A Compendium

Addresses by Past Presidents

National Academy of Agricultural Sciences

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Contents

Change We Must, But Change is Difficult

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I would like to speak to you today on an extremely vital yet often unaddressed theme: "**Change we must, but change is difficult**". It is particularly important in view of changing scenario of agricultural research and development in our country. Having accomplished an impressive progress by all count, we are presently faced with numerous challenges to be urgently addressed so as to achieve our ultimate goal of making "**India a developed nation through progress in agriculture**". However, as we move into the next millennium, the immediate task before us is to address the following issues on priority:

- To ensure both economic and ecological access to food and nutrition security, particularly for those living below the poverty line.
- To secure higher productivity combined with profitability through minimum input use and improved efficiency of our production systems.
- To address the second generation problems of our historic Green Revolution followed by other Revolutions such as White, Yellow and Blue.
- To remain competitive and to take full advantage of globalisation of agriculture through advanced preparedness for the new WTO regime.
- To generate of resources in the wake of dwindling donor support for agricultural research and resource development.
- To improve our preparedness to meet effectively the economic and technological sanctions presently imposed or likely to be imposed in future as we demonstrate our scientific excellence and capabilities.

All these would require a strong National Agricultural Research System (NARS) committed to a paradigm shift from the present "**productive and purposeful**" to that of a "**responsive and responsible**" organisation. In order to accomplish this, we shall have to introduce major changes, however difficult they may be to revamp the institutional system for agricultural

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Presidential address delivered at the Annual General Meeting of the National Academy of Agricultural Sciences held at PHD House, New Delhi on June 5, 1999.

research in India. Our National Agricultural Research System (NARS), despite being one of the largest in the world, has its own strengths and weaknesses which must be clearly understood. As a matter of fact, we are still functioning as a National Agricultural Research Institute (NARI). Hence, we must move fast to become in a true sense, the National Agricultural Research System (NARS) involving besides the ICAR Institutes and State Agricultural Universities (SAUs), all other stakeholders such as traditional Universities and institutions, NGOs, private sector institutions, farmers and agri-business entrepreneurs. Obviously, the change from NARI to NARS is not a simple task it would require appropriate policy initiatives, change of our mindset and above all commitment of all those involved in the process. We have also to guard against the possible danger of complacency creeping into in any of our system. This would require self introspection, reorganization and revamping of the system for its 'Renewal', thus, demanding full involvement of all concerned. Similarly, we need to revisit our 'Land Grant System' of education on which we had built the foundations of our State Agricultural Universities (SAUs) and the ICAR National Institutes having Deemed to be University status. In other words, we have to reinvigorate the system faster and bring in the required 'Change' for the better. A new research agenda will have to be drafted around the competent cadre of our young scientist, trained in the areas of new science such as Biotechnology, Environmental Science, information communication technology (ICT), GIS and crop modelling, agri-business management, post-harvest technology (PHT) etc. Also the Institutional mechanisms for effective governance will have to be put in place through requisite O&M reforms.

The new work culture linked with incentives and accountability would first demand a change in the 'mindset' of senior research managers. This in itself is a major challenge. Those organizations that have changed in time have survived and prospered, whereas those which did not, have lagged behind.

Despite these formidable challenges, Indian agriculture offers tremendous "**uncommon opportunities**" that can be harnessed to take full advantage in the near future. Some of these are:

- Vast institutional and human resource base that can be further strengthened and made more efficient and effective.
- Threshold of low productivity which can be further enhanced substantially through increased input use and production efficiency.
- Reservoir of proven technologies which have yet to reach the farmers/stakeholders.
- Vibrant private sector, whose potential is yet to be tapped for R&D in agriculture.
- Strong network of public and private sector institutions well organised to provide needed technical backstopping for agricultural advancements.
- Opening up of the world markets for the Indian agri-products, particularly the new crops, commodities and value-added products as well as health foods.

- The present low input use efficiency that can be enhanced considerably through adoption of available technological options as well as policy interventions.
- Availability of vast arable land, all kinds of climate, cheap labour and above all the hard working farmers.
- Future possibilities of resource generation by bringing in the new corporate culture into the existing research organizations.

There is no doubt that these "uncommon opportunities" can be harnessed to our advantage provided we bring in the needed "change" despite stiff resistance from within. This paradigm shift is a must now in order to make our NARS both responsive and responsible. Having said this, I would now like to dwell upon the four major areas where the “change” has become imminent and must be accomplished on priority.

I. Institutional Change

Institutions are the foundations of required social change and advancement of any society. Most of our research institutions have become 40-50 years old. Also, the equipments have become old and obsolete. They need immediate renovation and replacements. The process of mushrooming of institutions and empire building needs to be curbed. Rather than horizontal expansion, we now need to consolidate and revamp the existing institutions and bring in inter-institutional partnership in order to maximize the returns from our investments in agricultural research. The support for "one time catch up grant" of Rs. 4000 million during the IX Plan period, as agreed to by the Planning Commission, is indeed a timely step in the right direction.

Another area of institutional concern is to remove the imbalance from the difficult agro-ecologies, especially the remote and difficult eco-regions. This change is warranted as a concern for equity and the required institutional support to those areas, which have been denied the benefits of new technologies in the past. Recent directive of the Government to spend 10 percent of the allocations of each department for activities in the north-eastern region reinforces this concern. Support of this kind is critical for the faster growth of the hitherto bypassed regions as well as social sector of our country. This obviously calls for a major change in our policies and programmes.

II. Organizational Change

As stated earlier, there is an urgent need to move from NARI to NARS through an effective involvement of all the stakeholders. The need for organization and management (O&M) reforms in areas of human resource development, incentives and rewards for the performers, impact assessment and evaluation (IAE) with inbuilt transparency, project-based budgeting, and decentralization linked with accountability are some of the critical elements associated with the future growth of the system. Hence, the enforcement of required change in the O&M system is fully justified now than ever before. Public-Private sector linkages are also

to be built and institutionalized faster. Similarly, institutional collaboration with the advanced research institutions (ARIs) and International Agricultural Research Centres (IARCs) will have to be strengthened for required excellence in science as well as for human resource development. The Information Communication Technology (ICT) networking at the global level will provide access to value-added information and knowledge, so critical for the advancement of science. This would demand a massive change in the existing IT culture in the system.

Globally, the donor support for agricultural research and training is declining. At tile same time, we have to have the human resource, which is globally competitive. To obviate this paradox, the best option is to generate resources internally and to build the required facilities for excellence in science. Fortunate in the past, our scientists did not face this challenge mainly on account of unstinted support from the Government and the policy makers. However, as this pressure is now building up, it is critical that our scientists and the system start responding favourably to this paradigm shift and start mobilizing internal resources fast. Many international organizations are already adjusting to this change. In future, a system's sustainability will have to be addressed more seriously. We must, therefore, respond favourably to this wake-up call. Areas of contract research, consultancy, training, generation of technology linked inputs in institutional laboratories/farms/workshops, patenting and corporatization are some of the options that need to be explored through appropriate change in our policies and procedures.

III. Change in Research Portfolio

Radical changes are also called for in our method of conducting research. We have to continuously prioritize as well as re-prioritize our research portfolio, to be in tune with the fast-changing global, regional and national needs. The 'top-down' approach adopted in the past will have to be changed to make it a 'bottom-up' approach. A shift from project to programme mode and also from commodity/crop to a system's approach is now warranted. This would require a matrix mode of research management necessitating an inter-disciplinary teamwork among scientists. We can no longer afford individual-scientist-oriented research agenda. Research must address institutional priorities in future and open-ended research will have to be made time bound and targeted in a 'Mission Mode'. Matrix mode of management would demand effective partnership between both the divisional head and the programme leader, besides sharing of responsibilities among scientists involved. This is a change, which is most critical for the future success of our system and would demand a complete commitment and positive mindset of all the partners involved.

Excellence in science will have to be recognised through needed change in our incentive and reward system. In future, centres of excellence will have to be built around scientists and not around institutions. These centres of excellence will have to take added responsibilities for human resource development in their field of expertise. Also institutions will have to undertake an ambitious programme for HRD through careful planning and separate allocation of resources. As stated earlier, the research portfolio will have to be carefully balanced to meet

the concern of different ecologies, conservation of natural resources and the protection of our environment. Globalization would also demand preparedness in areas of ITC, IPR, Sanitary and Phytosanitary Systems (SPS), possible impact of removal of quantitative restrictions, likely imposition of non-tariff barriers, etc. Those NARS prepared to change fast to address these concerns would obviously be ahead of others. Hence, the need for urgency cannot be over emphasized.

IV. Change in Technology Dissemination

We have run out of soft options in the area of technology dissemination. Also it is recognised more now than ever before that with available technologies, significant advancements in agriculture can be made provided these are effectively disseminated to the farmers. Training and visit (T&V) system has outlived its utility. It had mainly relied on "technology generation - technology transfer" model and presumed that all technologies would have wider acceptance and adoption, whereas it is well understood now that a continuum between "technology generation-assessment and refinement-transfer" is critical for the success on new technologies. Hence, there is need to change the front-line extension approach for the assessment and refinement of research information by establishing linkages between scientists and farmers and between institutions and villages. The ensure suitability of new technologies, scientists will have to adopt now the farmers' participatory approach and move out to use farmers' field for revalidation and refinement of technologies. Also, the existing gap between the scientists and the farmers will have to be bridged. The recent ICAR model of 'Institution-Village Linkage Programme (IVLP) is a 'bottom up' initiative in this direction focussing on farmer's specific needs rather than providing input related package technology which has been found to be unsustainable in the long run. Scientist-farmer linkages also ensure reduction in technology dissemination losses, so critical for the success of any new technology.

In an 'information age' the role of appropriate information package and its dissemination is equally important. It is not enough to generate information but also to see that the required information is delivered to the end-users at the earliest and with least dissemination loss. Thus there is a need to have a single window system of delivery for the farmer/end-users at the institute gate instead of expecting them to run from pillar to post. Establishment of Agricultural Technology Information Centre (ATIC) will provide such a mechanism in contributing towards dissemination of information. This will serve as a single window system with the objective to help farmers and other stakeholders to provide solutions to their problems and make available all technological information alongwith technological product for their testing and use.

To meet the changing needs, it is essential to create a cadre of 'Technology Agents' from among the unemployed youth who are better trained, equipped and committed to serve our farming community, while generating self-employment for themselves. Also, it is being felt that public supported system for technology transfer may not be the best model in future. We may, therefore, have to generate a new breed of competent technology agents, who are well

trained and committed to provide specialized services on custom hire basis. In this process, not only the technology dissemination losses are avoided but also appropriate technologies are disseminated faster. Another advantage of this approach would be that these technology agents will become job creators and not the job seekers. Obviously, this would demand the Institutions and the SAUs to undertake greater responsibility in future for the vocational training programmes, thus, requiring a change from existing formal degree to an informal education system in different areas of agriculture.

An effective TOT approach would also demand quick delivery of technology related inputs through a mission mode approach. For this purpose, provisions of a revolving fund to the institutes/scientists to generate more of the technology related inputs for an effective dissemination is a welcome development and would put pressure on our system to be more accountable in future.

The Krishi Vigyan Kendra is emerging as an effective institutional mechanism at the rural district level for technology assessment, refinement and dissemination of latest technologies. Their growing utility and demand has raised their number to almost 300 now and it is proposed eventually to open one each in approximately 500 rural districts of the country. Such a vast network of KVKs raises the questions of their performance, financial sustainability as well as their effective governance. The make them more effective and useful, the joint ownership of these institutions, besides the ICAR, by the Department of Agriculture of the Centre and the State Government, Panchayati Raj institutions, the NGOs, farmer's etc. has become necessary. All the stakeholders involved as well as the line departments will have to own these KVKs and provide required backstopping. Such an approach would provide appropriate reinforcement of the programmes as well as required interface at the grassroot level, which is so critical for reaping the benefits from available new technologies. These KVKs would also have to serve as ATIC in future and also as information centres for distance education and public awareness programmes using mass media and better communication mechanisms. Also these institutions will have to have a paradigm shift from farmer's training at individual level to that of a group or community training approach so that a larger section of our society is benefited.

All these initiative will require a strong interface between the research organizations and developments at the centre, state and regional levels to bear the fruit. While the 'DAC-ICAR' interface provides such an opportunity at the centre, a mechanism needs to be worked out and institutionalized at the state and district levels.

Epilogue

Change is a sign of growth. No organization that shows resistance to change can grow. Change is also a difficult process and requires commitment of not only the leader, but of entire organization and the system. Often the process of 'change of mindset' meets with stiff internal resistance. Yet the dynamic institutions have grown through needed periodic reforms in order to meet the new challenges over time. The ICAR, as an apex organization for research and education in the field of agriculture, has grown with time.

In the process, the ICAR got recognition and required visibility as evidenced by various revolutions (green, white, yellow and blue) - which many developing countries are still unable to replicate.

Today, the National Agricultural Research System (NARS) comprising of ICAR and SAUs, has emerged as a strong organization through timely policy and structural reforms. The system must now gear itself to meet the future challenges that are indeed daunting. Obviously, this would demand yet another critical self-introspection coupled with a paramount 'change' in the system. Change for the better must always be welcome despite difficulties encountered. Any dynamic change will indeed require commitment of the entire scientific community and all those associated with the system. We have done this in the past to make our agriculture strong and resilient, and while we enter into the next millennium, we shall do so collectively again in order to realize the dream of making "**India a developed nation through progress in agriculture**".

Science and Technology for Bharat Nirman

Prof. M.S. Swaminathan
President
National Academy of Agricultural Sciences

I. Introduction

Our Academy was established on the World Environment Day, fifteen years ago (June 5, 1990) to emphasise that safeguarding and strengthening the ecological foundations, essential for an ever-green revolution on our farms, must be the bottom line of our agricultural research and extension programmes. The Academy has followed up this resolve by getting policy papers prepared by inter-disciplinary groups of scientists on issues like water, soil, biodiversity, weather and technology. Over 30 policy documents have been prepared to help in generating synergies between technology and public policy. An integrated publication has been prepared highlighting the principal policy recommendations emerging from the studies carried out so far.

2005 is a significant year in the history of India's agricultural research and education, since this year marks the centenary of the birth of organized institutions for agricultural research and higher education in the country. The Indian Agricultural Research Institute, which housed our Academy in its early years, was established at Pusa in Bihar in 1905. Steps were also taken during 1905 to establish Agricultural Colleges at Coimbatore, Nagpur, Kanpur, Pune and Lyallpur (now Faisalabad in Pakistan). All these Colleges have since become Agricultural Universities. While inaugurating IARI at Pusa, Bihar, in 1905, Lord Curzon, the then Viceroy of India, referred to farming as India's greatest living industry. He also emphasized that agricultural education, particularly in villages should begin in schools. The Imperial (now Indian) Council of Agricultural Research was established in 1929 on the basis of a recommendation of the Royal Commission on Agriculture headed by Lord Linthgow.

The Royal Commission emphasized the critical role of research in fostering sustainable advances in agricultural production in the following words:

"However efficient the organization which is built up for demonstration and propaganda be, **unless that organization is based on the solid foundations provided by research, it is merely a house built on sand"**.

Presidential address delivered at the 12th General Body Meeting of the National Academy of Agricultural Sciences held at New Delhi on June 5, 2005.

In the light of these remarks, it will be useful to first look at the current agricultural scenario emerging from the mid-term evaluation undertaken by the Union Planning Commission on our agricultural progress during the Tenth Five Year Plan period.

II. Current Agricultural Scenario: Assessment by Union Planning Commission

1. Growth Rate

- GDP growth in agriculture and allied sectors during the **first three years of the Tenth Plan averages only 1 percent per annum, in contrast to the Tenth Plan target of 4 percent.**
- The share of agriculture and allied sectors was 3.9% of the total Tenth Plan outlay, as against 4.9% in the Ninth Plan. The total share of agriculture, irrigation and rural development stood reduced from 20.1% in the Ninth Plan to 18.7% in the Tenth Plan.
- Tenth Plan expenditure of the Ministry of Agriculture during 2002-03 and 2003-04 was 27% of the total Tenth Plan outplay.

2. National Accounts

- Growth rates of livestock and crop output have averaged about 3.6% and 1.1% per annum, respectively **after 1996-97,** down from 4.5% to 3.1% during 1980-97.
- Within the crop sector, only fruits and vegetables grew at over 2.5% per annum. **The output of remaining crops fell below 0.5% per annum after 1996-97** as compared to over 3% earlier.
- Growth of input use in agriculture **decelerated after 1996-97**, to about 2% per annum from over 2.5% during 1980-97.
- **After 1997-98, output prices began to fall relative to input prices.**
- Part of the deceleration in agricultural growth can, therefore be attributed to lower profitability leading to a slow increase in input use. **Growth of input productivity became negligible after 1996-97.**
- During 1997-2002, agricultural prices declined **relative to prices not only of inputs** but also non-food consumer goods. Purchasing power of agriculture incomes decelerated more than GDP at constant prices. **Real farm incomes showed no per capita growth after 1996-97.**
- Real per capita food consumption declined after 1998-99, despite fall in relative food prices. **Per capita consumption declined absolutely in case of cereals, pulses and edible oils.** The growth rate in the consumption of fruits, vegetables and milk also declined.
- Input use and productivity growth decelerated from the 9th Plan onwards. **This was accompanied by low demand growth and higher farm income variability.**

3. Crop Production

- The Tenth Plan foodgrains target is 230 million tones in 2006-07. **The production was 212.9 million tones in 2001-02 and since then it has been declining.**
- Trend of rice and wheat production was less than population growth by the end of the 9th Plan. **Yield growth throughout the 1990s was about 1% per annum, as against 3% during the 1980s.** Large exports at below domestic prices and subsequent poor monsoons have now reduced the stocks to a low level.
- Yield growth in coarse cereals was about 2% per annum throughout the 1990s, mainly **because of maize**
- A Technology Mission in Pulses has been in existence since the early 1990s. Pulses yields have stagnated and the area under cultivation has also shrunk. **A sharp increase in imports of pulses has further reduced incentives for home production.**
- Oil Seeds Technology Mission started in 1986. There was a substantial expansion of area, yield and production till the mid 1990s. The production went up to 24.4 million tones in 1996-97. The production was 25.1 million tones in 2003-04, but growth continues to be negligible.
- Imports of edible oils, was less than 10% of domestic production till 1994-95. **Now the volume of imports equals domestic production**.
- There is an urgent need to **review the work of the Technology Mission on Oilseeds and Pulses, since the mission mode approach to project formulation and implementation should yield the anticipated outputs.**
- **Cotton Production** has been good during 2004-05, but yield and quality are still poor. The Technology Mission on Cotton needs to promote a symphony approach, linking the cotton producers and the textile industry in a symbiotic manner.
- **Sugarcane** yield has been either stagnating or declining – recovery of sugar from cane has not increased.
- **In fruits and vegetables, there has been no increase in yield**. Vegetable yields are declining. **Output increase is entirely through area expansion. The National Horticulture Mission will have to concentrate on increasing yield and quality**. Post-harvest processing and management need urgent attention. The National Horticulture Board needs careful restructuring and revitalization.

4. Livestock and Fish Production

- Milk and egg production has decelerated. There is, however, an increase in the number of crossbred cattle and poultry since 1997. Feed, Fodder and marketing need attention.
- Fish production is growing at a rate of 4% p.a. and the production was 6.4 million tones in 2003-04.

5. Overall Trends

- Almost every sector experienced lower growth after 1996-97. Even in **the excellent monsoon year of 2003-04, per capita output was less, except in horticulture.**
- Food consumption has stagnated since the beginning of the 9th Plan. National Accounts data show that real per capita consumption of cereals, pulses, edible oils, sugar, milk, fruits and vegetables was lower in 2003-04 than in 1998-99.
- Overall employment growth has been very slow. Real agricultural incomes have been stagnating or declining.
- Agriculture will progress only if demand (both home consumption and export) increases. Consumption should be increased through both nutrition intervention programmes and through accelerated non-farm employment.
- Cost of production should be reduced through enhanced factor productivity. The average fertilizer response of food grain output to NPK fertilization works out to 7.8 kg grain per kg NPK. This is a very low return. How can we become globally competitive if our factor productivity is both low and declining?
- Imports of pulses and oilseeds are growing. Import of pulses, which used to vary in the range of 3 to 6 lakh tonnes in the 1990s surged to over 2 million tones in 2001-02 and has remained at that level since then. Imports of edible oils increased from 1 million tonne in 1995-96 to over 4 million tonnes in 1999-2000. It is now ranging in the order of 4.2 to 5.3 million tones per year accounting for about half of domestic consumption.
- Sustainability of food production is threatened by depletion and pollution of the aquifer, soil health degradation, failure of research, extension and input supply systems and declining investment in the farm sector. In addition to being a gamble in the monsoon, farming is becoming increasingly a gamble in the market. “The fatigue of the green revolution” is due to both ecological damage and technology fatigue.
- India today has the largest number of under-nourished children, women and men in the world. Maternal and foetal under-nutrition is resulting in low birth weight babies. Such LBW children are handicapped at birth in brain development, the cruelest form of inequity. Yet, we often hear glib talks about India becoming a Knowledge Superpower. Unless there is widespread realization among political leaders and policy makers that we are on the threshold of an unprecedented human tragedy, we will have to revert once again to the “begging bowl” phase of our agricultural evolution. Also, where hunger rules, peace will not prevail.

III. New Deal for Rural India

Pledging the commitment of the Government of India to providing a New Deal for Rural India, Prime Minister Manmohan Singh, a distinguished Fellow of our Academy said, “**We want India to shine, but India must shine for all**”.

The steps taken to implement this commitment include the following:

- Reversing the declining trend in investment in agriculture
- 30% of increase in credit flow to farmers
- Increasing public investment in irrigation and wasteland development
- Increasing funds for agricultural research and extension by almost 40%
- Creating a “single market” for agricultural produce
- Investing in rural healthcare and education
- Investing in rural electrification
- Investing in rural roads
- Setting up commodities futures markets
- Insuring against risk in farming and rural business

The Union Planning Commission had set up last year a Task Group to suggest steps for revamping and refocusing agricultural research. I had explained the principal recommendations of this Task Group convened by Prof V L Chopra, in my address at the Agricultural Science Congress held at Pune in February this year. Hence, I do not want to repeat them, but I would like to stress the urgency of revitalizing our national agricultural research system and for retooling, retraining and redeploying in an appropriate manner our rich human resource in agricultural research, education and extension. **We in the Academy should not remain silent spectators to the steady decline in agricultural growth rates, particularly in the context of both a high growth rate in population and widespread occurrence of under- and mal-nutrition both in rural and urban areas**. We must harness the collective voice and wisdom of the agricultural sciences community and help our Government to convert its commitment to provide a New Deal to Rural India into practical accomplishments.

This year, the comity of Nations constituting the United Nations will be reviewing the progress made during 2000 to 2005 in achieving the UN Millennium Development Goals, among which elimination of hunger and poverty occupies the first place. Our progress in achieving the MDGs is not satisfactory, although many Indian policy makers have played an important role in drafting them. The reasons will be obvious from the analysis of our current agricultural scenario. As a single step, improving small farm productivity will make the greatest contribution to the eradication of hunger and poverty.

I would like our Academy to play a particularly catalytic role in achieving nutrition and education for all. Nutrition and education represent two basic needs for anyone to lead a life of dignity and accomplishment. Nutrition and education have feed back relationships. Maternal and foetal under-nutrition leads to the birth of children with low weight (2.2 kgs or below). A consequence of mal-nutrition induced low birth weight is impaired brain development and reduced cognitive

abilities. Nearly a third of the children born in our country experience this cruelest form of inequity. Fortunately, for older children (starting from 2 years of age), we now have different nutrition support programmes. In the case of economically under privileged individuals suffering from TB, HIV/AIDS, leprosy etc., a drug-based approach alone is not adequate. A food cum drug based approach is essential for helping the sick individual to get back to a healthy and productive life.

IV. Missions 2007

NAAS helped in setting two important goals for August 15, 2007, which marks the 60th anniversary of our independence. These are:

a. A Hunger-free India

b. Every Village a Knowledge Centre

These two goals link nutrition and education in a symbiotic manner. Both are achievable through a mutually reinforcing blend of political action, professional skill and peoples' participation.

A hunger-free India can be achieved by integrated action in the following areas:

a. Redesigning the delivery of nutrition support programmes on a life cycle basis, starting with pregnant women and infants and ending with old and infirm persons.

b. Enhancement of small farm productivity through integrated action in improving soil and plant health, water conservation and use, and post-harvest technology.

c. Promotion of diversified livelihood opportunities through market driven micro-enterprises supported by micro-credit; self-help groups will help to confer on small producers the power of scale both at the production and marketing ends of the enterprise. Large companies can get their products produced in villages by well trained self-help groups. Such outsourcing of productive work from urban to rural areas is one of the main strengths of the Rural – Township Enterprises movement in China.

Our Academy also hosted a consultation which led to the birth of a National Alliance for Mission 2007 : Every Village a Knowledge Centre. The Government of India has also joined this National Alliance committed to ensuring knowledge connectivity throughout the country. This is also essential to give meaning and content to the Right to Information Act recently adopted by our Parliament.

Ecologically, economically and technologically, the world is becoming a global village. Social, economic and gender inequity is however growing in such a global village with disastrous consequences for the future of humankind. Trade should become not only free but also fair. Both unsustainable life styles and unacceptable poverty should become problems of the past.

Intellectual property rights should not lead to social exclusion in terms of access to technology and knowledge. Our Academy should foster a pro-nature, pro-poor and pro-women orientation to

technology development and dissemination – be it biotechnology or information communication technology.

We should also foster a commitment to increasing gross national happiness through partnerships with other relevant Science Academies. In this context, I would like to cite two recent instances of mutually beneficial partnerships.

First, our Academy and the Italian National Science Academy have agreed to collaborate in producing outstanding *durum* or macroni wheats for the Italian market (land under *durum* wheat is going down in Italy due to the opportunity cost of land).

Second, our Academy, the Pakistan Academy of Sciences and the US National Academy of Sciences have agreed to co-sponsor a pro-nature and pro-poor agricultural biotechnology programme for the purpose of breeding crop varieties tolerant to drought and salinity and for sharing experience in risk and safety assessment.

Based on a suggestion from the Third World Academy of Sciences, our Academy is now in the process of organizing an International Network of Agricultural Science Academies.

We should do our best to foster such mutually beneficial partnerships in science and education. 2005 is also the International Year of Physics to mark the Centenary of Albert Einstein's discovery of the Realtivity Theory. Hence, I will like to conclude with two quotations from Einstein.

Concern for man himself and his fate must always form the chief interest of all technical endeavours in order that the creation of our minds shall be a blessing and not a curse"

"**Remember your humanity and forget the rest**. If you can do so, the way is open to a new paradise; if you cannot, there lies before you the risk of universal death".

Restoring Farmers' Faith in Farming

Prof. M.S. Swaminathan
President
National Academy of Agricultural Sciences

Fellows of the Academy,

It will be an understatement if I say that our country is facing a serious agrarian crisis. According to a recent survey by NSSO, 40 percent of farmers would like to quit farming if they have another option. A recent report (May, 2006) of the Punjab State Farmers' Commission headed by Dr. G. S. Kalkat has the following statement.

"The Punjab Agriculture, which is based largely on wheat, rice and cotton, seems to have almost touched the plateau with the available technology. Water table is going down at the rate of 74 cm per year (2004-05). Sixty six percent of blocks have gone dark. **The agriculture of Punjab has progressed, but farmers have become poorer**. The current agricultural system in Punjab has become unsustainable".

The implications of this situation for national food security are serious. During 2004-05, Punjab contributed 9.2 million tonnes of wheat and 9.1 million tonnes of rice to the central pool, which constitute 55 and 37% of the total foodgrain procurement in India. Our population is still growing at over 2 percent and the rate of growth in food production is tending to fall below this population growth rate. The growth rate in non-farm employment is poor, with the result that there is enormous pressure of population on land. It is in this context that the Prime Minster of India and a Distinguished Fellow of our Academy, Dr. Manmohan Singh, posed the following challenge to scientists in his address at the Dr. B.P. Pal Centenary Celebration symposium organized by The Energy and Resources Institute (TERI) on 27 May, 2006.

"There are no new, big ideas on how we can extend the benefits of modern science and technology effectively to our farmers, and on new pathways to revitalize the farm sector".

We should seriously ponder over the above statement. It is in this context that I will like to share with you some of the suggestions made by the National Commission on Farmers in their 3rd and 4th Reports presented to the Ministry of Agriculture in December 2005 and April 2006, on methods of revitalizing our agriculture during the agriculture year 2006-07.

Presidential address delivered at the 13th General Body Meeting of the National Academy of Agricultural Sciences held at New Delhi on June 5, 2006.

Situation facing our farmers

Farming is both a way of life and the principal means of livelihood for 65 per cent of India's population of 110 crores. Our farm population is increasing annually by 1.84 per cent. The average farm size is becoming smaller each year and the cost-risk-return structure of farming is becoming adverse, with the result that farmers are getting increasingly indebted. Marketing infrastructure is generally poor, particularly in perishable commodities. The gap between what the primary producer of vegetables and fruits gets and what the urban consumer pays is high.

The livelihoods of pastoralists and small holder farmers are threatened by the progressive loss of grazing land for their animals, limitations to mobility, inadequate or inappropriate government policies, and lack of animal health and other services. These developments are also causing the progressive loss of the livestock breeds and species that provide rural livelihoods and lifestyle options.

The social prestige and status accorded to farmers are also low. **Farmers seldom receive recognition through Padma Awards on Republic Day - an index of the low recognition given to the contributions of 650 million farm women and men not only to food and livelihood security, but also to national sovereignty**. Lal Bahadur Shastri's slogan "*Jai Kisan*" is yet to be converted into public policies which recognise the pivotal role of farming communities in national well-being and security.

Policies are needed for making the sub-marginal, marginal and small farmers economically viable and environmentally sustainable. Well-defined guidelines are needed for assisting such families with assured and remunerative marketing opportunities, particularly in the case of perishable commodities, and 'orphan'" crops like a wide range of millets, tubers, pulses and oilseeds.

Technology has been a major factor in the rich-poor divide until now. We should now enlist technology as an ally in the movement for gender and social equity. This will call for a pro-poor, pro-woman and pro-nature orientation to technology development and dissemination. Also, Intellectual Property Rights (IPR) policies should be such that **there is social inclusion in access to technologies**. This will call for a considerable stepping up of investment in **public good research** and an **antyodaya** approach to technology development and dissemination. There is no option except to produce more food and other commodities under conditions of diminishing per capita arable land and irrigation water resources. Hence, we must harness the best in frontier technologies and integrate them with traditional wisdom and thereby launch an eco-technology movement.

Research should be tailored to the need for adding economic value to the time and labour of the poor, particularly women. Also, the advantage of the National Rural Employment Guarantee Programme (NREGP) should be taken for launching a massive adult and functional literacy programme using computer-aided joyful learning techniques. The poor are poor because they have no assets, neither land nor livestock nor fishpond. They are often illiterate also. Modern technologies can help to achieve a quantum jump in imparting literacy and market-

driven skills. They should therefore be harnessed for the benefit of resource poor farm and landless labour families living below the poverty line. Further, the NREGP should be used to create productive assets in rural areas, particularly in the areas of water harvesting and aquifer recharge.

Within a week after the launch of NREGP, 2.7 million applicants reportedly registered themselves for employment under this programme in 13 districts of Andhra Pradesh and a million registered in 12 districts of Maharashtra. The average wage under this programme is about Rs. 60 per day. While this will help them to get their daily bread, the programme cannot solve the challenge of pervasive poverty. Since NREGP represents employment of the last resort and caters only to unskilled work, the extent of despair and deprivation in rural India is obvious from the demand for placement in this programme.

Addressing the nutrition, healthcare and education needs of the poor, and particularly of agricultural labour, tribal women and men and fisher families should be given top priority. Nearly 75 per cent of children in the country are under-weight due to inadequate nutrition. India has the largest number of under-weight and low birth weight children and their prevalence is almost double that of Sub-Saharan Africa. Micro-nutrient deficiencies are widespread. More than 75 per cent of preschool children suffer from iron deficiency anaemia. About 57 per cent of pre-school children have sub-clinical vitamin A deficiency. Traditional food habits in rural and tribal areas included a wide range of millets, tubers, grain legumes and leafy vegetables. **The revitalization of nutrition-centred farming systems is an urgent task. Both dying crops and dying wisdom should be saved and harnessed for local level community managed food security systems, like Community Food Banks.**

While farm families are crying for additional investment in infrastructure and farm innovation, there has been a drop in government investment in the agriculture sector. The drop in government as well as private investment has significantly slowed down momentum in the entire rural economy. Public policies in the area of farm subsidies have led to distortions in land use and fertiliser consumption and have promoted the unsustainable exploitation of groundwater. The intensive wheat-rice rotation in the Punjab-Haryana region has led to the depletion of groundwater and to soil salinisation in some areas. Balanced fertilisation has been affected by the heavy subsidy given to urea-based fertilisers, particularly in the context of a sharp rise in the prices of all chemical fertilisers. Soil micro-nutrient deficiencies are not being addressed. **Consequently, factor productivity is going down, with a consequent adverse impact on the cost of production.**

Ours is a nation of subsistence farmers, who constitute one fourth of the global farm population. There is little or no evidence that policy is being shaped by that reality. Farming is the largest people's private sector and not a corporate domain. The immediate step Government must take is to implement the NCF recommendation for a Price Stabilisation Fund. While a multiplicity of factors is driving the farm suicides, the greatest worry of the farmer relates to the price he is likely to get for his produce at harvest time. This has proved true regardless whether the produce is cotton, onions, groundnut, sugarcane or pulses. **Assured and remunerative price for farm produce is the core issue. Farmers should**

be assured that there will be strong Government intervention to prevent distress sales.

The review and overhaul of credit operations ought to be far more transparent and rigorous. The credit cycle in chronically drought prone areas like Vidharba should be 4 to 5 years. An Indian Trade Organisation (ITO) should come into existence soon as a watchdog body to safeguard farmers' interests. The ITO could be supported by a Trade Advisory Body for Small Farmers. The objective would be to allow farmers to engage with decision makers in the formulation of appropriate policy responses to developments in agricultural markets.

Another area where the Central and State Governments can help is input costs. High quality inputs should be made available at affordable prices at the right time and place, along with credible extension advice. Today, the farmer depends on the input dealer who sells seeds, pesticides and fertilisers for technical advice. In many "Suicide Hot Spot" areas, the input dealer is also the moneylender, the scientist, agricultural expert, counselor and buyer all rolled into one.

Until such time we do not recognise the root causes of this sad chapter of our agricultural history, remedial actions will largely be cosmetic.

Livestock and Livelihood

According to the 17th Livestock Census released in January 2005, India has 57 per cent of the world's buffalo population and 16 per cent of the cattle population. Also, we rank third in sheep wealth and second in goat population. The contribution of the livestock sector to agricultural GDP has increased from 18 per cent in 1981 to 26 per cent in 2004-05. **It is clear that livestock and livelihoods are very intimately related in our country and that crop-livestock integrated farming is the pathway for farmers' well being**.

The ownership of livestock is much more egalitarian since resource poor farming families own a majority of cattle, buffalo, sheep and goats. The major constraints experienced by such families relate to fodder, feed and healthcare. There is an urgent need for establishing **Livestock Feed and Fodder Corporations** to assist SHGs to produce good quality animal feeds. Such a Corporation should be a facilitating body for providing seeds and planting material of improved varieties to SHGs for local level production. The productivity of our livestock is low and can be easily improved through better nutrition and healthcare. Agri-clinics operated by veterinary and farm science graduates will be very helpful to enhance the income of livestock owners through higher productivity. At the same time, crop-livestock mixed farming systems should be promoted since this will help to improve both income and household nutritional security. **It should be noted that suicides by farmers are rare in areas where there are multiple livelihood opportunities.** India's achievement, in becoming the largest producer of milk in the world, has an important message, namely, concurrent attention to all links in the production, processing and marketing chain through cooperatives and group endeavour will lead to striking results.

The Union Finance Minister while presenting the 2006-07 budget had announced that banks are being asked to provide a separate window for SHGs as well as for joint liability groups of tenant farmers. This window will provide an opportunity for achieving a fodder and feed revolution for enhancing the health and productivity of our unique livestock wealth. Livestock insurance also needs revamping and made accessible to small livestock owners. Livestock rearing can be linked to organic farming, so that there is value addition to the produce from small farms.

Need for a Non-Farm Livelihood Initiative

China has addressed the need for creating opportunities for skilled non-farm employment through a massive Township and Village Enterprises (TVE) movement. There were 21.15 million TVEs in China at the end of 2001, employing a total of 130 million workers. Their added value of 29356 billion Yuan (3669.5 billion US $) accounting for 31.1 percent of the national total (He Kang, 2006, *China's Township and Village Enterprises*, Foreign Language Press, Beijing).

Several programmes have been initiated by KVIC and NGOs for generating off- and non-farm employment. The SHG movement is helping women, particularly in South India to come out of the poverty trap. There is need for a counterpart to NREGP in the skilled employment sector. Initiatives like Small Farmers' Agri-business Consortium (SFAC), Agri-clinics and Agri-business Centres, Food Parks, Textile and Leather Parks, etc., which could have provided substantial additional livelihood opportunities to the rural poor are yet to take off. **It would be useful to integrate all of them into one initiative like China's TVEs and launch a Rural Non-farm Livelihood Initiative** for families without land or other productive assets. The joyful learning programme through computer aided adult/functional literacy procedures should help to accelerate the progress of eradication of illiteracy. **The Rural Non-farm Livelihood Initiative** could have as its core the KVIC and restructured SFAC and bring all rural non-farm employment programmes together, in order to generate convergence and synergy among them. A Consortium approach could be adopted involving Central and State Governments, Academia, NGOs, public and private sector industry and financial institutions. The sooner we initiate a massive and market-driven rural non-farm livelihood programme, the greater will be the prospect for peace and security in rural India. Also, food security in India is best expressed in terms of million person years of jobs, rather than in million tonnes of foodgrains. Where there is work, there is money. Where there is money, there is food. There is, therefore, need for a restructuring and revamping of organisations like SFAC, KVIC, Agri-clinics and Agri-business Centres.

Public Policies for Sustainable Livelihoods

The cost-risk-return structure of farming is getting adverse, leading to increasing rural indebtedness. The following steps will help to ensure that the well-being and livelihood security of farm and rural families become the bottom line of public policies.

- The scope of the Minimum Support Price (MSP) programme should be expanded to cover all crops of importance to food and income security for small farmers. Arrangements should be made to ensure MSP at the right time and at the right place, particularly in the areas coming within the scope of the National Rainfed Area Authority. **Also, advice to farmers on crop diversification should be linked to the assurance of MSP. Small farm families should not be exposed to administrative and academic experiments and gambles in the market.**

- A Market **Risk Stabilisation Fund** should be established jointly by Central and State Governments and financial institutions to protect farmers during periods of violent fluctuations in prices, as for example, in the case of perishable commodities like onion, potato, tomato, etc.

