Strategy Paper

TAAS Foundation Day Lecture

Climate Change and Food Security :

From Science to Sustainable Agriculture

by

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Doha, Qatar

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Progress Through Science

Trust for Advancement of Agricultural Sciences

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Trust for Advancement of Agricultural Sciences (TAAS)

GOAL

An accelerated movement for harnessing agricultural sciences for the welfare of people.

MISSION

To promote growth and advancement of agriculture through scientific interactions and partnerships.

OBJECTIVES

- To act as think tank on key policy issues relating to agricultural research for development (ARD).
- Organizing seminars and special lectures on emerging issues and new developments in agricultural sciences in different regions of India.
- Instituting national awards for the outstanding contributions to Indian agriculture by the scientists of Indian and other origin abroad.
- Facilitating partnerships with non-resident Indian agricultural scientists visiting India on short leave.

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Climate Change and Food Security: From Science to Sustainable Agriculture

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1. Introduction

The climate change issue is global, long term and involves complex interaction between demographic, climatic, environmental, economic, health, political, institutional, social and technological processes. It has significant international and intergenerational implications in the context of equity and sustainable development.

Climate change will impact social, economic and environmental systems and shape prospects for food, water and health security. The world's capacity to mitigate and to adapt to climate change impacts is strongly related to future development paths. Socioeconomic and technological characteristics of populations strongly affect emissions, explaining the pace and capacity of societies to adapt to and mitigate climate change.

Recent developments in geographical information systems, data acquisition by remote sensing, and increasing quality and spatial coverage of global resource databases, has enabled modeling to identify potentials and environmental constraints to crop production at regional and national levels. The integration of these assessments in the global food economy together with projections of future climate change enables evaluation of impacts of climate change on food security and agriculture and provides a basis of prioritizing regional and commodity specific agricultural research for adaptation and mitigation.

2. Food Security and Agriculture

Food is universally recognized as a fundamental human right. At the global level there is enough food to meet every person's need, and yet one sixth of the world's population continues to be undernourished. Every year some 15 million people die from hunger and over 200 million suffer health consequences due to deficiencies including proteins, micronutrients and essential amino acids. Balanced nutrition is the foundation of good health and healthy people are less susceptible to infection and disease.

For decades, the world community has failed to deliver the universal right to food. In 1974 the World Food Summit promised to "eradicate world hunger within a decade." In 1996, 2000 and 2002 the pledge came to "reduce world hunger by half by 2015." Sadly, these remain empty promises with little progress. It is particularly concerning that the most recent 2009 World Food Security Summit in Rome concluded with the urgency to eradicate world hunger but with no mention of a time line. We have the capacity and resources to eradicate hunger but we lack the political will and commitments to mobilize and implement actions.

Beyond the overarching problem of world hunger, today there is also an emerging problem of "over" consumption resulting in obesity and related health disorders such as diabetes and cardio vascular diseases. More than 800 million people worldwide are estimated to be obese and this number is growing. The next world food crisis will undoubtedly be of human health, whether caused by too little food or too much food that will affect people in all countries, developing and developed.

Agriculture is the dominant user of the environment and natural resources, and it has the greatest impact on sustainability of ecosystems and their services. The agriculture sector is often not given the political attention and commitment it deserves, especially in developing countries. It is here where trends indicate reduced allocation of national development budgets to agriculture, including investments in agricultural research, extension services and training and rural infrastructure and services. Furthermore there has been a substantial decline in multilateral lending and bilateral aid for this sector.

It is a paradox that the while farmers tend to be strong political lobbyists in cities like Washington, Brussels, and Tokyo, in developing countries their voice is seldom heard. This in spite of the fact that agriculture often accounts for a significant share of the gross domestic product and rural employment.

Many interactive processes determine the dynamics of world food demand and supply. Agro-climatic conditions, land resources and their management are a key component, but they are critically affected by distinct socio-economic pressures, including current and projected trends in population growth, availability and access to technology and development. In the last three decades, average daily per capita intake has risen globally from 2,400 to 2,800 calories, spurred by economic growth, improved production systems, international trade, and globalization of food markets. Feedbacks of such growth patterns on cultures and personal taste, lifestyle and demographic changes have in turn led to major dietary changes – mainly in developing countries, where shares of meat, fat, and sugar to total food intake have increased by about 40 percent.

