INDIAN METEOROLOGICAL SOCIETY
VISAKHAPATNAM CHAPTER

Citation to
Padma Vibhushan Prof.M.S.Swaminathan

It is our good fortune to have the privilege of welcoming ' a living legend' and a scientist of world renown, Padma Vibhushan Prof.M.S.Swaminathan, as the Chief Guest at this important function. It is no exaggeration when I say that Prof.Swaminathan needs no introduction to any audience anywhere in the world. In the words of the former Secretary General of the United Nations this living legend's "contributions to agricultural science have made an indelible mark on food production in India and elsewhere in the developing world. By any standards, he will go into the annals of history as a world scientist of rare distinction".

Almost half a century ago Monkombu Sambasivan Swaminathan, then in his twenties, went to Cambridge, United Kingdom, to do research in the improvement of major crop plants. The young agricultural scientist from Tamil Nadu had earlier been a UNESCO Fellow in genetics at the Agricultural University at Wageningen, the Netherlands during 1949-50 before joining Cambridge for higher studies. After obtaining the Ph.D. degree from Cambridge in 1952 he left for the United States to join the Wisconsin University as Research Associate in genetics. That was the time when India was launching its five year plans aiming at economic progress mainly through agricultural self-sufficiency. Not many had then expected that a decade later an Indian agricultural scientist would make history with his path-finding studies and research in agricultural research. Prof.Swaminathan's pioneering studies on the genetic improvement of major crop plants particularly wheat, rice and potato have revolutionized agricultural science. Among his many original and significant contributions are: conservation of plant genetic resources, in situ and ex situ conservation of biodiversity, manipulation of genes to improve the yield, quality and stability wheat, rice and potatoes, identification of the barrier to high yields in wheat and initiation of the dwarf wheat breeding programme, identification of cytotoxic agents in irradiated food material and demonstration of the indirect effects of radiations and organization of the National Demonstration and Lab to Land programmes.

His commitment to ecology and gender and social equity in productivity improvement has earned for him global recognition as 'the father of economic ecology'. He has held high and prestigious positions with remarkable dignity and endearing modesty and mention may be made of some important positions such as Director of Indian Agricultural Research Institute (1966-72), Director General of the Indian Council of Agricultural Research (1972-78), Acting Deputy Chairman and Member Planning Commission, Director General, International Rice Research Institute, Chairman, Science Advisory Committee to the Cabinet, Chairman, UN Advisory Committee on Science and Technology, Independent Chairman FAO Council and President of the International Union for the Conservation of Nature and Natural Resources. A Fellow of the Royal Society of London, United States National Academy of Sciences, Russian Academy and several science academies, including the Indian Academy of Sciences and National Academy of Sciences, Prof.Swaminathan was also the Founder-President of the National Academy of Agricultural Sciences.

Very few Indians have been so widely honoured both at home and abroad as Professor Swaminathan. The President of India honoured him with Padmashri in 1967. Padma Bhushan in 1972 and Padma Vibhushan in 1989. He was awarded the Albert Einstein World Award on Science in 1986, which is regarded as a Nobel Prize in agriculture, the Ramon Magsaysay Award in 1971 and the World Food Prize at the Smithsonian Institute when Mr.Javier Perez de Cuellar, Secretary General of the United Nations commended his work. 36 Universities from all over the world conferred on him honorary doctorate degrees. He has authored over 250 papers in international journals and several books, besides guiding 55 students for their Ph.D. degrees. His reports on ecology and sustainable development have been hailed all over the world. He has introduced the 'Techniracy' concept of imparting training in the latest technical skills entirely through work experience, in order to bypass the problems created by illiteracy and fostered the establishment of a chain of Krishi Vigyan Kendras (Farm Science Centres) for this purpose by the Indian Council of Agricultural Research.

Having happily crossed the Biblical span of three score and ten Prof.Swaminathan continues to be busy as ever, giving lectures, chairing conferences and running the foundation he heads, the M.S.Swaminathan Research Foundation at Chennai, on sound lines. One of the harbingers of the green revolution Prof.Swaminathan has earned the gratitude and admiration of not only the people of India but of the entire humankind as well. This unique person is India's gift to the world. Prof.Swaminathan's scientific genius in providing answers to the global challenges of poverty and malnutrition is splendidly matched by his humanism and adherence to high ideals. Everyone present here and in fact the City of Destiny is today greatly honoured to have Prof.M.S.Swaminathan in Visakhapatnam.