- There is also need for an **Agriculture Risk Fund** to insulate farmers from risks arising from recurrent droughts and other weather aberrations.

- The scope of Agricultural Insurance Policies should become wider and there should also be coverage for health insurance, as envisaged under the **Parivar Bima Policy** recommended by NCF in its First Report. There should also be insurance provided by Seed Companies in the case of GM crops, so that farmers who pay high prices for the seeds for such crops do not suffer in case of crop failure.

- Nutrition support to rural families affected by HIV/AIDS, tuberculosis, malaria and leprosy is needed to assist in recovery and restoration to a productive life. There is evidence to suggest that a pure drug based approach alone, is not adequate to help economically underprivileged rural women and men recover from diseases involving prolonged treatment. A basic requisite for enhancing small farm productivity is the health of the farm worker. Hence, a Food-cum-Drug based approach to healthcare should become an integral part of the National Rural Health Mission.

- An **Indian Trade Organisation** (ITO) and an **Agro-ecological Land Use Advisory Service** should be established on the lines recommended by NCF in its Third Report. The ITO should help Government to operate a Livelihood Security Box.

- Since agriculture is a State subject, every State Government should set up a **State Farmers' Commission** with an eminent farmer as Chairperson. The Membership of the Commission should include all the principal stakeholders in the farming enterprise. Such Commissions should submit an Annual Report for being placed before the respective State Legislature for discussion and decision. The State Farmers' Commission could have the following terms of reference, with appropriate additions or modifications depending upon the situation prevailing in each State.

    - ♦ To bring to the attention of the State Government emerging problems in crop and animal husbandry, fisheries and the environment in a pro-active manner, so that timely steps can be taken to avert extreme hardships to farming families.

    - ♦ To recommend measures in the areas of technology development and dissemination,

input supply and input-output pricing, which can help to enhance the productivity, profitability and sustainability of both the crop and livestock farming systems.

- To suggest pro-small farmer methods of conferring the power and economy of scale to farm families with small holdings, such as Cooperative Societies, SHGs, Contract Farming, Producer Companies etc.
- To suggest how Panchayati Raj institutions can help to advance the cause of agriculture and how Gram Sabhas can function as **Pani Panchayats**.
- To give inputs for the preparation of the Eleventh Plan and all subsequent plans in the areas of agriculture including livestock and fish production, on the basis of the major agro-climatic and agro-ecological regions of the State.
- To serve as a think-tank for taking the State agriculture forward in the areas of quality improvement and national and global competitiveness. In particular, the Commission could advise the Government on improving trade opportunities both within the country and outside.
- To recommend measures which can help to generate more income and employment both in on-farm and non-farm activities and enterprises and which can help to impart an income and skilled employment orientation to agricultural strategies, programmes and policies.
- To serve as the voice of Kisans in all aspects of Government Policies which will affect either positively or negatively on the well-being of rural families.

It would be better if the Commission is a compact one with not more than nine members drawn from different agro-ecological regions. The Members should be genuine farmers (including farm women) and the Chair could be a distinguished farmer – achiever. There could be an Advisory Committee to the Commission comprising of officials and scientists drawn from the Agricultural and Veterinary Universities and the relevant State Government Departments.

- Agricultural progress should be measured by the growth in the net income of farm families. Along with production growth rates, income growth rates should also be measured and published by the Economics and Statistics Directorate of the Union Ministry of Agriculture.
- Article 243 G of the 11th Schedule of the Constitution (73rd Amendment) Act, 1992 entrusts *Panchayats* **with responsibility for agriculture including agricultural extension**. In addition, *Panchayats* will also have to attend to:
  - Land improvement, implementation of land reforms, land consolidation and conservation
  - Minor irrigation, water management and watershed development
  - Animal husbandry, dairying and poultry

- Fisheries
- Social forestry and farm forestry
- Minor forest produce
- Small scale industries, including food processing industries.

At the moment there are about 2,25,000 *panchayats* in the country. The problems facing Indian Farmers are generally dealt with in an aggregated manner – i.e., taking into consideration the problems of over 100 million farming families as a whole. They then appear formidable. **However, if such problems are disaggregated and dealt with by *Gram Sabhas* and *Panchayats*, location-specific problems can be attended to speedily and effectively.** The extreme distress faced by farmers in certain regions of the country can then be dealt with promptly. Therefore, it is time that the provisions of Article 243 G are implemented, both in letter and spirit. Panchayats should be involved in water conservation and management as well as in the resettlement of those who will be displaced by big dams through *Gram Sabhas* serving as *Pani Panchayats*. Also, one woman and one male member of the *panchayat* should be trained to serve as Farm Science Managers. In the areas prone to drought, floods and cyclones, one male and one female member could also be trained to serve as Climate Managers. *Panchayats* could also be the location for the Gyan Chaupals. They can then play a very important role in agricultural renewal and renaissance.

2006-07: The Year of the Farmer

To restore farmers' faith in farming, the National Commission on Farmers has recommended that the agricultural year of 2006-07 (June 1, 2006 to May 31, 2007) may be observed as the **Year of the Farmers**. The steps recommended by NCF are simple, doable and affordable. They however need a change in mindset from one which regards farmers as "beneficiaries" of small government programmes, to one which treats them as partners in development and custodians of food security and national pride. Integrated action on the following five points will help to get our agriculture back on the rails.

First, undertake soil health enhancement through integrated measures in improving soil organic matter and macro-and, micronutrient content, as well as the physics and the microbiology of the soil. Gujarat has already issued Soil Health Cards to farm families and other States can do likewise.

Second, promote water harvesting, conservation and efficient and equitable use by empowering Gram Sabhas to function as **Pani Panchayats**. Such Pani Panchayats should foster the establishment of community managed water banks and the recharge of the aquifer. A sustainable water security system should be put in place, particularly in rainfed areas lacking assured irrigation facility. This will be facilitated by mandatory water harvesting and greater attention to dryland farming.

Third, initiate immediately credit reforms coupled with credit and insurance literacy. The Finance Minister has announced a reduction in the interest on short term loans to 7%, but this

should be regarded as the first step in a series of measures including the revitalization of the cooperative credit system. Credit support should include attending to the credit needs of farm families for agricultural, health and domestic needs in a holistic manner. Also in chronically drought prone areas, the credit repayment cycle should be extended to 4 to 5 years. Credit delivery systems should be engendered since only a small proportion of women cultivators have been issued with Kisan Credit Cards inspite of the increasing feminisation of agriculture. Adequacy and timelines of credit availability are vital for institutional credit to be meaningful to small farmers.

Four, bridge the growing gap between scientific know-how and field level do how both in the production and post-harvest phases of farming through a slew of measures including the training of one woman and one male member of every Panchayat as Farm Science Managers, establishing Farm Schools in the fields of outstanding farmer-achievers, adding a post-harvest technology and agro-processing wing in every Krishi Vigyan Kendra, and organizing nationwide Lab to Land demonstrations in the areas of agricultural diversification, food processing and value-addition.

Also knowledge connectivity as proposed under **Bharat Nirman** should be accomplished by establishing Village Knowledge Centres or **Gyan Chaupals** throughout the country. Small farmers should not be subjected to administrative and academic experiments in the area of crop diversification, without first linking the farmer with the market for the new commodities. Crop-livestock-fish integrated production systems are ideal for small farmers since this can also facilitate organic farming. Low economic risk, high factor productivity, promotion of integrated farming systems, avoidance of ecological harm and assured income must be the bottom line of all agricultural research and development strategies. Had we adopted a pro-small farmer biotechnology strategy, we will by now have Bt-cotton varieties, whose seeds farmers can keep and replant, unlike in the case of the hybrids marketed by private companies.

Scientific strategies should include attention to both on-farm and non-farm livelihoods. We should confer the power and economy of scale on families operating one ha or less through management structures like cooperatives or group farming as well as contract cultivation based on a win-win model of partnership for both the producer and the purchaser. Institutional structures like Small holders' cotton, horticulture, poultry and aquaculture estates can be promoted by stimulating the formation of Self-help Groups at the farm level. Concurrently, we should launch an integrated Rural Non-farm Livelihood Initiative by revamping and integrating numerous isolated non-farm employment and income generation agencies such as the KVIC, Small Farmers' Agri-business Consortium (SFAC), Textile, Leather and Food Parks, Agri-Clinics, and Agri-business Centres. **Unless market driven multiple livelihood opportunities are created, the pressure of population on land will grow, the indebtedness of small farmers will increase, and the agrarian distress will spread**. Poverty will persist so long assetless rural families remain illiterate and unskilled. The National Rural Employment Guarantee Programme provides a unique opportunity for imparting functional literacy using computer aided joyful learning techniques. We should use new technologies to leapfrog in the area of human development in villages. At the same time, knowledge without access to

the inputs to apply that knowledge will have no meaning. Input supply systems need review and reform.

Finally, the gap between what the rural producer gets and what the urban consumer pays must be made as narrow as possible, as has been done in the case of milk under Dr. V. Kurien's leadership. The National Horticulture Board was created for this purpose over 23 years ago, but like SFAC, it also lost its way. It can only be hoped other expensive new programmes like the Fisheries Development Board, the National Rainfed Area Authority and the National Horticultural Mission will learn from the success achieved by agencies like the National Dairy Development Board, the Indian Space Research Organisation and the Atomic Energy Commission in achieving specific goals in a time bound manner, and benefit from strong professional leadership.

There is an urgent need for a National Land Use Advisory Service, structured as a virtual organisation on a hub and spokes model, the spokes covering the major agro-climatic zones and farming systems, for providing proactive advice to farmers on land and water use through an integrated analysis of meteorological, agronomic and marketing data. There is also need for an Indian Trade Organisation whose mandate is to protect the livelihood and income security of farm and fisher families. At the same time, there should be a Risk Stabilisation Fund and a farmer-centric Minimum Support Price (MSP) and Market Intervention Scheme (MIS).

Agriculture in our country is based on the technology of production by masses. As a consequence, it is the backbone of the national livelihood security system. The Indian tragedy of extensive poverty and deprivation persisting under conditions of impressive progress in the industrial and services sectors will continue to persist so long as we refuse to place faces before figures. NCF has suggested the mainstreaming of the human dimension in all agricultural programmes and policies, the adoption by the National Development Council of a National Policy for Farmers and the establishment of a State Farmers' Commission by every State Government, in order to voice the voiceless in the formulation of farm policies including the preparation of the 11th Five Year Plan. Let the Year of the Farmer help to shape our agricultural destiny in a manner that farming once again becomes the pride of the Nation on the occasion of the 60th anniversary of our independence on 15 August 2007.

Role of Farm Graduates in shaping our agricultural future

There are currently 45 Agricultural and Veterinary Universities in the country including Deemed Universities. Over 21000 Agricultural Graduates and Post Graduates are becoming available each year. Farming is become knowledge intensive and there is need for retaining Farm Graduates and Home Science Graduates in our villages in order to achieve the desired technological upgrading of farm enterprises. We need a national strategy for the knowledge and skill empowerment of farm families. At present, most of the Farm Graduates are either taking jobs in Government or Financial Institutions or in Private Sector industry. They are seldom taking to farming as a profession. This is not surprising, since as mentioned earlier over 40% of farmers would like to quit farming. There is an urgent need for increasing the productivity,

profitability and sustainability of major farming systems in the country through synergy between technology and public policy.

There are several ongoing technology transfer and extension mechanisms. The latest addition is the ATMA. Krishi Vigyan Kendras, lab-to-land programmes and regular extension services also exist. Inspite of these efforts, the gap between scientific know-how and field level do-how is widening. This is why, it is essential that steps are taken to attract and retain educated youth in farming. They can help to empower rural women and men with new skills and technologies including Biotechnology, Information Communication Technology and Renewable Energy Technology. They can also help to provide need-based services including appropriate and good quality seeds and other inputs at the right time and place. Extension of knowledge and of the inputs needed to apply that knowledge at the field level will have to be concurrent.

There has to be a two-pronged strategy for attracting and retaining educated youth in farming. Farm graduates who own land should be encouraged to take to farming as a profession. **Farm schools** on the lines recommended by NCF in its First Report, could be established in the fields of such Farm graduates who are operating agricultural enterprises efficiently. Secondly, Farm Graduates who do not own land can be assisted to provide demand driven services through Agri-clinics, Agri-business centres, Food Parks, etc. There should be Capacity Building and Mentoring Centres to assist Farm Graduates to set up Agri-Clinics and Agri-Business Centres. To the extent possible, groups of 3-4 Graduates can be formed for running these enterprises. For providing Mentoring and Hand-holding Services, professors and scientists as well as NGOs could be enlisted. Arrangements should also be made for the Farm graduates to undergo apprenticeship in suitable Companies.

Government should consider the following services to Farm graduates: low interest loans, venture capital funds, allotment of wasteland for setting up Agri-clinics and Agri-business Centres and facilities for establishing **Gyan Choupals** or Village Knowledge Centres. Self Help Groups of Farm graduates including women and men could be formed to avail of the new credit facility for SHGs and for undertaking a variety of market driven enterprises such as production of organic foods, bio-fuels, bamboo cultivation, etc. Groups of Farm Graduates can also be encouraged to form Producer Companies for undertaking the production of good quality seeds, agro processing, marketing, etc. They should be trained in Contract Farming methodology which benefits both the producer and the purchaser. Government may also consider providing land in State Farms for organizing seed production, livestock breeding, etc. The production of planting material and seeds necessary for the National Horticulture Mission could be undertaken by men and women Farm graduates.

In the case of medical and veterinary sciences, there is a system of registration of practitioners. It would be useful to develop a system for according recognition to Farm Graduates to provide Extension and other services by recognizing them as **Registered Farm Practitioners**. It may be necessary to set up an All India Agricultural Council on the model of the Medical and Veterinary Councils to give such accreditation. This will also be an oversight mechanism to ensure the quality and credibility of the services provided by farm practitioners.

There is need for a few Centres of Excellence in Agriculture (Crop and Animal Husbandry, Fishery and Forestry) on the model of IITs and the IIMs. The Agricultural Universities Association should not only bring about curriculum reform for imparting more practical training, but also reforms in the pedagogic methodology taking into account the new opportunities opened up by ICT for promoting a learning revolution among our students. By suitably restructuring the pedagogic methodology using ICT tools, it will be possible to save time for practical work. Agricultural Universities should also organize more non-degree training programmes. All Farm Universities should adopt the motto "**Every Student an Entrepreneur**". Entrepreneurship and innovation must be the key goals of Universities.

Areas like the North Eastern Region and Jammu & Kashmir requires special attention from the point of view of providing Farm Graduates with opportunities for gainful self-employment. For this purpose each State should organize a Recognition and Mentoring Programme (RAMP). In the hilly areas there is a particular need for service centres for farm machinery.

The Tenth Plan has called for paradigm shift from food security at the national level to nutritional security at the individual level. There are very large numbers of Home Science Graduates who are unemployed or in-appropriately employed. A new scheme should be formulated for organizing **Nutritional Clinics** on the model of Agri-clinics which will provide an opportunity for Home Science Graduates to ensure the success of ICDS and mid-day meal programme and to fight hidden hunger caused by the deficiency of micro-nutrients in the diet.

The facilities for practical training for Farm Graduates must be expanded. The Vidya Dairy at Anand which imparts end-to-end training as well as the Fish For All Training Centre which is being established by MSSRF at Nagapatnam are good examples of imparting skills through learning-by- doing. This move could be extended to all important commodities like lac, sericulture, ornamental fish production, etc.

Agricultural Universities should restructure their current Placement Bureaus in order to provide a special one-stop window for generating awareness of self-employment opportunities. Job Fairs can also be organized. There is considerable unmet demand in relation to the range of services needed by farm families. There is therefore considerable scope for training Farm graduates to provide demand driven services. Agricultural entrepreneurs are needed in large numbers for achieving successful farming systems diversification and value addition and for providing the right inputs at the right time and at the right place. Mobile phones have made communication easy. Farmers will be willing to pay for value added services.

There is need for a **National Alliance** for facilitating self-employment. Such an alliance can bring together all the stake-holders – Private and Public Sector Institutions, Commercial and Cooperative Banks and Farm Graduates Associations. Such a National Alliance can provide oversight for the implementation of a national strategy for the knowledge and skill empowerment of rural families and for imparting quality and trade literacy. They can also monitor progress in achieving the goal of **"every student an entrepreneur"** in our Agricultural, Veterinary and Fisheries Universities.

The process of preparation of the Eleventh Five Year Plan has started. In the Eleventh Plan, there is need for an integrated strategy of providing the services needed by farm families and for making our agriculture knowledge intensive. The strategy developed for this purpose should include providing space for self-employed Farm Graduates in undertaking enterprises and services which will help them to earn their living. At the moment, Government is running parallel services which are mostly free and therefore opportunities for earning by Farm Graduates are very limited. Therefore, while designing the new strategy for the scientific transformation of crop and animal husbandry, fishery, agro-forestry and agri-business, there is need for integrated planning and action so that the different actors (Government, industry and Farm graduates) all have well defined spaces. There must be synergy and convergence in the different initiatives.

No Time to Relax

The consequences of inaction in addressing the prevailing agrarian distress will be disastrous. Mentioning three of them would be adequate to highlight the serious implications of neglecting the "*Jai Kisan*" commitment.

- Expansion of threats to internal peace and security (e.g. spread of Naxalite Movement)
- Reverting to a ship-to-mouth existence, thereby diluting national sovereignty and enlarging the rural-urban divide in economic growth
- Jobless or even job-loss economic growth resulting in joyless growth for nearly half of our population and the consequent expansion of urban slums

If agriculture goes wrong, nothing else will have a chance to go right. If conversely agriculture goes right, the vision of a hunger and poverty free India can become a reality sooner than the time-frame set under the UN Millennium Development Goals. Therefore, our Academy should become the flagship of the movement for restoring faith and pride in farming.

Meeting the Challenges of Sustainable Agricultural Development in an Era of Global Change

Prof. M.S. Swaminathan

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Fellows of the Academy

The birth of our independence on August 15, 1947 was preceded by the great Bengal famine and severe food shortages. This prompted Jawaharlal Nehru to mention, "Everything else can wait; but not agriculture". During the last sixty years, we have made great progress in every field of social and economic development. The average life span of an Indian has been more than doubled, from about 30 years in 1947 to over 65 now. Annual Milk production has gone up from 20 to 100 million tonnes. Food production has also gone up and our farmers have disproved the belief held abroad that they are incapable of enhancing productivity substantially. During the first twenty years (1947-67) of independent India, the major concern was the creation of the necessary infrastructure for scientific agriculture. The second thirty years (1967-97) saw the benefits of synergy between technology, public policy and farmers' enthusiasm in the form of green revolution in wheat, rice and other crops. We witnessed during this period, the origin of a **green revolution symphony** characterized by a beneficial fusion of professional skill, political will and farmers' enthusiasm. Unfortunately, the third phase starting in 1997 has been witnessing a stagnation in production and productivity and a fatigue in the green revolution.

The other major problem has been the persistence of hunger and malnutrition. 2007-08 marks the mid-way point in the time frame set for achieving the UN Millennium Development Goals. The first among these goals is the reduction of hunger and poverty by half by 2015. Today, hunger and deprivation affect about 260 million people in the country. India is the home for 40 percent of the world's underweight children. Iron deficiency anaemia is estimated to affect 75% of children under 5, and 57% suffer from Vitamin A deficiency. Under-nutrition in women of reproductive age contributes significantly to child hunger. Consequently 30 percent of newborn babies weigh less than 2.5 kg at birth leading to multiple handicaps in later life including cognitive ability. No wonder India ranks 126 out of 177 countries in the UNDP Human Development Index.

Presidential address delivered at the 14th General Body Meeting of the National Academy of Agricultural Sciences held at New Delhi on June 4, 2007.

Soon after the United Progressive Alliance (UPA) Government came to power in 2004, a National Commission on Farmers (NCF) was set up with terms of reference drawn from the UPA's Common Minimum Programme. In its work, NCF adopted the approach, **"before advising farmers, listen to them"**, since they know both the problems and solutions better than others. Because of the serious situation in the area of nutrition security, one of the terms of reference to **NCF** was, **"*work out a comprehensive medium-term strategy for food and nutrition security in the country in order to move towards the goal of universal food security over time*"**.

NCF has dealt with this issue in detail in its reports and proposed the following six point action plan.

- Restructure the delivery of nutrition support programmes on a life cycle basis – from birth to death
- Universalise the Public Distribution System and enlarge the food basket by including nutritious cereals like **ragi, bajra, maize, jowar** and millets; promote community food security systems through a decentralized network of community managed grain banks.
- Launch a concerted attack on hidden hunger caused by micronutrient deficiencies through an integrated food cum fortification approach, with special emphasis on horticultural remedies for nutritional maladies.
- Attend to sanitation and the safety of the drinking water and strengthen facilities for primary health care and primary education
- Improve small farm productivity and pay concurrent attention to on-farm and nonfarm employment; bring about a paradigm shift from unskilled to skilled work, thereby adding value to the time and labour of the poor, particularly women. According to NSS data (2003), the average total income of farm households with upto 2 ha. land was less than 80% of their consumption expenditure.
- Develop and introduce as soon as feasible a **Food Guarantee Act**, combining the features of the food for work and National Rural Employment Guarantee programmes. Food as currency confers multiple benefits; it strengthens household food security and helps to raise production through increased consumption.

The above 6 point programme, if implemented holistically, would help to save our country from the unenviable and inexcusable reputation of being the home of the largest number of the hungry in the world.

I. Twin Challenges

The twin challenges facing Indian agriculture are: improving the productivity of small farms (less than 2 hectares) which constitute over 86% of the operational holdings, and the launching of an agro-processing and agri-business revolution. Small farm productivity enhancement can be achieved through an integrated 5-point action plan proposed by NCF

in 2005, when it recommended that the agricultural year of 2006-07 be observed as the Year of the Farmer. The components of the renewal strategy are: soil health enhancement with particular reference to soil organic matter and micronutrients and the issue of Soil Health Cards to farmers, rain water harvesting, conservation and efficient and conjunctive use, insurance and credit reform, technology and inputs for conservation farming, and producer oriented marketing. This programme was titled, **"Pancha Sutra"** for agricultural renewal by the Government of Karnataka.

In the area of agri-business revolution, a major initiative was announced by Dr Manmohan Singh in his budget speech in February 1992. "Special attention needs to be paid to supporting innovative ideas for generating income and employment in rural areas through support to various types of agri-business. As an experimental measure, Government proposes to set up a Small Farmers' Agri-business Consortium (SFAC) as an autonomous corporate entity funded by the Reserve Bank of India, NABARD and IDBI. The Consortium will include representation from Development Boards dealing with individual crops and public sector Corporations dealing with agriculture and agro-industries, private sector companies, banks, scientific organizations and farmers' associations. The Consortium will function on the principles of economic efficiency, environmental soundness and social equity. We must begin a new chapter in our agricultural history **"where farm enterprises yield not only more food, but more productive jobs and higher income in rural areas"**.

Unfortunately, SFAC became a bureaucratic organization and did not fulfill the original purpose for which Dr Manmohan Singh created it. In the first UPA Budget in 2004, the Finance Minister announced that SFAC will be revitalized, but this is yet to happen. **NCF** recommended in 2005 that during 2007-08, 60**,000 lab to land demonstrations** on **agroprocessing** and **agri-business** may be organized in collaboration with Agricultural Universities, ICAR institutes, the Central Food Technological Research Institute and Private Sector Food Processing Companies to commemorate the 60th anniversary of our Independence. This is also an idea whose time is yet to come.

Thus, systematic and synergetic steps for improving the productivity and profitability of small farms and for generating more income and employment opportunities through improved post-harvest technology are yet to be initiated.. We are not able to achieve the UN Millennium Development Goal in relation to hunger and poverty elimination largely because the majority of consumers are marginal farmers possessing less than one hectare, and assetless labour. Their income is not sufficient for balanced nutrition. A Small Farm Management Revolution can be achieved only by providing relevant centralised services to support de-centralised production. Without such support, it will be difficult to achieve a technological upgrading of small scale agriculture and confer on small producers the power and economy of scale in the production and post-harvest phases of farming. NCF recommended for this purpose the organization of Small Farmers' Cotton and Horticulture Estates. Unfortunately, schemes like agri-clinics and agri-business centers are yet to take off. In the case of rainfed areas constituting over 60% of our cultivated area, there is need for group endeavour among small farmers in the areas of water harvesting and effective and equitable use. The yield

of pulses and oil seeds can be doubled in such rainfed areas through concurrent attention to conservation, cultivation, consumption and commerce. This is why I have been pleading for the establishment of Special Agricultural Zones (SAZ) both in irrigated and rainfed areas in order to provide integrated services to small scale cultivators. Special Agricultural Zones can also be organized for the production of health foods, medicinal plants and for organic farming as well as areas like the Indira Gandhi Canal area of Rajasthan and Kuttanad area of Kerala.

In this context, it would be useful to study the Farm Bill 2007 of United States. The number of farming families in USA was less than 1 million in 2005. Much of the support of the US Government goes to areas like **Conservation Farming, Market Support, Credit and Insurance and support for attracting young people to take to farming**. An amount of 618 billion dollars will be provided to farm families during the next 7-8 years. All this is considered as essential support and not as subsidy.

Our packages should be similarly designed for launching an ever-green revolution leading to the enhancement of productivity in perpetuity without associated ecological harm. The small and marginal farmers of our country, who constitute 25% of the global farming population, have to lead this revolution. NCF has submitted a draft **National Policy for Farmers** summarizing what needs to be done to revive farmers' interest in farming by making agriculture economically rewarding and intellectually satisfying. If adopted, this will be the first time either in the history of colonial or independent India that the human dimension will guide agricultural policies and strategies.

II. Synergy between Technology and Public Policy

Our Academy since its inception in 1990 has been preparing papers for policy makers on different aspects of agriculture since it is only interaction between technology and public policy that can drive sustainable development. I am glad we have been able to put together all these papers with the help of the Academic Foundation under the title, **"Agriculture Cannot Wait : New Horizons"**. I hope this publication will help to spread widely the scientific view point in different areas of public policy related to agriculture. Our Academy has an important role in spreading both public and political understanding of science.

During this year, we have also undertaken on behalf of the Ministry of External Affairs a Mission to help Afghanistan to establish a National Academy of Agricultural Sciences of Afghanistan. This is in response to a request made by H E Hamid Karzai, President of Afghanistan, when he addressed the Academy on November 19, 2006. The Afghan Academy will have the important features of both our Academy as well as the Chinese and Russian Academies of Sciences, which, unlike us, manage research institutions.

The **NAAS expert team** has made the following suggestions:

- Establishment of an Afghanistan Academy of Agricultural Sciences (AAAS) with mandate to serve as the think tank for agriculture, effectively organize educational needs at post graduate

level, formulate and supervise the undergraduate curriculum through taking responsibility for agricultural education and to develop a research agenda.

- Incorporation of such an Academy as an independent statutory body with responsibility for research and education under the Ministry of Agriculture and Irrigation.
- Restructuring of the research and education set up in Afghanistan into a compact, smooth flowing, accountable system capable of responding to the urgent short and long term needs of the country.
- Assigning a central role for AAAS for innovating, initiating, monitoring, evaluating and directing national agricultural research schemes, seeking and receiving need-based national and international collaboration,
- Bringing the exiting National Institutes of Agriculture, Animal Husbandry / Veterinary science, research stations and sub-stations and all farm research and education programmes under one umbrella of a unified overall administrative setup and function.
- Preparing a roadmap with milestones, activities and financial costing for such a demand driven, futuristic requirement of the people of the Islamic Republic of Afghanistan
- It is our hope that the Afghanistan Academy of Agricultural Sciences will come into existence soon and that it will help to rejuvenate and revitalize the agriculture of this great and ancient country.

III. International Cooperation : New Avenues

Among the other areas where our Academy can take the initiative in the coming years, I would like to refer to a few.

1. Sustaining and expanding Africa's Green Revolution

Green Revolution in Africa is an idea whose time has come. The growth rate in African Agriculture was 3.9% during 2004, as against the global average of less than 2%. The work done by FAO, the Earth Institute of Colombia University in Malawi and in numerous Millennium Villages in Africa has shown that a doubling in maize production is possible, if fertilizers, seeds and treadle pumps can be made available to small farmers at affordable prices. The support given to resource poor farmers for adopting yield enhancing and environmentally benign technologies should be referred as, "**technology adoption support**" **and not as subsidy**. In areas affected by HIV/AIDS, support for nutrition should be given, in addition to making available relevant drugs. Finally, opportunities for assured and remunerative marketing are essential for sustaining farmers' interest in productivity improvement. The numerous agencies working in Africa like FAO, Bill and Melinda Gates Foundation, the Rockefeller Foundation and the Earth Institute could join together to form an **African Green Revolution Symphony**, in order to sustain and enlarge the Africa's green revolution. Our Academy can be a part of this symphony, sharing the experience gained in India.

2. Harmonising Energy and Food Security:

It would be useful to organize a **Scientific Consultation on Land Use Policies for Biofuel production** in order to develop approaches which will lead to the steps taken for food and fuel security becoming mutually reinforcing. The current steep rise in the price of maize in the global market as a result of the increasing use of maize for ethanol production, has serious implications for the food security of the poor in Africa and Latin America. Biofuels are currently being derived from corn, soybean, rapeseed and groundnut, as well as from non-grain food crops like cassava, sugarcane and oilpalm.

Other plants like **Jatropha** and **Pongania** are now attracting attention. It is important to accord priority to biotechnological approaches to energy production. Also, biomass utilization for energy generation (eg, pyrolysis and gassification of biomass) deserves greater attention. **Land use policies in every country should be based on a careful consideration of the needs for food and energy security in a holistic manner**.

Market forces in the area of using grains for energy generation should take into consideration the overriding importance of food security of the nearly one billion members of the human family who are currently undernourished.

3. Transboundary Pandemics:

African breeds of cattle like Boran and N'Dama have trypano-tolerance traits. Similarly, it is likely that some indigenous breeds of poultry may have resistance to the Avian influenza virus. The dreaded H5N1 strain of the Avian Influenza virus is leading to the indiscriminate killing of native breeds of poultry. The time has come for a scientifically designed international effort to conserve and evaluate the native breeds of livestock for resistance to important transboundary disease causing organisms like the H5N1 strain of the Avian Influenza virus.

The Svalbard International Seed Vault established by Scandinavian countries under perma-frost conditions near the North Pole with a holding capacity for 3 million seed samples for preserving for posterity plant genetic resources is a good example of valuable international collaboration. A similar initiative both for conserving and evaluating genetic variability in livestock is needed urgently. Priority in the international effort can be given to diseases of transboundary importance.

4. Capacity Building for Sustainable Development:

Investment in capacity building confers multiple benefits – on individuals, organizations and the environment. Capacity building efforts should cover both grassroot workers and national and international policy makers. An **Action Education** model of capacity building which integrates academic course work with field experience will be essential for developing a cadre of professionals well versed in the art and science of sustainable development and in bridging the growing gap between scientific know-how and field level do-how. The

Earth University in Costa Rica is a good example of designing institutions for breeding transformational agents who combine scientific humanism and humanistic science in a symbiotic manner. A hub and spokes model of organization will help such institutions to spread their pedagogic methods for sustainable development speedily around the world. The Indira Gandhi National Open University (IGNOU) is initiating a programme of education for sustainable development.

5. Bridging the Divides:

The world is witnessing many divides, such as economic, technological, digital, genetic and gender divides. How can we bridge such divides and ensure social inclusion in access to technologies of importance to human food and health security? Patents and intellectual property rights (IPR) should not come in the way of all members of the human family deriving benefit from the products of the human brain, particularly in areas relevant to achieving the UN Millennium Development Goals. UN MDGs represent a global common minimum programme for sustainable human security and well being. For achieving the goal of social inclusion in access to relevant technologies, it will be useful if the Inter-Academy Council, International Council for Science (ICSU) and the Academy of Sciences for the Developing World (TWAS) would jointly sponsor the establishment of an **International Patents Bank for Sustainable Human Security**, to which scientists can assign their patents which are relevant to safeguarding food security and human and animal health and mitigating the adverse impact of global warming and sea level rise. The Science Academies can then help to ensure that access to relevant technologies is not denied to those who are unable to pay for them. At the national level, NAAS could take the lead in establishing such a **Patents Bank for Public Good** with reference to agriculture.

6. International Networks:

Global and Regional Action Research Networks which can help to develop location-specific methodologies for conserving the basic life support systems will be useful for purchasing time in technology development and dissemination. Many such Networks already exist, particularly under the auspices of CGIAR, ICSU, TWAS and other organizations. It would be useful if inter-disciplinary networks are organized for developing field level action plans for the sustainable management of tropical rainforests and coral reefs. These habitats are rich sources of biodiversity and a well planned global effort for saving them will be valuable.

7. Threats to Sustainable Food Security:

Among other areas we should deal with are threats to sustainable food security. These may arise from ecological, technological, economic and equity factors. Some of the areas which require consideration are the following:

- *Safeguard and strengthen* the ecological foundations essential for sustainable agricultural progress – land, water, forests, biodiversity

- *Strengthen* the adaptation and coping mechanisms against climate change
- Strengthen capacity in the field of **biosecurity**, H5N1 strain of avian influenza, Ug 99 strain of wheat stem rust, etc. and assist all nations to develop a Biosecurity strategy
- *Bio-fuels*: Land use policies should strike a balance between food and fuel security depending on local conditions.
- *Bread and Biotechnology*: The role of biotechnology in food security should be carefully assessed based on potential risks and benefits.
- Small Farm Management Revolution – productivity and power and economy of scale
- Income Security – Non-farm employment. **Bridge the Human Capital Divide.**
- Gender equity – skill and technological empowerment of women

8. Climate Change:

Climate change poses the single most important threat to the future of food production and security. Irrespective of who is responsible for climate change, the poor nations and poor in all nations will suffer most. The changes needing attention from the point of farmers and farming are:

- Temperature
- Precipitation
- Sea level rise
- Atmospheric CO_2
- Pest epidemics and disease pandemics
- Methods of adaptation will have to be area specific. Organic agriculture and traditional farming practices will not alone be able to provide food to 7 billion people. Issues like carbon trading, Clean Development Mechanisms and the provisions of the Kyoto protocol need understanding at the level of farm, fisher and rural populations. A massive awareness campaign is essential.

It would be useful if our Academy could help in designing a **Special Programme for Adaptation to Climate Change** in the major farming systems of the country. The aim should be to minimize climate related risks and maximizing the benefits of the available moisture. Computer simulation models can help farmers to adopt alternative cropping strategies depending on likely changes in temperature and precipitation. Knowledge dissemination should involve concurrently the supply of the inputs needed to adopt the knowledge.

- Conservation farming, dying wisdom in relation to water storage and other coping mechanisms, and vanishing crops all need attention. A cadre of grossroot level **Climate**

Managers will have to be trained (atleast one woman and one man in every village). NAAS could promote the establishment of National Research and Training Centre for the management of the impact of climate change on local level agricultural production. Livestock need particular attention with reference to feed, fodder and water. **Ground Water Sanctuaries** will have to be established in the form of concealed aquifers, which may be utilized only when absolutely essential for saving livestock and human lives. Cattle camps can be established near such sanctuaries.

IV. Indian Agriculture : A way Forward:

At recent meeting of the National Development Council held on 29 May 2007, the Prime Minister has drawn attention to the following urgent needs.

- Overcoming the technology fatigue which seems to have developed in major farming systems, so that we can continue to improve productivity and profitability of small farms on an environmentally and economically sustainable basis.
- Bridging the large yield gap prevailing today in most cropping systems.
- Orgnisation of a Food Security Mission which will help to enhance the availability of wheat, rice, pulses and oil seeds, so that prices can be kept under check and there is adequate supply of these essential commodities to the common man.

The above are urgent tasks and can be achieved only through bringing about synergy between technology, services, public policies and farmers enthusiasm. The Academy can particularly help in the development of a second fertile crescent in our country covering Bihar and Eastern India.

Traditionally the Punjab-Haryana-Western UP Region has been serving the role of a fertile crescent in India. This Region is the heartland of the green revolution. However, there are other parts of the country waiting to become fertile crescents. A very eligible candidate for such a role is the Bihar, Eastern UP, West Bengal and Assam Region. This Region is characterized by good soils and adequate rainfall and irrigation facilities. What is needed is a holistic approach to enhancing productivity and profitability on an environmentally sustainable basis. We are currently in the process of setting up a study team which will prepare a detailed road map for converting this region is to a fertile crescent. This Region is known for its vast untapped production reservoir with reference to crop and animal husbandry, fisheries, agro-forestry and agro-processing. Unless we develop this region into an agriculturally prosperous area, our country may have to revert to a ship-to-mouth existence once again after 40 years.

There is a vast untapped production reservoir available in UP, Madhya Pradesh, Bihar and Rajasthan. The ICAR Wheat Directorate in Karnal has calculated that we can produce an additional quantity of about 24 million t of wheat immediately by bridging the gap between potential and actual yields, with technologies and varieties now on the shelf (Table 1).

Table 1. Achievable Targets by Bridging Yield Gaps through available Technologies under irrigated conditions (based on National Demonstrations during 2003-04)

State	Area (,000 ha)	Yield gap t/ha	Additional production possible (000 t)
UP	8418.0	1.346	11330.5
MP	2831.8	2.071	5864.7
Rajasthan	2103.1	1.646	3461.7
Bihar	1483.0	1.196	1773.6
Haryana	2303.0	0.581	1338.0
Gujarat	660.7	0.714	471.7
Maharashtra	581.1	0.656	380.0
Karnataka	97.0	0.998	96.8
Punjab	3444.0	0.241	82.9
			24800.0

It will be prudent to launch a well designed farmer-centric production programme in Bihar, Rajasthan, MP and UP, with priority attention to soil health enhancement, varietal choice and **assured and remunerative marketing**.

Similarly, there is vast scope for increasing rice production in West Bengal, Assam, Orissa, Andhra Pradesh, Tamil Nadu, Karnataka and even Kerala during the **rabi** season. The yield of **boro** rice is high in Assam and West Bengal. Over 27 high yielding rice hybrids are now available to suit different agro-climatic and growing conditions, as well as grain quality requirements. They are from both the public and private sectors. Pusa RH-10 is a superfine, aromatic grain hybrid suitable for cultivation in North-West India. KRH2 is a high yielding and widely adapted hybrid, while DRRH 2 is an early hybrid with a good yield potential. **States with an unutilized yield reserve in their Agricultural Production Bank should be encouraged immediately to initiate action with the guidance of experienced farmers and scientists to utilize the yield reserve wisely to improve production and productivity**. The precise agronomic package will have to be developed on a location specific basis with the help of Agricultural Universities.