Many food insecure countries rely on imports for their food security. This is highly concerning as situations may arise where food is not available on world markets to purchase at any price. The world food crisis in 2007-2008 saw staple food prices rising more than two folds in a matter of weeks, triggering food riots around the world. The situation was exacerbated by a number of factors including, for example, low levels of world food security stocks, increased food import demand from emerging nations such as China and also diversion of food crop land in some countries to biofuels mandated targets. A number of major producers reacted to the crisis by imposing embargoes on staple food exports, for example, a ban on rice exports by India.

The challenge in the 2050s will be doubling food production to meet the food needs of an additional 2.5 billion people. Land expansion is not an option in all but a handful of countries. Over 75% of additional food production will need to come from productivity increases. This will require a new Green Revolution and substantial investments in public and private research with a particular emphasis on the crops of the poor.

The key issues comprise how to link agricultural sciences, research and technology development, sustainable land, water and biodiversity management, integrated national and international policies and actions. The scientific community, civil society, national governments, and the international development community bear the fundamental responsibility to achieve nutritionally healthy, productive and sustainable food systems. Climate change will also make the task of achieving food security for all that much more challenging in the 21st Century.

3. Climate Change and Agriculture

There is significant concern about the impacts of climate change and its variability on agricultural production and productivity worldwide. Issues of food security figure prominently in the list of human activities and ecosystem services under threat of dangerous anthropogenic interference on the earth's climate. Each country is naturally concerned with potential damages and benefits that may arise over the coming decades from climate change impacts on its territory, since these will affect domestic and international policies, trading patterns, resource use, regional planning, and ultimately the welfare of its people.

Current research confirms that while crops would respond positively to elevated CO_2 in the absence of climate change, the associated impacts of high temperatures, altered patterns of precipitation, and possibly increased frequency of extreme events such as drought and floods, will likely combine to depress yields and increase production risks in regions, widening the gap between rich and poor countries. A consensus has emerged that developing countries are more vulnerable to climate change than developed countries, because of the dominance of agriculture in their economies, the scarcity of capital for adaptation measures, their warmer baseline climates, and their heightened exposure to extreme events.

Climate change will result in irreparable damage to arable land, water, and biodiversity resources, with serious consequences for food production and food security. These effects will be heightened in developing countries with a low capacity to cope and adapt. While the international community has focused on climate change mitigation, the issue of adaptation to climate change is equally pressing.

Scientific assessment of the causes and consequences of climate change is important, but the real need at the local and national levels is adaptation and mitigation measures. At most, we have a 30 year window of opportunity to deal with the threats of climate change; if we wait any longer, it will be too little too late. At the same time, climate change is a global phenomenon and requires a global partnership. The developed countries should take the lead in view of their substantially higher energy consumption and emissions, resulting in the accumulation of GHG in the atmosphere. In contrast, most developing countries have contributed relatively little to the causes of climate change, yet will bear the brunt of its impacts. The world community must take stock of the differences in nations past and future emissions, and take prevailing socio-economic conditions into account as well.

Today, we have scientific knowledge of climate change, but we do not yet have a functional partnership between politicians, scientists, the business community and the consumers in order to move beyond rhetoric to real actions. While many developed countries have carried out assessments of the impact of climate change on their own economies and natural resource environments, most developing countries thus far have not done so. International negotiations are often constrained in an environment where one group of countries is well-informed and another is not. A concerted worldwide effort is required to carry out national analyses of the potential impacts of climate change and to adopt policy regimes and measures to mitigate and adapt to its risks and consequences.

The recent climate change summit in Copenhagen focused on reducing greenhouse gas emissions and mitigating climate change. The issues of adaptation to climate change, especially with regard to food security and agriculture were not given due consideration. Without this eradication of world food insecurity will be hindered. The world desperately needs an ethical commitment to implementation and an acceptance of differential responsibility. Without action there can be little hope to feed and save the world from the real, emerging and definitive threats of climate change.

4. Food Security and Agricultural Sciences

The scientific and technological experiences of the last half century, including the remarkable progress in science based conventional breeding, will need to be combined with safe and ethical biological sciences- molecular genetics, informatics and genomic research and improved land, water and agro-biodiversity management systems, ethical and environmentally sound livestock production and fish farming.

