workshops for the faculty and an informational website. The project participants will also use the Annual Meeting in Boston in 2000 as a platform for their environmental education work.

The results from this work have been implemented, such as the Student Environmental Attitude Survey and the Youth Encounter on Sustainability (Y.E.S), which was held in Braunwald, Switzerland.

Delivering Research Results to the Educational Process

One of the key goals of the AGS is to “prepare a new generation of leaders in all sectors who are focused, competent, and decisive in the effort to meet the significant challenges of sustainability”. A task force within AGS has been exploring various strategies for achieving these ambitious and important educational goals, including student attitude surveys, curriculum development and, most notably, establishing the Youth Encounter to Sustainability, a summer course in Braunwald, Switzerland.

During the course of these efforts, it has become evident that a clear strategy is required for transmitting the results of current research on sustainability and the environment. Students need to acquire the knowledge that is applicable to specific solutions and to develop the expertise needed to devise and implement these solutions within a complex, multidisciplinary framework. At the same time, the educational products offered must be effective and capture the students’ interest.

The goal of the present project is to identify gaps and opportunities in existing and completed research projects at the AGS partner universities, to analyse and describe suitable case studies dealing with different questions in different areas and applications, and to present these case studies, based on good educational materials, to motivated students for a self-directed learning process

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MOBILITY

Enhanced mobility is both an end that directly enhances well-being and a means to further human development. However, there is a growing realisation that sustaining even the present levels of mobility, let alone accommodating anticipated growth in demand, will require difficult trade-offs. AGS research on mobility is extensive and is moving towards understanding and reconciling these factors.

Background Systems and New Technologies that Make Urban Transportation Work

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Mobility is fundamental to our economic and social vitality, influencing the structure of cities and urban areas. Increased mobility and economic development have proceeded in unison. Automobiles instilled an unprecedented level of personal mobility, reconfigured urban landscapes and influenced lifestyles.

In recent years, there are numerous indications of our inability to maintain, let alone improve, mobility. Increased mobility has also caused serious social concern, such as the allocation of scarce land resources for the transportation infrastructure, the depletion of finite energy resources and the detrimental environmental and safety impact. While governments have responded to these concerns through policy and regulation, their implementation has not always produced the desired results. Large public sector initiatives, such as building roads, have seldom alleviated public concern. Although the need for mobility to facilitate social and economic well-being are well recognised, mechanisms to provide that mobility in an efficient, socially responsible manner have not been articulated sufficiently.

The goal of this project is to understand what makes actions to improve urban transportation work in some places and not in others. The research is based on the knowledge that many of these preconditions are not attributes of the transport policy itself but are conditions of the economy, financial practice, political management and the institutional structure of each venue.

The project has established a comparative analysis of technology options for sustainable transportation, it has evaluated the performance of advanced hybrid vehicles and electric vehicles, it has studied the use of fuels from renewable sources in fuel cell vehicles and it has conducted case studies of the cities' experience of mobility measures in both developed and developing countries.

Implications of Fuel Additives to Global Sustainability

One of the major human activities affecting the earth is the use of fossil fuels for transportation. Substantial efforts have, and continue to be, made to evaluate the influence of associated releases of CO_2 on global climate, the roles of fuel-derived hydrocarbons and oxygenates in the formation of photochemical smog, and the prospect of environmental damage due to fuel spills above and below ground.

However, almost nothing is known about the environmental fates and effects of the suite of synthetic additives being added to fuels in order to tailor the fuel properties to meet the needs of modern combustion engines and constraints imposed by recent legislation. This is alarming, especially in light of the historical problems derived from the addition to gasoline of the antiknock agent, tetraethyl lead.

The aim of this project is to identify problematic additives and to develop a model and approach for estimating the prospective environmental hazards of new additives before they are utilised widely.

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The Role of Innovative Technology in Promoting Sustainable Mobility

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The key result of this research is a comprehensive rating of policies that support the introduction of low-emission vehicles. Such a rating is based on a long-term, scenario-based integrated assessment that incorporates various technological, social, economic, and environmental assessment criteria.