Rabi and **boro** rice production can be enhanced considerably by giving attention to balanced fertilization, particularly to the supply of the needed micronutrients like zinc, boron and sulphur. Together with plant protection, the enhancement of soil health will help to improve productivity atleast by an additional tonne per hectare. There are nearly 5 million ha under **Rabi** and boro rice in the country and improved varieties are available for all the States where rice is cultivated between November and May. Striking progress in improving the yield of rainfed maize, soybean, sorghum, green gram, blackgram, pigeon pea, chickpea, finger millet (ragi), pearl millet (bajra), castor etc., can be achieved through balanced fertilization (NPK and the needed micronutrients). Seeds of improved varieties should be maintained in Village Seed Banks

in rainfed areas, so that alternative cropping strategies can be introduced depending upon monsoon behaviour. Improved cultivars alone can enhance productivity by 10 to 50%. Varietal choice should be based on the likely moisture availability. The short duration chickpea variety **Shwetha** (ICCV2) has revolutionized chickpea production in Andhra Pradesh. The productivity increased from 470 kg per ha in 1993 to 1084 kg per ha in 2004. Area also increased seven fold. There are nearly 12 million ha of rice fallows in MP, Orissa, Jharkhand, Chattisgarh and West Bengal. In such rice fallow areas, chickpea can be grown by using residual soil moisture. Simple seed priming technologies like soaking seeds in water and micronutrient solution for 6 hours and drying in shade will help in establishing a good chickpea crop in rice fallows. In Madhya Pradesh 2 million ha remain fallow during the **kharif** season. Using broad bed and furrow, balanced nutrient management and short duration soybean cultivars like Samrat, farmers in the Vidisha district were able to take a crop of chickpea or wheat during **rabi** and thereby double their income. Many such simple steps in soil-water-crop management can lead to major advances in both crop output and farmers' income. This is the pathway to making farming economically viable.

Eastern India (eastern UP, Bihar, Chattisgarh, Orissa, West Bengal, Assam and NE States) have a large untapped production reservoir even with the technologies now available. In these areas, poor water management, rather than water availability, is the major constraint. **The Indo-gangetic plains offer scope for becoming the major bread basket of India through an appropriate mix of technology, services and public policies.** In many of these areas, the aquifer should be enriched during the S W Monsoon period, and extensive ground water use should be promoted during the October – April period. Given the right strategy, the Ganges Water Machine could become the main anchor for our food security system. **Bihar in particular is a sleeping giant in the field of agriculture**. The work of IARI in the Dharbhanga district and Sone Command area has shown that the wheat yield can be increased substantially with good seeds and improved agronomic practices. The major bottleneck is however the absence of a Grain Purchasing Machinery which will provide the MSP to farmers.

Action to extend the gains of higher productivity and profitability should cover all rainfed areas. This should be a priority task of the National Rainfed Area Authority. The recommendations of the Swaminathan Committee on "More income per drop of water (2006)" should be converted into action plans on a location and farming systems basis. The country can enter into an era of ever-green revolution if the proposed additional central grant of Rs. 25,000 crores during the 11th Plan period is used mainly for bridging the prevailing yield gap by converting scientific know-how and field level do-how.

V. Food Security Mission

Finally, the proposed Food Security Mission prepared by the Prime Minister will be successful only if the following basic principles enunciated by Prime Minister Rajiv Gandhi over 20 years ago is adhered to :

Prime Minister Rajiv Gandhi started the Oilseeds and Pulses Missions to give holistic attention to all links in the production-consumption chain. The Missions led by eminent

scientists like Dr M V Rao had a striking impact in their early years. Subsequent policy changes and leadership vacuum unfortunately led to the stagnation in the productivity of these life enriching crops.

The country can produce as much pulses and oilseeds we need through synergy between technology and public policy, since there is a stockpile of improved varieties of dryland crops. The new hybrid **arhar** strains (Pigeon pea) can trigger a pulses revolution. The largest section of consumers in India is the farming population. By helping farmer-consumers to have greater marketable surplus because of higher productivity, we can eliminate substantially poverty induced hunger and malnutrition in the country.

Technology Mission as a technique or a method to achieve specific development goals was initiated by the late Shri Rajiv Gandhi in 1986. Five Technology Missions were initiated, out of which was Technology Mission on Oilseeds. In his Convocation Address at the IARI, New Delhi in February, 1986, late Rajiv Gandhi said, "One of our biggest problems today in the agricultural sector is the oilseeds. We are setting a thrust Mission for oilseed production. **When we talk of a Mission, we mean an exercise starting from engineering of the seeds and finishing with the finished products of the vegetable oil, which could be delivered to consumer**. We would like to put one person in-charge of such a mission with the full funding with no restriction on him whether bureaucratic or otherwise. **The only limits will be certain achievements, which must come within a certain time frame"**.

Rajiv Gandhi envisaged that a Technology Mission should have well defined objectives, an end-to-end approach in implementation, and inspiring professional leadership. The Food Security Mission will be successful if these principles are followed. It is the duty of our Academy, as the collective voice of the agricultural, scientific community of India to give our best in helping the country to make farmers and farming the pride of the nation. This is a pledge we should take on the eve of the 60th anniversary of our tryst with destiny.

Agriculture and Biotech Culture

Dr. Mangala Rai
President
National Academy of Agricultural Sciences

Fellow of the Academy,

Inclusive growth has become the *mantra* of our economic planning and developmental strategy. In fact, the foundation of our developmental path should have been based on the principles of inclusion of the poorest of the poor and the downtrodden in sharing the benefits of higher economic growth. A high and inclusive growth trajectory will leapfrog the economy to higher frontiers and accomplish the goal of social welfare. Failure of such growth would witness economic, social and regional disparities that would lead to social conflicts. Therefore, we must ensure that we produce enough food to meet the growing demand and generate sufficient income augmenting opportunities without compromising the sustainability of our natural resources and the environment.

2. Agriculture is the backbone of Indian economy. It supports more than half a billion people providing employment to 52 per cent of the workforce. Despite the fact that since independence, the contribution of agriculture and allied sector to the overall GDP has fallen from 61 to 17.8%, high dependency of majority of poor makes this sector all the more important. As of today, India has about 17% of the world's population living on 4.2% of the world's water resources and 2.3% of the global land. Per capita availability of resources in India is about 4 to 6 times less as compared to the world average. This will further decrease as a consequence of declining size of land holdings and increasing land fragmentation due to high demographic pressure and law of inheritance.

3. A large proportion of India's geographical area is under cultivation, being 51%, as compared to mere 11% of the world average. The present cropping intensity of 137% has registered an increase of only 26% since 1950-51. The net sown area that was 140.27 m ha in 1970-71 has not changed much and was 141.32 m ha in 2004-05. Similarly, the net irrigated area that was 50.29 m ha in 1992-93 increased to only 57.08 m ha in 1998-99. Thereafter also, negligible expansion occurred in net irrigated area being 58.54 m ha in 2004-05. Presently, the total net irrigated area covers 41 percent of the net sown area, which the remaining 59% is rainfed. Even if we realize full irrigation potential, nearly 50 percent of the cultivated area would remain rainfed. It is important to note that the livestock production in such areas is a major source of livelihood for the rural households.

Presidential address delivered at the 15th General Body Meeting of the National Academy of Agricultural Sciences held at New Delhi on June 5, 2008.

4. There is an unprecedented degradation of land (107 m ha) and surface as well as ground water resources, due to which fast deterioration of soil health is compounded in most parts of the country. There is deceleration in the rate of growth of total factor productivity. A major concern before us today, is that the current levels of efficiency of resources, both natural (water, soil, bio-energy, etc) and man-made inputs (fertilizers, pesticides, fossil energy) are much below the desirable level. Currently, only 29% of the total precipitation is conserved, and that too not optimally utilized. With the existing practices, water use efficiency seldom exceeds 40%, while the use efficiency of nutrients ranges from 2 to 50%. Such a low input use efficiency not only increases the cost of production, but also leads to marked adverse effect on production and severe environmental consequences. Besides, there are regional imbalances in the use of fertilizers and the ratio of N:P:K application is highly skewed. The severe deficiency of multiple micro nutrients is being observed in most of the states. Since agriculture is increasingly mechanized, issues related to poor mechanical efficiency also come in the forefront of energy management.

5. Losses due to biotic (insect-pests, diseases, weeds) and abiotic (drought, salinity, heat, cold, etc.) stresses account for about one-fourth of the value of agricultural produce. Invariably, the crops and livestock are faced with biotic or abiotic stresses in various forms, at some stage of their life cycle that impacts their production potential. In the tropical environments, there are a number of pathogens that act as constraints to the agricultural production as compared to the temperate regions because of more congenial living conditions. Many pathogens such as *Puccinia graminis* in wheat, *Pyricularia oryzae* in rice, *Aspergillus* spp. on groundnut, TMV in tobacco, coconut wilt virus, and rinderpest, FMD, avian flu, salmonella infections, etc in livestock have caused enormous productivity loss and even mortality. Recent outbreak of avian flu has threatened the very survival of flourishing poultry industry. Emergence of Ug99 strain of wheat rust could devastate wheat crop. We in India have already initiated research to insulate the wheat crop against Ug99 and hopefully, the anticipatory wheat breeding programme would certainly pay good dividends for alleviating the threat of this race.

6. Besides pests and diseases, weeds compete with crop plants for moisture, light and nutrients. Moreover, losses due to inadequate and inefficient post-harvest handling are enormous. The storage, transportation, processing, value addition and marketing of farm produce need to be improved to enhance household food, nutrition and livelihood security. This trend needs to be reversed and agricultural productivity must be almost doubled to meet the growing demand for food and feed by 2050.

7. Economic reforms, initiated in the country in early 1990s, have put our economy on a higher growth trajectory. Annual growth rate in GDP has accelerated from below 6 percent during the initial years of reforms to more than 8 percent in the recent years. This happened mainly due to rapid growth in non-agriculture sector. However, faster growth in non-agriculture sector did not help in shifting workforce from agriculture to non agriculture sector. The workforce engaged in agriculture between 1980-81 and 2006-07 witnessed a very small decline; from 60.5 percent to 52 percent. This has created a serious disparity between agriculture and non agriculture, and urban and rural India. The magnitude of this can be seen from per worker income in agriculture and non agriculture. During 1978-2003, the growth rate of average income of an

agricultural worker has slowed down. Growth rate of income (based on 1993-94 prices) during the period 1978/9¬1983/4 was 1.08 percent, which marginally rose to 1.16 percent during 1988/9 to 1993/4, and sharply declined to 0.28 percent during 1998/9 to 2003/04. The irony of disparity is that a worker in non agriculture sector earns five times more income than an agricultural worker.

8. Like any growing economy, India is experiencing profound changes in consumption pattern of food. However, due to low level of per capita income, foodgrain consumption is the principal determinant of food and nutrition status. In recent years, due to slowdown in growth rate of staple foods like cereals and pulses, food self sufficiency is facing threat. The per capita availability of cereals was 137 kg in 1976 which steadily increased to 171 kg in 1991, but next five years witnessed decline in the per capita availability, which became quite severe during the last five years (152 kg). The first casualty of this trend was import of wheat during 2005-06 and 2006-07.

9. Investment in agriculture witnessed a substantial decline. However, the gravity of the situation was realized about 3 years ago, and some corrective measures were taken that resulted in slight acceleration in public and private sector investment in agriculture. Price policy, which was deterrent to agricultural growth, was rectified by substantially increasing the support prices and reforming age-old APMC (Agricultural produce Market Committee) Act by Model Marketing Act to link producers directly with the markets. These measures resulted in record harvest of foodgrains, soybean, cotton, sugarcane, etc. during 2006-07. The record foodgrain production of 217 million tons in 2006-07 was further broken with an estimated harvest of about 227 million tons in 2007-08. There is an all time record harvest of maize to the tune of 18.54 million tons; an increase of over 3 million tons over the preceding year. The estimates, as recent as last week of May, indicate growth rate of agriculture around 3.5 per cent for 2007-08, up from the earlier estimate of 2.6 percent , which is the highest since 2002. This has brought much-needed confidence in the national agriculture capability in a background of threatened food security at the global level and incidences of food riots in many countries. The record procurement of about 22 million tons of wheat and much awaited improvement in the growth rate of agriculture in 2008 bear a testimony of various measures initiated during the last three years.

10. India's import dependence to meet domestic requirement exceeds 40 percent in the case of edible oil and is around 11 percent for pulses. Our requirement for various agricultural commodities by the year 2011-12 and 2020, and growth rates needed to meet those requirements are presented in Table below :

Table. Demand projection for agricultural commodities towards 2011 and 2020

Commodity	Projected demand (million tonne)		Required growth rate to match demand (%/year)	
	2011-12	2020-21	By 2011-12	By2020-21
Rice	105	122	2.06	1.71
Wheat	79	84	0.95	0.73

Commodity	Projected demand (million tonne)		Required growth rate to match demand (%/year)	
	2011-12	2020-21	By 2011-12	By2020-21
Total cereals	232	273	2.21	1.84
Pulses	20	24	2.35	1.96
Total foodgrains	252	297	2.21	1.85
Milk and milk products	113.0	140.72	3.18	2.76
Egg	62.0	82.68	6.09	4.48
Meat	8.6	11.40	5.03	4.06
Fish	8.6	11.86	4.39	3.95
Edible oilseed 40% Import dependence	31.8	39.06	2.87	2.55
Vegetables	109.0	128.22	2.51	2.12
Fresh Fruits	67	85.98	3.46	3.06
Sugar and gur	35.50	40.55	3.87	2.55

11. Global climatic change, is now a reality and a major challenge for agricultural production systems. World climate is gradually becoming warmer due to continuous increase in the emissions of carbon dioxide, methane and nitrous oxide. It is projected that temperature increase by the end of this century is likely to be in the range 2 to 4.5°C.

12. The likely impact would be rapid receding of Himalayan glaciers, decrease in irrigation water availability, especially in the Indo-Gangetic plains, more intense tropical cyclones, increased frequency of droughts and floods, sea level rise and submergence of coastal areas. Recent reports of the Inter-Governmental Panel on Climate Change (IPCC) indicate considerable probability of loss in crop production due to these factors in tropical regions. Indian studies also confirmed these findings. Increasing temperature in future is likely to reduce fertilizer use efficiency and lead to higher emissions of greenhouse gases (GHG). Since agriculture is one of the major sources of GHGs, this could become a cause for concern. Global warming is also projected to increase water, shelter, and energy requirement of livestock, and to affect fish breeding, migration, and harvests. Unless we put far greater efforts, these factors would bring additional stress on our food security in near future. Greater attention is needed on adaptations to climatic change and mitigation of GHG emissions from agriculture. The issue is deliberated at length and point for action is drawn through national consultation and conference (**Annexure**). The same has been further examined in the national conference of ministers of agriculture and horticulture of various states under the Chairmanship of Union Agriculture Minister on May 26, 2008 at Hyderabad.

13. Good quality seed is a primary determinant of productivity. Often, farmers do not distinguish between grain and seed, and the seed replacement rates are very low. The main reason for this is non availability of quality seed and to some extent, lack of awareness

among the farmers. Harnessing benefits of improved technologies requires well developed system for production and distribution of seeds and plant propagation materials. In India and many developing countries, public sector dominates multiplication and supply of seed which includes fish fingerlings and plant propagation material, but it is highly inadequate to meet the emerging and growing demand in future. There is a need to develop competitive seed industry by involving private sector in seed production and distribution. The innovative initiatives launched by the ICAR have doubled the seed production by institutes/Universities in 2006-07, which is estimated to double further in 2007-08.

14. During the last 15 years, agricultural research system has faced serious resource crunch. A recent report from the Department of Science and Technology reveals that our investments in research are far below than that of many developed countries and even some developing countries. For instance, in India we spent about 0.8% of GDP towards agricultural research, whereas in China, Japan, US, Israel and Sweden the corresponding figures are 1.23, 3.11, 2.67, 5.11 and 4.27 percent, respectively. India has only 110 researchers/million population, whereas China has 633; US-4526; Japan 5085; and Sweden 5171 researchers/million. Inadequate human and financial resources devoted to scientific research are the important constraints to the agricultural growth.

15. Problems and challenges facing agriculture sector require immediate action on several fronts – technology, policy, infrastructure, finance, markets etc. Though all factors are important, technology has high potential to trigger expansion of other drivers. Simultaneously, very strong integration is needed in research, education and extension for efficient and effective delivery system. An effective system needs to be evolved in a continuum right from basic/ strategic research to location-specific technology development, so that technologies generated are adopted at the farm level. Therefore, raising agriculture growth on a sustainable basis requires substantial increase in public investments. Nevertheless, no technology can show desired impact if enabling conditions, policies and economic environment are not in place. Among the various options available for improving the farm productivity, production, quality and sustainability, the new tools of biotechnology and of other frontier sciences have started offering tremendous opportunities for application in agriculture.

16. Starting from the nineteenth century, the world has seen the rise of genetics as a scientific discipline (1900s), the finding of DNA as the hereditary material (1944), the elucidation of the double helix structure of the DNA molecule (1953), the cracking of the genetic code (1966), the ability to isolate genes (1973), and the application of DNA recombinant techniques (from 1980 onwards). Methods of crop and livestock improvement have also changed dramatically throughout this vital period.

17. In order to feed the ever-growing population, a far greater challenge in front of the scientific community is to develop varieties/breeds that are highly productive even under adverse conditions (e.g. high temperature, drought, excess water, and salinity). In addition, genetic enhancement has to address post-green revolution problems like micronutrient deficiencies, depleting soil carbon levels, and hidden hunger. Varieties/breeds also have to be now tailor-made to suit the requirements of the farmers, consumers and processors. While doing so,

the principal goal must be to increase income of smallholders and make them viable through improved and new technologies. Careful choice of biotechnology and realistic assessment of their potential in crop and livestock improvement are indeed the needs of the hour. Hence, in today's presentation I would concentrate on this issue only.

18. Biotechnological interventions, including (i) **transgenics** which can integrate foreign or synthetic genes of interest into target organisms across species barriers; and (ii) **molecular breeding** for targeted improvement of specific traits in crops, livestock or fish; (iii) **molecular diagnostics and vaccines** for effective control of diseases; (iv) **nanotechnology** for biosensor development, and (v) **precision farming**, have tremendous scope for revolutionizing the agricultural production and farmers' income.

19. Biotechnology has already made tremendous impact on the world agricultural production. Genomics and bioinformatics are important components of modern biotechnology. These are unraveling secrets of life processes at molecular level, and are reckoned as the knowledge engine for discovery of new DNA markers for molecular breeding as well as genes required for transgenic development. Genome sequences of more than 300 microbes, one dozen higher animals, three fish species, and three higher plants, are already available in the public domain. Genetically engineered plants now cover more than 100 million hectares within just ten years of their introduction. Molecular markers are being used routinely for authentication of varieties and strains, and molecular marker-assisted breeding is being practised routinely in USA, EU and Australia both in the public and private sectors. We have also released two varieties, one each of rice and pearl-millet using this technology. Further 100 scientists are planned to be trained and equipped during 2008, of whom 39 scientists have already been imparted training. Leading world economies, particularly the USA, EU, Japan and China, have invested heavily in genomics and molecular marker technologies in agriculture. Even countries like South Korea, Singapore and Brazil have taken strategic initiatives in agricultural biotechnology.

20. India has enormous opportunities to tap the potential of biotechnology due to four major factors: (i) presence of tremendous genetic diversity in plants, animals, fishes and microbes; (ii) excellent germplasm collections (gene banks); (iii) an unique and strong coordinated system (including ICAR-SAU linkages) for phenotyping in diverse ecologies, coupled with domain knowledge in dealing with all kinds of crop plants, livestock and fishes; and (iv) computational and mathematical expertise.

21. The country has made a beginning in the adoption and generation of biotechnologies, but is far behind the world leaders. A significant achievement in the recent years has been the completion of rice genome sequencing. The transgenic Bt¬cotton, released in 2002-03 in India, has already demonstrated the potential of biotechnology, leading to unprecedented increase in cotton production. Now, transgenic inbred cotton is in the field for commercialization by the public sector institutions which would ensure drastic cut in the seed cost. However, to become a global leader in biotechnology, India must fully utilize the power of genomics and become a share holder in the global biotech IPR to protect the interests of our farmers. With the increasing role of private sector in commercialization of biotech products, the public system

needs to redefine its niche in the entire spectrum of activities starting from identification of problems, basic research and discovery, proof of concept, technology incubation and dissemination in biotechnology.

22. Genomics has opened new frontiers for discovering new genes and DNA markers. A thorough understanding of gene function from genotype to phenotype is critical to many areas of agricultural research. There could be myriad positive implications of genomics with respect to food, nutrition and environmental security of the nation.

23. The sequencing of genomes has provided new dimension in conservation of plant biodiversity and its genetic enhancement. Genomics will accelerate the utilization of candidate genes through genetic transformation without barriers across plant species or other living kingdoms. Functional genomics involves an integrated and often high-throughput approach to the complete set of an organism's genes and the expression of these genes. Proteomics involves identification of the complete set of proteins that are produced from these genes and their concentrations in cells under particular environment.

24. Gene mining (finding of new genes that add value to agricultural products) and allele mining (identifying favourable allele of a gene influencing an important trait) have become extremely important research areas, particularly in the private agri-business. Unique gene databases are being assembled by the industry with the massive amount of data generated by genomics research.

25. Genomics may provide a means for the elucidation of important functions that are essential for crop adaptation. Regions of the world should be mapped by combining data of geographical information systems, crop performance, and genome characterization in each environment. In this way, plant breeders can develop new cultivars with the appropriate genes that improve fitness of the promising selections. Fine-tuning plant responses to distinct environments may enhance crop productivity. Development of cultivars with a wide range of adaptation will allow farming in marginal lands.

26. Likewise, research advances in gene regulation, especially those processes concerning plant development patterns, will help breeders select genotypes for specific environments. Photoperiod insensitivity, flowering initiation, vernalization, cold acclimation, heat tolerance, and host response to parasites and predators, are some of the characteristics in which advanced knowledge may be acquired by combining molecular biology, plant physiology and anatomy, crop protection, and genomics. Multidisciplinary cooperation among the researchers will provide the required holistic approach to facilitate research progress in these areas.

27. The application of genomics to problems in agricultural and natural diversity can be thought of as a "genomic census" that allows us to characterize raw genetic variation in populations wherever they are in the world (of plants, microorganisms, animals), and thus determine how our genetic resources might be used most effectively and preserved to achieve sustainable production. The development of a genomic census will provide the tools and understanding necessary to develop and improve crop plants.

28. For whole genome strategies to be easily interpreted and ultimately implemented in practical breeding, analysis and visualization of the data become crucial. We need to train the present and future generations of geneticists and plant breeders in bioinformatics, especially for managing the pedigree, genotypic and phenotypic databases. Such training is extremely important to generate graphical genotyping, to follow allele flow through complex pedigrees, to compare genotypes from pedigree, and backcross programs against the preferred genotypes. With regard to agricultural bioinformatics, we have made some progress, but there is a long way to go. Besides developing databases, user-friendly software packages have to be developed for the breeding community. These should assist in both short-term decision making on crossing and selection strategies and long term strategic planning of breeding programs to manage and utilize molecular data most effectively.

29. India has made a good beginning by contributing to the global efforts in rice genome sequencing. New initiatives have been taken during the X Plan including: (i) Buffalo genomics (ii) National Consortium on Functional Genomics of Rice for yield and biotic stress tolerance; and ICAR network Projects on: (i) Transgenic and functional genomics in crops, including functional genomics of selected traits in rice, wheat, maize, mustard, chickpea, banana and tomato, and a genome informatics component, (ii) Application of Microbes in Agriculture and Allied Sectors, and (iii) Pigeon pea genomics under Indo-US Agriculture Knowledge Initiative (AKI). Through these efforts we have demonstrated our capabilities. However, India's capacity is far behind the global leaders in genomics. An institutional mechanism has to be established for effective coordination and implementation of functional genomics in all crops-/commodity-based institutions/SAUs in NARS. In this endeavour we need to :

- Generate resources for undertaking functional genomics (ESTs, high density maps, BAC libraries, mutants, mapping populations)
- Establish/strengthen high through-put genome sequencing facilities; wherever necessary, outsourcing for sequencing work to save on time and resources
- Design and implement proper 'phenotyping' of target traits, especially complex traits like drought tolerance, by developing state-of-the-art facilities at selected locations in India
- Develop reverse and forward genetics approaches, including expression profiling and proteomics for key target traits in prioritized crops / animals/fish
- Apply tools for allele mining, association genetics and haplotyping
- Innovations in development of statistical packages and databases
- Identify centres of excellence for training scientists and students in genomic tools and techniques, including BAC library development, fingerprinting of *contigs*, physical mapping, assemblies and annotation, gene prediction, microarrays, proteomics, etc.

30. DNA marker-based diversity analysis enables gene banks to define core collections, which will provide a user friendly entry point for breeders to access large and varied germplasm

collections. 'Allele mining' strategies are now available that can help better utilization of variation in the gene banks. Using markers tightly linked to a gene of interest, so called 'locus haplotyping' can be performed on accessions of germplasm to identify those samples that bear different alleles at the gene of interest, which can then be evaluated into further detail with respect to performance. This enables the breeders to efficiently identify new traits or better versions of existing traits for quick introgression into breeding lines.

31. QTL discovery, both from exotic and adapted germplasm, will produce endless choices to the breeders for improving diverse traits, including yield, disease resistance, abiotic stress tolerance, input use efficiency and quality. Generation of large-scale molecular marker datasets provides us with an opportunity to determine the genetic basis for various traits of agronomical importance. Also, methods for assessing the allelic variation at these agronomically important loci are now available. This combined knowledge will eventually allow the breeder to transfer favourable alleles at several loci in a controlled manner, leading to superior varieties.

32. Molecular breeding enables to change the focus from merely phenotypic breeding based on probabilities, to genotypic breeding that will increase the certainty of successful outputs and outcomes. The vision of breeding programmes in the future is one where molecular markers will have a significant role at critical stages. This will include selection in early generations, managing linkage blocks, enrichment of F_1s, monitoring of traits and the recipient genome in backcrossing, identification of parents and novel alleles, diversity analysis, and checking the genetic purity of elite breeding lines and hybrids.

33. Molecular breeding has been in rapid transition, as modern molecular tools are applied to commonly accepted field techniques. Predictably, the scientific development in this field is headed towards sequence-based knowledge which should improve both reliability and adoption in agriculture. Breeders will have to change their modus operandi with the development of objective marker-assisted introgression and selection methods. Parents of elite crosses may be chosen based on a combination of DNA markers and phenotypic assessment in a selection index. To achieve success in these endeavours, cost effective, efficient and rapid diagnostic marker procedures are required.

34. There are many areas of basic and strategic research in breeding and genetics that are being facilitated by molecular marker-aided analysis and generating new knowledge. Such information should be incorporated into genetic enhancement programmes, especially those with an evolutionary breeding scheme. Likewise, say for plant ideotypes for each crop, should drive the work of plant breeders. Specific plant morphotypes have been defined in rice and wheat based on accumulated knowledge of crop physiology and crop protection. Advances in automated technology and applied genomics are further enabling a novel approach to molecular marker-assisted breeding, referred to as 'Breeding by Design'. Generation of large-scale molecular marker datasets provides us with an opportunity to determine the genetic basis for various traits of agronomical importance. Also, methods for assessing the allelic variation at these agronomically important loci are now available. This combined knowledge will eventually allow the breeder to transfer favorable alleles at several loci in a controlled manner, leading to superior varieties/breeds.

35. In the past, domesticated animals were genetically improved by identifying meritorious individuals, mating animals displaying desired traits, continued breeding of related animals to perpetuate their superior traits, and crossbreeding when inbreeding depression became evident. Today, assisted reproduction and biotechnology allow breeders to design and direct the reproductive course, disseminate desired traits and hasten genetic improvement. Generation interval can be greatly reduced by combining artificial insemination, which is the oldest and most widely used assisted reproductive technology, with the more recent techniques, such as oestrus synchronization, superovulation, ovum pick-up from immature females even out of breeding season, and *in vitro* embryo production and transfer. Furthermore, the sex and genetic make-up of the offspring can be selected by using sex-sorted sperm for insemination, marker-assisted selection, functional deletion or addition of specific genes to the offspring's genome, or somatic cell nuclear transfer for cloning. It is important to improve the technical efficiencies of some of these procedures for large-scale application in the Indian context.

36. Integrating MAS in breeding strategies will become increasingly important in the coming years to realize genetic gains with greater speed and precision. We have a few success stories in molecular breeding, particularly with respect to molecular characterization of germplasm, gene tagging, QTL analysis and MAS in crops like rice, wheat, maize and *Brassica*. However, there is significant scope for extending the gains of molecular breeding to a wider array of crop plants, livestock and fisheries. Currently, MAS is more widely used for simply inherited traits rather than for polygenic traits. However, with the development and access to reliable PCR-based markers, such as SSRs and SNPs, efficiency of genotyping large populations or breeding materials, and consequently utilization of MAS for precision breeding, shall increase significantly.

37. Molecular breeding in a network mode has already taken its roots in India. For instance, the recently initiated ICAR Network Projects on 'Molecular Breeding in Crop Plants' and 'Gene Pyramiding', though confined to a limited number of institutes, crops and traits, are already giving good results. These programmes have also demonstrated on a pilot-scale, that networking has to be scaled up to all NARS and Universities / Institutions for making molecular breeding an integral part of crop improvement. It is necessary to evaluate the gains of using molecular markers over the conventional phenotypic selection. Tight linkage of the marker to the trait, reproducibility of the marker, automation of the analysis, and cost-effectiveness of the analysis, are some of the parameters that need to be taken into account before going for MAS.

38. Gene/QTL tagging and MAS should become an integral component of the breeding strategies being undertaken by all the research institutions/ SAUs. For this, it is extremely important to strengthen the infrastructure, including molecular marker laboratories, greenhouses/net houses, rain shelters, etc. Modern phenotyping facilities are lacking in most institutions which are critical for large-scale screening of germplasm for biotic and abiotic stresses.

39. However, there are some constraints in making molecular breeding a routine strategy in NARS. These include: (i) lack of high throughput genotyping facilities commensurate with

the demand, potential and scope of the technology; (ii) lack of efficient and high throughput phenotyping facilities for some important traits (e.g., drought and temperature tolerance); (iii) need for a critical mass of scientific and technical personnel adequately trained in molecular marker applications; and (iv) availability of large number of tagged and validated markers for important agronomic traits. These issues need to be addressed on priority and in a systematic manner.

40. The thrust areas for molecular breeding in crops, livestock and fish need to be prioritized in a phased manner. A Task Force may be needed to review the progress in both basic and applied work in each of major crops, livestock and fish, and work out an overall strategy for breeding in these identified core species of national/regional importance. This would need to:

- Systematic phenotypic and molecular characterization of Gene Bank accessions, including landraces and wild relatives
- Formulate 'core collections' for utilization in breeding
- Prioritize key target traits and identify relevant germplasm for molecular breeding
- Initiate intensive research programmes in various field and horticultural crops, livestock and fish with respect to gene tagging, QTL analysis and marker validation
- Identify and validate markers for the target traits, particularly resistance to diseases and tolerance to abiotic stresses, productivity, input use efficiency and quality
- Identify centres of excellence for high through-put genotyping
- Design optimum breeding strategies (based on organism and target traits) for extensive and most efficient use of molecular information.
- Access, curate and manage large amounts of data (phenotypic, genotypic and pedigree) using bioinformatics
- Develop breeder-friendly software packages to assist in short term decision making on crossing and selection strategies, and long term strategic planning of breeding programs using molecular data
- Utilize the selected Centres of Excellence for large-scale training of breeders and scientists from relevant disciplines in molecular breeding
- Conduct workshops in different universities for orientation of both faculty and students
- Improve community understanding of plant breeding and associated molecular technologies
- Utilize the selected Centres of Excellence for large-scale training of breeders and scientists from relevant disciplines in molecular breeding
- Conduct workshops in different universities for orientation of both faculty and students
- Improve community understanding of plant breeding and associated molecular technologies

41. Conventional breeding techniques are limited in some situations, like (i) lack of sources of resistance in the cultivated crop germplasm or even in wild relatives for some of the major insect-pests and pathogens; (ii) problems in sourcing genes from wild relatives; (iii) rectifying problems with respect to nutritional quality; and (iv) developing novel germplasm to meet the changing consumer demands/needs by modifying metabolic pathways.

42. In the new IPR regime, knowledge is property, and hence, knowledge-based technologies must be preferably generated *de novo*. With the advent of transgenic technology the entire biosphere is now a single gene pool and useful genes can be moved from one species to other. The Bt-cotton is a commercially successful example of gene transfer from a soil bacterium to plant. This is just the beginning of a new paradigm in the genetic improvement of crop plants, livestock and fish.

43. The nation anticipates great benefits from the modern tools of biotechnology in the next decades to come, to meet our future food, feed, fodder, fuel and fibre needs. Globally, transgenics / Genetically Modified (GM) crops, developed and deployed by several nations, have resulted in reduced dependency on chemical inputs. Transgenic technology has great potential to improve the much-needed tolerance capacity of crop plants to drought, high temperature, salinity and micronutrient deficiency, and to further boost the nutritional as well as keeping quality of food and horticultural crops. In the changing climatic situations, this is the technology which is going to help the much needed adaptation and mitigation efforts.

44. It is vital to ensure self-reliance in critical components of transgenic development; for instance, developing appropriate gene constructs for desired traits, vectors for genetic transformation and functional protocols for effective regeneration and transformation in crop plants of present and potential importance to the nation. This calls for developing effective network programmes.

45. Many issues with regard to the release of transgenics are not understood correctly by a large section of the society owing to the lack of information on this subject. The strategy for promoting public awareness in agriculture biotechnology must address facts, providing specific information capsules for each of the identified stakeholder groups. For instance, a farmer would like to be educated on benefits of modern biotechnology *vis-à-vis* other alternatives, and the post-release management and benefit-cost aspects of transgenics. Similarly, a consumer would be interested to know quality of transgenic products, including health and related issues. An agro-industrialist would need to know ways and means to meet the credit needs, market opportunities, trade environment, etc. A scientist or a research manager, who is directly involved in the process of technology generation, will also have to be conversant with the peripherals like the protection of IPRs, community and farmers' rights, and legal issues related to biotechnologies. Our national leaders and policy makers would like to be informed of all the important aspects of biosafety, risk assessment guidelines, review mechanism, investment needs for biotechnology R&D, and the socio-economic impact of agricultural biotechnologies. The extension agents, who form the most important link between the scientists and the farmers, must be equipped with comprehensive kits for understanding

the various aspects covered in the information capsules for different target groups. To attain and sustain success, action on following would be essential :

- Mining genes for target traits from diverse sources (plants, microbes, etc.)
- Prospecting for strong constitutive and tissue-specific promoters
- Develop efficient genetic transformation procedures in key crops of national importance, including cotton, chickpea, pigeonpea, mung bean, animals and fish.
- Design novel approaches for gene targeting and targeted insertion / homologous recombination of transgene(s)
- Optimize large-scale transformation programs, especially in public research system
- Establish state-of-the-art facilities for transgenic research and development for high through-put genetic transformation and transgenic event evaluation
- Utilize the selected Centres of Excellence for large-scale training of scientists from SAUs/ ICAR institutions in transgenic research and development
- Promote public awareness of strengths and constraints of transgenics

46. Detection of pathogenic bacteria and viruses in plants/animals/fishes, vectors or natural reservoirs is essential to ensure safe and sustainable agriculture. Molecular diagnostics have evolved significantly in the last few years to allow the rapid and reliable detection of pathogens, like viruses, bacteria and other disease-causing agents as well as chemicals (e.g. aflatoxins) and impurities in food. Technological advances now permit fast, accurate detection and quantification of pathogens, and are now being applied to practical problems. The advances in genomics and proteomics represent a new source of information for the development of sensitive and specific detection techniques for the microorganisms. Molecular diagnostics could be effectively used to improve disease control decision making. In this endeavour, strategic action on the following would be desirable :

- Improve the capabilities of diagnostic laboratories
- Provide scientific information to protect crop plants / animals /fishes from pests, infectious diseases and other disease-causing entities
- Intensify research and education efforts to rapidly identify pests and diseases that enter the country
- Increase scientific monitoring for a broader array of emerging agricultural pests and diseases
- Develop, validate and deploy new identification devices that can rapidly detect pathogens and toxins that threaten livestock, poultry, plants and food

47. It will be impossible to implement any of the ambitious projects in frontier areas without trained and capable human resource. Only a handful of institutions/universities currently exist

in India with the knowledge depth and the operational field programs required to educate future geneticists and breeders. Therefore, it is important to (i) build the capacity of the institutions in modern biotechnology; and (ii) to train the present generation of scientists/ teachers of genetics and breeding in the basics as well as in the advances of molecular breeding and genomics. Future breeders will require the skills to fully exploit molecular technologies in conjunction with traditional methods.

48. Recruitment and retention of competent scientists/faculty in the frontier sciences, including breeding, need to be given top priority so as to achieve a critical mass in the area of genomics, molecular breeding, transgenics and molecular diagnostics. Also, we need to reorient the training of our agricultural graduates to give them more professional knowledge on the patterns of engineering and medical graduates with an eye on their skill development. It is also of crucial importance to hire and retain the best talent for undertaking R & D in frontier areas in the public sector institutions. This is a major challenge in view of the better remunerative packages in the private sector and abroad. The only solution is to bring in institutional reforms and hire talented scientists as well as technicians from India and abroad through offer of competitive packages and performance-linked incentives, in addition to the regular practice of promotion to higher positions.

49. Breeding research with the modern tools and techniques should be viewed in terms of a "value chain" in which the disciplinary walls should be broken to ensure much needed adaptation, adoption and commercialization. Regardless of whether genetic diversity is hidden in wild species or available in existing germplasm or even outside the species boundaries, the challenge is to find good variation and to utilize such variation in developing much needed genotypes with tangible benefits on changing time scale.

50. The real issue is to take effective action for meeting everyone's expectations. The equation is expectation minus achievement is equal to frustration. To avoid frustration, the only way is interaction and harnessing synergistic interaction effects to make things happen and happen with far greater velocity and vigour. In this endeavour, I invite your best for science, society and humanity.

Thanks

Annexure

National Conference on Climate Change and Indian Agriculture

12 – 13 October 2007

NASC Complex, DPS Marg, New Delhi-110012

Organised by: **Indian Council of Agricultural Research**

Inter-Governmental Panel on Climate Change (IPCC) in its recently released report has reconfirmed that the global atmospheric concentrations of carbon dioxide, methane and nitrous oxide, greenhouse gases (GHGs), have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The increase in GHGs was 70% between 1970 and 2004. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture.