The developments in geographical information systems including remote sensing and the increasing quality and coverage of sub national, national and global resource data bases of soils, climate, land cover, together with methodologies for crop, livestock and fish productivity assessment and policy analysis tools will need to be systemically integrated to ensure environmental, economic and social sustainability.

The increasing privatization of agricultural research and patenting requires a new paradigm of mobilizing public-private partnerships, especially with regard to ensuring that the poor have access to the new breakthroughs in agricultural science and technology.

The national and international agriculture research system faces a formidable challenge to harness the power of science. Difficulties include:

- Using Science Responsibly — combining the best of conventional breeding with safe and ethical molecular and cellular genetics research and biochemistry for productivity and nutritional enhancement. Biotechnology tools can introduce genes that counter soil toxicity, resist insect pests, and increase nutrient content. Still, the questions of biosafety and the ethics of manipulating genetic material need to be resolved before the potential of biotechnology and genetic engineering can be realized.
- Ensuring ecological sustainability — new scientific tools need to be combined with knowledge about natural resources to ensure sustainable and productive use of land and water resources and to reduce loss of arable lands, productivity decline, deforestation and destruction of ecologically critical water sheds, loss of biodiversity, health and environmental

risks of intensive livestock production and fish farming. A pressing need relates to climate change research investments in developing adaptation and mitigation measures

- Harnessing the Information Revolution — the phenomenal potential of the information and communication revolution including the Internet, remote sensing and GIS, etc can enable interactive global agricultural research systems combining the best of science with traditional knowledge.
- Integrating ecology and socio-economy: The progress in understanding the functioning of ecological systems, the compilation of agricultural resources data basis at sub national, national and global levels, the development of analytical and mathematical modeling tools will be critical to enable spatially relevant application of the results of agricultural research to ensure that the best choice at the sub national level in the context of national needs within a world food economy.

Governments, civil society, and the private sector must provide the means for mobilizing science and research for food and agriculture. A participatory world wide effort, building on the lessons and experiences of the last green revolution combined with the best of new agricultural sciences can enable the next agricultural revolution to meet world-wide food needs in the 21st century.

5. Food Security, Agriculture and Climate Change: Spatial Integrated Agro-ecological and Socio-Economic Methodology and Policy Modeling

The Food and Agriculture Organization of the United Nations (FAO) and the International Institute for Applied Systems Analysis (IIASA) has developed an integrated agro-ecological (AEZ) and socio-economic policy analysis model (BLS) and global databases for assessing the prospects of world agriculture and food security in the context of future socio-economic development path scenarios and future climate change.

The impacts of different climate change scenarios on bio-physical, soil and crop growth yield determinants are evaluated on a 5' by 5' latitude/longitude global grid. The size of potential agricultural land and related potential crop production is computed and the detailed bio-physical results are then fed into a closed economy general equilibrium model of the world food system, to assess how climate impacts may interact with alternative development pathways, and key trends expected over this century for food demand, production and trade, as well as computing composite indices, such as risk of hunger and malnutrition.

This integrated modeling approach connects the relevant bio-physical and socio-economic variables within a unified and coherent framework to produce a global assessment and policy analysis of food production and security under climate change.

5.1 Agro-Ecological Zones (AEZ) Methodology and Model

The AEZ modeling framework synthesizes essential components of both the crop and ecosystem models. It uses detailed agronomic-based knowledge to simulate land resources' availability and use, farm-level management options, and crop production potentials; at the same time, it employs detailed spatial bio-physical and demographic datasets to distribute its computations at fine gridded intervals over the entire globe. This land-resources inventory is used to assess the suitability of crops in relation to both rain-fed and irrigated conditions for specified management conditions and levels of inputs, and to quantify expected attainable production of cropping activities relevant to specific agro-ecological areas. Crop modeling and environmental matching procedures are used to identify crop-specific environmental limitations under various levels of inputs and management conditions.

The AEZ framework contains the following basic elements:

- Land resources database containing geo-referenced climate, soil and terrain data;
- Land Utilization Types (LUT) database of agricultural production systems, describing crop-specific environmental requirements and adaptability characteristics, including input level and management;
- Mathematical procedures for matching crop LUT requirements with agro-ecological zones data, including potentially attainable crop yields estimates by land unit and grid-cell (AEZ global assessment analyzes 2.2 million grid cells, covering a 5'×5'

latitude/longitude grid, based on a 1:5,000,000 scale global soil map);

- Assessments of crop suitability and land productivity, and
- Applications for agricultural development planning.