23rd March 1998
Visakhapatnam

Prof.A.R.Subramaniam
Chairman

PADMA BHUSHAN PROFESSOR PANCHETI KOTESWARAM FIRST MEMORIAL LECTURE 23rd MARCH 1998

PADMA VIBHUSHAN

Professor M. S. SWAMINATHAN

UNESCO Chairman on Ecotechnology

and

Chairman, M. S. Swaminathan Foundation, Chennai

Indian Meteorological Society

Visakhapatnam Chapter

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Prof. P. Koteswaram Memorial Lecture

Climate and Sustainable Food Security

Prof. M S Swaminathan

23 March 1998

I am grateful for being asked to deliver a lecture in memory of the late Prof. Koteswaram. I had the privilege of knowing Prof. Koteswaram for over 25 years and I turned to him for advice and guidance in all matters relating to the impact of climate on food production. We interacted closely during the severe drought years of 1966, 1974 and 1979. His deep knowledge and mature advice were extremely helpful in developing a monsoon management strategy for the country. He helped to build the India Meteorological Department into a powerful ally of our farming families. The India Meteorological Department has been doing our nation proud by the accuracy of its short and medium-term forecasts.

Prof. Koteswaram was not only a great scientist but also a warm human being. He combined science with humanism and spirituality. His life and work will always be a source of inspiration to us. I thank and congratulate the India Meteorological Society for initiating a lecture series in his memory. In this lecture, I would like to discuss a few issues relating to climate and food security.

I. Science and Agricultural Progress

Agriculture is the world's largest solar energy harvesting enterprise. India, being blessed with abundant sunlight throughout the year, has thus this potential to become a leading agricultural nation in the world from the point of view of food security at home and global supplies of agricultural commodities internationally. During the last 50 years, the process of transforming Indian agriculture from a static to a dynamic state has begun. For example, an early evidence of wheat cultivation in India is the wheat grains found in the Mohenjadaro excavations dated over 2000 BC. From those days upto 1947, the country developed the capacity to produce 6 million tonnes of wheat. Between 1964 to 1968, when high yielding, semi-dwarf varieties of wheat were first introduced into cultivation, coupled with appropriate agronomic and water management practices. Wheat production increased from about 10 to 17 million tonnes. **Thus, the production advance recorded during 4 years exceeded that of the previous 4000 years.** Such progress became possible when our hard working farm families were assisted with appropriate technologies, services and public policies. Concurrent attention to technology, training, techno-infrastructure and trade is vital for sustained agricultural progress.

The progress made during this decade in the production of rice, wheat and food grains as a whole is shown in Figures 1 to 3. The improvement in production has come largely from productivity improvement and not from area expansion. The productivity pathway of increasing food supply has helped to save millions of ha. of forest land from being cleared for the cultivation of annual crops. The introduction of hybrid rice technology and of the tools of molecular breeding have helped to raise continuously the ceiling to yield in rice and wheat (Figures 4 and 5).

The agricultural progress made so far has largely been confined to irrigated areas. Out of 142 million ha. cultivated land in India, 92 million ha. (i.e. about 65%) are under the influence of rainfed agriculture. Unlike irrigated agriculture, rainfed farming is usually diverse and risk prone. It is integrated with livestock rearing. Mixed cropping and mixed farming systems are important elements of the food and livelihood strategies adopted by rural families in rainfed areas. At present, 3 ha. of rainfed area produce cereal grains equivalent to that produced in 1 ha of irrigated area. However, the gap between potential yield, as achieved in National Demonstrations and farmer's fields is high. There is scope for rapidly doubling the average yield in dry farming areas. Since greater attention to dryland farming is essential for minimising the adverse impact of aberrant monsoons on food security. I would like to deal with this aspect first.