These increases in GHGs have resulted in warming of the climate system by 0.74°C between 1906 and 2005. Eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850). IPCC has projected that temperature increase by the end of this century is likely to be in the range 1.8 to 4.0°C. It is also likely that future tropical cyclones will become more intense. Himalayan glaciers and snow cover are projected to contract. The projected sea level rise by the end of this century is likely to be 0.18 to 0.59 meters. Analyses done by the Indian Meteorologists also generally show the same trends for temperature, heat waves, glaciers, droughts and floods, and sea level rise as by the IPCC although the magnitude of the change varies.

Such global climatic changes will affect agriculture through their direct and indirect effects on crops, soils, livestock and pests. Increase in atmospheric carbon dioxide has a fertilization effect on crops with C_3 photosynthetic pathway and thus, promotes their growth and productivity. Increase in temperature, depending upon the current ambient temperature, on the other hand, can reduce crop duration, reduce net photosynthesis, alter pest populations, decrease fertilizer use efficiencies, and increase evapotranspiration. Uncertainty in precipitation causes droughts and floods, and these have been responsible for many famines, rural poverty and migration despite development of impressive irrigation potentials. These environmental changes, particularly temperature increase and sea level rise, could also affect fisheries directly and indirectly though the availability of feed. Similarly, increased temperatures and changes in fodder and water availability may affect production of meat and milk.

The brunt of environmental changes is expected to be considerable in our country due to predominance in agriculture and limited resources. Information is, therefore, needed to

formulate integrated agricultural development plans that will maximize food production, minimize environmental degradation, and attain socio-economic goals.

Indian Council of Agriculture Research has decided to give this area of climate change a major thrust. A *National Conference on Climate Change and Indian Agriculture* was organized to prioritize research and development activities, and to develop an action plan for its implementation. The specific objectives of the meeting were:

1. To review the current state of understanding of the climate change and its probable impact on Indian agriculture.
2. To analyze the feasibility of scientific, technological, economic and policy adaptation options in agriculture.
3. To quantify the mitigation potential in Indian agriculture, and associated costs.
4. To identify research and development priorities, and policy imperatives for climate change.

Recommendations of The Conference

RESEARCH AND ASSESSMENT

Impacts

1. Strengthen research on impact assessment of climate change on production resources, crops, livestock, fisheries, and microbes using field and controlled environment facilities, and simulation models: The key aspects could be:

- Spatial and temporal availability of surface and groundwater for irrigation
- Sensitive processes such as pollen germination, spikelet sterility and grain development.
- Agricultural production (demand and supply of commodities, prices, trade, regional and societal differences)
- Quality of produce
- Germplasm variability and evolutionary trend
- Diversity and dynamics of key insects and microbes including fungi, bacteria and viral pathogens
- Livelihood of farmers and fishermen

2. Institutionalize the monitoring of phenology, especially of perennial crops, as a bio-indicator of climatic variability and change

Adaptations

1. Develop new genotypes
    - ♦ Intensify search for genes for stress tolerance across plant and animal kingdom
    - ♦ Intensify research efforts on marker aided selection and transgenic development for biotic and abiotic stress management
    - ♦ Develop heat and drought tolerant genotypes
    - ♦ Attempt transforming C_3 plants to C_4 plants
2. Develop new land use systems
    - ♦ Evolve new agronomy for climate change scenarios
    - ♦ Explore opportunities for maintenance /restoration/ enhancement of soil properties
    - ♦ Use multi-purpose adapted livestock species and breeds
3. Enhance value-added weather management services
    - ♦ Develop spatially differentiated operational contingency plans for temperature and rainfall related risks, including supply management through market and non-market interventions in the event of adverse supply changes
    - ♦ Enhance research on applications of short, medium and long range weather forecasts for reducing production risks.
    - ♦ Develop knowledge based decision support system for translating weather information into operational management practices
    - ♦ Develop pests and disease forecasting system covering range of parameters for contingency planning and effective disease management.
4. Conduct an integrated study of 'climate change triangle' and 'disease triangle', especially in relation to viruses and their vectors
5. Develop a compendium of indigenous traditional knowledge and explore opportunities for its utilization

Mitigation

1. Improve inventories of emission of greenhouse gases using state of art emission equipments coupled with simulation models, and GIS for upscaling
2. Evaluate carbon sequestration potential of different land use systems including opportunities offered by conservation agriculture and agro-forestry
3. Critically evaluate the mitigation potential of biofuels; enhance this by their genetic improvement and use of engineered microbes

4. Identify cost-effective opportunities for reducing methane generation and emission in ruminants by modification of diet, and in rice paddies by water and nutrient management. Renew focus on nitrogen fertilizer use efficiency with added dimension of nitrous oxides mitigation

5. Assess biophysical and socio-economic implications of proposed GHG mitigating interventions before developing policy for their implementation

Capacity building

1. Establish automatic weather station in each KVK for agromet observations. A system for remote access of data at a central place and its on-line distribution to ICAR/SAU scientists should be developed. Weighing lysimeters should also be established in key centers

2. Develop specialized, state of art, climate control facilities (CO_2, temperature, water and ozone). These are expensive, not available in the country, and hence international collaboration in this area, including research partnerships and training, should be developed.

3. Enhance national capacity on decision support systems, especially on integrated, dynamic and agro-economic modelling based systems.

4. Enhance national capacity on carbon trading in agriculture.

5. Intensify efforts for increasing climate literacy among all stakeholders of agriculture, including students, researchers, policy planners, science administrators, industry as well as farmers.

DEVELOPMENT PROJECTS FOR ADAPTATION

1. Strengthen surveillance of pest and diseases. Increasing climatic variability and change could lead to rapid movement of pathogens and insect pests.

2. Develop mechanisms for integrated management of rainwater, surface and ground water. Augmentation of the water resources will be highly complimentary.

3. Weather based insurance products should be provided to increasing number of farmers at an early date for management of enhanced temperature and rainfall risks.

4. Establish a science based *Agricultural Intelligence System* to facilitate understanding of impact of real-time weather and other inputs on production of important commodities.

5. Establish Weather Watch groups for climate sensitive commodities in ICAR commodity institutes for real-time monitoring of weather impacts and to enable appropriate policy response.

6. Support community partnerships in developing food and forage banks to manage scarcity during projected increased periods of drought and floods.

POLICY SETTING

1. Mainstreaming adaptation in current policy considerations: Climate change impacts and adaptations should be considered in all major development planning activities.
2. Develop new infrastructure, policies and institutions to support the new land use arrangements identified by science and technology.
3. Enhance investment in water harvesting and conservation options; and promote small farm mechanization and efficient water use technologies.
4. Facilitate greater adoption of scientific and economic pricing policies, especially for water, land, energy, and other resources.
5. Explore international partnerships for joint food security.
6. Consider financial incentives and package for improved land management including resource conservation/ enhancement (water, carbon, energy), and fertilizer use efficiency.
7. Establish an inter-ministerial institutional mechanism for strategic follow-up action.
8. Consider incentives for industry and farming community for producing and using slow release fertilizers and Green House Gas inhibitors.
9. Explore CDM benefits for mitigation strategies for farmers and agriculture-based industry.
10. Explore international partnerships for collaborative research on adaptation of climate change research.
11. Establish 'Green Research Fund' for strengthening research on adaptation, mitigation and impact assessment.

ACTION PLAN FOR RESEARCH AND ASSESSMENT

1. ICAR has already established a Network project with the involvement of 15 institutes and SAUs for critical research on crops, livestock, and fisheries. The network partnership will be expanded.
2. NAIP (National Agricultural Innovations Project of ICAR) has also identified climate change as a thrust area. Grants are especially available for climate change related research and development projects.
3. Human resource development; workshops for carbon trading will be organized shortly; for capacity building in other areas training courses would be organized.
4. A multi-disciplinary expert group in ICAR would be constituted for developing short-term programmes for XI Plan and a road map for medium-and long-term programmes.
5. Recommendations will be circulated to all concerned departments for their necessary action

Agriculture – Fast Forward

Dr. Mangala Rai
President
National Academy of Agricultural Sciences

Distinguished Fellows of the Academy, Ladies & Gentlemen

On this very day, last year, the text of my address was *Agriculture and Biotech Culture*. Therein, a number of concerns were expressed. Much-needed corrections in nutritional imbalances for soil-health were highlighted, and subsequently a path-breaking decision was taken on the nutrient-based subsidy and fortification of fertilizers by the Union Government. A mega project on "Gene Discovery and Allele Mining" has been initiated, involving 35 institutions, at an outlay of Rs 57 crore. A series of path-breaking programmes on the basic and strategic researches are undertaken. For ensuring continuum in the basic, strategic and adaptive researches befitting location, situation and system as many as 14 National Research Centres are converted into Directorate mode of operation. A series of networks cutting-across crops, commodities and disciplines are also put in place. And new institutes to address biotic and abiotic stresses and harnessing fruits of biotechnology are established/ contemplated. Further, the series of policy papers and deliberations brought out by the Academy have helped tremendously the National Agricultural Research and Development System to reorient its research, education and extension strategies and approach. Thus, the activities of the Academy have contributed considerably towards research, development and policy-setting of our country.

At this juncture, I would like to recall our country's efforts made over 5-6 decades, owing to which production of foodgrains increased by 4 times, horticultural crops by 6 times, of milk 6 times, meat 8 times, fish 9 times (marine 5 times and inland 17 times), and of eggs 27 times. Thus, a visible impact on the national food and nutritional security has been realized. In the last two years, our agricultural production has broken all records, and our granaries are full. This has happened when there was a global food crisis, and since 40 years our area under cultivation remained constant at around 140 million hectares. As our population is increasing, the demand for food, fodder, fibre and fuel is also increasing. And accelerating economy is widening choices of food basket. Hence, we are essentially called upon to ensure more and more quality produce with less and less resources. It is in this context, the role of Academy assumes paramount significance, as a think-tank, to provide a sense of direction

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Presidential address delivered at the 16th General Body Meeting of the National Academy of Agricultural Sciences held at New Delhi on June 5, 2009.

to researchers, development officials and policy-planners to choose the best of action with a force to reckon with.

With tremendous effort of the Academy, the book on the **State of Indian Agriculture** was released only yesterday by the Hon'ble Union Agriculture Minister. It is a monumental work in the right direction. It would provide much-needed impetus to inclusive growth contemplated during the XI Plan and would also provide an insight as to how to move, and move forward on research, development and policy fronts. I am sure, our resolve to bring out subsequent annual volumes regularly on the thematic areas would provide food for thought to correct imbalances, if any, and to move in the frontier areas of science and technology, human resource development and policy-setting. Today I am attempting to present a few of the basic issues and strategies that are expected to enable agriculture to move forward with a far greater velocity and vigour.

1. Managing Abiotic and Biotic Stresses

In a country like ours, where farming is predominantly rainfed, the agriculture is at a high risk on account of climatic change and due to frequent spells of abiotic stresses. The situation, therefore, warrants technological interventions of advanced nature and highly competent human resource to counteract the impact of abiotic stresses on agriculture. A National Network Project entitled 'Impact, Adaptation and Vulnerability of Indian Agriculture to Climate Change' has been launched with a focus on impacts of climate change on different sectors of agricultural production such as crops, fish and livestock. The programme is being implemented in 21 research institutions.

A series of projects in network mode have also been initiated - converting C_3 to C_4 photosynthetic system in rice; adaptation and facilitation of livestock to impending climatic changes through shelter management; identification of salt-tolerant genes in marine tiger shrimp; methane emission; gene-based genetic maps and molecular markers for biotic and abiotic stress tolerance, molecular diagnostics of avian diseases etc.

The researches to manage biotic stresses have also to be addressed through novel scientific approach in view of the rapidly evolving farming systems, climate change and impedance of biotic stresses. The recent episodes of diseases in important crops and livestock have brought out the inadequacy of the knowledge to address basic issues, such as generation of pathogenesis. Our existing capability and competence in protecting farm crops and livestock are challenged immensely due to rapid movement and evolution and alterations in the patterns of pestilence and their intensity.

A mini-revolution is essential to tune up technology of prediction of diseases and pests before overt symptoms appear. Quantifying pestilence-based risk to crop and metabolism that threatens anticipated crop yields is essential for suitable diagnostics and mitigation. Mitigation demands unconventional approaches in the present time and context. Advances in biology, including molecular aspects, in physical sciences having developed cutting-edge knowledge initiatives in nanotechnology, and many other areas in material science provoke

intense thoughts for inter-disciplinary interactive research programmes in addressing various applications in protection research. New forms of therapy for plant-health management such as RNAi-derived products, vaccines, novel delivery systems of agro-chemicals and targeted biological processes could be looked upon. Developments in novel bio-materials have offered benefits of targeted delivery and controlled release in human and animal therapeutics. Nano-scale structured materials and devices also hold a great promise for advancement of diagnostics and biosensors. Advances in biosensors and gene amplification are in the offing to enable real-time cure of phytomaladies.

Availability of cutting-edge technologies and platform technologies can empower scientists to address stress-related issues in agriculture. A National Institute on Abiotic Stress Management has already been started, and in principle approval for establishment of additional two institutes, National Institute for Biotic Stress Management and National Institute on Biotechnology, has been accorded. These will also be the deemed-to-be-universities under the ICAR. And these institutes are expected to provide necessary protection to our agriculture against biotic and abiotic stresses and improve in productivity and quality through generation of appropriate technologies and competent human resource. In some of the blue-sky research areas, we need to invest heavily on a long-term sustainable basis to break likely impediments and bottlenecks to attain and sustain cutting-edge over our competitors.

2. Managing Genetic Resources with Modern Tools

It is a very fortunate situation for Indian agriculture to possess a large collection of germplasm of several crops, animals, fishes and microbial species of agricultural importance. However, efficient utilization of germplasm resources would be possible only if these are thoroughly characterized, catalogued and understood much beyond their passport data. This calls for focused efforts to characterize them and use them for discovery of genes and alleles. The crops/commodity in which the existing diversity is less and/or if one wishes to create alleles other than those available in the germplasm, it is possible to create large mutant populations for use, in addition to the germplasm lines, for allele discovery. The mega-project on “Gene Discovery and Allele Mining”, initiated during this year, aims at identification of new alleles of known or candidate genes for traits of importance in the germplasm lines including induced mutants, which can be used for direct transfer of target alleles to desirable agronomic backgrounds through conventional breeding. Alternatively, the novel alleles, when available across sexual barriers, can be cloned and transferred through genetic engineering. This, however, requires massive efforts supported by liberal funding so that raw materials for future improvement become readily available, and in the process, we safeguard our food and nutritional security.

We need to ensure a well-characterized germplasm resource and core sets of germplasm in different crop species; elite germplasm lines with desirable agronomic traits for future use in crop improvement; new information on the SNP/haplotype structure in different known/candidate genes for important traits including drought tolerance, yield and disease

resistance; novel alleles of known/candidate genes for target traits; and more importantly, a pool of trained human resource and state-of-art infrastructure to handle large-scale genotyping of germplasm and carry-out association mapping of quantitative trait loci (QTLs). This endeavour will go a long way in developing efficient strategies for management of abiotic and biotic stresses in different crops/commodities, and will also broaden window of optimal growth conditions for cultivated crops under adverse climates, thereby increasing yield under changed climatic conditions.

This year, a National Genomic Resources Repository, has been established at the National Bureau of Plant Genetic Resources (ICAR), New Delhi. The Repository would conserve and manage genetic resources of animals, marine organisms, and agriculturally important microbes and insects in the form of DNA materials. The Repository is mandated to provide a centralized, methodical and institutional framework for conservation and documentation of genomic resources that are either by-products of the large-scale sequencing or allele-mining projects, or specially carried out work to generate genomic resources of non-model crop plants. The facility will conserve cloning vectors, cloned genes and promoters, different libraries (sub-genomic, cDNA, EST, repeat enriched), BAC, YAC, PAC clone sets from sequencing projects as well as genomic, mitochondrial or chloroplast DNA; making it a unique effort. The Repository also aims to create a "National Genomic Resources Information System".

The National Bureau of Agriculturally Important Insects has also been established this year at Bangalore. The bureau has the primary objective of exploiting the biodiversity in enhancing the benefit of parasitoids and predators in biological control of pests, productive insects particularly honey bee, pollinators and lac insects and identify potential genes from insects which can confer the tolerance of abiotic stresses like temperature, salinity, pesticides, pollutants and effluents. The bureau shall be the nodal agency for introduction and exchange of insect genetic resources and shall serve as repository of agriculturally important insects.

3. Feed and Food versus Biofuels

Despite the fact that agriculture has recently received high priority on the world's developmental agenda, there is an unprecedented rush to use agricultural produce as biofuels in many developed countries, and sadly so in some developing countries as well. A caution is needed because the presently identified first-generation biofuels that are competing with food crops are not tenable in the long run. If, as a consequence, the diversion of food crops is compensated by planning expansion of the cultivable land into forest, grassland, and woodland areas, the increase in carbon emissions would greatly nullify effort, besides the approach is not so feasible in many developing countries. The cereal production and consumption estimates even without biofuel expansion are presently short of demand (Table 1).

As an alternative strategy which will not curtail use of crops for biofuels and would

Table 1. Cereal production and consumption; baseline without biofuel expansion

REF-01	Cereal production (million tonnes)				Cereal consumption (million tonnes)			
	2000	2020	2030	2050	2000	2020	2030	2050
North America	478	623	660	713	317	418	437	473
Europe and Russia	530	583	611	664	546	593	622	700
Pacific OECD	40	51	54	60	45	47	49	58
Rest of World	75	100	113	156	99	114	117	121
Africa	75	135	173	299	107	182	236	367
Asia, East	423	536	591	694	458	567	615	702
Asia, South	345	462	519	629	338	486	548	700
Latin America	130	212	249	334	140	197	230	296
Middle East & N. Africa	54	80	93	147	102	170	208	281
Developed	1,123	1,357	1,438	1,593	1,008	1,172	1,225	1,352
Developing	1,027	1,424	1,624	2,104	1,145	1,603	1,837	2,345
World	2,150	2,781	3,062	3,697	2,152	2,775	3,062	3,698

Source: IIASA World food system simulations; scenario REF-01, December 2008.

also provide for additional energy source, following not mutually exclusive options are suggested.

(i) Second-generation biofuels such as those from ligno-cellulosis feed-stocks are less likely to compete for land and water resources than the current first-generation biofuels that are based on food crops. This would require far more investment and research and developmental efforts as the second-generation biofuels are still very much in the developmental stage.

(ii) Use of such biomass that comes as a by-product in case of food crops should be encouragingly used for biofuels rather than the current trend of diverting edible part of the first-generation biofuel sources such as maize.

(iii) Targeted production of biofuel crops under waterlogged/degraded/barren lands so that it does not compete with food, feed, fodder and fibre.

Eventually, the shift should be towards the second-generation biofuels for which current estimates show a spurt in its projected demand (Table 2). In no case, the conventional food-forming plant parts particularly of major food crops should be diverted towards biofuel production. The potential wasteland and similar area that can be feasibly brought under food crops should also not be brought under non-food biofuel resources until-and-unless supported by highly convincing economic and energy gains on a sustainable basis.

Table 2. Biomass demand for second-generation biofuels, by scenario

Scenario	Global biomass demand for second-generation biofuels (million dry tonnes)			Biomass demand for second-generation biofuels in developed countries (million dry tonnes)		
	2020	2030	2050	2020	2030	2050
WEO-V1	19	106	370	19	95	300
WEO-V2	0	0	125	0	0	74
WEO-V3	97	240	615	87	186	440
TAR-V1	35	234	660	35	207	500
TAR-V2	0	0	254	0	0	128
TAR-V3	315	725	1402	297	583	875

Source : OFID study prepared by IIASA, 2009

4. Revamping Higher Agricultural Education in India

Science-led and technology-driven agricultural growth would not only provide resilience to Indian economy at large but would also result in addressing equity concern that is of paramount importance. It is in this endeavour that the National Agricultural Research System should strive for enhancement of quality and relevance of higher agricultural education to ensure much needed human resource for the kind of science and technology, it considers essential.

Agricultural education existed in India even during medieval period. Agriculture was included in the curricula of Nalanda and Takshila Universities as one of the 18 arts. In the relatively recent past, agricultural education in India has started way back in 1877 with the establishment of the first agricultural school at Saidapet in Madras. However, organized courses in agricultural education were started in the beginning of the 20th century when six agricultural colleges were established at Kanpur, Lyallpur, Coimbatore and Nagpur in 1906, Pune in 1907 and Sabour (Bihar) in 1908. The present higher agricultural education system comprises 44 State Agricultural Universities, 5 Deemed to be universities, one Central Agricultural University (CAU) and 4 such Central Universities (CUs) that have agriculture faculty. These Agricultural Universities (AU) have been serving their designated purpose of unified teaching, research and extension education. Over the years, these universities have faced severe financial constraints and lack of faculty. As such, they could not keep pace with the changing needs to develop globally competitive infrastructure and manpower for technology generation, and quality human resource development.

Agriculture including higher agricultural education is the state subject. The ICAR/DARE extends ample academic/professional yet limited financial support to the SAUs. Such financial support enables them partially in (i) maintaining quality of teaching facilities and upgrading learning materials and environment, (ii) conducting post-graduate research, (iii) building faculty competence and (iv) ensuring timeliness in admissions and conduct of practical training in a laboratory or field.

In general, India's present higher agricultural education suffers from (i) low access (gross enrolment ratio in higher education in general being about 10% compared with 60% in the USA and Canada and 40% in several European countries), (ii) not meeting quality standards, (iii) low funding, (iv) gender inequality, (v) old course curricula and delivery methods, (vi) inbreeding and, (vii) lack of faculty-competence in cutting-edge technologies.

Agricultural education has to evolve owing to (i) new areas of specialization such as IPRs, other WTO-related areas, techno-legal specialties emerging new sciences, (ii) stakeholders' expectations, especially for utilitarian mode, (iii) new cutting edge technologies - biosensors, genomics and biotechnology, alternative sources of energy, nanotechnology, etc., (iv) improved tools of content delivery including ICTs and (v) globalization of education.

The Universities should take up the noble mission of generating human resource that not only is highly specialized but should be potentially job-creator, rather than job-seeker. Knowledge alone is not enough. In our philosophy also, wisdom is placed higher than knowledge. Emphasis should be laid on realizing a confluence of knowledge, skill and attitude - the three realms of pedagogy. The knowledge and skill are to be permanently ingrained into learners' personality. The experiential learning cycle is a pre-requisite to entrepreneurship development. Towards this goal, 219 such units have already been set up across the agricultural education institutions. Examples are mushroom production, apiary, poultry, vermi-composting, bio-fertilizer production, agro-processing, bakery and confectionery products, value-addition in aonla, mango and tomato, floriculture, dairy, etc.

An agricultural educational system needs to have situational advantage, legacy of expertise in an area and such strategic strength that it may nationally and globally excel in that area, called 'niche area of excellence'. The ICAR stands to promote one or two niche areas in each AU, so that in years to come we can have about 100 such centres of excellence to compete with the best in the world.

It is praiseworthy that a massive exercise involving over 1,000 academicians was undertaken, and post-graduate course curricula and syllabi in 95 disciplines have been revised for implementation. Broad Subject Matter Area Committees (18) and a Review Committee of 18 Vice-Chancellors as experts, assisted the Group. The exercise took about 20 months to complete, and the report spans about 2,500 pages. It is to be appreciated that the Under-graduate course curricula have already been revised. Most agricultural universities have already implemented the revised UG curricula and syllabi during 2008, and have accepted to implement the revised PG curricula and syllabi with effect from the next academic session, starting from July 2009. The revised PG Course Curricula on adoption would greatly help in further making higher agricultural education more utilitarian and relevant in tune with the scientific and technological advancements and with the demands of growing economy of the country.

Farms constitute the basic skeleton in AUs established on Land Grant pattern. For "Modernization of Agricultural Universities' Farms", an outlay of Rs 422 crore has been made. The grant is for renovation and modernization of farm infrastructure and facilities. It has started enhancing practical and experiential exposure in students and entrepreneurship development, augmenting supply of seed/planting material, providing a common space for

interface of public-private partnership, facilitating technology-incubation and upscaling of technologies towards commercialization and resource-generation.

It is heartening to note that for the first time, provision has also been made by way of Overseas Fellowships to attract foreign students to Indian universities. The Fellowship has a dual objective of serving both ways: (i) facilitating education of Indian nationals in the best of the Universities abroad, and (ii) facilitating admissions of foreign students in Indian agricultural universities. The Fellowships will develop competent human resource in the country and will also enhance visibility of Indian ICAR-AUs system abroad.

Several other HRD Initiatives have also been taken recently in the NARS. The ICAR has also made provision for specific catalytic support for faculty exchange and also for facilitating guest/ faculty. Support is extended for infrastructure and creation of ICT facilities. Development of e-courses has also started. For enhancing quality and ensuring minimum standards, Model Act has been revised and accreditation of AUs has been expedited. Girls' hostels have been provided with other girls-related amenities.

Enhanced Collaboration between the AUs, the ICAR Institutes and other related agencies is needed to converge for developing need-based projects with plurality and breadth to meet contemporary challenges. This would help in tapping funds from the Rashtriya Krishi Vikas Yojana (RKVY), the National Agricultural Innovation Project (NAIP) and other such agencies. Convergence is also needed on areas that do not recognize any geographical boundaries such as biosafety and biosecurity.

As agricultural education is a state subject, it is essential that there should be an adequate and desirably a distinct budget-line for agricultural research and education at the state level. A minimum, if not adequate, strength of faculty should be ensured on war-footing in each discipline/faculty. State funding to AUs needs to be enhanced substantially, lest required agricultural growth would remain a far cry.

It is good that about 2,400 scientists are trained every year in emerging areas through 100 summer/winter schools organized in cutting-edge areas. Also, faculty competence improvement is undertaken through 31 Centers of Advanced Studies. Several other HRD initiatives have been taken recently. For inbreeding reduction, quality enhancement and national integration, centralized entrance examinations for admission in UG (15% seats) and PG (25% seats) courses and SRF examination are conducted annually for admission/award of the National Talent Scholarship (1,000) to UG, Junior Research Fellowship (475) to M. Sc. and Senior Research Fellowship (200) to Ph.D. students. Every year, about 1,500 meritorious candidates are admitted in UG programmes and 1,800 in PG programmes. Promotion of excellence for creating a culture of basic research at the National level has been undertaken through 10 positions of the National Professor Chairs and 25 ICAR National Fellow positions. With the objective to utilize services of outstanding superannuated scientists from the NARS, a total of 141 emeritus scientists were appointed since 2003. However, imagining the dimension of the problem and potential it inherits, these efforts need enhanced support and added thrust.

Specific human capacity-building in identified priority areas, particularly that under the National Agricultural Innovation Project, has been undertaken in a big way by (i) sending scientists for international training under the approved consortia (ii) sending scientists in priority cross-

cutting frontier areas in agricultural sciences, and (iii) bringing international experts for training 1,000 Indian scientists in the country.

The 26 priority areas comprising (i) allele mining, (ii) apomixis, (iii) bioinformatics, (iv) micromolecules, (v) bioremediation, (vi) biosecurity, (vii) carbon trading carbon sequestration/ climate change, (viii) fermentation technology, (ix) genome resource conservation, (x) gene knock-down technology, (xi) marker assisted selection (MAS), (xii) microbial molecular taxonomy, (xiii) molecular diagnostics, (xiv) molecular breeding, (xv) nanotechnology, (xvi) nutraceuticals, (xvii) sensor - based applications including bio-indicators, (xviii) stem cell research, (xix) transgenic technology, (xx) geo-informatics, (xxi) image-processing technology for characterization of agricultural produce, (xxii) mitigation strategies for methane production from livestock, (xxiii) non-chemical non-thermal processing and membrane technology, (xxiv) smart packaging, (xxv) social science, and (xxvi) IPRs are identified, and 478 scientists at an estimated cost of Rs 33.82 crore are to be trained in these areas. Besides the provisions of the International/national level trainings, every institute/agriculture university has been provided with sufficient HRD budget to undertake additional need-based capacity-building.

There is a dire need to further propel growth in terms of enhancing access, quality and relevance of higher agricultural education and need-based HRD activities. The following areas, in particular, need expeditious attention and support.

(i) National sponsored university chairs

(ii) Modern communication system

(iii) Modern decision-support system

(iv) Modern technology incubational commercialization system

(v) IP enabled technology management system

(vi) Modern learning resources and delivery system

(vii) Textbook and operational manual

(viii) Forecasting, Forewarning, GIS for technology targets

This will lead to outputs and outcomes such as (i) enhanced agricultural/food production and elevated socio-economic status of the farm community through use of knowledge, technology and materials generated by the AUs, (ii) globally competitive infrastructure and facilities for education, research and training, (iii) enhanced capability and confidence in teachers, researchers, students and development officials and (iv) enhanced entrepreneurship development and placement/employability and job opportunity.

The XI Plan Working Group on Agricultural Research and Education constituted by the Planning Commission has made an in-depth analysis and recommended Rs 30,000 crore for the ICAR. However, Planning Commission made an allocation of Rs 12,023 crore out of which ICAR could allocate Rs 2,585 crore for education. Unless we enhance budgetary support both at the Centre and the State level, it would be hard to attain and sustain enhanced velocity and vigour, and the sufferer would be the poorest of the poor. Can we afford it ?

Towards Developing an Innovative Model for Transformation of Agriculture in India

Dr. Mangala Rai

President
National Academy of Agricultural Sciences

Distinguished Fellows of the Academy, Ladies and Gentlemen!

In the recent months, I had first-hand information of prevailing hunger, poverty, malnutrition, unemployment, under-employment, unrest, disparity and diversity in our rural areas. I feel, there is a real decay and a dent in the fabric of our growing economy and society.

With tremendous improvement in accessing information, people now are far more aware of the disparities in *Kathani* and *Kami*. Hence, despite visible developments, discontentment is increasing. The area and the people I visited are the readers of Gita. They understand, "*Dukhon ke Sanyog ke Viyog Ka Nam Yog Hai*". But they don't want to be *yogi*. In the modern materialistic world, they firmly believe that they are remembered only to be forgotten in the real inclusive growth process. In my best judgement, if this situation is allowed to continue, it would not only speak on the health of food, nutrition and environmental securities but also on the very basic fabric of our country. It is, therefore, imperative that the real agricultural situation is appreciated, and concrete measures initiated to help producers and consumers alike.

With the onset of Green Revolution, the very first World Food Summit in 1974, promised to "*eradicate world hunger within a decade*". Since then, 45 years have passed, and 3 World Food Summits held at the short intervals in 1996, 2000 and 2002, although in testimony to the importance and urgency, that resolved to reduce world hunger only to half by 2015. Unfortunately, with the on-going efforts, even this target is not likely to be met as continents after continents, decades after decades, investments in the R&D in agriculture have been reduced in the real comparative terms.

Soon after Independence in 1947, realising the importance of agriculture, Pandit Nehru declared "*Everything else can wait but not agriculture*". Reflecting his thinking in action, in the earlier decades thereafter, we could harness fruits of enhanced efforts and supports. Subsequently, in the last 2 to 3 decades, the ground reality changed for the worst. Nevertheless, in the recent years again, gravity of the situation has been realised and some corrective measures have

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been initiated. But they are far and a few, and certainly not commensurate with the dimension of the challenges.

Increasing population; food, feed, fodder, fuel, fibre, timber demand; biotic and abiotic pressures; climatic uncertainties; temperature; nutritional imbalances; nutrient deficiencies; fragmentation of land holdings etc. and decreasing biodiversity, resource-use efficiency, investments, nutrient and water resources, water quality, factor productivity etc. have put tremendous challenge to produce more and more from less and less resources.

In the last 4 decades, agricultural area continues to be the same but the population has doubled. With the acceleration of economy, enhancement of purchasing power and improved access to food, it is a difficult task to meet growing food and feed demands of India, the second-most populous nation of the world.

With all the industrial development, still more than half of the India's population is employed in agriculture. With the kind of intensification and diversification system in the country, it would be harder to provide appropriate job opportunities to the people engaged in agriculture. There is a vast gap between technology generated and adopted, and a very little effort has been put on the value-chain. Agriculture predominantly even at present also continues to be subsistent with scattered efforts on commercialization and technology-led inclusive growth.

Owing to globalization and liberalization, agriculture in India needs to change. Diversification of products has now started along with the widespread dietary evolution. Commodity-based production is giving way to system-based orientation, and there is an initiation of a paradigm shift in the farming system, keeping production-to-consumption system of operation in view. Private sector's participation and investment have started increasing. As agriculture is becoming more and more knowledge-intensive and market-driven, far more innovative research, development efforts, efficient policies and effective delivery of services, supplies and markets are imperative. Agriculture cannot be closed any more, its orientation has to be global and open to capitalize on all opportunities.

The demand for food is expected to double by 2050, and this will only be met if small-holders contribute for increased production. And this would happen only if agriculture is remunerative, and the first-rate technology is brought to bear on production, processing, value-addition, income, and employment to ensure it a bankable venture. There are about 600 million small-holder farmers in India, and therefore, extension is a strategically important link for ensuring that small-holders needs are at the centre of the technology development and delivery system.

The IPCC's SRES scenarios have been constructed with the projections of 2.3% to 3.3% economic growth at the global level. Different scenarios depict different global populations, varying from 8.1 to 14.0 billion in 2080. India's population may cross 1.5 billion mark. Hence, the central question, as to how, we are going to meet our needs will have to be addressed to in the right earnest. We will have to periodically look at our means, mechanisms and systems, and need to ensure on course correction commensurate with the changing ground realities and goal posts, so that we continue to be competitive, efficient, effective and relevant.

Soil, water and nutrient

India with a total area of 329 million ha is the seventh largest country in the world. Traversing from east to west and north to south boundaries, one finds that nature has given us diverse climatic and edaphic conditions. We have snow-covered mountains, extremely arid *Thar Desert*, *Cherapunjee* with highest rainfall in the world, tropical and subtropical areas as well as over 8,000- km long coastline. Our forest cover is around 23 % as against the desirable 33%. The degraded lands in our country are around 107 million ha.

In a country like ours with shower of bountifulness of Nature, land-use systems for multifunctional agriculture need to be varied, best suited for local agro-ecological conditions and most specifically must aim for overall rural development.

Present per capita availability of less than 0.13 ha of net cultivated land and 1020 m^3 of utilizable water exert tremendous pressure and expectations from resources and technologies. Several parts of India face severe water shortages. By 2020, we would need about 29% more water for agriculture whereas availability of water is likely to reduce by 12%. Therefore, we need to augment, conserve and manage water resources through improved water storage, conveyance, application and crop-water-use efficiency, without detriment to environment and natural resource base. In addition, conservation agriculture, integrated nutrient management, carbon sequestration and amelioration of polluted soil and water need to be undertaken on a priority basis. Effective policies and strategies for management of range and pasture lands are required to be developed and implemented.

The impaired soil health and declining productive potential are primarily due to imbalanced fertiliser-use coupled with low use of organic manures, lack of biological activity, uncontrolled irrigation, waterlogging, salinization etc., and in many regions the prevalent land use does not commensurate with land capability. The soils are not being adequately replenished even with macronutrients, let alone secondary and micronutrients. The improper nutrient management has, therefore, led to multinutrient deficiencies in the Indian soils. The deficiencies range from 3% of copper to 89% of nitrogen, with other elements falling in range. And deficiencies of sulphur, zinc and boron are becoming more critical. About 47 million ha in major cropping systems is deficient in sulphur, and zinc deficiency is rampant in alluvial soils of the Indo-Gangetic plains, black soils of Deccan Plateau and red and other associated soils. Boron deficiencies are showing up in red, lateritic and calcareous soils of Bihar, Orissa and West Bengal. Limited nutrients does not allow full expression of other nutrients and thus lower response to fertilizers on crop productivity.

The role of conservation agriculture in improving efficiency, equity and environment is well recognised and many global treaties have raised concerns to conserve natural resources for a better quality of life. Geo-referenced, soil-fertility maps including macro, secondary and micro nutrients need to be prepared speedily at the district and block levels to serve as the guide for proper fertilizer allocation, distribution and application. A good number of well-equipped and functional soil-testing laboratories, at least one in each district, are required to have precise soil test-based fertilizer recommendations. Researches need to be guided towards

development of nano-fertilizers for enhancing nutrient-use efficiency, that is still very low for majority of the nutrients.

With increasing pressure on the land and land-based food production systems, it is appropriate that we look at the water- the sea all around. The paradigm of 'look to the seas' is awaiting our attention to utilize this vast resource for various products, starting from drinking water to high-value compounds apart from fish wealth. Our efforts in this direction need to be enhanced, with co-ordination between various agencies, along with constant vigil and introspection. We must endeavour to realise potential fish farming to ensure a smile on every fish-farmer of our country. Development of entrepreneurship for freshwater aquaculture in wetlands and ornamental fish culture and trade merits added efforts and support to capitalize on the vast potentials available in the country.

Land and livestock distribution in India has shown that in 2002-03, marginal land holders (<1.0 ha), who comprised 47% of the rural households, were having 51% of bovines and 62% of the small ruminants. Together, marginal and small landholders possessed three-fourths of the large and small ruminants, more than 80% of pigs and poultry. However, the landless that comprised 32% of the rural households were the ones who were deprived of land as well as livestock.

In the present scenario, with increase of food trade, importance of virtual water at the global level is likely to be felt more. In the water-scarce areas, the transfer of virtual water embedded in the food being traded would become an important component of the water management. Therefore, assessment of virtual water in terms of its value over space and time and its consideration at the agricultural and water policy levels, is of paramount importance. For proper water resources management, Geographical Information System, simulation tools and also remote sensing are required to be integrated with scientific management of irrigation networks, water distribution, crop planning, watershed activities and related operational activities, as they will enable system managers to take corrective and timely decisions for efficient and economical water utilization.

Among various production elements, land and water continue to be constant. Hence, effective policy instruments for (i) making land and water resources development and utilization economically viable, (ii) enforcing environmental laws to control water pollution, land degradation and erosion, (iii) providing adequate public funds for conducting frontier water and soil management research, and a mass movement and large-scale people's participation in dejvelopment, supply and utilization of water and land resources at all levels, are expected to ensure food and livelihood security on a long-term sustainable basis. The role of institutions, infrastructure, and supportive services and policies will continue to be critical in this national endeavour all along.

Once resources are limited, precision in all the activities pertaining to agriculture is the key for attaining enhanced competitive-edge in meeting growing requirements. Mahatma Gandhi National Rural Employment Guarantee Scheme provides opportunities to integrate social capital of unemployed with natural resource management. This manpower can be unleashed

for conserving rainwater, arresting land degradation and erosion, agroforestry, developing horticulture, producing grasses, fodder, acquiring numerous other assets of livestock and enterprises to generate enhanced opportunity for self-employment. Transparent, equitable participation of people, capacity-building, technologies incubators and enabling alternative institutions are called upon to meet governance challenges to convert safety-net efforts into asset-net creation-much needed for inclusive growth, food security and environment protection.