The AEZ model computes amounts of non-arable and arable land as a function of environmental constraints. Land is classified as having severe constraints (too cold, too wet, too steep, or having serious soil quality constraints); moderate, slight, or no constraints to cultivation. Classification is also made between rain-fed and irrigated land, depending on water deficits, computed internally as precipitation minus evapo-transpiration.

5.2 BLS World Agricultural Trade and Economic Modeling

The Basic Linked System (BLS) comprises a series of national and regional agricultural economic models. It provides a framework for analyzing the world food system, viewing national agricultural components as embedded in national economies, which in turn interact with each other at the international level. The BLS model has been calibrated and validated over past time windows. Further details of the optimizing procedures and economic decisions regarding the national agricultural demand and production systems are given elsewhere.

The 18 individual national models, 2 regional models and 14 country group models are linked together by means of a world market model, where international clearing prices are computed to equalize global demand with supply. The BLS is formulated as a recursively dynamic system, working in successive annual steps. Each individual model component focuses primarily on the agricultural sector, but attempts to represent the whole economy as necessary to capture essential dynamics among capital, labor and land. For the purpose of subsequent international linkage, production, consumption and trade of goods and services are aggregated into nine main agricultural sectors, though individual regional models are more detailed. The nine agricultural sectors include: wheat; rice; coarse grains; bovine and ovine meat; dairy products; other meats and fish; protein feeds; other food and non-food agriculture. The rest of the economy is coarsely aggregated into one simplified non-agricultural sector. Agricultural commodities may be used within

BLS for human consumption, feed, intermediate consumption, and stock accumulation. The non-agricultural commodities may contribute as investment and for processing and transporting agricultural goods. All physical and financial accounts are balanced and mutually consistent: the production, consumption, and financial ones at the national level, and the trade and financial flows at the global level.

5.3 Future Climate Change Scenarios

General circulation models (GCMs) represent a powerful tool to generate characteristics of future climates under anthropogenic forcing, i.e., under present and projected future emissions of greenhouse gases. GCMs provide internally coherent climate dynamics by solving all climate-relevant physical equations globally to run simulations with the AEZ model under climate change.

The AEZ-BLS study involved climate projections of five Global Circulation Models, namely, HadCM3, a coupled atmosphere-ocean GCM developed at the UK Hadley Centre for Climate Prediction and Research; ECHAM, developed by the Max-Planck-Institut für Meteorologie in Germany; CSIRO, developed by the Commonwealth Scientific and Industrial Research Organization, Australia; CGCM2, developed by the Canadian Center for Climate Modeling and Analysis; and the NCAR-PCM Parallel Climate Model implemented at the National Center for Atmospheric Research (NCAR) and involving several research laboratories in the United States.

Climate change parameters are computed at each grid point by comparing GCM monthly-mean prediction for the given decade to those corresponding to the GCM "baseline" climate of 1960-1990. Such changes (i.e., delta differences for temperature; ratios for precipitation, etc.) are then applied to the observed climate of 1960-1990, used in AEZ, to generate future climate data – a plausible range of outcomes in terms of likely maximum future temperatures, pressures and rainfall, for the nominal years 2030, 2070 and 2100, and related to the "storylines" A1, A2, B1 and B2 is described in the next section.

5.4 Future Socio-Economic Development Path Scenarios

In order to assess agricultural development in this millennium, with or without climate change, it is necessary to first make some coherent assumptions about future development outcomes. To this end, we used plausible socio-economic development paths, as specified in the IPCC Special Report on Emissions Scenarios (SRES).

The IPCC's SRES scenarios have been constructed to explore future developments in the global environment with special reference to the production of greenhouse gases and aerosol precursor emissions. All the SRES scenarios are "non-mitigation" scenarios with respect to climate change.

Scenario A1: a future world with very rapid economic growth (world economy growing at 3.3%, low population growth) world total population of 8.9 billion in 2080), and rapid introduction of new and more efficient technologies. Major underlying themes are economic and cultural convergence and capacity building, with substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system: fossil-intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).