II. Revolution in Rainfed Farming

Historically, attention to develop rainfed agriculture dates back to the year 1880, when the First Famine commission was appointed by the then British Government. A significant programme on dryland agriculture research was, however, initiated only 50 years later. It was in 1933-35, that the then Imperial Council of Agricultural Research (now the Indian Council of Agricultural Research or ICAR) sponsored a Dry Farming Scheme at 5 centres Viz., Sholapur, Bijapur, Raichur, Hagari and Rohtak. The India Meteorological Department also started giving detailed information on the relationship between monsoon behaviour and food production. Crop-weather Calendars were issued periodically. The setting up of Soil and Water Conservation Research and Training Institute at Dehradun in 1954 was, perhaps, the first initiative made in independent India to focus on problems of soil and water conservation. Since then a number of research and development initiatives have been launched from time to time to stabilize and raise the productivity of dryland crops combined with sustainable natural resource (land, rainwater) management. A chronicle of research and development related programmes is given below :

History of dryland research and development in India

Year	Research and Development Programme
1880	First Famine Commission
1923	Dry Farming Research on a Small Plot at Manjari, near Pune
1928	Report of the Royal Commission on Agriculture
1933-35	Dry Farming Schemes at 5 centres
1954	Soil and Water Conservation Research Institute at Dehradun with 8 Soil Conservation Centres.
1959	Central Arid Zone Research Institute
1956-61	Several dry farming projects
1962	Indian Grasslands and Fodder Research Institute at Jhansi
1970	All India Coordinated Research Project for Dryland Agriculture (AICRPDA) at 23 Centres
1972	Establishment of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) at Hyderabad
1973	Rural Works Programme of 1970 renamed as Drought Prone Area Programme
1976	Operational Research Projects to validate technologies in farmers' fields
1977	Desert Development Programme
1983	Model Watersheds at 47 sites
1985	Central Research Institute for Dryland Agriculture (CRIDA) at Hyderabad
1988	National Research Centre for Agroforestry at Jhansi
1990	National Research Centre for Arid Horticulture at Bikaner
1990	National Watershed Development Project for Rainfed Agriculture (NWDPRA)
1991	Several Watershed Projects with support from World Bank, DANIDA, EEC, FRG, and DFID of UK
1993	Ministry of Rural Development Programme on Watershed Development in DPAP districts of the country.

Apart from the Government of India support, several projects were initiated with external funding. In the nineteen sixties, a dry farming project had been started in Anantapur district in Andhra Pradesh with support from the Government of France. The All India Coordinated Research Project for Dryland Agriculture got extensive support from CIDA (Canadian International Development Agency) through a bilateral collaboration agreement between the Government of India and Canada signed in 1970. Almost coinciding with that event, the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) was established at Hyderabad in 1972 by the Consultative Group on International Agricultural Research (CGIAR). A number of watershed projects, starting with an Indo-British Project at Indore in the early 1980s, received external funding from the United Kingdom, World Bank, European Economic Commission (EEC) and Governments of Denmark and Germany.

To sum up, over 50 years of research and development efforts by the National Research Institutes and Development Departments with support from International Agencies have led to the evolution of useful techniques and information on agronomic practices, appropriate choice of crops and their varieties and cropping systems. With time, greater area coverage under high yielding varieties receiving relatively more amount of nutrients have contributed to rise in the productivity of rainfed crops. No doubt the rate in growth of productivity continues to lag behind that observed in irrigated areas. More importantly, the yield gap between the research stations and farmers' fields continues to be very wide. Persistence of a wide yield gap despite 60 years of research and development efforts, has taught us the following lessons.

- The research farm programmes have mostly been scientist oriented and not farmer or user centred. These were preceived, planned, implemented, supervised and evaluated by scientists. The transfer of results followed a top-down approach. In this "take it or leave it approach", the farmer was at best a passive participant. Scientific findings which became the so-called 'technologies' were born from small plots and short-term research and were invariably not associated with critical cost-benefit studies.

- Acceptance of improved technologies was largely co-terminus with the period of financial support. The moment financial support was withdrawn, farmers reverted to their traditional practices or adopted only some selected componets of technologies. Rarely, a total package constituting an integrated technology was adopted. Risk aversion rather than production and profit enhancement is the major goal of resource poor farmers. To adopt new technologiies they will have to take loans either through the formal credit system or through village money-lenders. If they are unable to repay the loan due to crop failure, they get excluded from the credit system. Hence, they prefer risk-minimising agronomy.

- Acceptance of certain components of technologies did lead to a moderate increase in productivity, but emphasis on employment generation was lacking. Consequently, male out migration in search of jobs continues to be a serious problem. In a majority of the instances the introduced technologies did not suit the women who primarily manage the fields in the absence of male members. This glaring neglect of gender issues has seriously affected the success of rainfed projects.