This project studies criteria for the successful introduction of technical solutions supporting sustainable mobility. As new technologies will only be successful with the acceptance of societal stakeholders, such as consumers, automotive companies, energy companies and public authorities, it is necessary to understand and reflect on their views in the assessment of potential policy measures.

This research is concerned with the supply side of mobility and transport as well as interactions between supply and demand, and explores the options available to provide the necessary transportation services and goods to people affordably with minimum use of resources and environmental impact.

The aim of this research is to contribute to policy assessments for low-emission car fleets that integrate the perspective of real-world stakeholders in a realistic manner. The research project has three specific objectives:

- To assess various vehicle technologies according to their economic and ecological criteria
- To analyse the traffic system as a whole, looking at the interplay between the various demand and supply options
- To assess mobility from the standpoint of sustainability using quantitative indicators

The Future of Mobility

Mobility is one of the most fundamental societal and economic needs. Satisfying this need involves striking a careful balance between demand and supply, taking into account social, ecological and economic concerns. It is necessary to explore how societies can balance the goals of enhanced physical mobility for citizens, continued economic growth and environmental sustainability to reduce pollution, protect crucial ecosystems, conserve natural resources and provide a high quality of life.

The research has focused on examining the potential of new technologies to reduce adverse environmental impact, preparing metropolitan-level case studies to document and assess innovative approaches in order to provide mobility, and modelling future worldwide and regional demand for mobility and exploring the environmental consequences of this activity.

The objectives of this research included the following:

- To analyse technological measures for the reduction of transportation carbon dioxide emissions
- To estimate the potential of urban management measures, both on the supply and demand side, for carbon dioxide emission abatement on a world-regional scale in North America and Western Europe
- To advance powertrain studies and life-cycle assessments of fuels, emphasising energy efficiency and the use of material resources during the lifetime of a vehicle, from construction to disposal, and associated pollutant emissions

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Fundamental Patterns of Travel Behaviour and Their Policy Implications for Land Use, Congestion and Air Quality

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The growth in motorised travel has generated various external effects, including land-use, congestion and air quality. To cope with these problems, policy-makers worldwide need to see and understand the links between society and our transportation system. Such complete studies have so far been lacking and have led to hasty conclusions on how to affect automobile use and travel behaviour in general.

The aim of this research team is thus to perform a large-scale analysis of human travel behaviour to help policy-makers find the appropriate policies to generate a shift toward more sustainable travel patterns.

The project team has examined a large number of travel surveys and analysed travel patterns in different regions and countries, using a standardised methodological approach to obtain an overall picture of mobility. The analysis revealed largely comparable travel behaviour across very different settings, such as income, degree of urbanisation, etc., underlining the fact that human behaviour is very similar.

Having learned that human travel behaviour is very similar, it appears, in principle, that one specific package of policies can result in a similar consumer reaction in different parts of the world. However, such packages need to be fine-tuned very carefully due to differences in economic development and other factors.

POLICIES AND INSTITUTIONS

Policies and Institutions are the building blocks for the transition to sustainable pathways to development. The AGS is working towards the development of a coherent theory of clean development and improvement in methodologies for decision-making on all levels in both the public and private sectors. Our orientation is to contribute to a paradigm shift in policies and structures for sustainable development.

Breakthroughs in the System of Sustainable Technologies

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It is generally accepted that the development of new technologies is necessary for a sustainable future. However, as we search for ideal economically and environmentally friendly technologies, we often lack the knowledge of what makes specific solutions marketable. This project looks at factors such as price, disclosed information regarding techniques, consumer habits and policies and their effect on the acceptance and actual application of an idea.

The primary objective of the project is to understand the dynamics of the complex interorganisational networks that drive sustainable technology development. These networks are constituted, and are sustained, by problem-centred interactions among the developers and consumers of technologies, financial institutions, governmental agencies and, increasingly, non-governmental and other civic organisations. The translation of these findings into practice-relevant terms for these different organisations and the management of transdisciplinary dialogues among these organisations is a second objective that is a continuous part of the research process.