Energy

Energy is the prime driver of economic development. Consumption of energy has risen steadily, and is bound to rise further. In India fossil fuels, coal and oil constitute 65% of the total energy, with 26 and 3% coming from hydro and nuclear sources, and just about 4 - 5% coming from renewable energy sources. Agriculture gets about 23% of the total electricity produced, and domestic and industrial consumptions are 25 and 36%, respectively. We also consume more than 120 million tonnes of crude oil; of which about 10% consumption is in agriculture.

Agriculture is basically an energy-conversion activity. Traditional sources of energy, power and inputs do not meet requirements of modern intensive agriculture that will lead to production and productivity levels for assuring food and nutrition security of the country. Use of the commercial energy, directly and indirectly, is inevitable. Indigenous R&D on energy has established that specific energy consumption per unit of productivity of Indian agriculture is higher than that of the developed nations, and is on the rising trend. This raises unit cost of production and reduces competitiveness in the global market. Energy-efficient agricultural practices and equipments can conserve commercial energy. Use of biogas, biofuel, solar-cooking, solar-water heating, solar-crop drying, photovoltaic gadgets, wind and hydro electric power, can help meet energy needs partly. Refinements in cropping and crop-rotations can be energy-saving. Non-availability of grid electrical power impedes rural agro-processing and entrepreneurship, which otherwise can generate additional income and employment, thus reducing livelihood base; essential for the socio-economic development.

We need to chalk out a sustainable path of energy development. Promotion of energy conservation and increased use of renewable energy sources should be the twin planks for a sustainable energy supply. Renewable sources of energy are perennial, available locally, are environment-friendly; and are well suited for decentralized applications and use in remote areas. Fortunately, India is blessed in abundance with variety of renewable energy sources. Let us harness them and make agriculture efficient and environmentally sustainable. The R&D agenda for improving energy efficiency in agriculture and sustaining a clean environment, needs to be revisited.

Biomass has been one of the main sources of energy for mankind ever since the dawn of the civilization. Of all the biomass that is produced through agriculture at present, only one-third is utilized as food, feed and fibre. A fraction of the remaining biomass is utilized as roughage for animal feeding; and some for domestic and industrial fuel. The rest of it, still a huge quantity, is available for value-addition and alternative applications. It is estimated that about 150 million tonnes of

surplus biomass is still available for conversion into fuel. Briquetting, solid-state fermentation, gasification and pyrolysis, are a host of technologies that are available today to efficiently convert available surplus biomass into solid, liquid and gaseous fuels. This biomass can generate about 15,000 MW of quality power for meeting demands in the production catchments.

There are numerous examples to clearly indicate that agricultural byproducts can be converted into useful products, and at times main products, adding to income, generating employment and reducing negative impacts on the environment. In view of the national concern to prevent infiltration of pollutants in the environment, there is a need to develop indigenously cheaper substitutes for sources of energy, fertilizers, for several products and for diversifying agro-industry. Recycling and reuse of the 'so called agricultural waste' will surely reduce pressure on our natural resources, generate employment, enhance sources of income, and also increase the returns to investments on research and development. The utilization of waste will create beneficial activities, which will also directly mitigate environmental pollution.

Seed and breed improvement

India is rich in agro-ecological diversity and crop and livestock have co-evolved. Consequently, a range of unique production systems have been developed for each region in tune with the naturally available resources and needs of the people. The diversity begins with the choice of species cultivated/reared, seed/breeds that have been evolved, management and feeding practices, healthcare systems that are closely linked to natural flora and fauna, and local marketing systems. Among various systems, mixed crop-livestock farming and pastoralism are the two common production systems found across different agro-eco-regions. In the former, farmers derive their livelihood somewhat equally from agriculture and livestock; in the latter, people's livelihood depends primarily upon livestock, which are exclusively maintained on grazing. There is a strong synergy between crop and livestock sub-sectors because of their complementarity. Livestock wealth in India is more egalitarian, compared to land, and hence it is found to promote equity and livelihood security. Another attractive feature of livestock sector in the country is that significant employment and income generated by this activity accrues primarily to women, who have their own social gains.

Intensified efforts on genorne-wide genome analyses, effective use of transgenes in potential backgrounds, development of cultural/ rearing practices commensurating with potential and dimensions of the problem and linking innovative technological developments and their translation into actual production systems, are vital for meeting existing and emerging challenges. Researches contemplated for adaptation would be input-intensive; many with long-gestation period, requiring highly specialized human resources with innovative institutional set-up and partnership mechanisms. These would call for action and added investment in agriculture, human resource development and technology transfer.

To meet ever-increasing needs, hybrid culture in agriculture, irrespective of crops and livestock, would prevail. The hybrid technology facilitated with modern biotechnologies would be one of the most relevant technologies for agricultural transformation. In fact, contrary to the belief, if parents are carefully developed, cross-combinations effectively made and evaluated,

exploitation of allelic and non-allelic interactions in the form of heterosis would be providing for greater resilience and enhanced sustained productivity and production over the varietal threshold in the fragile and harsh environments, be it biotic or abiotic. Similarly we have all the reasons on the ground that transgenic culture in agriculture would be the order of the day as we go along. In fact, that would be the saviour in the fast climate change scenario, for which little has been done so far.

Production of seed, planting material, semen, fingerlings and germplasm in case of field and horticultural crops, animals and fish has to be enhanced both in terms of quantity and quality. In case of fish seed, a major producer and supplier has yet to emerge in the Indian scenario. These facts highlight the scope of seed production as employment provider besides ensuring food and nutritional security. Training and HRD of farmers, trainers and entrepreneurs in seed production and tissue culture/micro-propagation; modern facilities and built-up capacity would be essential in the country.

Massive development support for continued availability of quality semen, chicks, piglets etc. and production of improved breeds and effective supply system for different regions befitting varying production systems, are imperative to capitalize on the potential of breeds for substantially enhancing productivity and production. Policy-setting and effective plan of action for potential indigenous breed improvement in livestock say cattle, buffalo and goat are essential, for which quality semen production, storage, transportation, cold-chain facility and effective insemination system are required for reaching to the end-users. In this endeavour, sampling of existing genetic variability and utilizing potential livestock using both conventional and molecular approaches are essential.

A steady increase in the productivity of cattle and buffaloes is achievable by improving their genetic potential in a scientific manner. Presently, about 20% breedable bovines are being bred artificially and 80% are bred naturally. To accelerate genetic progress, proportion of bovines bred through AI needs to be increased substantially. Conception rate through AI in the field is not more than 25%, and there is an urgent need to improve success rate, as this results in delayed conception and loss of productive life.

The National Commission on Agriculture (1976) estimated deficit in dry fodder, green fodder and concentrates to the extent of 49, 53 and 43% respectively. In 1991, the estimated deficiency in dry fodder, concentrates and greed fodder was 31, 47 and 23%. Present scenario is not different. There is, therefore, an urgent need for fodder crops improvement, quality seed production, and systematic fodder production, storage and grassland management. To address critical issue of feed shortage, there is a need for enhancing bio-availability of feeds, identifying newer unconventional feeds, developing resource-based region-specific feeding modules and fodder warehouses in the form of enriched feedblocks even to mitigate impact of drought and other natural calamities. The fodder development programmes have been in the hands of the Animal Husbandry Departments with limited qualified manpower and infrastructure. Development of a system and involvement of NGOs and self-help groups would be critical to address this issue.

We often forget that the producers, the farmers, suffer thrice: first, when they do not get the kind of quality input they need, second when they do not get the worth of their produce because

of man-made and natural calamities, and finally when they have to buy consumables from the market at enhanced rates. To start with, availability of the right kind of inputs at the right time holds the key to help them. The spurious seeds, insecticides and fertilizers are becoming impediment and bottleneck to enhance farm productivity. Hence, quality control and quality law enforcement is crucial. We have to think of bringing on a system's reform by even contemplating a system of having effective outlets for these essential ingredients for agriculture, say at each of the petrol pumps in the rural areas, where farmers go for refilling of tractors.

Extension

Technological intervention is the most important source of growth in total factor productivity and in improvement of efficiency. The twin goals can be achieved by harnessing potential of underdeveloped regions and through development of specialization pockets. The best suited enterprises should be identified for different agro-ecological settings, and these should be supported by physical as well as institutional infrastructure.

The future developments in agriculture are going to be technology-led and therefore knowledge- and resource-intensive. The business as usual approach has to be shed off and innovative solutions are called for. The application of information and communication technologies and a sensor-based decision support system, especially for the knowledge empowerment of the farmers have to receive priority attention.

The extension system is required to be reoriented from commodity focus to system's perspective to address entire value-chain from production to consumption. Research, Education, Extension and Marketing are required in a continuum for efficient and effective commercialization and enhancement of productivity and profitability. Hence, a system is to be evolved right from basic/strategic research to location-specific technology development, technology assessment, refinement and dissemination in an effective interactive model, so that technologies generated are adopted at the farm level. An ideal framework for technology development and delivery system should involve all stakeholders, players and partners, including a feedback mechanism for mid-course correction.

The Krishi Vigyan Kendras in operation in over 570 rural districts in the country are expected to be empowered and backstopped with the first-rate relevant technologies. Extension requirements of today are different from what they were in the past. They need to be knowledge-intensive, specific in extent, content and quality to meet users' diversified needs. Technology transfer now needs to answer questions: what is to be done, why to be done, how to be done, when to be done, what not to be done? and why not to be done? Recent efforts have started bearing some fruits in about 200 KVKs with e-connectivity.

To address challenges, a multi-pronged strategic intervention should focus primarily on : (i) enhancing investment for need-based agricultural infrastructure; (ii) developing human resources and effective knowledge management system; (iii) enhancing productivity and competitiveness of farm produce; (iv) creating and promoting farmer-consumer linkages by improving marketing efficiencies; and (v) providing an enabling policy environment so that farmers could access input and output markets, reduce cost, and receive remunerative prices.

Market and trade

The greatest opportunity for agricultural growth is the indigenous market. Disappearing tariff trade barriers have also given major impetus to export of Indian commodities. While seeking the attention of the National Agricultural Research System about the implicit requirement of streamlining package of practices towards good agricultural practices (GAP), there is an imminent need to sensitize from farm gate-level to all, including markets, regarding the necessity for ensuring toxin-free quality food commodities to consumers.

For an efficient-and-spirited technology outflow, we need to capitalize on the potential of PPP in the IPR regime for enhancing technology transfer and use in all fields of agricultural technology. Building an environment of trust and confidence in the partnership would hold the key to success. In all the partnership or business models, whether relating to -the transfer of IPR enabled technologies, or their joint validation, or up-gradation, or incubation, or scaling-up or product development and transfer, or mechanization, or cost-effective quality production, or a joint exploration of local and global markets for requisite demand, or test marketing of new products or market development, partnerships are to be forged on mutually agreed terms. Rapid developments in the areas of intellectual property rights, benefit-sharing, increasing role of private sector in agricultural research and development and for sharing gains from commercialization, require a system for Intellectual Property Portfolio Management and Commercialisation of Technologies to be evolved rather quickly.

Despite low level of processing, food processing industry is one of the largest industries in India - it ranks fifth in terms of production, consumption, export and expected growth. The extent of processing of fruits and vegetables is very low (1.8%). Although, dairy products have the highest rank in terms of percentage of processing, but still it is quite low. The demand for processed food is increasing rapidly due to rising urbanization, change in the dietary habits and income levels. Due to this, processed food market is likely to go up manifolds in the near future. Food processing has, therefore, been declared as one of the priority sectors. However, availability of quality value-added products is a major concern considering low shelf-life of the products.

Beef and buffalo meat production in India is not purposive, but merely an outcome of milk production system. Surplus males and unproductive animals end up as meat animals. Meat production in India, except in case of broiler industry and the meat from culled layers in organized farms, is all in the traditional production systems with a little investment. Meat prices in India and Net Productive Capacity indicate fairly high international competitiveness. However, they along with fish lose due to low Sanitary and Phytosanitary (SPS) standards, and have only limited markets confined to West, South and South East Asia. Livestock extension education can play an important role in this context to make livestock products quality specific and cost-effective by training farmers and entrepreneurs on export quality standards and phytosanitary requirements. Market intelligence through information technology-cyber extension; Sensitization training to middle-level extension functionaries to improve their technical and professional knowledge and skills; Conducting Livestock' Extension Education programmes on Good Agricultural Practices (GAP), Good Laboratory Practices (GLP) Good Manufacturing Practices (GMP); Capacity building in the areas of understanding WTO, SPS,

legal issues of SPS, food safety, risk analysis, diagnosis etc are the prime areas of importance for quality production and trade.

For bringing commerce in agriculture, the key is to ensure value-chain operation right from production to consumption. The whole chain of operation in agriculture will have to be addressed to attain and sustain competitive edge.

Partnerships

The research institutes under the CGIAR and the NARS have proved to be one of the most successful examples for research partnerships. But in the changed scenario, the seeds for instance, which contributed most in the IPR regime, are being seen as a perfect private good. Hence, developing economies need to think seriously for setting their agenda commensurate with their growing needs. Now time has come to set up a strong and vibrant symbiotic association between traditional universities and institutions, let it be public or private within the country and have potential-based common national and global initiatives that respond to improved research efficiency for productivity enhancement, economic growth, environmental safety, employment generation and poverty alleviation, above all to ensure judicious use of precious resources. All those important and relevant, need to join hands to foster new and strengthen existing linkages to create a win-win situation for the local, state, country, region and world as a whole.

To promote entrepreneurship, it is necessary that our public sector institutes and universities apart from technological backstopping should extend guidance/counselling to potential entrepreneurs on how to develop an economically viable proposal, organize resources, understand basic economic principles of supply and demand factors which influence price, common risks and problems likely to be encountered in agri-business marketing strategies. Extending relevant information to farming entrepreneurs on production, marketing, management and other related issues must receive priority attention, especially with regard to resources for small-scale ventures.

System has to play a proactive role with the right institutions in place, competent human resource available, right enabling environment, inter-institutional, inter-regional and inter-national linkages and facilitated access to knowledge, resources and technology - both new and traditional, within the legal framework and respecting all IPR rights on the principles of equity. The time has come to again demonstrate the surge of a new science, even if apprehensions and conflicts will take their own time and course to get resolved. Awareness is, nevertheless, important and the awareness we must provide in the best interest of science and society.

It would be desirable to plan and manage all resources in an integrated manner for maximization of environmental, social, economic, livelihood, equity and to advance all inclusive benefits. Thus, the key of likely success would be new innovative partnerships in agriculture. On the whole, the economic, technological, social and political dictates seem to demand a re-moulding of agriculture with the involvement of various stakeholders and alternative players to provide far greater velocity and vigour to agricultural growth.

Purpose in place aiming at

1. Resource carrying capacity based enhancing farm productivity, profitability, sustainability, employability, and inclusive growth.
2. Developing forward and backward linkages, forging efficient, effective and relevant partnerships with an end to end approach involving stakeholders, players and partners.
3. Ensuring technology generation, Extension, adoption, production, processing and marketing in continuum.
4. Enhancing skill, capacity and knowledge empowerment for technology-led growth.
5. Advocacy for integrated, intensified, diversified, harmonized, need- oriented, demand-driven and forward-looking production-to-suppiy system.
6. Striving for quality input supply system for quality output, outcomes and impact.

Principles to be followed and instruments needed to fulfil the purpose

1. Developing an innovative system involving credible institutions, associations and non-government organisations.
2. Putting purpose in place and inculcating missionary zeal in a mission -mode approach with a decentralized yet integrated and harmonised model of operation.
3. Ensuring, freedom, flexibility and accountability with measurable and quantifiable targets in the centre
4. Capitalizing on complementarities, harnessing competence and coherent synergies providing appropriate and adequate windows for interaction.
5. Essential human resource with adequate financial and physical support.
6. Governance structure, monitoring mechanism and reporting system with as little room as possible for any loop formation.
7. Location, situation and system based bottom -up perspective planning to achieve policy and programme goals formulated in a participatory mode.
8. Simple, implementable, result- oriented operation frame work and monitoring evaluation and on course correction mechanism.
9. Convergence orientation, coordination mechanism and corporate governance structure and function.
10. Contractual services with performance oriented remuneration, incentives and rewards.
11. Developing system for realising maximum output and impact with minimum paperwork.

The Hungry Child Cannot Wait

Prof. R.B. Singh
President
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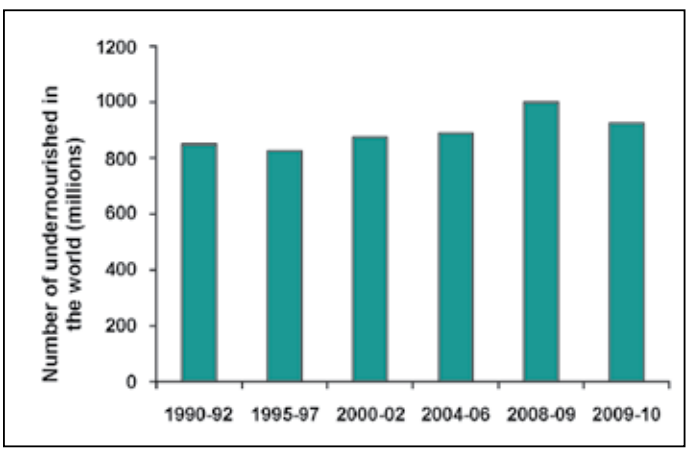
I. Global Dimensions of Hunger

Distinguished Fellows of the Academy, Ladies and Gentlemen!

The number of undernourished people in the world has been increasing for a decade or so (Figure 1) and the number of hungry for the first time had crossed the 1 billion mark in 2008-09 (FAO, 2009), but the number came down to 925 million in 2009-10. Nearly all hungry people were from developing countries. The gains made in the 1980s and early 1990s in reducing chronic hunger have been lost and the hunger reduction targets of the Millennium Development Goal 1 (MDG1) as well as of the World Food Summit (WFS) remain elusive.

The soaring food prices of 2007-08 had drawn the poor farther from food, resulting in the unusual increase in the number of undernourished. Despite the fall in international food and fuel prices starting in the late 2008, the prices in domestic markets remained 15 to 25 percent higher in real terms than the trend level – continuing the distress for the poor. In India, high food prices and inflation rates have emerged as a major livelihood concern. As shown in Figure 2, The Asia-Pacific region, with 578 million undernourished, and Sub-Saharan Africa with 239 million hungry people accounted for 62 and 26 percent, respectively (jointly 88 percent), of the world's hungry people.

Fig. 1. *Chronic hunger in the world has been increasing since 1995-97*

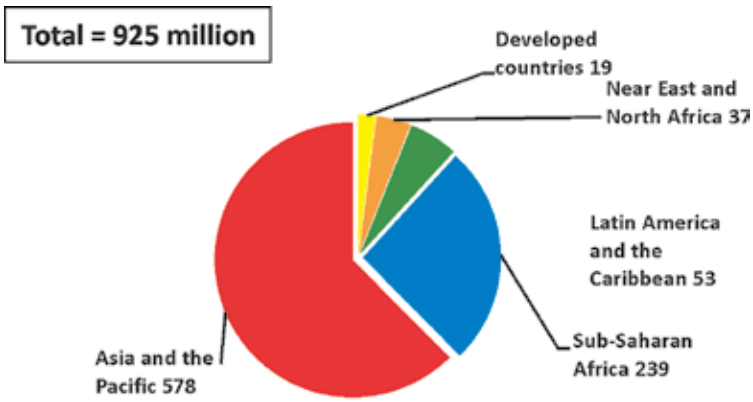


Source: FAO, 2009, 2010

Poverty is the principal cause as well as consequence of hunger.

Presidential address delivered at the 18th General Body Meeting of the National Academy of Agricultural Sciences held at New Delhi on June 5, 2011.

Fig. 2. Number of hungry people by region, 2010



Source: FAO, 2010

As per a World Bank study, nearly 1.4 billion people in the developing countries live on $ 1.25 a day or less. Generally, the hunger intensities (undernutrition percentage) followed the poverty incidences (Table 1). But, this general trend is necessarily not always true and other factors such as women status, education, health care services etc. make significant difference.

Table 1. Poverty ($ 1.25 a day or less) and hunger levels in the developing world, percentages

Region	% Poverty	% Hunger (undernourished)
Asia-Pacific	27	17
Latin America & Caribbean	8	10
Sub-Saharan Africa	51	32
Total Developing Countries	29	20

Source: FAO, 2010

Performances of countries and regions have varied widely. India has made little progress towards WFS and MDG targets, whereas China and Brazil are fairly close to achieving the targets (Table 2)

Table 2. Prevalence of undernourishment and progress towards the World Food Summit (WFS) and the Millennium Development Goal (MDG) targets in developing countries.

World/ Region/ Country	Total popln 2004-06 (Million)	Number of People Undernourished (Million)				Progress in Number towards WFS (Target 0.5) *	Progress in prevalence towards MDGs (Target 0.5) **
		1990-92	1995-97	2000-02	2004-06		
India	1134.4	210.2	193.5	223.0	251.5	1.2	0.9

World/ Region/ Country	Total popln 2004-06 (Million)	Number of People Undernourished (Million)				Progress in Number towards WFS (Target 0.5) *	Progress in prevalence towards MDGs (Target 0.5) **
		1990-92	1995-97	2000-02	2004-06		
China	1320.5	177.8	143.7	132.5	127.4	0.7	0.6
Brazil	186.8	15.8	15.6	16.6	11.9	0.7	0.6
Asia-Pacific	3518.7	585.7	528.5	552.1	566.2	1.0	0.8
Developed Countries	1269.5	19.1	21.4	18.7	15.2	0.8	Na
Developing Countries	5213.8	826.2	803.5	838.0	857.7	1.0	0.8
World	6483.3	845.3	824.9	856.8	872.9	1.0	0.9

Source: FAO, 2009

** Ratio current/baseline number of undernourished – ratio for WFS target = 0.5*

*** Ratio current/baseline prevalence of undernourished – ratio for MDG target = 0.5*

Under Brazil's Zero Hunger Programme, led by the then President, His Excellency Lula, various food and nutrition programmes, including food distribution programmes (via both private and public sector channels) and direct subsidies, were implemented. These programmes were almost fully supported by national resources and food and nutrition spending between 2003 and 2007 was more than doubled to about US$13 billion annually (see Box 1).

In China, effective adoption of packages of modern technologies *viz.* hybrid rice, biotech products and dedicated extension system leading to extremely high and stable yields, integrated on-farm and non-farm employment and Village Township Enterprise programme were the main elements of the success. Moreover, China pursued a successful poverty alleviation strategy along with rapid economic growth and effective nutrition, health, and family-planning interventions (see Box 2).

II. The Indian Enigma

India faces the rare enigma of attaining and maintaining an impressive economic growth of about 8% per annum accompanied by a stubbornly high incidence of malnutrition, food insecurity and rural poverty. Despite the Green Revolution leading to India's national level food self-sufficiency and security, the number of food insecure people in India has remained unacceptably high, in recent years hovering around 250 million, one-fourth of the world's food insecure people. In fact, during 2005 to 2010, the number of hungry in the country, as in the world as a whole, has increased. In percentage term, however, food insecurity in India had reduced from 25 percent in 1990-92 to 20 percent in 2001-2003, but in recent years has increased to 21 percent (Table 3).

Box 1 (Brazil)

Policy instruments:

- The period of sharpest economic growth and poverty reduction occurred from 1970 to 1980, before improvements in child malnutrition and infant mortality (that is, there was a lagged response).
- Coverage of safe water increased from 35 percent in 1967 to 80 percent in 1980. Sewerage coverage increased to 50 percent by 1980.
- Immunization coverage more than tripled from 1975 to 1988; the number of physicians per 1,000 people doubled.
- Major investments were made in direct nutrition inputs (food programs) and in social-sector spending on water and sanitation, health, and education.

Success factors:

- Various food and nutrition programs, including food distribution programs (via both private and public sector channels) and direct subsidies, were implemented; these programs were almost fully supported by national resources.
- Food programme expenditures went from 0.06 percent of GDP in 1980 to 0.21 percent of GDP in 1989. Food and nutrition-related expenses went from 0.16 percent to 0.25 percent of social-sector expenses.
- Investments in health showed an upward trend from 1975 to 1982, with lower levels in 1983–84. They further increased to a peak of US$68.73 per capita in 1989 (2.4 times the expenditures in 1975).
- Spending on education increased during 1976–82. Per capita education expenditure was US$31.9 in 1982, dipped to US$24.5 in 1984, but increased again to reach US$54.8 in 1988 (a sevenfold increase compared with 1970).

Since 2004, Brazil has further accelerated its nutrition policy efforts with its Zero Hunger programme and nutrition has improved significantly. That programme more than doubled food and nutrition spending between 2003 and 2007 (to about US$13 billion annually in 2007).

Table 3. Number and percentage of undernourished people in India since the base year 1990-92

Year	Total Population (Million)	Undernourishment	
		Number (Million)	Percent
1990-92	863	215	25
1995-97	949	202	21
2001-03	1050	212	20
2005-07	1116	221	20
2009-10	1168	250	21

Source: Ministry of Agriculture, GoI 2007 and FAO 2010

Box 2 (China)

Policy instruments:

- China pursued a successful poverty alleviation strategy along with rapid economic growth.
- Effective nutrition, health, and family-planning interventions were implemented at a large scale.
- China also focused on complementary interventions to address other determinants of child malnutrition, such as water and sanitation (which help reduce illness from infectious diseases) and education (between 1992 and 2005, the share of mothers who had completed middle school increased from 32 to 57 percent and the share of illiterate women fell from 22.5 to 7 percent).

Success factors:

- Central leadership was combined with a commitment to the process and the establishment of local government ownership.
- China established an effective data collection system that provides regular data for monitoring progress, and the country's strong research institutions ensure that data and information are effectively communicated to policymakers and used for policymaking.
- Strong and effective partnerships were established between the Chinese government and international partners.

The budget share of government expenditure on education increased to 20 percent during the 1990s, although the share spent on health was relatively low (~3–4 percent).

Although most rampant in children, malnutrition is prevalent in every age group (Table 4), adversely impacting health (increased susceptibility to infections), productivity and overall quality of life. And, between the two latest surveys, there is little progress in reducing the hunger indices.

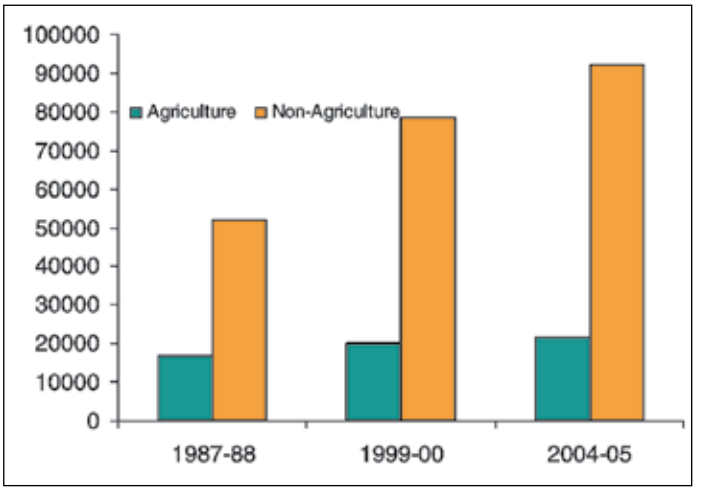
Table 4. Levels of malnutrition (percent)

Indicators	NFHS-2 (1998-99)	NFHS-3 (2005-06)
Children under 3 yrs. who are stunted	45.50	38.40
Children under 3 yrs. who are wasted: weight for height	15.50	19.10
Children under 3 yrs. who are underweight: weight for age – less than 2 S.D.	47.0	45.9
Anemia among children aged 6-59 months	74.0	70.0
Women in 15 to 24 years with BMI < 18.5		44.1
Women in 25 to 49 years with BMI < 18.5		30.7
Women in 15 to 49 years with BMI < 18.5	36.2	35.6
Men aged 15 to 24, with BMI < 18.5		47.3
Men aged 25 to 49, with BMI < 18.5		26.9
Men aged 15 to 49, with BMI < 18.5	N.A.	34.2

Source: National Family Health Survey

Another enigmatic paradox is that more than 50% of the two-thirds of the farming families, the marginal and sub-marginal farmers, are undernourished and poor - below poverty line (Table 5). As per the 59th Round NSS, GoI, 2004, 57 percent of the rural poor were marginal farmers and another 26 percent were agricultural labourer. As regards hunger, marginal farmers and agricultural labourers accounted for 51 and 22 percent, respectively of the rural undernourished persons. The overall high rate of economic growth has thus been highly iniquitous and hollow for the rural masses. The disparity in the per worker GDP in agriculture and in non-agriculture during the past 20 years had widened from 1:3 to 1:5 (Fig. 3).

Fig. 3. *Per worker GDP in agriculture and non-agriculture sectors, Rs at 1999-00 prices*



Source: FAO, 2009.

Table 5. Proportion of poor and undernourished persons in different farm-size groups in rural India, 2004

Farm Size	Share of each group in total poor, %	Share of each group in total under-nourished, %
Agrl. labourer	26.4	22.0
Marg. Farms	56.8	51.3
Small Farms	2.9	3.9
Med. Farms	1.3	2.1
Large Farms	0.4	0.6
Other Rural	12.2	20.1

Source: 59th Round NSS, GOI

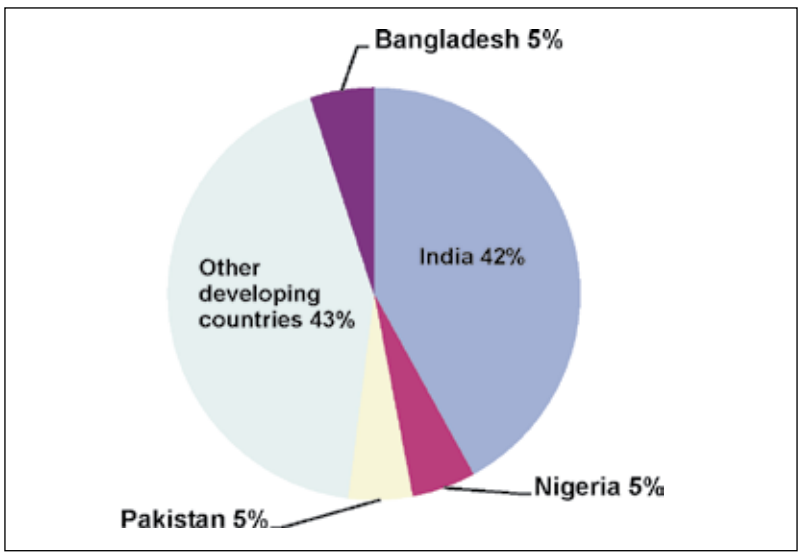
Thus, national level food production and self-sufficiency, although a necessary condition, is not a sufficient condition to lead to family and individual level food and nutrition security. Several interdependent factors, namely, poverty, inadequate food availability and distribution, inequity

and gender imbalance, poor child care and health care, unsafe drinking water, poor sanitation and limited access to education and social services affect food security and nutrition.

III. Child Malnutrition

India is home to 44 percent of the world's severely malnourished children under five and 35 percent of the developing world's low-birth-weight infants. A recent UNICEF report reveals that India accounts for 42 percent of world's underweight (low weight for age) children under five years of age (Figure 4). Forty eight percent of our children are stunted (low height for age) and nearly 20 percent are wasted (low weight for height). Overall, nearly 40 percent of the undernourished children in the world are our own children.

Fig. 4. *Share of underweight children under five years of age.*



Source: UNICEF (2009)

As seen from Table 6, India is far behind other most populous countries of the different continents in nutritional status of its children. This must not be acceptable to the Fellow scientists and other stakeholders.

Table 6. Extent of child undernutrition in selected countries

Indicators	India	Brazil	China	Russia	Nigeria
Low birth weight: 0% of infants with LBW – 2000-2007	28.0	8.0	2.0	6.0	14.0
Children under 3 yrs. who are stunted, %	47.9	7.1	21.8		43.0
Children under 5 yrs. who are underweight: weight for age – less than 2 S.D.: %	43.5	2.2	6.8	-	27.2

Source: UNICEF: maternal and newborn health, State of world's children 2009

Every year, 2.5 million children die in India, accounting for one in five child deaths in the world - the highest for any Nation. According to one estimate, 32 babies out of every 1,000 born alive die before their first birthday. The Infant Mortality Rate (IMR) in India has declined from 114/1000 live births in 1980 to 58 in 2004, but it is still high by international standards, although, there are wide variations amongst and within the states. In 2004, while Kerala recorded an IMR of 12/1000 live births, in the same year the IMR in Madhya Pradesh was 79/1000. The other states with an IMR significantly above the national average of 58/1000 live births are Orissa (77), UP (72), Rajasthan (67) and Assam (66). It is generally believed that more than half of these deaths could be prevented if children were well nourished.

Among the hungry children, one population is especially vulnerable – those upto two years of age. Undernutrition in the first two years of life threatens a child's life and can jeopardize physical, motor and cognitive development. Those who survive, being undernourished during the first two years of life, can suffer irreversible long-term damage. It is therefore of particular importance that we take concerted action to combat hunger especially among young children.

Undernutrition has a whole range of effects that impede not only children's nutrition and development in the short term, but also their cognitive abilities and productivity in adulthood, with measurable economic impacts. The economic cost of child malnutrition may be more than 10 percent of lifetime earnings for individuals and 2-3 percent of GDP for the nation. Recent studies have shown that the window of opportunity for addressing child nutritional needs in ways that produce healthy and productive adults lasts from conception through age two. After that, the effects of undernutrition are largely irreversible. By addressing the large and severe problem of early childhood undernutrition, policymakers could maximize the effectiveness of investments designed to achieve overall development goals. Copenhagen Convention (2008) had brought out that greatest development good would come from a nutrition intervention viz. micronutrient supplements for children.

Another study estimates "that every year of schooling increases adult yearly income by 9%. The loss of adult income for being stunted but not in poverty is 22.2%, the loss from living in poverty but not being stunted is 5.9% and from being both stunted and in poverty is 19.8%. Clearly when large number of children is affected national development will also be substantially affected". In particular, the availability of quality labour in the fast-transforming India would be a matter of major concern.

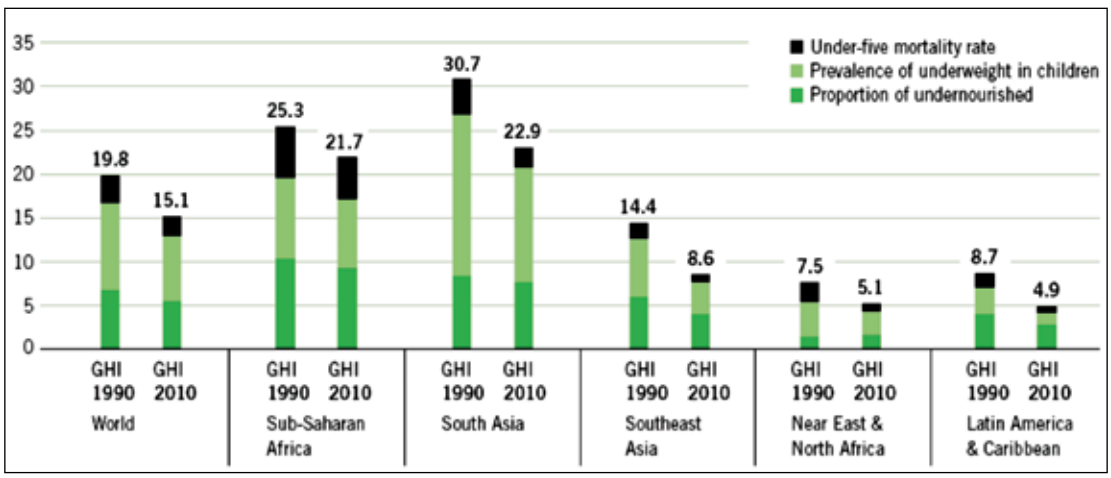
IV. Prevalence of underweight children underpins India's Global Hunger Index (GHI)

The Global Hunger Index (GHI), a new concept and tool developed by the International Food Policy Research Institute (IFPRI) in 2006, is being widely used to comprehensively measure and track global hunger. The GHI incorporates three interlinked hunger-related indicators –

the proportion of undernourished in the population, the prevalence of underweight in children, and the mortality rate of children. Although the relative weight of the three indicators varies across regions, the extent of child underweight is the highest contributor to the GHI, especially in South Asia (Figure 5).

The GHI aims to raise awareness of regional and country differences in hunger and trigger action to eliminate hunger. Targeted at a wide range of audiences – including policymakers,

Fig. 5. *Contribution of components to 1990 GHI (based on data from 1988-92) and 2010 GHI (based on data from 2003-08)*



Source: 2010 Global Hunger Index

donors, nongovernmental organizations, educators, the media, and the broader public, the GHI provides insights into the drivers of hunger and highlights successes and failures in hunger reduction. The index ranks countries on a 100-point scale, with 0 being the best score (no hunger) and 100 being the worst, although neither of these extremes is reached in practice. Values less than 5.0 reflect low hunger, values between 5.0 and 9.9 reflect moderate hunger, values between 10.0 and 19.9 indicate a serious problem, values between 20.0 and 29.9 are alarming, and values of 30.0 or higher are extremely alarming.

As seen from Figure 5, the GHI worldwide improved from 19.8 percent in 1990 to 15.1 percent in 2010. The higher GHI was for South Asia at 22.9. In 2010, among the 84 countries (for which data could be available), having GHI above 5.0 (ranging from 5.2 percent in Syria Arabs Republic to 41.0 in Cango, Democratic Republic), India, with GHI at 24.1, ranked 67th, which could be considered as an alarming situation. The high GHI in India was driven by high levels of child underweight (Table 7) resulting essentially from the low nutritional and social status of women. Thus, in order to improve the GHI score, India must accelerate progress in reducing child underweight by improving childhood nutrition and awareness and social status of women.