Scenario A2: A very heterogeneous world. The underlying theme is that of strengthening regional cultural identities; with high population growth (projected world population of 14 billion in 2080), and less concern for rapid economic development (world economy growing at 2.3% annually in the period 2000-2080).

Scenario A2r: A very heterogeneous world. Fertility patterns across regions converge only slowly. The underlying theme is that of strengthening regional cultural identities; with high population growth (projected world population of 12 billion in 2080), and less concern for rapid economic development (world economy growing at 2.3% annually in the period 2000-2080).

Scenario B1: A convergent world (global economy grows at 2.8% annually and projected world population reaches 8.1 billion in 2080) with rapid change in economic structures, "dematerialization" and introduction of clean technologies. The emphasis is on global solutions to environmental and social sustainability, including concerted efforts for rapid technological development, dematerialization of the economy, and improving equity.

Scenario B2: A world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is again a heterogeneous world (global economy grows at 2.5% annually until 2080 and world population reaches 9.3 billion in 2080) with less rapid, and more diverse technological change.

Emissions of greenhouse gases connected to specific SRES scenarios are translated into projections of climate change throughout this century by using general circulation models (GCM). Further details of the AEZ and BLS system feedback effects are given elsewhere.

Climate change is clearly seen as a consequence of complex social, economic, and environmental interactions, possibly modulated by the capacity to mitigate and adapt regionally and globally.

6. Results

The main simulation results of the AEZ-BLS global assessment include climate change impacts on agro-climatic resources, potential arable land, and related changes in crop production patterns. Our economic analyses assess over this century changes to food demand, production, trade and prices, and the scale and location of risk of hunger.

6.1 Agricultural Resources Security

According to the IIASA analysis, of the unused cultivable land available in the world today, 70 percent is found in just seven countries in South America and sub Saharan Africa. There is little prospect of expanding arable land in Asia, making research essential to enhance agricultural productivity in the continent. Currently more than 30 countries with a total population of over 500 million are regarded as water scarce. By 2025 some 50 countries with a total population of about 3 billion may be in that category. The analysis provides levels of potential food production according to agricultural natural resources and technology—important information for national policy makers concerned with agricultural resource planning and investments. Moreover, climatic changes will further undermine agricultural resource security in many poor and least-developed countries in Africa—a possible 60 percent reduction in boreal and arctic ecosystems is forecast, together with an expansion of tropical zones to cover most of sub Saharan Africa.

6.2 Agricultural Science and Technology Security

The IIASA results highlight the yield gaps in areas currently under cultivation and evaluate ways of closing them. The future environmental constraints projected —for example, higher temperatures and water restrictions due to climate change—show where investments in targeted agricultural research are needed to develop suitable and location-specific crop varieties.

In the twenty-first century the challenge is to mobilize and utilize the best of agricultural science and technology in support of sustainable food systems. The rapidly increasing privatization and patenting of agricultural research is shown as a particular cause for concern where the hungry and poor are concerned. A stronger public sector role is required to prevent "scientific apartheid," whereby cutting-edge science becomes oriented toward industrial countries and large-scale farming.

6.3 Globalization and Livelihood Security

IIASA results show that agricultural GDP in parts of the developed world will benefit from climate change, whereas in many developing regions it will decrease. The net cereal imports of developing countries will increase within the 170– 430 million ton range, depending on the future demographic and economic development pathway and climate change. Such a substantial increase in world cereal trade needs to be considered in the context of the economic and environmental cost of food transport over long distances as well as the inability of many food-insecure countries to finance long-term essential food imports.

IIASA is currently formulating scenario analysis to assess the worldwide food security implications of agricultural subsidy reforms, international food prices, globalization of diets, and the impact on international food supplies and prices of, for example, droughts and crop failures in major production and food deficit regions.

6.4 Global Environmental Change

Climate change and variability will result in irreparable damage to arable land, water, and biodiversity resources, with serious consequences for food production and food security. Most of these losses will occur in developing countries with low capacity to cope and adapt. While the international community has focused on climate change *mitigation*, the issue of *adaptation* to climate change is equally pressing. This is of critical importance to many developing countries that, to date, have contributed little to greenhouse gas emissions but whose food systems will bear the brunt of the negative impacts of climate change and variability. The IIASA analysis has relevance for assessing crop–land–water adaptation options as well as evaluating levels of agricultural greenhouse gas emissions and the prospects for mitigation.