The case studies have show that when regulations are relatively lax, firms would have little incentive to make innovations, responding instead through the use of end-of-pipe technologies. Under stringent regulation, companies are encouraged to look for new, radical solutions, although if these solutions are applied in an inflexible way it may lead to the adoption of inappropriate technology and technological lock-in.

Researchers have also identified seven roles that are significant to public entrepreneurship. This determination is critical to initiate action that motivates participants and shapes the action environment that characterises the successful cases of technology development. The roles are: pioneer, venture capitalist, organiser, superintendent, mediator, educator and steward of the common good

Capacity Building for Industry and Business and the Value of Knowledge

The 1999 AGS Mapping Project, in its extensive review of the organisation, found that while much useful information originates from AGS research, a significant gap exists between the scientists with their results and industry members who can actually use them. This project aims to make the knowledge acquired as a result of AGS available to industry for implementation.

The purpose of the project is to:

- Explore and define the best ways of representing, exchanging and applying the knowledge generated by AGS partners and industrial collaborators in business and industry applications 'on the ground'
- Extend knowledge about the best ways of representation to regional business and scientific networks, and on this joint basis
- Formulate and execute a pilot strategy of knowledge-sharing in applied contexts
- Reduce the gap between the knowledge generated by the AGS researchers on the one hand and industry capacity in the sustainability domain on the other.

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Environmental Concerns in Lending and Environmental Risk

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Wise investors profit by taking prudent risks. One of the risks firms (and investors) are increasingly exposed to is the environmental risk. This risk may take many forms, including the potential for increasing costs due to stricter governmental regulation of by-products in production, disruption in the availability of key factor input due to material scarcity or regulatory decree etc. While firms and investors are far more aware of environmental risks today than they were ten years ago, no systematic methodology exists at present to guide investors in underwriting environmental risk.

The objectives of this project are:

- To understand how lenders and other investors underwrite or evaluate environmental risk. In addition to producing a series of cases, the aim of the project is a better understanding of how principles of sustainability might be incorporated into the routing processes of investment analysis.
- To understand how environmental consideration influences lending practices at financial institutions. The focus lies on investment decisions concerning companies, projects and real estate. In addition to case studies, the goal is a better understanding of how sustainability principles might be incorporated into the routine of lending processes to be of benefit to the environment and the competitiveness of lending institutions.

Through this research it was found that banks very seldom use quantitative indicators to measure the environmental risks of their debtors.

North-South Joint Ventures for Sustainable Financial Investments

North-South joint ventures are of increasing importance in sustainable development. The Kyoto protocol provides a framework for planning and building such ventures jointly across different continents. Sustainability networks striving for joint activities in the Cleaner Development Mechanisms (CDM) involve many and diverse agents, ranging from large banks in Europe to small forestry project owners in Latin America.

The aim of this project is to investigate the agencies' network as well as differences in mental models (preferences, beliefs etc.) of individual agents. This study evaluates the sustainability of such joint ventures as well as their business risks and opportunities. As a result we expect to suggest improvements for sustainable North-South joint ventures in terms of efficiency and effectiveness from an organisational point of view.

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Cross National Variation in Environmental, Health and Safety Risk

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A major constraint in effective policy formulation for government and industry is the lack of understanding of how regulatory regimes and business strategy can reconcile competing private and public interests. There is limited knowledge of how to reconcile competing private interests in sustainable development programmes, especially the market competition objectives of individual businesses.

The overall aim of AGS research into corporate strategies is to analyse various links of environmental regulation and corporate strategies, and to explore mechanisms by which complementarities between public environmental interest and private environmental performance may be enhanced to achieve sustainable development. The research has been carried out through three related AGS grants since 1997.