- The absence of a farming system perspective ignoring the rural energy or fuel needs for households and forage needs for farmers' animal support system affected the sustainability of the programmes and long-term acceptance.

- Watershed programmes, whether funded from internal or external resources, were labelled as Government programmes, with minimal involvement and empowerment of farmers in planning and implementation. Despite the fact a watershed is owned by many farm families, soil and water conservation approaches did not emphasize community approach and group action on sharing water resources. **Pani Panchayats** of this type fostered in Maharashtra did not become a mass movement.

Based on these lessons and taking into account the emergence of grassroot democratic institutions we can now design programmes which are more likely to meet with sustained success.

III. Panchayat Centred Eco-development Mission for Rainfed Agriculture

Rainfed agriculture to be productive, should be based on a watershed as the unit of development. Watershed is not a technology but a concept which integrates conservation, management and budgeting of rainwater through sample but discreite hydrological units. Simultaneously, a watershed supports a holistic framework which means a combined application of technologies on soil and water conservation with improved crop varieties, farming systems and agronomic management, taking into account both arable and non-farm land.

Although low gains in a majority of the watershed programmes continue to be a matter of concern, success of watersheds like Rale Gaon Sidhi (Maharashtra) and Sukkomajri (near Chandigarh) has attracted nation wide attention. Future development of rainfed agriculture can draw some valuable lessons from these success stories. It was the total development of the ecosystem in a mission mode format that formed the hallmark of success. Efficient rainwater harvesting and management and equity in water sharing formed the nucleus of watershed development. With water availability assured, farmers get motivated to accept more profitable, sustainable and innovative farming systems. Water availability has also catalyzed the adoption and spread of value-added arable technologies in the entire area of the watershed, such as horticulture. A major reason for the success of projects executed by several non-governmental agencies is the cooperative effect generated among the members of the Watershed Community. Stakeholder participation and control are vital for promoting efficiency in water harvesting and gender and social equity in water sharing.

Integrating the watershed development programme with the village development plan to be executed by the Panchayat will be an effective method of ensuring peoples' participation and the sustainable and equitable use of water. In villages where there are several watersheds, an integrated master plan for watershed management could be developed. Also, cropping systems need to be tailored to suit different rainfall cum soil zones, as indicated below.

a. High rainfall areas (Mean annual rainfall > 1000 mm); Soybean will be a suitable crop. Specific efforts should be instituted to realise the full potential of the crop in high emphasis of the mission should be to achieve two crops a year through selective mechanization and drainage of low-lying areas.

b. Medium rainfall regions (mean annual rainfall : 750 - 1000 mm) : Cotton could be given high emphasis in this region. Depending upon soil and length of the growng reason a suitable intercrop could be introduced to increas overall profitability of the system. A Cotton Technology Mission can be initated in such areas.

c. Low rainfall regions (mean annual rainfall < 750 mm) : Pulses will be ideal. Farmers should be allowed to process the pulse into **dal.** In order to improve the availability of seeds of new varieties of pulses, including hybrid *arhar* (pigeon pea), Seed Villages could be organised in such areas. Due to lower Relative Humidity, the incidence of pests and diseases is relatively low during the non-rainy season.

Thus a lead crop could be identified for each major rainfall cum soil zone. In every case, the Panchayat-led Watershed management system should have the following goals.

- Conservation of water, enhanchement of supply and management of demand.
- Sustainable and efficient use.
- Equitable sharing of benefits.
- Value-addition to water by cultivating high value but low water requiring crops.

A Government of India Committee on Remedying Regional Imbalances in Agricultural Deve;opment, which I chaired during 1996-97, has recommended such a Panchayati Centred Eco-development Mission in rainfed areas to trigger rapid agricultural progress in such areas. In my view, this is vital for stepping up agricultural production to a level which will ensure both food self-sufficiency and surplus produce for export.

IV. FICCI - SPIC - MSSRF Programme for Dryland Farming

Based on the principles outlined above, FICCI (Federation of Indian Chambers of Commerce and Industry), SPIC (Southern Petrochemical Industries Corporation) and MSSRF jointly initiated a programme for organising Pulses Villages in the chronically drought-prone areas of Ramanathapuram and Pudukkotai districts of Tamil Nadu. Dedicated non-governmental organisations like Renaissance and Speech were associated with the programme.