Table 7. Contributions of the three components of GHI and the underlying data for calculating the 1990 and 2010 GHI

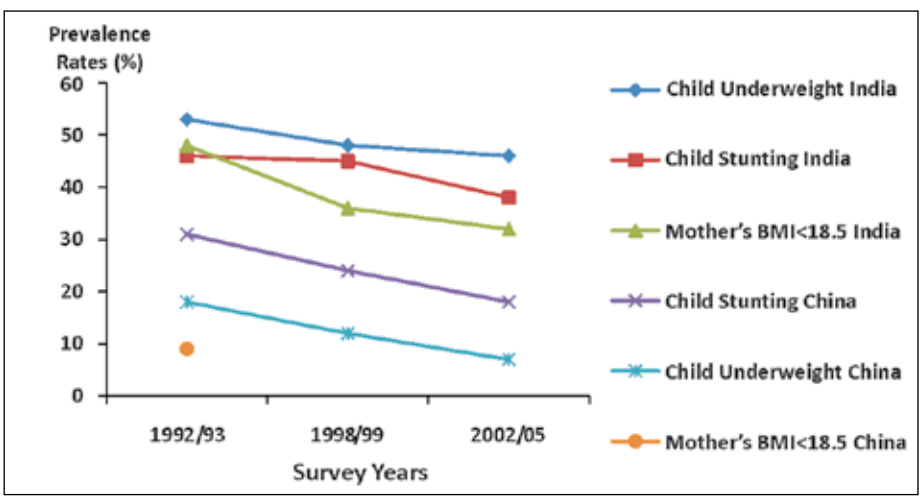
Country	Proportion of undernourished in the population (%)		Prevalence of underweight in children under five years (%)		Under five mortality rate (%)		GHI	
							With data from 1988-92	With data from 2003-08
	1990-92	2004-06	1990-92	2003-08	1990	2008	1990	2010
India	24.0	22.0	59.5	43.5	11.6	6.9	31.7	24.1
Bangladesh	36.0	26.0	56.5	41.3	14.9	5.4	35.8	24.2
China	15.0	10.0	15.3	6.0	4.6	2.1	11.6	6.0
Pakistan	22.0	23.0	39.0	25.3	13.0	8.9	24.7	19.1
World	-	-	-	-	-	-	19.8	15.1

Source: Global Hunger Index, 2010

V. India-China Comparison in Child Malnutrition

Drawing from an IFPRI study (2007), in the early 1990s, India and China together accounted for 50 percent of the malnourished preschool children in the world. Child malnutrition has since then declined in both countries but from different levels and at different paces. In 1992, in India the incidence of stunting among children aged 0–3 years was notably higher than in China (47 versus 32 percent), and underweight was three times more prevalent (52 and 17 percent respectively in India and China), as shown in Figure 6.

Fig. 6. *Child stunting and underweight, and mothers with low body mass indexes in China and India, 1992/93 to 2002/05.*



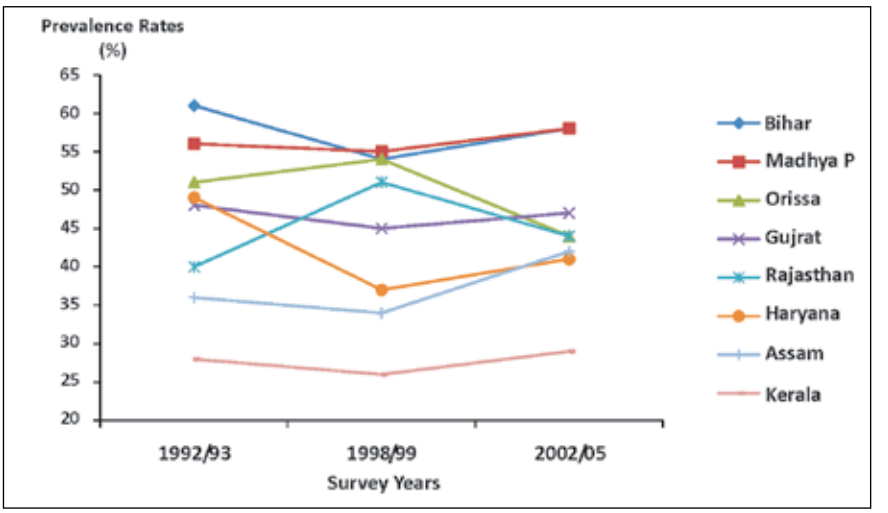
Source: 2010 Focus Brief, IFPRI, 2007

In India, the share of underweight children declined by a few percentage points between 1993 and 1999 but remained virtually unchanged from 1998/99 to 2005/06. Child stunting, in contrast, was almost flat between 1992/93 and 1998/99 but declined by 8 percentage points between 1998/99 and 2005/06. In China, the incidence of child underweight and stunting between the 1992 and 2002 surveys was halved (Figure 6).

As further seen from Figure 6, in India, the share of mothers with a body mass index (BMI) of less than 18.5 declined notably between the first two surveys, but only by 3.2 percentage points between 1998/99 and 2005/06, from 36.2 to 33.0 percent. For China, in the 1992 survey, 9.9 percent of adult women were underweight, about one-fifth of the prevalence rate in India around that time.

As regards intracountry differences, among 15 larger Indian states the prevalence of child underweight has uninterruptedly declined in 7 states since 1992/93, while it increased in the other 8 states between two of the survey years. In 6 of these states, the increase took place between the two most recent surveys (Figure 7). In 2005/06, the incidences were lowest in Kerala (28 percent) and almost twice as large in Bihar, MP and Orissa.

Fig. 7. *Child underweight in eight large Indian states where it increased in a subperiod between 1992/93 and 2005/06*

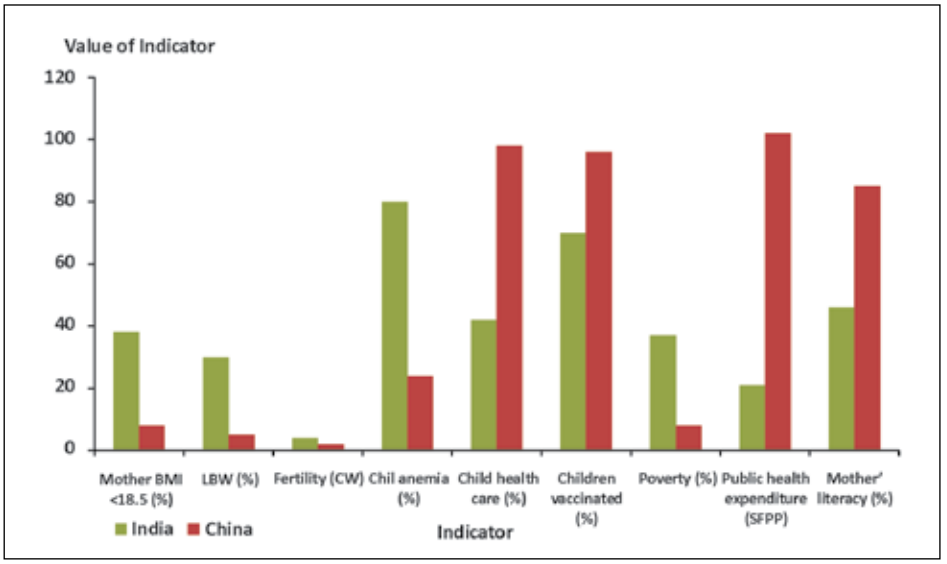


Source: 2020 Focus Brief, IFPRI, 2007

Regarding rural-urban divide, the prevalence of child stunting and underweight in India was 30 percent higher in rural areas as compared to that in urban areas. In China, the relative concentration of child malnutrition in rural areas was almost 300 percent of that in urban areas.

The differences in the incidence of child malnutrition between China and India can largely be attributed to the differences in levels of income, female (mother's) status and nutritional status, birth weight and health care (Figure 8).

Fig. 8. *Selected proximal and underlying determinants of child malnutrition in India and China, 2004 or nearest year*



Source: 2020 Focus Brief, IFPRI, 2007

VI. Leveraging Agriculture for Improving Nutrition

Prime Minister of India, Dr. Manmohan Singh, while inaugurating the Global Conference on Leveraging Agriculture for Improving Nutrition and Health in February 2011 in New Delhi observed that "Leveraging agriculture for improving nutrition and health is particularly important in developing countries, where agriculture is also the mainstay of a very large number of people". This is particularly true for India.

At the above Conference, Madam Hillary Rodham Clinton, Secretary of State, United States of America had observed that we must find ways "to do even more to improve agricultural productivity, more to connect farmers to markets, more to increase access to nutritious crops and health care, and more to support the women who are growing food and caring for children around the world".

The above profound statements underpin the centrality of agriculture in alleviating hunger and undernutrition. The food price crises of 2007-08, and more recent increase in food prices and inflation expose the high vulnerability of global food system to disruptions caused by weather and government policies. Moreover, agriculture is facing challenges of burgeoning population, climate change, water crises, land degradation and soil health deterioration, urbanization, changing dietary pattern, energy crises, and recurrent intense natural disasters. Can agriculture meet the challenges? The answer must be 'yes' for the Indian Agriculture.

Greater thrust must be put on accelerating domestic production of food. Per capita production of foodgrains had peaked to 207 kg during 1991-95, but has since been declining and slided

to 193 kg in 2006-07, although during the last two years the foodgrain production has been around 230 million tons – all time high. Per capita availability of milk, fruits and vegetables – the high value commodities, had fortunately steadily increased (Table 8).

Table 8. Per capita production of various food items (kg)

Year	Cereals	Pulses	Food-grains	Oil-seeds	Sugar-cane	Milk	Fruits	Vegetables	Fish
1991-1995	192	15	207	23	283	67	33	64	5.0
1996-2000	191	14	205	24	297	75	45	83	5.6
2001-2005	177	12	189	20	258	82	43	88	5.8
2005-2006	176	12	188	25	254	88	50	99	6.0
2006-2007	180	13	193	21	281	90	51	100	6.2

Source: Ministry of Agriculture, GoI, Various years

As seen from Table 9, the production growth rates for foodgrains (cereals and pulses) – the mainstay of food security, during the decade ending 2007 was hardly 0.6 percent, which was almost one-third of the rate of the population growth. The required growth rate of these commodities towards the year 2020 is about 2 percent, seeking much greater efforts on part of all stakeholders (scientists, extensionists, farmers and private sector).

Table 9. Required growth over the base year production of 2006-07 to achieve domestic demand by 2020

Commodity	Domestic production 2006-07 (million tons)	Projected demand (2020-21)	Growth rate during 1998-99 to 2006-07	Required growth rate over 2006-07 to meet the demand (%)
Cereals	201.9	262.0	0.62	1.9
Pulses	14.2	19.1	0.47	2.1
Foodgrains	216.1	281.1	0.61	1.9
Oilseeds	23.6	53.7	1.96	6.0
Vegetable	111.8	127.2	3.68	0.9
Fruit	57.7	86.2	3.06	2.9
Sugarcane	315.5	345.3	-0.60	0.6
Milk	100.9	141.5	3.65	2.4
Fish	6.9	11.2	2.89	3.5
Egg (billion)	50.7	81.4	6.60	3.4

Source: Agricultural Statistics at a Glance, GoI, 2007; and Kumar, P. (personal communication)

With the increasing emphasis on value chain management, detailed analysis of value chains should be used to assess the problems and prospects of the main components of food and

nutrition security, namely, availability, economic access and quality. This approach can lead to increased production, better distribution and greater consumption of desirable and diversified food such as fruits, vegetables, dairy products and fortified foods. It can also trigger new initiatives in the food industry to create more processed foods and also induce the farming community to diversify their production systems to meet such demands.

New initiatives such as effectively planned and managed home gardens can greatly enhance house-hold nutrition by increased consumption of micronutrient-rich vegetables, fruits, and animal-source foods to address deficiency in vitamin A and iron especially in young children and women. Besides, these will be helpful in augmenting the livelihoods of women and small holder farmers though improved access to markets.

As regards the economic aspects, as mentioned earlier, while India is the fastest growing economy in the world, the rates of child undernutrition in the country have remained stubbornly high, unlike most countries. This disconnect between agriculture and nutrition in India must be researched to find ways to break the myth. In the predominant agrarian economy, the economic levers must be friendly to farmers and the cultural settings. Home production of high quality complementary foods, which is often labour intensive, would greatly enhance availability of locally produced nutritious infant foods. Women self help groups, farmer cooperatives, small producer companies, duly supported with quality certifications, would help families meet their requirements of nutritional infant foods.

Socially, national mobilization of people, especially those at community level (supported by the national leadership) can greatly enhance the synergy between agriculture and nutrition. The Zero Hunger Program launched by the President Lula, in Brazil to fight extreme poverty and to ensure the human right to adequate food and nutrition, as described earlier, is an excellent example of social mobilization at national level to meet the highest priority of the people – freedom from hunger and undernutrition. The Brazilian program was marked by synergy among public policies, including income transfer, school feeding and support for public restaurant and food banks. This model is particularly suitable for India because of the high concentration of smallholder farmers.

The social empowerment should be accompanied with empowerment of communities through improved access to information and increased income. The private companies can also participate in such national social mobilizations by empowering smallholder farmers and other poor communities by aligning themselves with value chain. Support to producers companies and women self help groups will be particularly rewarding.

Research should be pursued for combining high productivity with high nutritional quality and sustainability of food, fruit and vegetable crops. Suitable varieties and management practices for home gardens can greatly improve both nutrition and income. A recent study shows that home gardens in India can provide more than 100 percent of people's recommended daily allowance of beta-carotene and vitamin C, 75 percent of protein, and 20-25 percent of iron. Special arrangement will have to be made to ensure timely supply of quality seed and planting materials of the identified varieties.

Breeding fortified staple crops to have a higher content of micronutrients like iron, zinc, and vitamin A, should be a high priority as it will improve poor people's nutritional status in an extremely cost-effective way. Biofortification has already been achieved in rice (Golden Rice), sweet potato and potatoes, and work is in progress on bananas/plantains, beans, cassava, lentils, maize, pearl millet, sorghum, and wheat. Several of these products should be popularized. Biotechnology holds great promise for designer crops, but the food safety, regulatory and gene literary aspects must be streamlined towards unleashing the huge potential of this technology.

This year the Government of India has allocated Rs. 300 crore for developing nutri-cereals, especially the millets, towards meeting the nutritional gaps. The rich crop, tree, animal, and fish diversity of the country should be evaluated and characterized for nutritional attributes and utilized in the development of nutritionally superior (and safe) genotypes. Through a Brainstorming Session on the role of millets – nutricereals, the Academy has recently evolved a strategic plan and framework for mainstreaming millets and their veritable products in nutrition augmentation.

Researchers should collect and analyze more information on people's dietary preferences, food consumption patterns and nutrient intakes. It would be helpful to know what populations eat now, where they obtain that food from, and where the "gaps" are in their ability to meet their nutrient requirements. Field-friendly and affordable methods to measure nutritional status, especially for several micronutrients simultaneously would be helpful in strategic planning by having reliable and more accurate demand estimates.

VII. Strategies and New Initiatives

The Life Cycle Approach to Fight Child Malnutrition: A Life Cycle Approach should be adopted for fighting malnutrition so as to target resources towards the critical nutritional periods of the human life cycle which includes the following: vulnerable women during pregnancy, the first two years of life of the child and during adolescence.

According to an estimate, malnutrition, as measured by stunting, affects 32.5 percent of children in developing countries. Geographically, more than 70 percent of malnourished children live in Asia, 26 percent in Africa and 4 percent in Latin America and the Caribbean. In many cases, they were handicapped even before birth with a malnourished mother. Under-nutrition among pregnant women in developing countries leads to 1 out of 6 infants born with low birth weight (the GHI Study).

In the past, India and most other developing countries had targeted children under the age of five for nutrition, but generally the outcome had not been very encouraging. Recent evidence shows that the window of opportunity for improving nutrition is much narrower, spanning the period from -9 to +24 months (that is, the 1,000 days between conception and a child's second birthday). This is the period when children are in greatest need of adequate amounts of nutritious food for healthy development. Further, most importantly, interventions during this period are most likely to prevent undernutrition from setting in. Studies show that after

the age of two, the effects of undernutrition are largely irreversible. Moreover, when poorly nourished girls grow up, they tend to give birth to underweight babies, perpetuating the cycle of undernutrition. Thus, the well-being of mothers is a critical element of the solution and for breaking the vicious cycle of undernutrition. Further, access to safe water, sanitation, and preventive and curative healthcare are critically essential.

The Right to Adequate Food and Nutritional Health: At the World Summit on Food Security in 2009, UN Member States reaffirmed "the right of everyone to have access to safe, sufficient and nutritious food, consistent with the progressive realization of the right to adequate food in the context of national food security." The right to adequate food is a human right laid down in international legal human rights conventions, together with other rights conducive to food security and nutritional health. The majority of UN Member States have ratified these conventions and are thereby bound to implement their content.

An increasing number of states, international organizations, and civil society have begun to explore a rights-based approach to development efforts, including activities promoting food security and nutritional health. They recognize that merely increasing food production will not end hunger and malnutrition and that those who are poor, hungry, or undernourished must get access to food. Who and where they are must first be identified, and the causes of their situation fully understood and exposed. Vulnerable and marginalized groups can then be specifically supported by agricultural programs facilitating their ability to feed themselves or social protection schemes ensuring that no individual in need is left out.

A human rights-based approach to such programmes and schemes necessitates strict adherence to certain principles in their implementation. Some of those principles are already generally accepted in development language, such as transparency, empowerment, and participation, while human rights also require respect for human dignity, non-discrimination, a high request for accountability, and respect for the rule of law.

"Adequate food" entails not only sufficient quantity, but also dietary diversity to satisfy nutritional needs, food safety, and compliance with cultural food values. These attributes have traditionally not received proper attention in food security policies and programming, and should be internalized in assessing consumption patterns and estimating future food demands and supplies. New political commitments and initiatives should emerge from governments of food- and nutrition-insecure countries toward policies and programmes conducive to the realization of the right to adequate food.

International Initiatives: New international initiatives are also specifically targeting nutritional security under the overall umbrella of food security and poverty alleviation – The Millennium Development Goal 1. Following the Copenhagen Consensus in 2008, which declared that investments in nutrition initiatives were the most effective development investments in terms of cost and benefit, a group of nutrition actors, representing a range of stakeholders, issued a set of recommendations in 2010 for global and national action called "Scaling Up Nutrition: A Framework for Action". This document endorses a package of nutrition interventions targeted toward the window of opportunity and estimates the costs of scaling up these interventions from current levels to the levels needed to achieve rapid reductions in undernutrition.

Further, based on discussions following the global food, fuel, and financial crises, the Group of Eight industrial countries agreed through the L'Aquila Joint Statement on Global Food Security to place new emphasis on food security and nutrition in poor countries. Building on this statement, multiple donors have contributed to the Global Agriculture and Food Security Programme (GAFSP), which will help countries develop comprehensive plans to address agriculture and food security to improve household resources for addressing child undernutrition. The Committee on World Food Security (CFS) underwent a reform process throughout 2009. The reform document sets forth its commitment to broader participation by food security stakeholders and also unequivocally states that nutrition is integral to the concept of food security and to the work of the CFS.

The United States Agency for International Development recently announced its Feed the Future initiative, which merges agriculture, health, and nutrition efforts and will spend at least US$3.5 billion to support countries in developing country investment plans for improving agriculture, reducing poverty, and improving nutrition. This followed pledges by other countries and a pool of over US$ 18 billion has been erected to support the movement. The United Kingdom Department for International Development also recently launched its new nutrition strategy that sets out to tackle the "neglected crisis of undernutrition" by focusing on a set of immediate and long-term actions to reach children during the critical 1,000 days from conception to two years of age (DFID 2010). The Hunger Task Force Report, which lays out the Government of Ireland's priorities for reducing and eliminating hunger, also includes as one of its three focus areas the implementation of programs focused on maternal and infant undernutrition.

Notwithstanding the much needed global initiatives, the national policies and programmes must be strengthened to reach the hungry and fight malnutrition. The successes of countries that have made concerted efforts to prioritize nutrition should set an example for others that lag behind. The success stories, although diverse in the specific modalities and instruments used to tackle undernutrition, rely on a few common principles:

- Strong government action coordinated across sectors and at central, state, and local levels; strengthening of existing health systems;
- Significant scaling up of public spending;
- Leadership and commitment at all levels;
- Focus on and empowerment of vulnerable populations, households, and age groups; and
- A strong monitoring and evaluation culture that provides a basis for incentives and correction of policy actions in the context of implementation.

VIII. Policy Options and Actions

To achieve significant improvements in child nutrition, health and survival, countries need to develop comprehensive strategies and policy options that include actions to address the immediate and underlying causes of child undernutrition.

Several countries have developed explicit policies on nutrition as an integratel part of their multi-sectoral national development plans and achieved expectant results. Brazil, China, Thailand and Vietnam, for example have effectively and quickly reduced child undernutrition by adopting the integrated approach. For instance, between 1990 and 2002 China reduced child malnutrition by more than two-third, from 25 to 8 percent, with highly successful poverty reduction strategy; effective large-scale health, nutrition, and family planning interventions; and increased investment on water, sanitation and education.

Targeted nutrition interventions for women and children in the window of opportunity (between conception and the age of two), using evidence-based and locally appropriate approaches should be scaled up. Universal coverage of a package of preventive nutrition interventions for children under age two could reduce the global burden of childhood undernutrition by 25–36 percent. Scaling up these interventions will require addressing the substantial challenges related to resources, governance, and capacity.

The National Nutrition Policy 1993 had identified key areas of action in various fields like food production, food supply, education, information, health care, rural development, and women and child development. The National Plan of Action on Nutrition 1995, through its Council headed by the Prime Minister ensures collaboration among national government agencies, State Governments, NGOs, the private sector and the international community. Several national programmes of the Ministry of Women & Child Development (MWCD), Ministry of Health & Family Welfare (MHFW), Ministry of Agriculture, Ministry of Rural Development, Ministry of Panchayati Raj and the Ministry of Urban Development, are involved in nutrition security. The National Rural Health Mission (NRHM), Integrated Child Development Services (ICDS) Scheme, National Food Security Mission (NFSM), National Horticulture Mission (NHM), Rashtriya Krishi Vikas Yojana (RKVY), National Rural Employment Guarantee Scheme (NREGS), Jawaharlal Nehru National Urban Renewal Mission and the Rajiv Gandhi National Drinking Water Mission are important programmes addressing nutrition issues. But, these have generally been operating in isolation. There is a need for greater focus at the household and community level. Among others, some of the challenges include:

- Lack of a comprehensive national programme or approach specifically aimed at improving nutrition, resulting in lack of convergence and synergy among existing programmes.
- Lack of a focus with nutrition as an outcome in the government programmes which have the potential to impact nutrition.
- Inadequate monitoring of delivery to the correct target groups.
- Insufficient national systems to collect and analyze data on nutrition outcomes as well as lack of data for monitoring and decision making.
- Weak implementation and poor governance which together impact on the effectiveness of most of well conceived programmes, *viz.* poor performance of the PDS.

In the 11th Plan, child malnutrition abolition is a high priority. The objectives of the Strategy to Address India's Nutrition Challenges, as defined in the Eleventh Plan Monitorable Targets, are:

- Reduce malnutrition among children in the age group 0-3 years to half its present level by the end of the Eleventh Plan.
- Reduce anemia among women and girls by 50% by the end of the Eleventh Plan.

The following core interventions were proposed:

1. Ensure household food security and livelihood through improved production of food and employment security.
2. Undertake food supplementation programmes and health care in the strategies for (i) addressing maternal undernutrition and low birth weight; (ii) improving infant young child nutrition; (iii) control of micronutrient deficiency; and (iv) addressing iron deficiency and anemia.
3. Ensure restructuring of ICDS and its efficient functioning.
4. Converge health services, hygienic interventions, food production and rural employment sectors.
5. Monitor nutrition interventions and dynamically upgrade the interventions leading to desired outcomes.
6. Ensure human resources development and align skilled workers along the value-chain to achieve effective implementation.
7. Undertake institutional, infrastructural and governance transformations for transparent and timely implementation of the various programmes, such as PDS, and the concerned Bills and Acts.

To achieve sustainable improvements in child nutrition, decision-makers must tackle the underlying causes of undernutrition: food insecurity, insufficient care for women and children, and limited access to healthcare and a healthy environment. Nutrition-sensitive policies; protective and productive social safety-net programs; and pro-poor, pro-women, pro-nutrition agricultural policies and programs that specifically integrate nutrition goals and actions and track nutrition impacts can play a critical role in improving the overall environment in which young children grow and develop.

Gender inequality and poor nutrition are intertwined. Therefore, in areas where women's health, nutrition, and social status are poor, these factors will compromise the impacts of interventions targeted to the window of opportunity and reduce overall household food security. Gender inequality needs to be tackled at all stages of the life cycle to prepare women for a healthy and safe reproductive life. It is particularly important to protect the health and nutrition of girls and young women before pregnancy, and this can be done by improving their access to health, nutrition, education, and social protection programs during adolescence and early adult life.

Recently, the Coalition for Sustainable Nutrition Security in India, chaired by Prof. M.S. Swaminathan, gave a Call for Nutrition Revolution in India, recommending the following interventions to improve nutrition security in India:

- Focus on proven, essential nutrition interventions viz. the timely initiation of breastfeeding, the timely introduction of appropriate complementary foods, dietary and micronutrient approaches to address micronutrient malnutrition etc.;
- Focus on proven, essential primary health care interventions, such as complete immunization, biannual vitamin A supplementation with deworming, appropriate feeding of children during and after illness, including oral rehydration with zinc supplementation during diarrhea, iron and folic acid supplements for adolescent girls and pregnant and lactating women;
- Promote personal hygiene, environmental sanitation, safe drinking water and food safety;
- Promote agricultural production, including horticulture, livestock and fish production, animal husbandry and fisheries and improved economic and livelihood to enhance household food and nutrition security; and
- Expand and improve nutrition education and behavior change programming at community level.

In order to ensure the above innovations, the Coalition had suggested that nutrition security should be a top priority on the development agenda of the country. A coordination mechanism with clear authority and responsibility for improving key nutrition indicators in the country should be established towards ensuring effective adoption of a life cycle based national nutrition programme.

IX. Conclusion

It is outrageous that despite being one of the world's largest and fastest growing economies, India is home to over 40 percent of the world's undernourished - stunted and wasted children. These "Children of the Lesser God" put at stake a whole generation of the future adult citizens.

Proven short route and long route interventions addressing immediate, underlying and basic causes of undernutrition have been effective in several large agriculturally important countries, such as Brazil and China, in significantly reducing the malady in all age groups, especially child undernutrition, and boosted economic growth with huge multiple benefits. Policies, technologies, quality investments, institutions, partnerships, and strong political will were the main drivers of the transformations.

Links between agriculture and nutrition are extremely strong and work on local, national and global scale as per the physical, social, legal, economic and governance settings. Anything that affects agriculture is bound to impact nutrition particularly in countries like India where agriculture is also the mainstay of a very large number of people, and the converse is equally true. In order to mainstream nutrition in agriculture-led and other human-oriented development plans, economic, social, equity, governance and science and technology components have to be synergistically congrued.

Distinguished Fellows, Ladies and Gentlemen!

The Academy's forte lies in augmenting and sharpening policy-science synergy in harnessing the whole bio-economy to free India from the stubborn twin curse of poverty and malnutrition in the context of a mammoth rising population, incomes and climate change. The ethically unacceptable level of child and women undernutrition needs policy-science champions among the academia to help alleviate the deprivation. The Academy may come up with a shared set of well-researched indicators to guide the various stakeholders in their actions.

Dear Fellows!

India has the knowledge, technologies and resources to free the child from undernutrition, but we must muster the necessary commitment and political will. The record foodgrain production of about 235 million tons during 2010-11 and the increased attentions of the Ministry of Agriculture, Health and Family Welfare and Women and Child Development towards reducing undernutrition augur well with the challenge. This is our chance to name the Hungry Child, "Today". "Tomorrow", is too late. His/her bones and brain are being formed today. The Hungry Child cannot wait. Time is not on our side. We must act now.

Millennium Development Goals: Promises to Keep

Prof. R.B. Singh
President
National Academy of Agricultural Sciences

Context

In September 2000, 189 Member Nations of the United Nations, 147, including India, represented by their Heads of State and Governments, and over 8000 other delegates present at the Millennium Summit, adapted the Millennium Declaration by which the Summit participants committed to a series of eight time-bound Millennium Development Goals (MDGs). The leaders promised to *"free our fellow men, women and children from the abject and dehumanizing conditions of extreme poverty, to which more than a billion of them are currently subjected"*. How far have the promises been kept? If unmet, how far are we from the target and how can we achieve the goals?

"Far from target, the House junks debate on MDGs" wrote Times of India (TOI) on May 12, 2012 on the eve of the 60th anniversary of Indian Parliament. *"The debate on Millennium Development Goals had to be junked due to India's uneven progress… The goals set in 1990 and due to be achieved by 2015, include targets like halving the proportion of people who live on less than $1 a day and population below the poverty line, children under five who are under-nourished and total coverage for kids eligible for primary education… While the millennium goals are laudable, it was found that India is quite adrift of targets"*, highlighted the TOI.

Sidelining the discussion on progress towards achieving the MDGs, is perhaps somewhat like missing an opportunity of collective self-introspection and national rededication to free the nation of the twin scourges of hunger and poverty. A few months ago, Hon'ble Prime Minister of India Dr. Manmohan Singh, while releasing HANGAMA, a report on hunger and malnutrition prepared by a credible NGO, had considered the stubbornly high hunger and undernutrition in the country as a national shame and exhorted all concerned to strive hard to overcome this widespread deprivation.

Having read that the Parliament is not debating the vital development goals and targets on its

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Presidential address delivered at the 19th General Body Meeting of the National Academy of Agricultural Sciences held at New Delhi on June 5, 2012.

60th Anniversary, it occurred to me that the house of agricultural academicians, which is directly concerned with some of the most important MDGs, should review the situation and suggest the path ahead on its 19th Birth Anniversary. Hence, I am privileged and honoured to give this Address on 19th Foundation Day of the National Academy of Agricultural Sciences (NAAS), and wish you all a very Happy Foundation Day, which coincides with World Environment Day.

The Millennium Development Goals framework provides opportunity for mutually reinforcing agro-ecological, socio-economic and environmental connectivity. In particular, Goal 1 - eradication of extreme poverty and hunger, which overwhelmingly impacts the other seven goals, and, no doubt, gets impacted by them, is the most important goal. The NAAS being the national scientific think tank to guide science-led agricultural transformation toward accelerated, inclusive and sustainable national development, this Address concentrates primarily on Goal 1 which is impacted the most by agriculture. It is well known that in an agriculturally important country, like India, agriculture is the foremost pro-poor force for alleviation of poverty and hunger.

Moreover, agriculture, in a comprehensive sense, includes crops, horticulture, livestock, forestry, fisheries, natural resources (land, soil, water and biodiversity), markets, value chain and related institutions. All these collectively and interdependently impact and get impacted by environment. In today's context, for instance, agro-ecologies, including forestry contribute 30 percent of the GHGs. Likewise, globally agriculture consumes over 70 percent of the freshwater. These are the main concerns of MDG 7, hence I hope to briefly touch upon these aspects as well. Moreover, food security, agriculture systems, food systems and climate change are now inseparably linked. Knowingly, the Academy was founded on 5th June – the World Environment Day, therefore, it is all the more befitting to discuss the achievements under Goal 7 at Academy Foundation Day celebration.

What are the Millennium Development Goals (MDGs)

The unprecedented UN decision to reach the unreached in September 2000 marked a global move to help the world citizens, especially the poorest and the deprived ones, to achieve a better life through congruent implementation of eight major theme areas with planned development goals in the areas of poverty and hunger alleviation, employment security, leveraging agriculture for nutrition, health and livelihood security and building knowledge-led national and international partnerships for sustainable conservation and judicious and equitable use of natural resources.

The eight MDGs, their 22 Targets and 53 Indicators are reproduced in Table 1. The MDGs provide a comprehensive framework for all nations, their governments at various levels, NGOs, Civil Societies and international UN and non-UN organizations to undertake, monitor and evaluate necessary actions to achieve the targets. Most governments are aware of the framework and have even been preparing annual reports and appointed nodal ministries and departments for the purpose. The well-defined targets and indicators constitute invaluable tools for undertaking judicious monitoring, evaluation and implementation.

Table 1. Millennium Development Goals, Targets and Indicators

Goals and Targets	Indicators for monitoring progress
Goal 1: Eradicate extreme poverty and hunger	
Target 1.A: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	1.1 Proportion of population below $1 (PPP) per day 1.2 Poverty gap ratio 1.3 Share of poorest quintile in national consumption
Target 1.B: Achieve full and productive employment and decent work for all, including women and young people	1.4 Growth rate of GDP per person employed 1.5 Employment-to-population ratio 1.6 Proportion of employed people living below $1 (PPP) per day 1.7 Proportion of own-account and contributing family workers in total employment
Target 1.C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	1.8 Prevalence of underweight children under-five years of age 1.9 Proportion of population below minimum level of dietary energy consumption
Goal 2: Achieve universal primary education	
Target 2.A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	2.1 Net enrolment ratio in primary education 2.2 Proportion of pupils starting grade 1 who reach last grade of primary 2.3 Literacy rate of 15-24 year-olds, women and men
Goal 3: Promote gender equality and empower women	
Target 3.A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015	3.1 Ratios of girls to boys in primary, secondary and tertiary education 3.2 Share of women in wage employment in the non-agricultural sector 3.3 Proportion of seats held by women in national parliament
Goal 4: Reduce child mortality	
Target 4.A: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	4.1 Under-five mortality rate 4.2 Infant mortality rate 4.3 Proportion of 1 year-old children immunised against measles
Goal 5: Improve maternal health	
Target 5.A: Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio	5.1 Maternal mortality ratio 5.2 Proportion of births attended by skilled health personnel
Target 5.B: Achieve, by 2015, universal access to reproductive health	5.3 Contraceptive prevalence rate 5.4 Adolescent birth rate 5.5 Antenatal care coverage (at least one visit and at least four visits) 5.6 Unmet need for family planning

Goals and Targets	Indicators for monitoring progress
Goal 6: Combat HIV/AIDS, malaria and other diseases	
Target 6.A: Have halted by 2015 and begun to reverse the spread of HIV/AIDS	6.1 HIV prevalence among population aged 15-24 years 6.2 Condom use at last high-risk sex 6.3 Proportion of population aged 15-24 years with comprehensive correct knowledge of HIV/AIDS 6.4 Ratio of school attendance of orphans to school attendance of non-orphans aged 10-14 years
Target 6.B: Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it	6.5 Proportion of population with advanced HIV infection with access to antiretroviral drugs
Target 6.C: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases	6.7 Incidence and death rates associated with malaria 6.8 Proportion of children under 5 sleeping under insecticide-treated bednets 6.9 Proportion of children under 5 with fever who are treated with appropriate anti-malarial drugs 6.10 Incidence, prevalence and death rates associated with tuberculosis 6.11 Proportion of tuberculosis cases detected and cured under directly observed treatment short course
Goal 7: Ensure environmental sustainability	
Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss	7.1 Proportion of land area covered by forest 7.2 CO_2 emissions, total, per capita and per $1 GDP (PPP) 7.3 Consumption of ozone-depleting substances 7.4 Proportion of fish stocks within safe biological limits 7.5 Proportion of total water resources used 7.6 Proportion of terrestrial and marine areas protected 7.7 Proportion of species threatened with extinction
Target 7.C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation	7.8 Proportion of population using an improved drinking water source 7.9 Proportion of population using an improved sanitation facility
Target 7.D: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers	7.10 Proportion of urban population living in slums
Goal 8: Develop a global partnership for development	
Target 8.A: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system Includes a commitment to good governance, development and poverty reduction – both nationally and internationally	8.1 Some of the indicators listed below are monitored separately for the least developed countries (LDCs), Africa, landlocked developing countries and small island developing States.

Goals and Targets	Indicators for monitoring progress
Target 8.B: Address the special needs of the least developed countries Includes: tariff and quota free access for the least developed countries' exports; enhanced programme of debt relief for heavily indebted poor countries (HIPC) and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction	*Official development assistance (ODA)* 8.1 Net ODA, total and to the least developed countries, as percentage of OECD/DAC donors' gross national income 8.2 Proportion of total bilateral, sector-allocable ODA of OECD/DAC donors to basic social services (basic education, primary health care, nutrition, safe water and sanitation) 8.3 Proportion of bilateral official development assistance of OECD/DAC donors that is untied 8.4 ODA received in landlocked developing countries as a proportion of their gross national incomes 8.5 ODA received in small island developing States as a proportion of their gross national incomes
Target 8.C: Address the special needs of landlocked developing countries and small island developing States (through the Programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the twenty-second special session of the General Assembly)	*Market access* 8.6 Proportion of total developed country imports (by value and excluding arms) from developing countries and least developed countries, admitted free of duty 8.7 Average tariffs imposed by developed countries on agricultural products and textiles and clothing from developing countries 8.8 Agricultural support estimate for OECD countries as a percentage of their gross domestic product 8.9 Proportion of ODA provided to help build trade capacity
Target 8.D: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term	*Debt sustainability* 8.10 Total number of countries that have reached their HIPC decision points and number that have reached their HIPC completion points (cumulative) 8.11 Debt relief committed under HIPC and MDRI Initiatives 8.12 Debt service as a percentage of exports of goods and services
Target 8.E: In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries	8.13 Proportion of population with access to affordable essential drugs on a sustainable basis
Target 8.F: In cooperation with the private sector, make available the benefits of new technologies, especially information and communications	8.14 Fixed telephone lines per 100 inhabitants 8.15 Mobile cellular subscriptions per 100 inhabitants 8.16 Internet users per 100 inhabitants

Source: http://mdgs.un.org/unsd/mdg/Host.aspx?Content=Indicators/OfficialList.htm

Overview of Achievements of MDGs

Global Level

World leaders reviewed the progress in achieving the MDGs in September 2010 and prepared a roadmap for meeting the agreed goals and datelines. The review had revealed

that *"already, the MDGs have helped to lift millions of people out of poverty, save lives and ensure that children attend school. They have reduced maternal deaths, expanded opportunities for women, increased access to clean water and freed many people from deadly and debilitating diseases. At the same time, the report shows that we still have a long way to go in empowering women and girls, promoting sustainable development, and protecting the most vulnerable from the devastating effects of multiple crises, be they conflicts, natural disasters or volatility in prices for food and energy".* It further points out that *"progress tends to bypass those who are lowest on the economic ladder or are otherwise disadvantaged because of their sex, age, disability or ethnicity. Disparities between urban and rural areas are also pronounced and daunting. Achieving the goals will require equitable and inclusive economic growth"* (UN, 2011).

Each Goal is self-comprehensive and directly addresses one profound issue, but, as mentioned earlier, the eight are interdependent, necessitating a multi-sectoral and multi-dimensional linkage to ensure synergetic outcomes.

Recalling the world leaders' pledges of freeing humanity from extreme poverty, hunger, illiteracy and disease and implementation of the framework and operationalization of the priorities at national and international levels, the 2011 Report highlights the following achievements at the global level:

- Continued decline in poverty, led by Eastern Asia, primarily China, the global poverty rate is expected to fall below 15% by 2015, well below the target of 23%.
- Some of the poorest countries, especially in sub-Saharan Africa, have made excellent progress in achieving the goal of universal primary education, and many more countries will meet the goal.
- Considerable progress has been made in reducing child mortality and the prevention of HIV, malaria and tuberculosis.
- Led by Eastern Asia again, globally additional over 1 billion people in urban areas and over 700 million people in rural areas had gained access to clean drinking water.