The aims of this research are:

- To investigate under which conditions convergence or divergence of environmental regulations in different countries or regions is preferable with regard to global sustainability
- To investigate conditions under which such convergence or divergence are likely to occur
- The research was carried out with a theoretical impact analysis and case studies that were region-, sector- and institution-specific.

Corporate Strategy, Regulation and Global Competition

The aim of this research is to determine, on the individual firm level, the strategic competitive benefits of promoting sustainable development, and to identify and assess the alternative corporate strategies for capturing those benefits. A basic constraint on both governments and businesses in formulating more effective approaches to sustainable development is the lack of clear conceptions of how regulatory regimes and associated corporate competitive strategies can reconcile competing public and private interests. Most importantly, we lack an understanding of how to reconcile competing private interests, especially the market competition objectives of individual business organisations, in promoting sustainable development programmes.

The evolving policy debate suggests that the contending interest groups themselves may not be clear about what their interests actually are, let alone how best to serve their interests. In this light, this research aims to address three basic questions: What are the potential benefits to individual businesses of pursuing aggressive sustainability strategies; what are the necessary conditions for capturing those potential benefits and what are the corporate strategic policy alternatives for establishing those conditions? What are their relative risks, costs and benefits and how can government policies encourage promotion of corporate sustainability strategies?

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URBAN SYSTEMS

Urbanisation is one of the most powerful phenomena influencing global sustainability prospects today. The convergence of economic growth, population growth, and urban expansion offers enormous, great challenges and potential for realising metropolitan sustainability. Ongoing work in projects on mobility, water and energy also focus on meeting needs in growing urban environments and the special challenges that this growth raises.

AGS Future Cities: Guangzhou

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Developing countries are faced with two major urban sustainability challenges. The first is a rapidly growing population, concentrated mostly in urban areas. The second is the increase in the demand for resources for consumption and production in cities, which are at the same time the centres of economic growth and social inequality. The combination of such pressures leads to environmental problems on a local, regional and global scale. Cities also depend on resources produced elsewhere and put pressure on the regional environment through resource depletion and solid waste generation.

The focus on addressing these environmental concerns has begun to shift from end-of-pipe technologies to early problem recognition and resource recovery and reuse. However, fast-growing cities often lack the tools and resources to introduce environmentally sustainable technologies and innovative policy approaches. This research aims to address such urban sustainability challenges from both a technological and political point of view, focusing on water, transportation and village renewal in Guangzhou, China.

The research has been carried out in three phases:

- To bring together scholars who have worked extensively in areas related to sustainable development within the urban building context.
- To support the city of Guangzhou in addressing problems related to urban transportation, housing, waste and water management through the application and adaptation of the technical, social and policy analysis tools developed.
- To focus on outreach and multi-disciplinary, cross-cultural and trans-disciplinary co-operation.

Air Pollution in Megacities in the Developing World

Air pollution imposes significant direct and indirect health and economic costs on society. It overlaps with other complex urban and environmental issues, such as traffic congestion and mobility, land use and global warming, in megacities throughout the world. The Mexico City Metropolitan Area is a prime example of a megacity in the developing world facing challenges posed by these issues.

The AGS has provided support for an ongoing research initiative at MIT, called the Integrated Program on Local, Regional, and Global Air Pollution, referred to as the Mexico City Case Study.

This research aims to integrate atmospheric monitoring, health impact evaluation and modelling of fine particulates for informed policy analysis. The research is being carried out in the form of four synergistic activities, with the aim of improving the capability to assess the effectiveness of proposed regulation of air pollution of fine particles. Specific objectives include:

- Assessing the levels and types of fine particulate matter affecting the population in megacities of the developing world, using Mexico City as a case study
- Evaluating the health effects related to the atmospheric presence of fine particulate matter and developing damage functions specific to Mexico City
- Estimating the effectiveness of different emission control measures, using atmospheric modelling
- Designing and developing emission control strategies to minimise population exposure to fine particles

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The project has grown out of research at the Global Engineering Laboratory at the University of Tokyo. The project was subsequently expanded to utilise the Distributed Object-based Modelling Environment (DOME), which was initiated by the Computer Aided Design Laboratory at MIT within a previous AGS project ("Holistic Design").