Experience gained under this programme during the last two years (1996 and 1997) has shown that the much-needed progress in the production of pulses can be achieved by spreading such a programme. The underlying principles are :

- Cooperative effort on the part of the village community in rain water harvesting and the storage of the rain water in suitably designed farm ponds.
- Establishment of community dug and tube wells.
- Cultivation of appropriate pulse crops chosen both according to the agro-ecological conditions and market demand.
- Cooperative processing and marketing of the pulses.

By cultivating high value but low water requiring pulse crops in low rainfall, dry farming areas, value addition is achieved both to water and to the crop. In a further innovation-seed villages for Pulse crops are being established in the Pudukkotai district with support from the Indian Overseas Bank.

If such programmes are enabled to spread through a Panchayat-Centred Eco-development Mission in rainfed areas, there can be rapid progress in bridging the gap between potential and actual yields on the one hand, and in accelerating the pace of progress in the production of pulses, on the other.

V. Converting Despair into Hope

FAO, the International Food Policy Research Institute and the World Watch Institute have made projections regarding the likely food scenarios in the years 2010, 2020 and 2030 respectively. According to IFPRI, global demands for cereals is projected to increase between now and 2020 by 41 per cent and for meat by 63 per cent. The "food gap" i.e. the difference between production and demand for food could be more than double in the developing world in the next 25 years. The World Watch Institute predicts that India may have to import more than 40 million tonnes of food grains by the year 2030. It has been predicted that China will also have to import more than 200 million tonnes by 2030. Where will this food come from?

It is clear that the further intensifications of food production in industralised countries will be ecologically disastrous. On the other hand, inability to achieve the intensification, diversification and value-addition of farming systems and farm products will be socially disastrous in developing countries like India, where agriculture is the main source of rural income and employment. It is socially, politically and economically essential that India realise its potential for becoming a major supplier of farm products in the world. How can this be achieved?

- **Contract farming rather than corporate farming :** This will involve firm buy-back arrangements of crops and commodities produced for a company. Such an arrangement can also be made in the case of tree species by the paper and pulp industries.

- **Wasteland development :** This is an urgent task. Upgrading degraded land requires technology and capital. Industry-farmer linkages can help enterprises requiring wood as raw material.

- **Water harvesting and Pulses and Oilseeds Villages :** In dry farming areas, industry-farmer partnerships will help to promote scientific water harvesting and the use of conserved water for producing high value - low water requiring crops like pulses and oilseeds. This has become clear from the FICCI - SPIC - MSSRF and MSSRF - IOB projects in the low rainfall areas of Tamil Nadu.

- **Urban Green belt Movement :** A green-belt movement can be fostered by industry linking the rural producer and the urban consumer in a symbiotic manner.

- **Seed Villages :** With the spread of hybrid strains even in self-pollinated crops like rice, there are many opportunities for business-farm families collaboration in seed production and technology.

- **Horticulture and animal husbandary :** Industry-producer linkages will be of particular value in perishable commodities, since these need capital and management intensive facilities at the post-harvest stage, such as cold storages and refrigerated transportation and processing technologies.

- **Agri-business enterprises :** The Small Farmer Agribusiness Programme designed by MSSRF at the instance of the Government of India needs for its success the active participation of industry in promoting value-addition to primary products and in linking products with markets.

- **Decentralised production supported by key centralised services :** There is need for such arrangements in the production and marketing of a wide range of processed foods, horticultural and animal products and goods produced in micro-enterprises. The **All-Women Biotechnology Park** being established at Chennai by the Government of Tamil Nadu with support from the Department of Biotechnology, Government of India, is an example.

- **Manufacture of Farm Implements :** This is another area where large industries can foster small scale manufacturing units in villages.

- **Farmers' Service Centres :** There is need for the growth of Farmers' Service Centres particularly in dry farming areas, for custom hiring of farm machinery and implements.

Such mutually beneficial industry-resource poor families linkages will help to strengthen the livelihood security of the economically under-privileged sections of the Society and thereby help to promote economic access to food.

Second, we must end the prevailing mismatch between production and post-harvest technologies. Value-addition to primary products as for example spices, cereals, pulses, oilseeds, tuber crops and vegetables should receive high priority. Wheat and rice afford opportunities for the manufacture of a wide range of processed foods such as flakes, noodles, breads etc. In the case of rice, every part of the biomass - straw, bran and husk could be used for producing a wide range of valuable products. For realising the full potential in value addition, we should also tailor crop varieties to end uses. This is particularly important in *durum* (macroni) and bread wheats (biscuits and leavened bread) as well as in vegetable crops like tomato and potato. **Breeding Crop Varieties for the processed foods industry** is yet to receive the attention it deserves. New kinds of semi-processed foods involving nutritious crops like millets and pulses need to be produced.