The Report also highlights that the world is not likely to meet several of the vital targets. Despite the above progress, a large number of vulnerable people are unreached. In particular, the following aspects need greater focused attention:

- Liberating the poorer children from undernutrition, especially in Southern Asia,
- Providing employment opportunities to women and unemployed youth,
- Retaining the child in school, especially in conflict zones,
- Bridging the huge sanitation gap, particularly in Southern Asia,
- Increasing access to safe drinking water particularly in sub-Saharan Africa, and
- Improving the lives of nearly 1 billion people living in slums.

Asia-Pacific Level

The Asia-Pacific region, accounting for 60% of the world population, has achieved impressive success in meeting several of the Millennium Development Goal targets. It is on-track for 12 of the 22 indicators for which reliable data are available. The most striking achievement of the region as a whole is that it has already attained target 1 of halving the percentage of poor, those living on less than $ 1.25 per day, from 50% in 1990 to 22% in 2009. Thus it is well on-track to meet one of its most important goals. The region is on-track also in reducing gender disparities in primary, secondary and tertiary education, prevalence of HIV and tuberculosis, in reducing the consumption of ozone depleting substances, and in increasing land area under forests and access to safe drinking water.

However, Asia-Pacific as a whole is off-track in meeting several of the vital targets, particularly those related to hunger, child mortality, maternal mortality, all children completing primary school, extending basic sanitation, and reducing CO_2 emission. Overall, primarily due to demographic reasons, the region continues to be home to majority of the world's deprived people.

National Level

The MDGs are national goals fully owned by individual nations. The onus of their achievements lies squarely with the national governments. The UN and other non-UN international agencies were a part of the system to assist the Member Nations to achieve the goals.

Table 2 presents status of four selected countries, namely, India, China, Bangladesh and Indonesia, regarding their being on- or off-track for the MDGs. Of the seven goals and 22 targets, India is off-track for 10 targets, namely, $1.25 per day poverty, underweight children, reaching last grade, gender tertiary, under-five mortality, infant mortality, maternal mortality, skilled birth attendance, anti-natal care, and basic sanitation. All four countries show regressive trends for CO_2 emission. China is on-track or ahead of for the remaining 21 targets. Bangladesh shows regressive progress also for primary enrolment, primary completion, and forest cover, whereas Indonesia is sliding back in HIV prevalence and forest cover.

Progress in Meeting the MDGs in India

The Ministry of Statistics and Programme Implementation, Government of India has regularly been bringing out States of India Report on MDGs. I have used the latest available report of October 2011 which gives a succinct account not only of the achievements but also of the gaps and data inadequacies. The report recognizes that a major change in the pattern of poverty incidence in the country has been caused by the introduction of new concepts in defining the poverty lines and related measures. We may recall, the poverty line has been changing fast during the past few months. Fortunately, it has now been referred to an expert committee to decide the most suitable poverty line. Outcome of this committee must be eagerly awaited, and, I am sure, the concerned Department will soon come up with updated

Table 2. On- and Off-track of the MDGs

Goal	1		2			3			4		5			6			7						
	$1.25 per day poverty	Underweight children	Primary enrolment	Reaching last grade	Primary completion	Gender primary	Gender secondary	Gender tertiary	Under-5 mortality	Infant mortality	Maternal mortality	Skilled birth attendance	Antenatal care (≥ 1 visit)	HIV prevalence	TB incidence	TB prevalence	Forest cover	Protected area	CO_2 emissions	ODP substance consumption	Safe drinking water	Basic sanitation
Bangladesh	■	▶	◀	■	◀	●	●	■	▶	▶	■	■	■	▶	▶	●	◀	●	◀	●	■	■
China	●	●				●	●	●	▶	■	▶	●	▶		●	●	●	●	◀	●	●	■
India	■	■	●	■	▶	●	▶	■	■	■	■	■	■	●	▶	◀	●	●	◀	●	●	■
Indonesia	●	■	●	■	●	●	●	●	▶	■	■	●	●	◀	▶	●	◀	●	◀	●	■	■

● Already achieved by 2015

▶ Expected to meet the 2015 target

■ Off track: Expected to meet target, after 2015

◀ Off track : Regressing/no progress

Source: Accelerating Equitable Achievement of the MDGs. Closing Gaps in Health and Nutrition Outcomes. UNESCAP, ABD and UNDP (authors). Asia-pacific regional MDG Report 2011/12 in collaboration with UNFPA, UNICEF and WHO.

poverty indicators and measurements. Until then, we accept the figures derived based on Tendulkar Committee report.

India had endorsed all the 53 indicators of the UNDG, but has found 35 of them more relevant to India. The progress on all the MDGs and 12 targets is summarized below (Table 3).

Table 3. MDGs and Targets – Summary of progress achieved by India

MDG 1: Eradicate Extreme Poverty and Hunger	
Target 1: Halve, between 1990 and 2015, the Percentage of Population below the National Poverty Line	*Off-track.* The newly appointed committee should come up with a new poverty line. The country is required to achieve a Head Count Ration (HCR) level of 23.9% by 2015 against the current projection of 26.72%.
Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.	*Severely off-track.* From an estimated 52% in 1990, the proportion of *underweight children* below 3 years is required to be reduced to 26% by 2015. At the current rate of decline 33% of children will be underweight, missing the target by seven percentage points.

MDG 2: Achieve Universal Primary Education	
Target 3: Ensure that by 2015 children everywhere, boys and girls alike, will be able to complete a full course of primary education.	*On-track.* India is likely to achieve 100% *Net Enrolment Ratio* for girls and boys ahead of 2015. The proportion of students starting Grade I who reach Grade V rose from 62% in 1999 to 81% by 2002 and declined thereafter to 73% in 2004. It dipped to 72% in 2007-08 though improved to 76 percent in 2008-09. According to the trend exhibited during 1991 - 2001, India is likely to attain 100% *Youth literacy* by 2015. The NSS estimates for the year 2007-08 show 93% and 83% youth literacy in urban and rural areas, respectively.
MDG 3: Promote Gender Equality and Empower Women	
Target 4: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015.	*On-track.* The *ratio of literate women to men* in the age group 15-24 years stood at 0.88 in 2007-08. Parity, in the ratio, is expected by 2015. The share of *women in wage employment* in rural areas was 19.6% and in urban areas, 17.6% in 2009-10. Parity in labour market participation is unlikely given the socio-cultural situation that is male dominated.
MDG 4: Reduce Child Mortality	
Target 5: Reduce by two-thirds, between 1990 and 2015, the under-five Mortality Rate	*Off-track.* The *under 5 mortality rate* target by 2015 is 42 per thousand live births. India is likely to attain 52 by 2015, missing the target by 10 percentage points. With the present improved trend, the national estimate of *Infant Mortality Rate* is likely to be 44 against the MDG target of 27 in 2015.
MDG 5: Improve Maternal Health	
Target 6: Reduce by three quarters, between 1990 and 2015, the Maternal Mortality Ratio.	*Off-track.* Based on the trend, India is likely to witness a *MMR* of 139 per 100,000 live births by 2015, falling short by 30 points. With the rate of increase in *deliveries by skilled personnel*, the likely rate by 2015 is 62%, far short of universal coverage.
MDG 6: Combat HIV/AIDS, Malaria and Other Diseases	
Target 7: Have halted by 2015 and begun to reverse the spread of HIV/AIDS	*On-track.* The adult prevalence was 0.26 and 0.38 percent among women and men, respectively, in 2008, and 0.25 percent and 0.36 percent in 2009, respectively. Among pregnant women 15-24 years, the *prevalence of HIV* has declined from 0.86% in 2004 to 0.48% in 2008.
Target 8: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases	*Off-track.* Total *malaria cases* have declined from 2.08 million to 1.6 million and *TB cases* have declined from 1.0 to 0.83 million cases, between 2001 and 2010. The prevalence of all forms of TB has been brought down from 338/100,000 population in 1990 to 256/100,000 population in 2010 and TB mortality in the country has reduced from over 42/100,000 population in 1990 to 26/100,000 population in 2010 as per the WHO global report 2011. Repeat population surveys conducted by Tuberculosis Research Centre indicate an annual decline in prevalence of the disease by 12%.

MDG 7: Ensure Environmental Sustainability	
Target 9: Integrate the Principles of Sustainable Development into Country Policies and Programmes and Reverse the loss of Environmental Resources	*On-track.* There is an increase in *forest cover* of about 1128 sq. km between 2007 and 2011. 668 Protected Areas have been established, extending over 161,221.57 sq. kms. The country is on track in increasing the protection network for arresting the diversity losses and for maintaining ecological balance. *Energy Intensity*, the amount of energy consumed for generating one unit of Gross Domestic Product at constant prices, at 1999-2000 prices, increased from 0.128 KWh in 1970-71 to 0.165 KWh in 1985-86, and reduced to 0.122 KWh, at 2004-05 prices, in 2009-10.
Target 10: Halve, by 2015, the Proportion of People without Sustainable Access to Safe Drinking Water and Basic Sanitation	*Early for drinking water; off-track for sanitation.* The proportion of households without *access to safe drinking water sources* in 1990, around 34% reduced to the order of 17% in 2007-08. A reduction in the proportion of *households without any sanitation* to about 43% by 2015 is anticipated missing the target by 5 percentage points.
Target 11: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers.	*The pattern is not statistically discernible*
MDG 8: Develop a Global Partnership for Development	
Target 18: In co-operation with the Private Sector, make available the benefits of new technologies, especially Information and Communication	*On-track*. The *Internet subscriber base* increased 97 fold from 0.21 million in 1999 to 20.33 million in 2011. 346.67 million wireless subscribers subscribe to data services, as reported by wireless service providers.

Source: Accelerating Equitable Achievement of the MDGs. Closing Gaps in Health and Nutrition Outcomes. UNESCAP, ADB and UNDP (authors). Asia-pacific regional MDG Report 2011/12 in collaboration with UNFPA, UNICEF and WHO.

From the above, it emerges that while India is on-track or nearly on-track for achieving the targets for MDG 2, MDG 7 and MDG 8, it is off-track in improving its situation in poverty reduction and particularly in eradication of hunger and undernutrition.

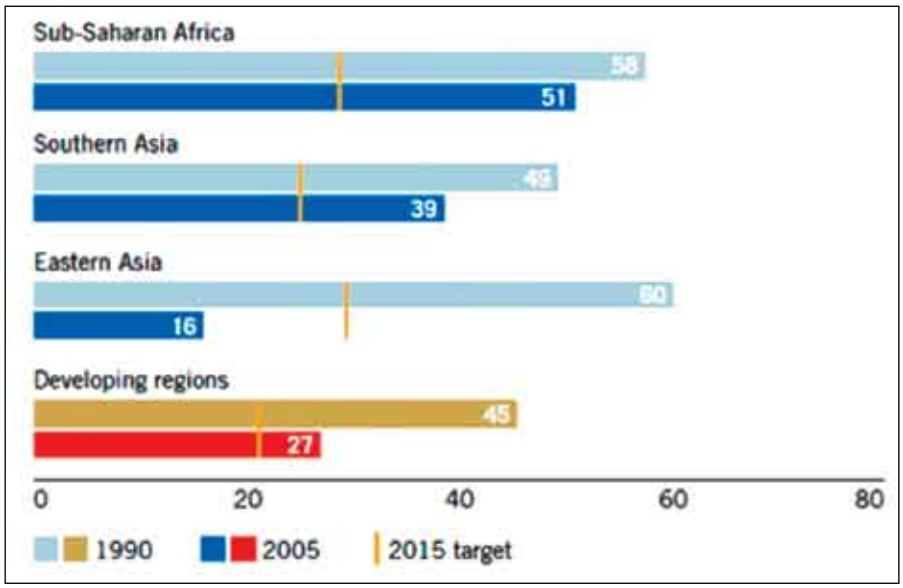
MDG 1: Eradication of Extreme Poverty and Hunger

Poverty Eradication

Global and Regional Levels

Despite economic crisis of 2007-2008, the developing regions are on-track to meet the target, poverty rate dropping from 45% in 1990 to 27% in 2005 (Fig.1). This has primarily been driven by Eastern Asia (mostly China). However, there are serious inter-regional differences. While the progress is slow in Southern Asia, Sub-Saharan Africa is far behind in meeting the target. Recent projections from World Bank are optimistic and hopeful of meeting the global target, and the number of people in developing countries living on less than $ 1.25 a day is projected to fall below 900 million in 2015 from 1800 million in 1990. In China and India together, the number of poor dropped by 455 million between 1990 and

Fig. 1. *Proportion of people living on less than $1.25 a day*



Source: The Millennium Development Goals Report, 2011, UN

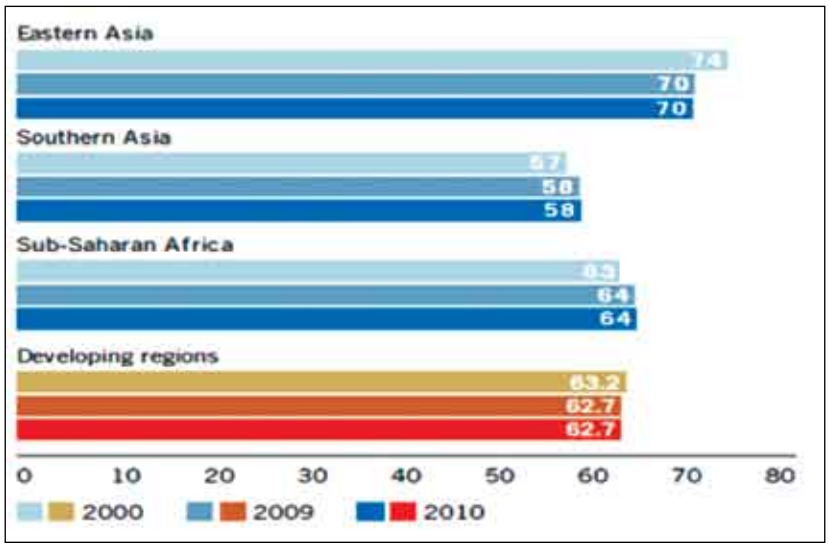
2005, and another 320 million may be dropped from the poverty list by 2015 (UN MDG Report, 2011).

Nearly two-thirds of the poor live in rural areas. The poor have low skills, are poorly educated, live in regions where soil fertility is low and connectivity with urban centers is limited. The poor have limited stocks of physical assets, low levels of savings and are vulnerable to uncertainties of both market and monsoon. Some major factors responsible for chronic poverty in rural areas are: limited education and skill, low income, limited capital and availability of social services, lack of capital and low savings. Social protection in form of cash transfers, universal food subsidies, rationed food subsidies, public works and social funds can positively assist the poor (Dowling and Chin-Fang, 2009).

Further, it is well known that employment security is closely linked with income and livelihood security and with poverty percentage. In general, the economic recovery after the 2008 crisis has little effect on employment opportunities. In the developing world as a whole there was a slight decline in employment percentage. In South Asia, which has the highest bulge of the youth, a good number being under or unemployed, the employment rate hovered around only 58% (Fig. 2).

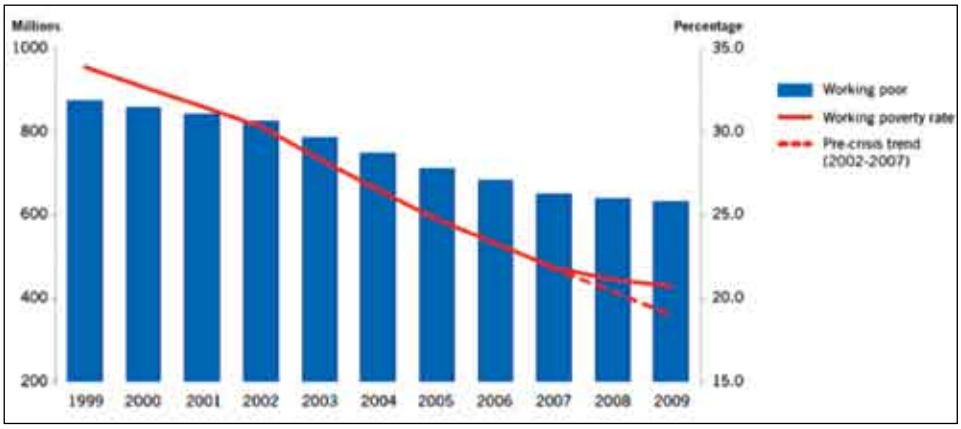
The number and proportion of workers living on less than $ 1.25 a day had steadily declined during 1999-2009 and reached one in five. But the 2007-08 financial crises had flattened the trend, thus hindering poverty reduction (Fig. 3).

Fig. 2. Employment-to-population ratio, 2000, 2009 and 2010



Source: The Millennium Development Goals Report, 2011, UN

Fig. 3. Proportion of employed people living on less than $1.25 a day (%) and number of working poor (millions), 1999-2009



Source: The Millennium Development Goals Report, 2011, UN

India's Situation

Poverty ratio in India as a whole declined from 45.3 percent in 1993-94 to 37.2 percent in 2004-05 and to 29.8 percent in 2009-10 (Table 4). As expected, inter-state variation was high. Of 29 states for which data were available, in eleven states, namely, Goa, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Sikkim, Tamil Nadu,

Tripura and Uttarakhand, poverty estimates decreased by at least 10 percentage points between 2004-05 and 2009-10. Despite their satisfactory performance during the past few years, some of the larger states, namely, MP, Orissa, Rajasthan, and Uttarakhand are not likely to meet their targets. During the same period, poverty percentages increased in 17 states. Some of the larger states, such as UP, Bihar and Chhattisgarh, which already had high poverty ratios, showed only marginal decline in their poverty percentages. Bihar is still likely to have about 51 percent of its population below poverty line. Additional eight states will have over 30% of their people classified as poor by end of 2015. Uttar Pradesh with over 34% poverty level will have about 65 million people classified as poor, the largest number in any state of the country.

Table 4. State wise poverty estimates (Tendulkar Methodology)

States/U.T.'s	1993-94	2004-05	2009-10	Estimate 1990	Target 2015	Likely 2015
Andhra Pradesh	44.6	29.9	21.1	49.74	24.87	16.93
Arunachal Pradesh	54.5	31.1	25.9	63.51	31.76	19.09
Assam	51.8	34.4	37.9	57.92	28.96	30.42
Bihar	60.5	54.4	53.5	62.28	31.14	50.51
Chhattisgarh	50.9	49.4	48.7	51.32	25.66	47.91
Delhi	15.7	13.1	14.2	16.49	8.25	12.89
Goa	20.8	25.0	8.7	19.78	9.89	30.05
Gujarat	37.8	31.8	23.0	39.62	19.81	20.87
Haryana	35.9	24.1	20.1	40.02	20.01	16.17
Himachal Pradesh	34.6	22.9	9.5	38.72	19.36	15.16
Jammu & Kashmir	26.3	13.2	9.4	31.74	15.87	6.45
Jharkhand	60.7	45.3	39.1	65.74	32.87	33.33
Karnataka	49.5	33.4	23.6	55.11	27.55	19.00
Kerala	31.3	19.7	12.0	35.51	17.76	9.29
Madhya Pradesh	44.6	48.6	36.7	43.57	21.78	38.31
Maharashtra	47.8	38.1	24.5	50.85	25.43	21.56
Manipur	65.1	38.0	47.1	75.40	37.70	35.32
Meghalaya	35.2	16.1	17.1	43.57	21.79	11.22
Mizoram	11.8	15.3	21.1	10.99	5.50	24.37
Nagaland	20.4	9.0	20.9	25.50	12.75	13.58
Orissa	59.1	57.2	37.0	59.63	29.81	36.16
Punjab	22.4	20.9	15.9	22.83	11.41	15.26
Rajasthan	38.3	34.4	24.8	39.44	19.72	23.31

States/U.T.'s	1993-94	2004-05	2009-10	Estimate 1990	Target 2015	Likely 2015
Sikkim	31.8	31.1	13.1	31.99	16.00	12.81
Tamil Nadu	44.6	28.9	17.1	50.20	25.10	13.44
Tripura	32.9	40.6	17.4	31.07	15.53	19.29
Uttar Pradesh	48.4	40.9	37.7	50.67	25.34	34.39
Uttarakhand	32.0	32.7	18.0	31.81	15.91	18.08
West Bengal	39.4	34.3	26.7	40.92	20.46	24.70
All India	45.3	37.2	29.8	47.80	23.90	26.72

Source: Central Statistical Organization, Ministry of Statistics and Programme Implementation, Govt. of India, 2011

Hunger Eradication

Global and Regional Situation

The number of undernourished people in the world had been increasing for a decade or so and the number of hungry for the first time had crossed the 1 billion mark in 2008-09 (FAO, 2009), but the number came down to 925 million in 2009-10. Nearly all hungry people were from developing countries. The gains made in the 1980s and early 1990s in reducing chronic hunger have been lost and the hunger reduction targets of the MDG1 as well as of the World Food Summit (WFS) remain elusive (Table 5). The soaring food prices of 2007-08 had drawn the poor farther from food, resulting in the unusual increase in the number and even proportion of undernourished. Despite the fall in international food and fuel prices starting in the late 2008, the prices in domestic markets remained 15 to 25 percent higher in real terms than the trend level, thus continuing the distress for the poor. High food price inflation and the associated household food security have been recurrent features in India.

Table 5. Prevalence of undernourishment and progress towards the World Food Summit (WFS) and the MDG target in developing countries

World/Region/ Sub-region/ country	Total Popln 2006-08 (Millions)	Number of people Undernourished 2006-08 (Millions)	Progress towards WFS targets	Proportion of undernourished in total population		
				1990-92 %	2006-08 %	Progress towards MDG targets
World	6652.5	850		16	13	
Developed regions	1231.3	10.6		-	-	
Developing regions	5420.2	839		20	15	
Africa	962.9	223.6		26	23	
Asia	3884.3	567.8		20	15	

World/Region/ Sub-region/ country	Total Popln 2006-08 (Millions)	Number of people Undernourished 2006-08 (Millions)	Progress towards WFS targets	Proportion of undernourished in total population		
				1990-92 %	2006-08 %	Progress towards MDG targets
China	1336.5	129.6		18	10	
Bangladesh	157.7	41.4		38	26	
India	1164.6	224.6		20	19	
Indonesia	224.7	29.7		16	13	
Brazil	190.1	11.17		11	6	

Source: FAO, 2011

Target already met or expected to be met by 2015

Progress insufficient to reach the target if prevailing trends persist

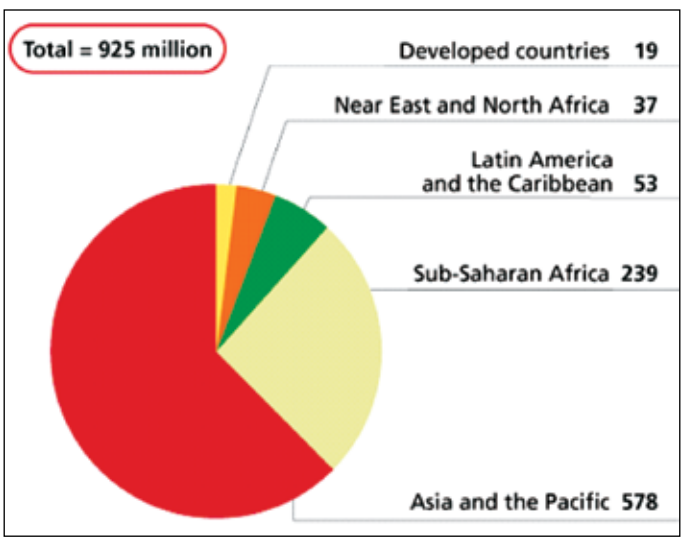
No progress, or deterioration

Country has a proportion of undernourishment below 5 percent

As shown in Fig. 4, the Asia-Pacific region, with 578 million undernourished, and Sub-Saharan Africa with 239 million hungry people accounted for 62 and 26 percent, respectively (jointly 88 percent), of the world's hungry people (FAO, 2011).

The proportion of children under age 5 who are under weight is a main contributor to a global hunger index and is a reliable indicator of food insecurity. Between 1990 and 2009,

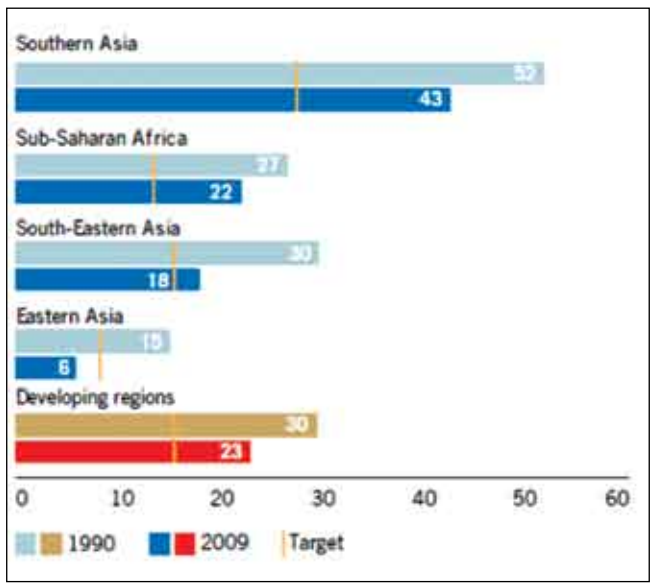
Fig. 4. *Number of hungry people in the world, 2010*



Source : FAO, 2010

the percentage of underweight children in developing countries as a whole declined from 30% to 23%. Progress in reducing underweight prevalence was made in all the regions, but it was not enough to reach the target by 2015. South Asia continues to have the unfortunate distinction of having 43% of its children under weight. On the other hand East Asia, essentially led by China, had distinctly surpassed the target (Fig. 5).

Fig. 5. *Proportion of children under age five who are under weight, 1990 and 2009 (%)*



Source: The Millennium Development Goals Report, 2011, UN

The Global Hunger Index (GHI) is being widely used to measure progress in the global fight against hunger. It is calculated as GHI = {PUN + CUW + CM}/3, with PUN: proportion of the population that is undernourished (in %), CUW: prevalence of underweight in children under five (in %), CM: proportion of children dying before the age of five (in %). The GHI 2011 Report shows that globally the GHI fell from 19.7 in 1990 to 14.6 in 2011 (Table 6). While India still has an alarming hunger situation, China and Brazil have reached the acceptable levels of hunger.

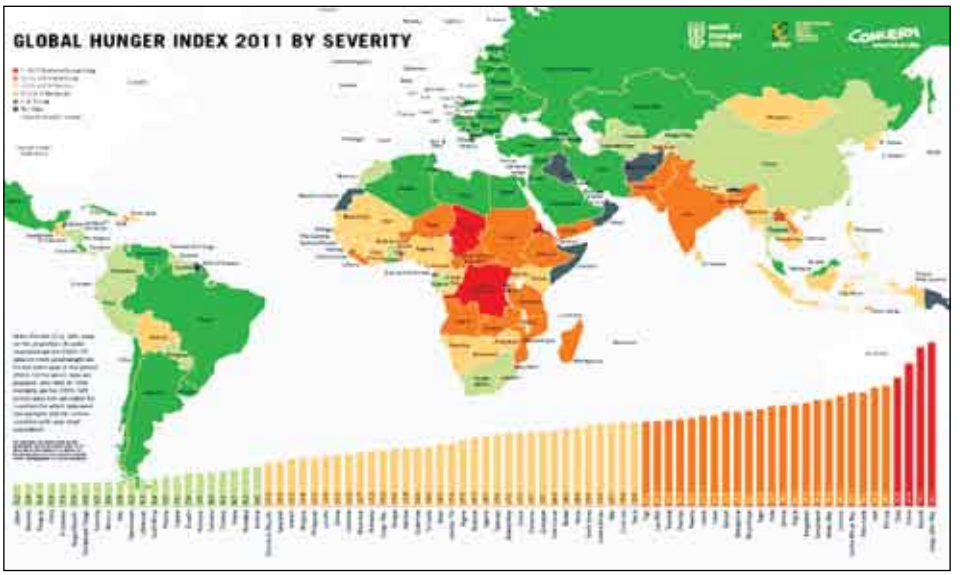
Table 6. Global Hunger Index Scores

World/Country	1990	1996	2001	2011
World	19.7	17.0	16.0	14.6
China	11.7	9.1	6.8	5.5
Brazil	7.6	6.2	5.3	< 5
India	30.4	22.9	24.1	23.7

Source: IFPRI, 2011

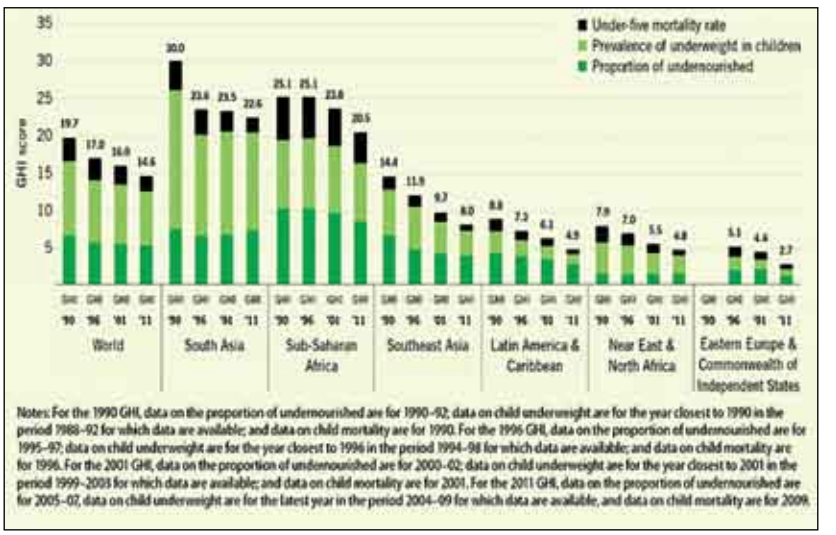
There were wide differences among regions and countries (Fig. 6). As seen from Fig. 7, South Asia has the highest GHI score (22.6), closely followed by Sub-Saharan Africa (20.5). The progress in South Asia since 1996 was rather slow. In South Asia the high prevalence of

Fig. 6. *The Global Hunger Index 2011 by Severity*



Source: IFPRI, 2011

Fig. 7. *Contribution of components to 1990 GHI, 1996 GHI, 2001 GHI, and 2011 GHI*



Source: IFPRI, 2011

underweight children was the main cause of high GHI, whereas in Sub-Saharan Africa high child mortality rate was prominent. The persistence of high GHI in South Asia despite the high economic growth is attributed to social inequality and the low nutritional, educational and social status of women.

The 2011 GHI Report had concluded that price increases and price volatility hit the poorest the hardest and reduce their economic access to appropriate food.

India is home to about 40 percent of world's undernourished children under five (UNICEF, 2009). As mentioned earlier, India will miss the target by about 7 percentage points and 33% of the children below 3 years will still be under weight (Table 7). Interstate variation in the intensity of undernutrition (Fig. 8 and 9) as well as in achieving the target was remarkably high (Menon, et.al., 2009). As seen from Table 7, most of the states will miss the target by significant margins. Among larger states, three, namely, Maharashtra, Punjab and Tamil Nadu are on track to achieve the target. Unethical as it is, given the current trend, nearly 70% of the children in Madhya Pradesh in 2015 will be underweight. The situation remains grim also for Jharkhand and Bihar where nearly 60% of the children will be underweight.

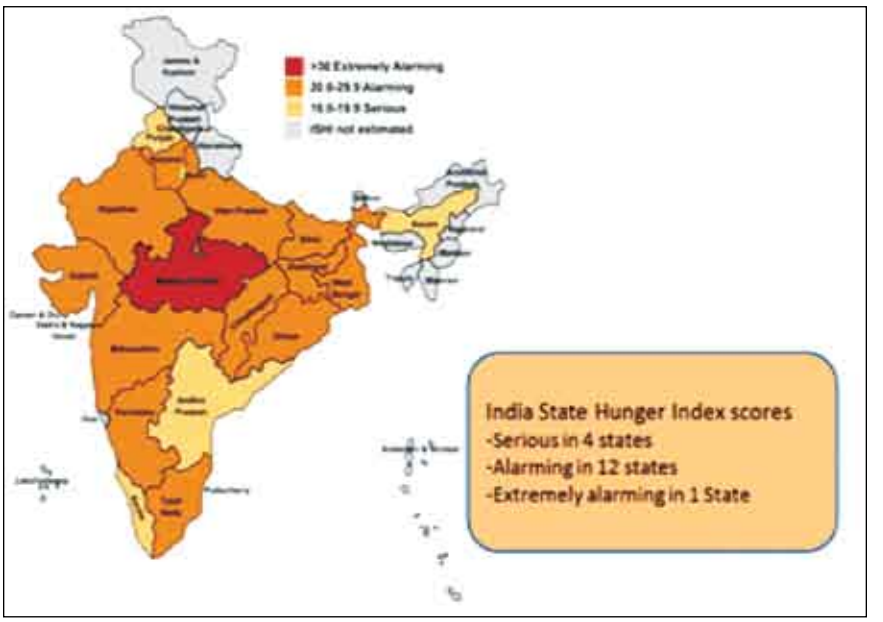
Table 7. Underweight Children (< 3yrs)

States/UTs	1992-93	1998-99	2005-06	Likely achievement 2015	Estimated 1990	Target 2015
Andhra Pradesh	42.9	34.2	29.8	22.17	44.41	22.21
Arunachal Pradesh	32.1	21.9	29.7	25.50	28.62	14.31
Assam	44.1	35.3	35.8	29.48	43.48	21.74
Bihar		52.2	54.9	59.00	49.28	24.64
Chhattisgarh		53.2	47.8	41.02	60.12	30.06
Delhi	36.2	29.9	24.9	18.58	38.09	19.04
Goa	29.3	21.3	21.3	15.92	28.90	14.45
Gujarat	42.7	41.6	41.1	39.82	42.82	21.41
Haryana	31.0	29.9	38.2	43.29	28.60	14.30
Himachal Pradesh	38.4	36.5	31.1	26.78	40.35	20.17
Jammu & Kashmir		29.2	24.0	18.14	36.54	18.27
Jharkhand		51.5	54.6	59.36	48.17	24.09
Karnataka	46.4	38.6	33.3	25.59	48.28	24.14
Kerala	22.1	21.7	21.2	20.54	22.25	11.12
Madhya Pradesh		50.8	57.9	69.80	43.75	21.87
Maharashtra	47.3	44.8	32.7	25.39	52.24	26.12
Manipur	19.1	20.1	19.5	20.03	19.33	9.67

States/UTs	1992-93	1998-99	2005-06	Likely achievement 2015	Estimated 1990	Target 2015
Meghalaya	36.9	28.6	42.9	44.17	32.02	16.01
Mizoram	17.2	19.8	14.2	13.03	19.27	9.63
Nagaland	18.7	18.8	23.7	27.66	17.36	8.68
Orissa	50.0	50.33	9.5	33.98	54.07	27.04
Punjab	39.9	24.7	23.6	14.79	39.66	19.83
Rajasthan	41.8	46.7	36.8	34.91	45.36	22.68
Sikkim		15.5	17.3	20.24	13.67	6.84
Tamil Nadu	40.7	31.5	25.9	18.06	42.88	21.44
Tripura	42.1	37.3	35.2	30.36	42.67	21.34
Uttar Pradesh		48.1	41.6	33.81	56.78	28.39
Uttarakhand		36.3	31.7	26.12	42.38	21.19
West Bengal	53.2	45.3	37.6	28.79	56.11	28.05
India	51.5	42.7	40.4	32.85	52.01	26.00

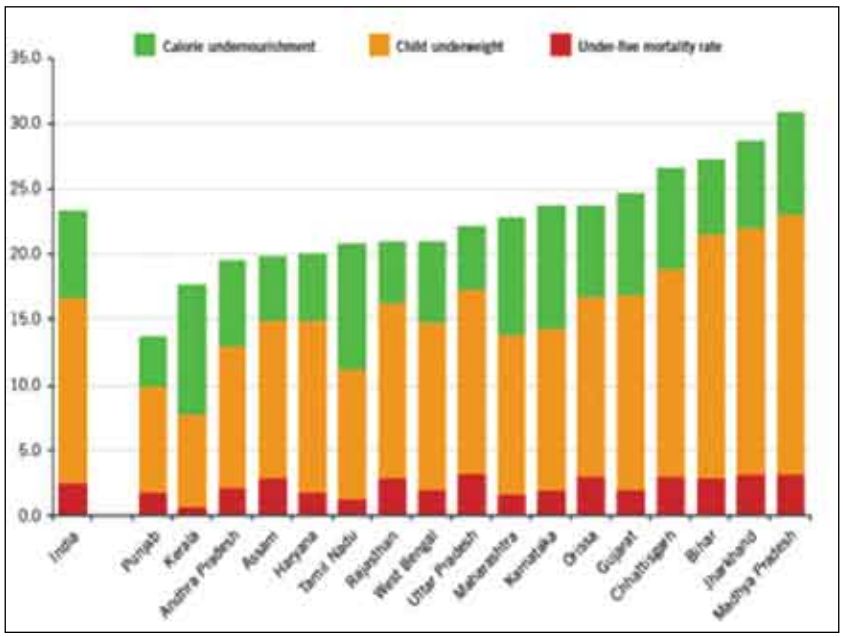
Source: MDGs, India Country Report, 2011

Fig. 8. *2008 India State Hunger Index*



Source: IFPRI, 2009

Fig. 9. *Contribution of underlying components of the India State Hunger Index to overall sectors*



Source: IFPRI, 2009

Generally, the economically well-to-do states had relatively lower hunger indices. However, there were some exceptions which should be critically analysed for initiating corrective measures. For instance, Gujarat is one of the most progressive states registering high GDP and agricultural growth rates during the past several years, but shows high GHI score. Likewise, while child underweight is the major contributor to the GHI, in case of Kerala the contribution of under five mortality rate is unusually high. Unusual because, besides the high literacy rate, Kerala is the hub of medically trained nurses and these two attributes should ensure desired level of child care, unless there is any other specific reason.

As noted earlier, the proportion of people in the developing world who went hungry in 2005-2007 remained stable at 16 per cent, despite significant reductions in extreme poverty. Based on this trend, and in light of the economic crisis and rising food prices, it will be difficult to meet the hunger-reduction target in many regions of the developing world. Further, the disconnect between poverty reduction and the persistence of hunger has brought renewed attention to the mechanisms governing access to food in the developing world.