The aim of the Tokyo Half Project (THP) is to discover integrated systems of ecologically effective and economically rational technologies with the ultimate target of achieving a 50% reduction in CO_2 emissions from the city of Tokyo. To achieve this, the project includes the following three objectives:

- To identify the analytical tools needed to assess building, energy, transportation and infrastructure, as well as policy alternatives; and
- To develop a dynamic, holistic simulation modelling system based on model integration on the Internet that allows specialised models of technological and policy alternatives to exchange information in order to comprehensively evaluate their overall impact on the overall system; and
- To evaluate how new and existing technologies might be integrated to reduce greenhouse gas emissions without compromising overall services.

The expanded research aims to create a prototype of an urban "sustainability collaboration platform," based on distributed peer-to-peer model integration to build networks of integrated system models, with the DOME software infrastructure as the main enabling information technology. This collaboration platform is envisioned as providing an Internet-based knowledge exchange and integration forum that can be used to develop integrated sub-systems of technologies and to comprehensively simulate the effects of those integrated sub-systems on the entire industrial ecology system of an urban region.

Designing, Implementing, and Measuring Sustainable Urban Development (DIMSUD)

This project has grown out of research at the Global Engineering Laboratory at the University of Tokyo. The project was subsequently expanded to utilise the Distributed Object-based Modelling Environment (DOME), which was initiated by the Computer Aided Design Laboratory at MIT within a previous AGS project ("Holistic Design").

The objective of the Tokyo Half Project (THP) is to discover integrated systems of ecologically effective and economically rational technologies with the final target of achieving a 50% reduction in the CO_2 emissions from the city of Tokyo. To achieve this, the project includes the following three objectives:

- To identify the analytical tools needed to assess building, energy, transportation and infrastructure, as well as policy alternatives; and
- To develop a dynamic, holistic simulation modelling system based on model integration on the Internet that allows specialised models of technological and policy alternatives to exchange information in order to comprehensively evaluate their general impact on the overall system; and
- To evaluate how new and existing technologies might be integrated to reduce greenhouse gas emissions without compromising overall services.

The expanded research aims to create a prototype of an urban "sustainability collaboration platform", based on distributed peer-to-peer model integration to build networks of integrated system models, with the DOME software infrastructure as the main enabling information technology. It is envisaged that this collaboration will provide an Internet-based knowledge exchange and integration forum that can be used to develop integrated sub-systems of technologies and to comprehensively simulate the effects of those integrated sub-systems on the entire industrial ecology system of an urban region.

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WATER AND AGRICULTURE

Access to water is a key condition for food production and economic development. Water shortages contribute to poverty and starvation and severely constrain industrial development. Yet today, more than two billion people are living in areas of the planet affected by severe weather stress and that the number is expected to grow to over four billion over the next 25 years.

Sustainable Water Management

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Fresh water is considered to be the first natural resource to reach its limit on a global scale as the demand from a growing global population continues to increase. In many arid and semi-arid regions of the world, water stress is already causing severe nutrition and health problems, limiting economic and social development and leading to political tension in trans-boundary river basins. Concerns about the sustainability of water resources give rise to the need for a better understanding of the driving forces and the consequences of water use. Enlightened watershed management is a necessary component in global sustainability.

The primary aim of this project is to derive generally applicable criteria and concepts for sustainable water management and in doing so to contribute to the evolution of an integrative evaluation methodology as a practical decision-making tool. The analysis focused on the process of utilising scientific findings in society and politics, particularly the interrelations between sustainable water management and social, economic, and institutional prerequisites.

The case studies highlighted different prioritisation of water management in the four areas, stemming from differences in the developmental stage, water usage, socio-cultural factors, etc. Such differences point to the challenges associated with developing globally applicable criteria and the concepts for sustainable water management.