6.5 Biofuels and food security

The IIASA study commissioned by OPEC Fund for International Development, "Biofuels and Food Security" reviews the global status of biofuels development, policy regimes and support measures and quantifies the agro-ecological potential of first-and second-generation biofuels crops. The study presents a comprehensive global assessment of the impacts of biofuels mandates and targets, set by some 20 countries including, the United States, European Union, Brazil, China and India, on transport fuel security, greenhouse gas emissions, agricultural prices, food security, land use change and sustainable agricultural development. The study concludes that the use of first-generation biofuels will increase food insecurity in the world's poorest countries and is unlikely to deliver any significant greenhouse gas mitigation benefit for at least 30 years and will negligible impact of rural incomes.

6.6 Responsible International Agriculture Investments

Over the last few years, a number of wealthy and food importing countries have begun to invest in farm land overseas, particularly in developing countries in sub Saharan Africa, South America and Asia. There is growing international concerns that unless such international agricultural investments are environmentally, economically and socially responsible and sustainable and are well-structured and legally executed, there is a real risk that food insecurity in the investing countries may end up being exported to host countries.

The forthcoming IIASA-World Bank study based on the AEZ-BLS system has quantified agro-ecological production potential for different types of crops at high level of agricultural technology and management. This includes currently cultivated land where yield gaps between prevailing yields and potential yields is large as well as the potentials in unprotected grassland and woodlands. The results quantify the net revenue potentials for investment partnerships in currently cultivated land. Such information can also be extremely useful at a national level because for any crop, with parametric assumptions on yield and input levels and application of a vector of output and input prices adjusted for transport cost over an appropriate time period would enable computation of expected investment returns and land rents from any given use.

As negotiations between land owners and outside investors hinge on the magnitude of these returns and rents and the way in which it will be distributed among the various partners to the deal, having such information will be of great usefulness from a number of perspectives, including also enabling host governments to better assess their comparative advantage. The results of the IIISA-World provide a foundation for more transparent debate and informed decisions by governments and investors.

6.7 AEZ-BLS Country Studies

Over the last 3 years IIASA has been working closely with over a hundred Chinese scientists at institutions in China to develop a national food and agriculture policy model (CHINAGRO). This detailed study is based on country level data and policy framework.

IIASA and India have also recently started a joint program to develop a spatial food and agriculture policy planning model (INDIAGRO). The goal here is to assess various food development futures and prioritize agricultural development policy at a spatial scale.

6.8 Concluding Remark

The current food crisis should be seen as a wake-up call for national governments and the international community. Agriculture and the rural sector must be given a high priority in terms of resource allocation and adoption of development policies that are locally relevant and globally consistent. Only then can agricultural vulnerability to climate change be reduced and progress be made to world-wide food security and sustainable agriculture

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From 2001 to 2009, Dr. Shah was Senior Scientist in Land Use Change and Agriculture as well as Dean of Young Scientists Summer Program and Coordinator of the United Nations Science and Policy Relations at the International Institute for Applied Systems Analysis in Austria (IIASA). He coauthored the 2002 Johannesburg World Summit Report "Climate Change and Agricultural Vulnerability" and the 2009 OPEC Fund for International Development/IIASA Report on "Biofuels and Food Security" . More recently, he is a coauthor of the forthcoming IIISA-World Bank Report, "Lessons for the Large-scale land acquisition of land from a global analysis of agricultural land use".

From 1997 to 2000, Dr. Shah served as Executive Secretary to the "CGIAR System Review" at the World Bank and coauthored with Maurice Strong "Food in the 21st century - from Science to Sustainable Agriculture." He also served as Special Advisor to the Secretary General of UNCED during 1991-92 and prepared the 1992 Earth Summit report "The Global Partnership for Environment and Development - A Guide to Agenda 21".

During 1988-89, he served the UN Office in Afghanistan as Director of Information and during 1984-86, he was Director of Monitoring and Evaluation Division, UN Office for Emergency Operations in Africa. From 1977 to 1983, he was a Senior Scientist with the Food and Agriculture Program at IIASA and coauthored the 1983 UNFPA/FAO/IIASA "Land Resources for Populations of the Future."

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