VI. Designer Crops

We should also design new crops to fulfill the needs of human health as well as food processing. For example, there is considerable variability in crops like rice and wheat in the content of iron, zinc and sulphur. There is also variability in tannin content and activity (tannins are phenolic components in plants that precipitate minerals and make them unavailable for absorption in the gut) For example, in rice varieties, the content of iron, zinc, sulfur and tannins has been found to vary from 40 to 77 ppm, 24 to 42 ppm, 1.69 to 2.79 ppm and 10 to 41 ppm respectively. Tannins not only reduce the nutritional value of foods with regard to iron and zinc; they also impede digestibility of proteins. It is possible now through the use of molecular breeding techniques to design new crop varieties which could cater to the health foods industry. India has a comparative advantage in providing to the global markets health and organic foods, because of its rich traditions in ecological farming.

In 1966, a programme for the development of high-yielding basmati rice variety was initiated at the Indian Agricultural Research Institute, New Delhi. After over 20 years of carefully planned breeding and selection work, the world's first high yielding dwarf basmati variety **Pusa Basmati** 1 was released. Pusa Basmati yields 1.0 to 1.50 tonnes more than traditional Basmati varieties. India is now exporting 0.5 to 0.6 million tonnes of high quality Basmati rice valued at around Rs. 1500 crores. The share of Pusa Basmati in such export is about 35 per cent.

By filling the gap between potential and actual yields and by adopting low external input sustainable agriculture and aquaculture methods, India can not only meet the food needs of its growing population but can also help to meet the food gap in both developing and industrialised countries. Industrialised countries, whose agriculture is driven by capital, technology and subsidies should help developing nations to increase their agricultural trade. Unfortunately, the reverse is happening as exemplified by the patent taken in the United States of America for rice varieties belonging to the **Basmati** category. Basmati rice has been cultivated for centuries in North West India and the Punjab part of Pakistan and is a major source of agricultural export earning for India and Pakistan. Unless patenting procedures are rooted in the principles of ethics and equity, agriculture, which is the foundation for a healthy and productive life for all, will become a source of conflict, rather than a source of partnership for achieving freedom from hunger.

The growing problems of unemployment, poverty, feminisation of agriculture and unplanned migration of the rural landless to towns and cities resulting in the growth of urban slums can be solved only through an agricultural renaissance. The opportunities for this are great. But to avail of these opportunities, it is essential that both Government and industry make a major investment in rural infrastructure, post-harvest technology, sanitary and phytosanitary measures and the information and skill empowerment of rural families. The future lies in precision farming based on the conservation of soil and water and the adoption of ecotechnologies, developed through an appropriate blend of frontier technologies like biotechnology, information and space technologies, renewable energy and management technology with traditional wisdom and methods. Agriculture should not be regarded only as a profession for feeding the urban population, since it is the only pathway which can ensure both the livelihood security of a majority of our population and the ecological security of the countryside.

Given correct public policies and a greater investment in science and technology, Indian farmers will not only help the country to maintain food security at home but also to enlarge very considerably our export trade in farm products.

VII. Components of a Global Climate Management System

In recent months two major climate related events have attracted global professional, political and public attention. These are **El Nino** and the Kyoto Protocol for reducing green house emissions. Unfortunately, we have not been discussing these issues as intensively as industrialised countries. Recent tornadoes in Florida and California have resulted in extensive media attention to the **EL Nino** phenomenon in the United States of America.

However, in the case of **EL Nino,** we do not know what anticipatory steps we should take. Computer simulation models based on past **EL Nino** experiences can however be prepared. Sea surface temperatures are still well above normal throughout the tropical Pacific Ocean and are expected to remain high until May.