Sustainable Water Management in Developing Countries

While there is more than enough fresh water available on a global basis to meet the needs of the present population, this water is not distributed evenly over time or space. Many areas with the fastest growing populations in the world are arid or semi-arid and face chronic water shortages. The pressure on water resources in arid regions with large populations raises the question of whether agricultural activity in the regions is sustainable.

The overall aim of this research is to assess and promote sustainable agriculture in a world of limited resources and growing demand by:

- developing a general hydrologic-economic model to analyse the sustainability of irrigated agriculture, which can provide the "virtual environment" to structure debate on the merits of different policy options
- gaining a better understanding of the state of water resources and the sustainability of agricultural practices in critical developing regions
- showing how new environmental assessment technologies can be used to evaluate the sustainability of current water management practices and to support the formulation of sustainable policies

AGS research has catalysed associated research and training support from other sources, including the Swiss Development Agency and UN agencies. The group has also been able to make concrete policy recommendations by working directly with the Department of Water Affairs in Botswana. In addition, Australian researchers have been using and improving the models developed during the first research phase in their assessments of local policy options, both in and beyond the original study area.

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Precision Management of Cereal Fields

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Ensuring food availability to the growing population of the world presents a major challenge to mankind. It is essential that global food production increases significantly in the coming decades. However, there is abundant evidence that even present production levels in many cases are achieved with considerable environmental damage and are not sustainable. Soil degradation affects approximately 35% of the earth's land surface. Ecologically sound agriculture should be aimed at preventing soil degradation, maintaining the soil's productive potential and reducing environmental pollution.

The use of minimum tillage systems improves important soil processes, such as erosion control, carbon sequestration, soil organic matter enhancement and water conservation. Such systems, combined with an information-based approach to pesticide and fertiliser application, could be used to improve the sustainability of wheat production. Some 60% of the world's cultivated land is still farmed in small units using traditional, subsistence methods. There is thus an urgent need to focus on the circumstances of small farmers, particularly in the developing world, and to redress the bias of agricultural research towards large enterprises.

The aim of this research is to evaluate the feasibility and application limits of sustainable crop-growing technologies in small-scale cereal production, including reduced tilling agriculture that integrates conventional technologies and micro-controlled agriculture that utilises innovative engineering technologies, and to present the knowledge acquired to policy-makers and researchers who can affect agricultural education and behaviour, focusing on a developing country.

Yellow Dust: Integrative Model Approaches

Yellow dust from arid land in China and neighbouring countries is an annual phenomenon that affects the environment, productivity and human health in the East Asia region. It causes air pollution and dust storms, impacts on agriculture and the transportation infrastructure and interferes with high-tech industrial operations in China, Japan, and Korea. It is suspected of causing a number of diseases along its trajectory. Some mitigating activities require water and land needed for agriculture, often in conflict with local demands. The increased incidence of the dust-blowing activity in recent decades and greater awareness have turned this phenomenon into a major point of debate among the three nations.

Different aspects of the issue have been studied using the best available methods and modelling tools in various disciplines. However, previous analyses tended to be compartmentalised and have not captured the problem in a holistic manner. The complexity of the environmental concerns as well as socio-economic considerations associated with this problem warrant a systematic approach that encompasses various disciplines.

The overall aim of the project is to conduct a comprehensive study of the yellow dust problem by developing a system to link the existing problem-solving techniques that maximise their merits.

The research aims to carry out a holistic and systematic analysis of how to minimise the economic and health impact in different regions, to alleviate effects on water and land resources in various sectors and to suggest necessary counter-measures. To do so, the research team uses an “interactive model approach” to describe complex interactions of the yellow dust phenomena by combining independent models.

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An Integrated Analysis of Water Scarcity, Food Security and Environmental Sustainability for Policy Development

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Water, environment and food security are interrelated on the local, regional and global level. The interdependency among these components is particularly important for water use in irrigated agriculture. With increasing water demand, the competition between agriculture, the environment, industry and domestic use has escalated in many areas of the world. On the supply side, the availability of useable water resources has decreased due to excessive exploitation of ground water and pollution.