While in the past we used to deal only with the impact of climate on agriculture, we are now discussing also the potential **impact of climate change** on food production. Changes in temperature and precipitation can exert a profound influence on crop production. An increase in ultraviolet-B radiation as a result of damage to the ozone shield will also offect agriculture adversely. Unfortunately, there is little public discussion on such issues in our country. Countries in the European Union prepared a proposal, in preparation of the December, 97 Kyoto meeting of the Conference of Parties to the Framework Convention on Climate, for achieving a 15% cut in the emission of greenhouse gases by the year 2010. This would require a drop of 800 million tonnes of CO2 emissions. Achieving this goal would cost between US dollars 15 to 21 billion or between 0.2 to 0.4 per cent of European GDP in the year 2010. Some of the steps involved in this transition are :

- UK's shift from coal to gas-fired stations will result in a 6% drop in greenhouse gas emissions by the year 2000.
- Closure of obsolete factories in East Germany would result in a 12% cut in emission.
- Modernization of power stations and switching to clear fuels will result in cutting CO_2 emissions by nearly 300 million tonnes.
- Increasing the contributions of renewable energy to about 10% of electricity generation by 2015. The real hope is wind power, using recent Danish technology which involves installing wind mills at sea, in shallow waters upto 45 feet deep.
- Introduction of fuel-efficient cars and transportation would lead to cutting down CO_2 emission by nearly 180 million tonnes.

Thus, the European strategy for preventing unfavourable changes in climate involve concurrent attention to the energy and transportation sectors. We should also develop a nationally debated and accepted strategy for achieving a balance between carbon emissions and absorption. Prevention of deforestation and promotion of greening will help to increase carbon sequesration. While the industrialised countries are largely responsible for the present situation where human activities are beginning to influence climate, it will be poor nations and the poor in all nations who will suffer most from adverse changes in temperature, precipitation, sea level and ultraviolet B radiation. Action at home and emphasis abroad on a "Polluter pays" principle should be our two pronged strategy in dealing with climate change issues.

VIII. Monsoon Management in India

We have more than a century of experience in managing the impact of the South West and Northeast monsoons on agriculture and human livelihoods. During British rule, detailed Famine Codes and Scarcity Manuals had been prepared for several parts of the country. The **annawari** system of estimating the impact of weather on crop yield had been developed, for deciding on tax remissions and relief measures.

Thanks to the work of the scientists of Indian Meteological Department and of the Meteorological scientists of our Universities, we now have the capacity to insulate our agriculture very considerably from abnormal monsoon behaviour. Contingency plans involving alternate cropping strategies can be prepared to suit different rainfall patterns. Monsoon forecasting is getting increasingly perfected. Crop life saving techniques are also becoming available. Using computer simulation models, we can be prepared both to take advantage of good monsoons and minimise crop damage and human hardship during adverse monsoons. (Swaminathan, 1972).

During the 1979 drought, I had requested State Governments, in my capacity as Union Agriculture Secretary, to establish crop Weather Watch groups at the District and State levels for taking concerted action in areas such as the following :

- Saving the crops already sown, through crop-life saving techniques.
- Preparing alternative cropping strategies and building up appropriate seed reserves.
- Setting up cattle camps near sources of water for saving animals.
- Dividing the State into **Most Seriously Affected** (MSA) and **Most Favourable Areas** (MFA). The aim is to give priority to relief and rehabilitation measures in MSA areas both for the human and animal populations and to enhanced crop production in MFA areas MFA areas are characterised by either assured irrigation facilities or by un tapped ground water availability.

An end to end approach will have to be adopted in climate research, if the knowledge and information gained from climate research are to be used in strengthening food and livelihood security.

Fortunately, modern information and telecommunication technologies can help our rural families to derive maximum benefit form meteorological data. Macro-level information has to be converted into micro-level action plans. What farmers need is location-specific information and advice. For converting generic information into a location-specific one, we need a cadre of workers at the village level who can add value to climate information and help to convert the know-how of meteorologists into field level do how. Helping to train and create a cadre of Panchayat level **Climate Managers** is the best tribute we can pay to the life and work of Prof. Koteswaram. We can then replace the old saying "indian agriculture is a gamble in the monsoon" with the following : "India's agricultural strength lies in its capacity to manage the monsoons.

While charity begins at home, we have also a global responsibility in preventing adverse changes in climate. A workshop organised by MSSRF and the Climate Institute of Washington, USA at Chennai In December 1995, has made valuable recommendations regarding the contributions we can make (MSSRF, 1997). I hope we will soon have a **National Policy Statement** on Climate and Monsoon Management policies and strategies adopted by the National Development Council.

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