Massive withdrawal and diversion of surface water have led to environmental and economic degradation. Unsustainable pumping rates for groundwater have caused a rapid decline in groundwater tables in many of the arid and semi-arid areas and the saltwater intrusion in coastal regions. Poor irrigation practices, accompanied by inadequate drainage, have often damaged soil through over-saturation and salt build-up. Inappropriate use of chemical fertilisers and pesticides has polluted water sources through return flows, further reducing freshwater availability.

The increase in water scarcity and the consequent environmental problems could threaten entire agricultural production systems, as well as human health and natural life systems. Solutions are urgently needed to accommodate these competing demands while improving both food security and environmental sustainability.

The aim of this research is to develop a framework for integrated analysis of water scarcity, food security and environmental sustainability and to:

- Identify the role and significance of integrated water, food and environmental policies in the process of agricultural and environmental protection, as well as economic growth
- Develop a framework for an integrated analysis for policy formulation
- Explore suitable channels to incorporate an education programme into the research project

Academic Collaboration for Water, Development and Sustainable Environment in the Greater Mekong Sub-region

The Greater Mekong Sub-region is one of the regions in the world with the lowest income levels. While abundant water supports the ecosystem and agriculture in this region it also causes natural disasters, such as flooding. Future economic growth may intensify water use and consequently have an adverse effect on aquatic ecosystems. A comprehensive and harmonious management plan of the watershed is therefore indispensable for sustainable water use and development and for maintaining ecological integrity.

For this kind of plan to be produced, basic data on water quantity and quality, water use, and alternative water sources is very important, likewise a comprehensive ecological model. In this study, we will focus on the lower Mekong Region, including Cambodia and the Mekong Delta in Vietnam. This region is the most productive in Indochina but suffers from a number of natural and man-made environmental problems, such as flooding, saltwater intrusion and groundwater pollution. Intensive agriculture and aquaculture may further aggravate the problems in water use and the conservation of natural ecosystems. Conflicts between different regions and different water uses may exacerbate the equitable and efficient use of water resources.

The aim of this research is to find the current problems preventing integrated management of the Mekong River Watershed and to propose ways for sustainable watershed management, socio-economic development and maintaining ecological integrity. To achieve this aim an academic network has been constructed to gather basic data, produce ecological and socio-economic models and strengthen the academic potential of the universities in the Mekong Region.

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Arsenic and Water Supply Systems

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In the early 1970s, one quarter of a million children died each year in Bangladesh and West Bengal from water-borne diseases. In response to this problem approximately four million tube-wells have been drilled in the last 30 years, which supply 90% of the population with water. These same wells however, may prove to be the largest mass poisoning in history. Groundwater throughout Bangladesh and West Bengal is contaminated with naturally occurring arsenic. Around 35% of the wells are contaminated with levels above 50 ppb, which is over the WHO's recommended standard of 10 ppb. It is not clear what proportion of the population is suffering poisoning or will eventually contract cancer as a result of arsenic.

The overall aim of this project was to establish scientifically reliable and socio-economically and culturally feasible guidelines for sustainable water use systems in arsenic-polluted areas in Asia, focusing on Bangladesh. Findings from this study include:

- Dermatological inspection revealed that 60% of the children examined had skin lesions, which may be related to arsenic exposure.
- Interview survey of adults revealed that the subjective consciousness of arsenicosis did not arise while the symptoms were mild or even moderate.
- Monitoring of eight tube wells showed that the arsenic concentration was fairly stable with less than double the max/min ratio
- The removal efficiency of arsenic is highly dependent on the concentration of iron. The recommendation is that all wells with a high iron content should be treated.
- Four to eight drops of lemon juice per litre of water proved to be an ample, low-cost, relatively effective means of arsenic removal (50-70%) particularly for the Bangladeshi communities.

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