The causes behind the apparent discrepancy between poverty and hunger reduction should be analysed to better inform hunger-reduction policies in the future. The success stories of reducing hunger, such as the Zero Hunger Programme of Brazil, under which, between 2004 and 2010, 28 million people were pulled out of absolute poverty status and hunger level had dropped to less than 5 percent, should be analysed and adopted/adapted by other

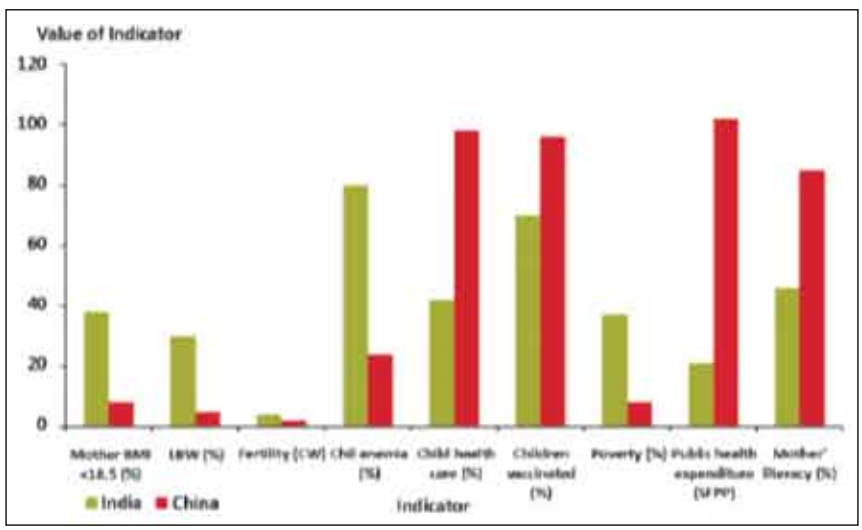
countries (also discussed later). Effectiveness of various social protection floors provided for food security should be improved and regularly monitored. As seen from Fig. 10, the differences in performances of India and China in reduction of child malnutrition are directly linked with the extensive measures, such as child health care, child vaccination, public health expenditure and mother literacy, adopted in China (Svedberg, 2007). The trend is reflected in the agricultural expenditure pattern in the two countries (Table 8).

Table 8. Agricultural expenditure in China and India

Country	Per capita agricultural expenditure of total population, 2005 international dollars			Ratio of agricultural expenditure to agricultural GDP (%)		
	1980	1995	2009	1980	1995	2009
China	17.1	17.2	121.0	10.9	4.5	19.1
India	7.8	10.9	32.5	2.5	2.9	6.4

Source: IFPRI, 2011

Fig. 10. *Selected proximal and underlying determinants of child malnutrition in India and China, 2004 or nearest year*



Source: 2020 Focus Brief, IFPRI, 2007

Path Ahead

Elimination of Hunger and Poverty Must be the Foremost National Goal

Prof. M.S. Swaminathan, Member of Rajya Sabha, and Chair of M.S. Swaminathan Research Foundation, Chennai, has strongly emphasized that hunger and poverty breed violence. The MDGs represent a global Common Minimum Programme for sustainable human security and well-being. He expressed concern that in India "far from declining, hunger is

increasing, particularly in South Asia and Sub-Saharan Africa and the situation will worsen mainly as a result of rising food prices." He observed that "poverty is a major cause of hunger." Therefore, anti-poverty programmes have to accord priority to hunger elimination. The economic, ecological and social costs of hunger are high and hence this goal deserves to be on the top of the political agenda and public concern. "We must use our intelligence and reason in humanistic endeavors to fight hunger" (Swaminathan, 2012).

Reaffirming their commitment to the MDGs, world leaders at the 2010 High-level Plenary Meeting of the General Assembly called for greater attention to equitable, inclusive, accelerated and sustainable growth. Several Member Countries have internalized these suggestions in their planning and package implementation process. Such as, India's XI and XII Five Year Plans emphasize accelerated and inclusive growth, with emphasis on smallholder farmers and resource-poor. Another important shift in the attitude and priorities of donors and national planners had been to bring back agriculture at the centre stage of development and, led by World Bank, the allocations for agriculture have increased substantially.

India's plight is further exacerbated by the entrenched stubbornly high poverty and undernutrition. Let us be reminded that poverty and hunger are the greatest polluters and destabilizers. Needless to assert, household and individual level food, nutrition, health, education and overall livelihood security will seek congruent solutions. The effort is handicapped due to the paucity of reliable, timely and disaggregated data from various levels and their use in developing District and Block level plans and programmes ensuring coherence and minimum overlap with clearly defined responsibility and accountability of partners. It is vital to bridge this gap.

Internationally, the Sustainable Development Goals to be championed at the Rio+20 Conference of the UN on Sustainable Development must emphasise the synergies of social, economic and environmental securities and not one over the other. There are indications that the developed industrialized countries may push for Green Economy emphasizing on environmental indicators and renewable clean but costly energy without much emphasis on poverty and hunger – the MDG1. In my view, such a shift in the approach will not be in greater interest of the majority of the humanity which is struggling to liberate itself from poverty and hunger. Poverty is the greatest polluter was the central message of Late Smt. Indira Gandhi, the then Prime Minister of India at the First UN global meet on environment and sustainable development in Stockholm in 1972, 20 years ahead of Rio and 40 years before the Rio+20. The situation has not changed for the poor, rather has worsened.

How could a Green World be built on the shoulders of millions of stunted and hungry children? We ought to define our priorities rationally and keeping in mind equity and equality principles. Thus, in its global approach all the nations of the world must genuinely adhere to the principle of "common responsibility but differentiated accountabilities". And, the foremost common responsibility should be to fully achieve the MDG1.

Agriculture-led Alleviation of Hunger and Poverty

Agriculture-led economic growth is central to inclusive and accelerated growth in India as still

over 50 percent of our people are directly dependent on agriculture. As seen from Fig. 11, an increase in agricultural growth is highly pro-poor (Ligon and Sadoulet, 2007). The national policy for poverty reduction and inclusive growth must emphasise this central dogma and allocate needed resources to agriculture for achieving the goal.

The Green Revolution had brought unprecedented success in enhancing production and alleviating hunger and poverty. In India, between 1965 and 1995, food and agricultural production had almost tripled and poverty and undernutriton percentages had halved (Singh, 2011). But, now it has waned and the number of hungry and poor remains stubbornly high.

Towards achieving the goals of livelihood security and narrowing the farmer-non-farmer and rural-urban divides, it is absolutely essential to improve economic viability of farming by ensuring that farmers earn a "minimum net income", and ensure that agricultural progress is measured by advances made in improving that income and livelihood security of the farming families. The following actions should be vigorously pursued:

1. Overcome unacceptably high levels of hunger and poverty and ultimately eliminate the twin scourges, through sustaining and accelerating growth in agricultural productivity, raising to at least 2.5 percent annual growth rate in foodgrains, especially pulses and oilseeds, and 6 percent each in livestock, horticulture and fisheries, and these will add up to the cherished overall agricultural growth rate of about 4 percent and above;

2. Reduce the productivity gap between marginal and favoured areas; increase average yields by 50 percent in rainfed areas and about 35 percent in irrigated areas during the next 10 years;

3. Bridge huge yield gaps of 50 to 200 percent by overcoming the technology fatigue, collapse of extension services and timely supply of adequate quantity of quality inputs, namely, seeds, fertilizers, other agro-chemicals and energy;

4. Prevent the colossal post-harvest losses (averaging about 30 to 40 percent in case of fruits, vegetables, fisheries and dairy and other livestock products) by developing cold chains and warehouse facilities, efficient retail systems to link farmers directly with markets and strengthening value addition along the farm to fork chain. This move will not only greatly strengthen off-farm rural employment but will also hugely save water; and

5. Develop comprehensive and effective adaptation and mitigation measures for enhancing resilience to climate change, and introduce integrated Flood Code, Drought Code and Good Weather Code for mitigating and managing aberrant weather and climate volatilities.

Inclusiveness and mainstreaming of the human and gender dimensions should be assured in all farm policies and programmes and given explicit attention to ensure sustainable rural livelihoods. Productivity, profitability and income of the overwhelmingly large proportion of small, marginal, sub-marginal and landless farmers should be enhanced through developing, transferring and providing appropriate technologies, inputs and services and improving

input use efficiency. India should emerge as a global outsourcing hub in the production and supply of products and processes developed through biotechnology and Information and Communication Technologies. Support is needed for comprehensive retooling and retraining of human resources to cope-up with new challenges and opportunities.

Research, technology transfer and extension supports are essential for agricultural transformation, especially for increasing science-led judicious and efficient use of the vital inputs as well as for mainstreaming marginal and sub-marginal farmers in agrarian development. Internal rate of return on investment in agricultural research is one of the highest, thus public-private investment in agricultural research and technology development should be at least doubled from the level of the XI Plan. With Focus on the resource-poor, strategic research for developing cutting edge technologies, like biotechnologies, and their bio-secure use is the need of the day. While allocating funds, the Planning Commission should devise ways to ensure that the funds reach the intended action points. The RKVY may provide the necessary mechanism.

Agricultural curricula should be restructured for enabling every farm and home science graduate to become an entrepreneur and to make agricultural education gender sensitive. Aspirations of nearly 600 million youth in the country should be defined. India having the largest bulge of youth, a good proportion, especially the rural youth, being unemployed or underemployed, all out effort is needed to gain fully retain the rural youth in agriculture following the guidelines suggested by the National Commission on Farmers (NCF, 2006).

Environmental Sustainability and Natural Resource Management

Generally encompassed under the MDG 7, the Goal is to “save and grow”, emphasizing sustainability of forest ecosystem, tribals and other communities living in and around forest areas, water resources, biodiversity, and climate change management.

The National Environment Policy 2006 recognises the importance of ecological sustainability and India has already enacted that Forest Rights Act 2006 to vest forest rights and titles on traditional forest dwelling communities, thus greening inclusiveness. A significant development has been an increase of about 1128 Sq Km in forest cover between 2007 and 2011, increasing forest cover to 21.02 percent. More structured intervention is needed for strengthening Social Forestry Action Plan with clear cut indicators. Non-timber forest economy should be streamlined for further greening the economy.

As one of the 17 mega biodiversity centres with 4 biodiversity hot spots, India must lead in the judicious conservation and utilization of its rich biodiversity, especially during this UN Decade on Biodiversity. Under the National Action Plan on Climate Change, the Green India Mission should be institutionally and technologically strengthened to benefit from the global movement on Reducing Emissions from Deforestation and Forest Degradation (REDD+) as a major strategy to fight against climate change. The overarching objective of the Green India Mission to increase forest and tree cover in 5 million ha area and improve quality of forest cover in another 5 million ha is indeed laudable toward improving ecosystem goods

and services, in enhancing biodiversity and restoring ecosystems and in community-based decentralized action. This will help also in understanding the scope of promotion of the concept of multi-functionality of agriculture, often furthered by developed countries at global negotiations.

Traditional knowledge should be linked with modern knowledge and traditional wisdom should be conserved and the conserving communities, particularly tribal populations, should be duly rewarded. Minimum support price mechanism for non-timber forest products should be implemented. Indigenous medicinal and aromatic plants, botanicals, and biofuel species should be judiciously harnessed and special policies for management of Exclusive Economic Zones (EEZs) and integrated development of coastal zones, hills and mountains and the major river basins should be developed and implemented.

The multiple values of biodiversity and ecosystem services should be incorporated into policy decisions and should influence planning for land, water and forest systems. The various international treaties and agreements should ensure equity in access to the benefits derived from biodiversity and the biodiversity conservers should be fairly compensated.

The livelihood crisis is often linked with entitlement crisis. The unfinished agenda in land reforms should be completed and comprehensive asset and aquarian reforms and access to assured energy and promotion of renewable energy should be initiated. Diversion of productive irrigated agricultural lands to non-agricultural uses should be strictly regulated. Water should be declared as a common property. Concealed tenancy should be eliminated and land-leasing acts and contract-farming provisions should be rendered transparent and farmer friendly. Waste/degraded lands should be reclaimed and distributed to landless farmers and allocated for non-agricultural uses. Support of industries and private sector should be sought in developing such lands and ensuring mutual reinforcement of agriculture, energy and industry in the national interest leading to Green Economy.

A National Land and Water Use Advisory Service should be established and linked to State and Block Level Land and Water Use Advisory Services on a hub and spokes model. These can be virtual organisations with the capacity to link land and water use decisions with ecological, meteorological and marketing factors on a location and season specific basis. They should provide proactive advice to farmers on land and water use. Farmers should be encouraged to diversify towards land-saving high value agriculture, but not at the cost of national level self-sufficiency in staple food.

Protection and improvement of land, water, bio-diversity and climate resources is essential for sustained advances in the productivity, profitability and stability of major farming systems by creating an economic stake in conservation. A Seeds and Breeds National Mission should be initiated under which could be established national livestock heritage banks, genome clubs and genetic literacy, biovalleys and gene sanctuaries.

The irrigation and fertilizer use efficiencies have been extremely low, resulting not only in poor efficacy but also in environmental degradation. The budget allocations should be

made or partly diverted also for enriching the knowledge base and software components to enhance use-efficiency of these inputs. Clear cut and simple guidelines must be formulated and made widely known for implementing the nutrient-based fertilizer pricing and subsidy policy.

Repeated outbreaks of Swine Fever and Avian Flu and the danger of new races of wheat rust are serious threats to food and health security. Strengthening the bio-security of crops, farm animals, fish and forest trees for safeguarding both the work and income security of farmer families and the health and trade security of the nation can hardly be overemphasized. IPR, SPS and other biosecurity and regulatory measures must be augmented. A comprehensive National Agricultural Biosecurity System ought to be established to be able to share developments in the global village without undue risk.

Resilience to Climate Change

The challenges of attaining sustainably accelerated and inclusive growth and comprehensive food security have been exacerbated by the global climate change and extreme weather fluctuations. The global warming due to rising concentration of greenhouse gases (GHGs) causing higher temperature, disturbed rainfall pattern causing frequent drought and flood, sea level rise etc. is already adversely impacting productivity and stability of production, resulting in increased vulnerability, especially of the hungry and resource-poor farmers, and is a growing threat to agricultural yields and food security. The World Bank projects that the climate change will depress crop yields by 20 per cent or more by the year 2050. Livestock and fish production will likewise be impacted. Pathogen virulences, disease incidences, pest-infestations, epidemic breakouts and biotic stresses in general are predicted to intensify.

Recognizing that agriculture is both a victim of and a contributor to GHGs and other environmental pollutions, a two pronged approach, to reduce the emission on one hand, and to develop adaptive measures to increase agricultural resilience on the other hand, will be needed. Fortunately, alternative agricultural practices designed for specific agro-ecologies are proving effective in reducing GHG emissions from agriculture and at the same time in improving yields under extreme weather.

The impact of climate change on major crops in India was evaluated under controlled environment conditions i.e., free air CO_2 enrichment, open top chambers and temperature gradient tunnels and using simulation models (Aggarwal, 2009). Spatial and temporal changes in key climatic parameters of agricultural importance were also characterized. Although there will be significant spatial and temporal differences in the impact of climate change, the increasing droughts and floods can seriously disrupt food supplies, overall kharif agriculture may become more risky due to increased climatic variability and pest incidence and rabi crops will be seriously threatened due to projections of large increase in temperatures and higher uncertainties in rainfall. Central and southern Indian regions, which are already warm at present, may be more seriously affected than north India. Small changes in temperature, CO2 and rainfall can have significant effect on quality of fruits, vegetables, tea, coffee, rubber

and other plantation crops, and aromatic and medicinal plants. Nutritional quality of cereals and pulses may also be moderately affected.

Agriculture contributes to the global warming primarily through the emission and consumption of GHGs such as methane, nitrous oxide and carbon dioxide. Research on GHGs emission from Indian agriculture started in 1990s when, based on very limited measurements done elsewhere, it was reported that Indian rice fields emit 37.5 million ton (Mt) methane per year (Pathak and Aggarwal, 2012). With sustained and systematic indigenous research the methane emission estimates have been rationalized. The current estimate (2010) shows that Indian rice fields covering an area of 43.9 Mha emitted 3.3 Mt of methane2. The nitrous oxide emission from Indian agricultural soils is 0.14 Mt. These estimates have provided strength to the rice-producing countries, which are primarily developing agriculture-dependent countries, at global negotiations on climate change.

Agricultural diversity is a manifestation of climatic adaptation. Farmers and farming communities have shaped and channeled the adaptation depending on technology availability, economic viability and their socio-economic capacity. A two-dimensional approach is needed to increase adaptive capacity of agriculture to climate change. In the longer term, adaptation to increased mean temperature and rainfall intensity will be important. In the short-term, adaptation to unpredictable weather extremes such as drought, flood, heat and cold will assume priority. Thus, both short and long term land and water use plans must be developed for ensuring climate resilience i.e. a climate smart agriculture.

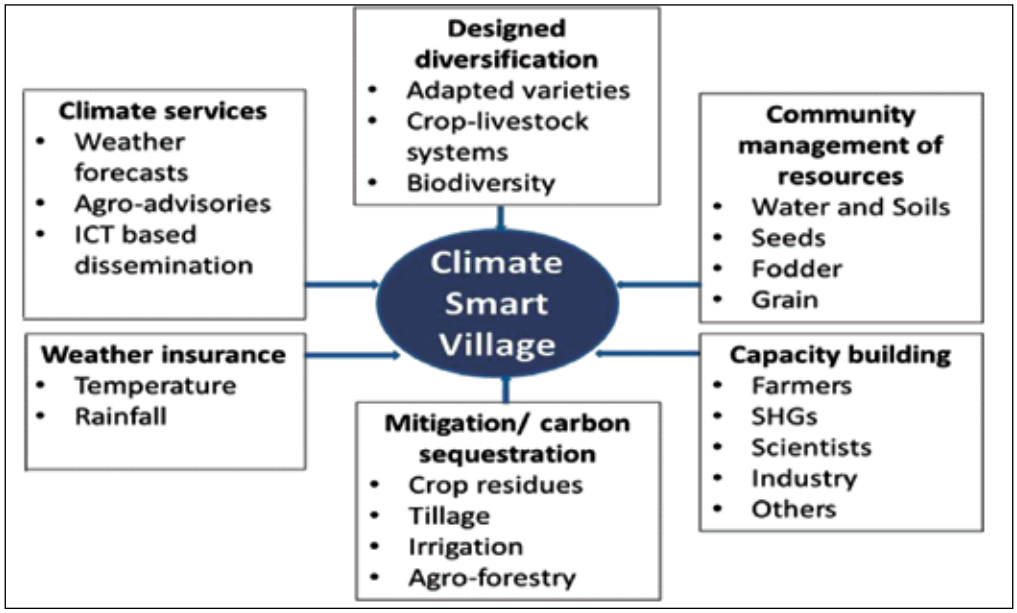
Under the United Nations Framework Convention on Climate Change (UNFCCC) in 2011, the commission on Sustainable Agriculture and Climate Change encouraged policy action to help achieve food security while addressing climate change. It recommended seven priority actions. Two of the most important priority actions in context of climate smart agriculture (CSA) are: 1) sustainably intensify agricultural production while reducing emissions and other environmental impacts and 2) create comprehensive information systems on human and ecological dimensions. Expanding CSA that results in increased food production, limits greenhouse gas (GHG) emissions and prepares for future climate change, is a major goal and challenge especially in agriculture-based countries such as India where rural livelihoods depends primarily on shrinking and degrading ecosystems.

Research and technology development (supported by policy and institutions) will need to be geared up to meet the veritable challenges. The much needed congruence of high productivity and sustainability in face of the intensifying volatilities due to climate change, biotic and abiotic stresses and market instabilities, let alone the challenges of adequately feeding the swelling population from shrinking and degrading natural resources, can be underpinned only by developing smart technological solutions and innovations. New and modern sciences and cutting-edge technologies, especially intensive characterization of germplasm, molecular breeding and genetic engineering for crop improvement and development of designer crops, coupled with associated resource management practices, including indigenous knowledge, practices and technologies, will increasingly be called upon to provide the desired solutions.

There is a need for more integrated research and improved knowledge systems on the specific agricultural production methods that would work the best for individual regions, farming systems, and landscapes. In addition, for agricultural practitioners in general, there is a need for public-domain systems that provide information on “repeated observations” of successful CSA practices that are suitable for both large- and small-holder agriculture. Impacts of such practices should be tracked and reported through : 1) design of standardized tracking metrics for measuring the impacts of CSA practices strategies in terms of food production, GHG emissions, and climate resilience, 2) development or adoption of a public domain system for reporting and illustrating the results of these efforts and 3) the potential establishment of a private sector supported Climate Fund providing a mechanism for corporates to participate in the promotion and sustainability of Climate Smart Agricultural Practices.

It is heartening that the National Initiative on Climate Resilient Agriculture (NICRA) of the Indian Council of Agricultural Research (ICAR) is pioneering CSA innovations and research through a blend of government, private sector, and NGO collaborations that hold great promise. The initiative, however, should develop common metrics and tools for demonstrating the impacts on a wider scale, as also for benefiting from external financing (eg. Clean Development Mechanism, Adaptation Fund of the Kyoto Protocol, Green Climate Fund and private sector sources) to support community-based efforts to implement CSA practices and projects. In this context, effective GHG accounting methods should prove helpful.

NICRA should develop, in partnership with rural communities and other stakeholders, a climate-smart model for agricultural development that includes a range of innovative agricultural risk management strategies, as depicted below. The flow chart of adaptation and mitigation was prepared in consultation with P.K. Aggarwal.



Finally, the following commensurate priority policy actions, as also suggested by UNFCC/ CSACC, are needed :

1. Integrate food security and sustainable/resilient agriculture into global and national policies,
2. Increase global and national investments in resilient/sustainable agriculture and food systems and
3. Target programmes and policies to assist vulnerable populations.

Scientists should inform policies regarding the relative importance of adaptation and mitigation across various sub-sectors of agriculture (crop, livestock, fishery and forestry) and provide guidelines to ensure synergies for improving food security and livelihoods. Effective methodologies should be developed for assessing risks and benefits and for evidence-based evaluations to enable scaling up to "safe operating space".

Nutritional Security

The very high incidence of child undernutrition in India is both an ethical and economic imperative. Evidences show that avoidable undernutrition among young children reduces the effectiveness of investments in education and economic development.

Overcoming early childhood undernutrition requires investing in targeted nutrition interventions for immediate impacts, as well as investing in targeted nutrition and in packages of interventions that address the immediate and underlying determinants of undernutrition simultaneously must be seen as the most paying investment. Building such an environment will require more effective collaboration among all of the sectors to ensure like cycle based sustained nutritional security, such as agriculture and rural development, water and sanitation, gender, and social development. The benefit-cost ratios for nutrition interventions range from 5 to 200, much more than other interventions.

Encouragingly, in the recent years, new national and international initiatives are specifically targeting nutritional security under the MDG1. Following the Copenhagen Consensus in 2008, which declared that investments in nutrition initiatives were the most effective development investments in terms of cost and benefit, a group of nutrition actors, representing a range of stakeholders, issued a set of recommendations in 2010 for global and national action called "Scaling Up Nutrition: A Framework for Action". This document endorses a package of nutrition interventions targeted toward the 1000 day window of opportunity and estimates the costs of scaling up these interventions from current levels to the levels needed to achieve rapid reductions in undernutrition.

Further, based on discussions following the global food, fuel, and financial crises, the Group of Eight industrial countries agreed through the L'Aquila Joint Statement on Global Food Security to place new emphasis on food security and nutrition in poor countries. Building on this statement, multiple donors have contributed to the Global Agriculture and Food Security Programme (GAFSP), which will help countries develop comprehensive plans to address agriculture and food security to improve household resources for addressing child

undernutrition. The Committee on World Food Security (CFS) underwent a reform process throughout 2009. The reform document sets forth its commitment to broader participation by food security stakeholders and also unequivocally states that nutrition is integral to the concept of food security and to the work of the CFS.

Notwithstanding the global initiatives, the national policies and programmes must be strengthened to reach the hungry and fight malnutrition. The success stories often rely on a few common principles: strong government action coordinated across sectors and at central, state, and local levels; strengthening of existing health systems; significant scaling up of public spending; leadership and commitment at all levels; focus on and empowerment of vulnerable populations, households, and age groups; and a strong monitoring and evaluation culture that provides a basis for incentives and correction of policy actions in the context of implementation.

Recently, Coalition for Sustainable Nutrition Security in India, chaired by Prof. M.S. Swaminathan, gave a call for Nutrition Revolution in India, recommending the following interventions to improve nutrition security in the country:

- Focus on proven, essential nutrition interventions *viz*. the timely initiation of breastfeeding, the timely introduction of appropriate complementary foods, dietary and micronutrient approaches to address micronutrient malnutrition etc.
- Focus on proven, essential primary health care interventions, such as complete immunization, biannual vitamin A supplementation with deworming, appropriate feeding of children during and after illness, including oral rehydration with zinc supplementation during diarrhea, iron and folic acid supplements for adolescent girls and pregnant and lactating women
- Promote personal hygiene, environmental sanitation, safe drinking water and food safety
- Promote agricultural production, including horticulture, livestock and fish production, animal husbandry and fisheries and improved economic and livelihood to enhance household food and nutrition security, and
- Expand and improve nutrition education and behavior change programming at community level.

In order to ensure the above innovations, the coalition had suggested that nutrition security should be a top priority on the development agenda of the country. A coordination mechanism with clear authority and responsibility for improving key nutrition indicators in the country should be established towards ensuring effective adoption of a life cycle based national nutrition programme. India has the knowledge and technologies needed to improve nutrition security, but we must muster the necessary commitment and political will. The Prime Minister and the XII Plan have highlighted the urgency of fighting the entrenched undernutrition.

It may be prudent to share experiences of other countries in managing their agricultural

transformation and food security programmes. One such example is of Brazil. The President of Brazil made a bold declaration in 2002 of Zero Hunger Programme under the Right to Food Act. The Zero Hunger Programme incorporates more than 40 social and social-security policies and programmes, reaching out to more than one-third of the Brazilian population (through means such as cash transfers, school feeding programmes and direct procurement from smallholder farmers). These programmes, which are associated with further agrarian reform and strong credit and technical support to smallholder agriculture, have allowed Brazil to mitigate the impact of the global food and economic crises on food security and overall economic growth. This Programme has paid rich dividends and the country is almost fully food secure even at individual level (Graziano, 2007; FAO, 2009).

Right to Food and the Food Bill

At the World Summit on Food Security in 2009, UN Member States reaffirmed "the right of everyone to have access to safe, sufficient and nutritious food, consistent with the progressive realization of the right to adequate food in the context of national food security." The right to adequate food is a human right laid down in international legal human rights conventions, together with other rights conducive to food security and nutritional health. The majority of UN Member States have ratified these conventions and are thereby bound to implement their content.

A right-to-food perspective provides a framework for the diagnosis of the food security problem as well as guidance for the design, implementation and monitoring of initiatives taken in response to the food crisis. In this context, the Right to Food Guidelines provide a context for translating political commitments into practical and concrete action and strategy by nations for the realization of the right to adequate food that includes: mapping the groups that are most vulnerable and ensuring their participation; clearly allocating responsibilities across different branches of government and improving coordination; setting benchmarks and imposing time frames; and empowering independent institutions, including courts, to enhance accountability. The Supreme Court's intervention to save foodgrains from rotting in storages, while million were going to bed hungry is commendable although the Government considered it as an interference. All concerned government departments need to jointly design and implement effective, integrated cross-sectoral initiatives in a participatory mode at established a credible food security system at the national, regional, village and even family levels.

An increasing number of states, international organizations, and civil society have begun to explore a rights-based approach to development efforts, including activities promoting food security and nutritional health. They recognize that merely increasing food production will not end hunger and malnutrition and that those who are poor, hungry, or undernourished must get access to food. Who and where they are must first be identified, and the causes of their situation fully understood and exposed. Vulnerable and marginalized groups can then be specifically supported by agricultural programmes facilitating their ability to feed themselves or social protection schemes ensuring that no individual in need is left out.

Indian Parliament took a historic decision to pass the National Food Security Bill on December 22, 2011 which will lead to an unprecedented Legislation to make Right to Food a legal Right. It is a great leap forward from the ship-to-mouth situation in the 1960s to the Right to Food (based on home-grown food) to each citizen of India. It will cover two-third of India's 120 crore people, including three-fourth of the rural population and half the people in urban areas. The chronically hungry people will get food for free. However, implementation of the Bill faces several constraints, particularly those related with the identification of the beneficiaries, the level of MSP for the grains procured year after year and the storage, and distribution and leakages problems. Moreover, the Bill does not adequately address the nutrition problems, let alone the annual subsidy of over 100,000 crore to implement the Bill.

It may be emphasised that food security is a function not only of production and market access, but also of the economic, social and political institutions at all levels. Thus, an understanding of the institutional set-up and the processes that allow interactions among stakeholders are critical factors for success or failure when formulating, implementing and monitoring policies, strategies and programmes related to food security at different levels, including the Right to Food and operationalization of the Food Bill.

Social Protection Floors

In order to benefit both the farmers and the consumers (in India 60% of the consumers are also farmers), price protection mechanisms as well as public distribution systems (PDS) would need to be strengthened. A Market Price Stabilization Fund should be established jointly by Central and State Governments and financial institutions to protect farmers during periods of violent fluctuations in prices; as, for example, in the case of perishable commodities like onion, potato, tomato etc. A national market system should be established to overcome many of the hurdles created by the state marketing systems. It would be helpful to have agricultural marketing on the 'concurrent list'.

The scope of the MSP programme should be expanded to cover all crops of importance to food and income security for small farmers. Also, advice to farmers on crop diversification should be linked to the assurance of MSP and agro-ecological capabilities. Small farm families should not be exposed to administrative and academic experiments and gambles in the market. Further, in order to buttress farmers as well as consumers from the negative impacts of WTO Agreements as well as from the outdated domestic market acts and provisions, as suggested by the NCF, an Indian Trade Organisation should be created and allowed to function professionally and transparently. As suggested by the NCF, the National Commission for Agricultural Costs and Prices should be restructured to comprehensively address the agricultural pricing, marketing and trade issues.

The quality of credit and its hassle free flow to the poor should be strengthened. Further, as recommended by the National Commission on Farmers, as already done in some states, the interest rate should be reduced to 4 percent and even to zero percent in the event of national disasters such as droughts and floods. An Agriculture Risk Fund, as suggested by the NCF, should be instituted to insulate farmers from recurrent droughts and floods, and also to avoid

ad-hocism in distribution of relief funds. Simple and reliable (such as based on weather) procedures should be adopted for farm family and farming insurance (including health).

National Rural Employment Guarantee Act, first implemented in 2006, is a landmark development for increasing inclusiveness through the congruence of Right to Employment, Right to Food and Right to Information. But, due to highly patchy implementation, it is far from being a "magnificent success". The usefulness of the Scheme could be broadened by promoting skill enhancement and skill-based employment. Further, congruence among analogous schemes should be effected to minimize wasteful duplications and to maximize synergistic outcomes.

India has the largest bulge of youth and unemployed youth. Measures should be introduced which could help attract and retain youths in farming by making it intellectually stimulating and economically rewarding and by conferring the power and economy of scale to small and marginal farmers both in production and post-harvest phases of farming. Each agricultural graduate should be an entrepreneur, and associated public-private sector support, such as creation of agri-clinics, e-chaupals and revamping of the Small Farmers Agribusiness Consortium, should be assured. Necessary programmes and budget provisions are essential for undertaking these activities and for rendering the graduates not as job-seekers but as job-providers.

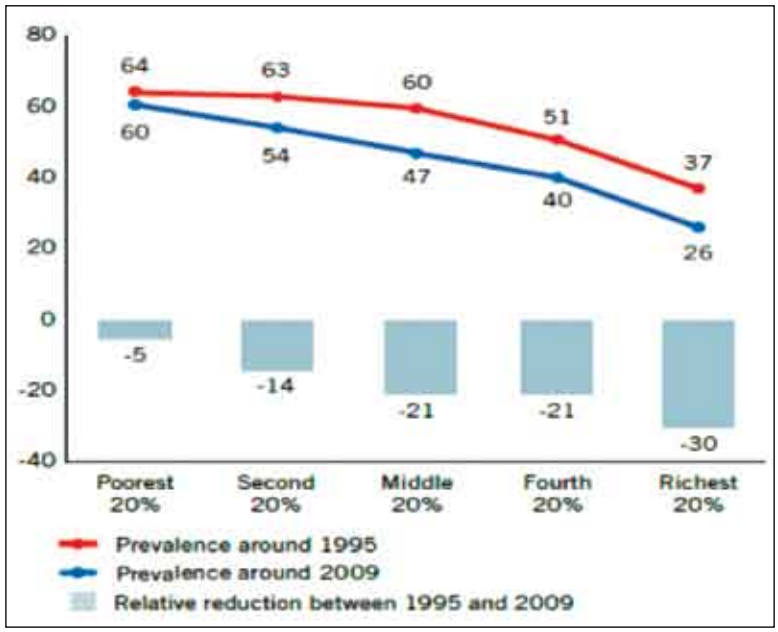
Mind the Gap: Enrich the MDGs

Notwithstanding the global economic setback during 2008-09, the world has witnessed considerable progress in achieving the MDGs. However, the global and national level averages conceal serious inequalities, highlighting the problem of effectively identifying and focusing on the hotspots and target groups and the overall distributional problems, the gaps. The achievements measured at global and national level often fail to reveal as to how often the programmes reach the targeted people and how broad based is the progress. For instance, in India and South Asia, the UN MDG Report, 2011 had revealed that the progress in combating child undernutrition amounts to bypassing the poorest (Fig. 12).

Children from the poorest households have much greater chance of being underweight when compared with their richer counterparts. Moreover, under usual conditions, the poorer households make minimal contribution to the reduction of underweight prevalence. In Southern Asia, for example, there was minimal improvement among children in the poorest households during 1995-2009, underweight prevalence dropping from 64 to 60 percentage points, a 5 percent drop, while among children from the richest 20 percent of households it decreased from 37 to 26 percent points, a drop of 30 percent. Moreover, there was a sharp rural-urban divide in the prevalence of underweight children in developing regions, being twice as much in rural areas. Hence, greater effort is needed for awareness raising as well as for programmes implementation in rural areas, including close links with ongoing programmes of ICDS and primary health care scheme in rural areas.

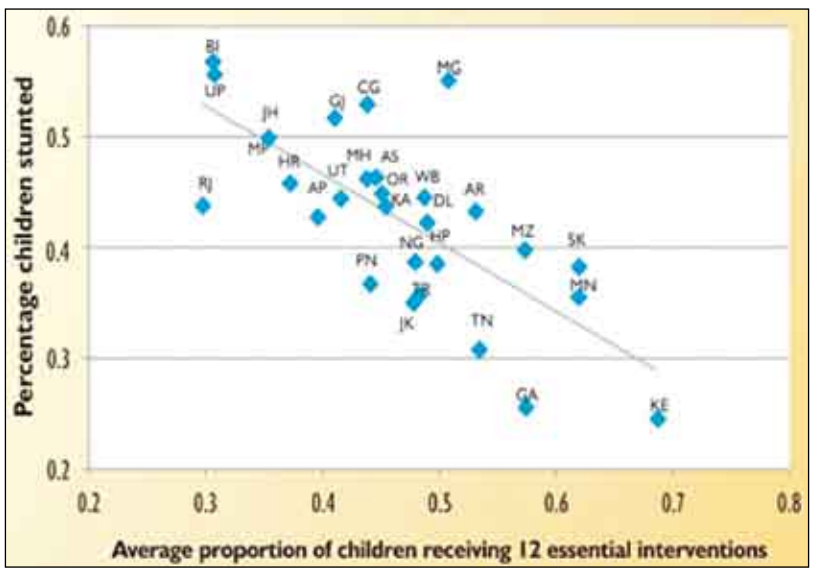
The governance and effectiveness of implementation of various nutritional interventions has direct bearing on the outcome. As seen from Fig. 13, as the proportion of children receiving

Fig. 12. *Proportion of under-five children who are underweight in South Asia, by household wealth, around 1995 and 2009 (Percentage)*



Source: The UN Millennium Development Goals Report, 2011

Fig. 13. *Association between coverage of essential direct interventions and stunting prevalence*

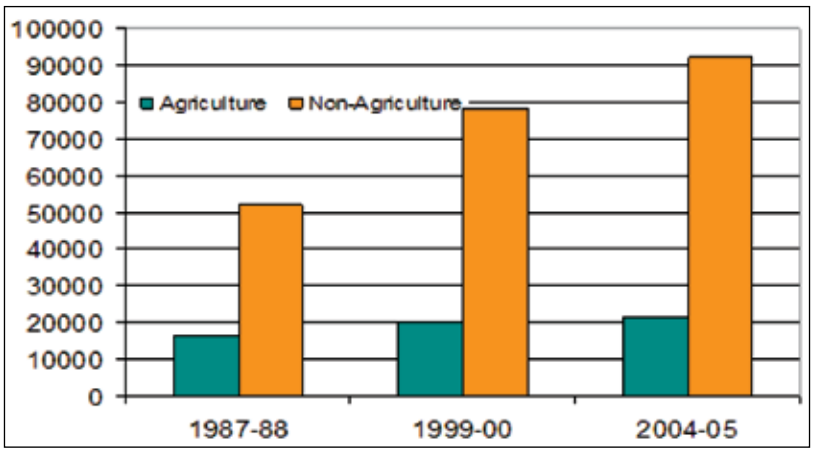


Source: Aguayo and Menon, 2011

essential interventions increased, the percentage of stunted children decreased almost linearly, the impact being high in Kerala, Goa, Manipur and Tamil Nadu, and being low in Bihar, Uttar Pradesh, Jharkhand, Madhya Pradesh and Rajasthan – the "BIMARU" states.

The impact of increasing inequality of farmers and non-farmers incomes is felt widely. Despite several pro-farmers programmes initiated by the Government, the high initial inequality between farmers and non-farmers has further widened, from 1:3 to about 1:5 between 1987-88 and 2004-05 (Fig. 14). The inequality factor also partly explains as to why the high growth rate of 8 to 9 percent in overall GDP growth in India during the past decade or so has been rather "hollow" for the farmers of India.

Fig. 14. *High Initial Inequality between Farmers and Non-farmers*



Source: Various rounds of NSS, GoI.

Marginal, sub-marginal and smallholder farmers comprise nearly 50% of the country's population and who are generally poor and under-nourished (Table 9) were largely bypassed in the rural development process. The high GDP growth registered in the country was thus less effective in reducing poverty and undernutrition, especially in rural areas. Recent research (Kwasi Fosu, 2011) confirms that "high initial levels of inequality limit the effectiveness of growth in reducing poverty, while increasing inequality reduces the impact of growth on poverty for any given level of growth".

Table 9. Proportion (%) of poor and undernourished persons in different farm-size groups in rural India, 2009

Farm Size	Poor	Undernourished
Agricultural Labourer	24.1	19.6
Marginal Farms	52.3	49.4
Small Farms	9.4	9.3
Med. Farms	3.1	5.5

Large Farms	1.1	3.1
Other Rural	10.0	13.1

Source: P. Kumar (personal communication)

The 2010 UN MDG Summit emphasized the need for making adjustment for inequality factor in the MDG framework to render the growth pro-poor or inclusive. Consequently, the 2010 Human Development Report for the first time provided Inequality–adjusted Human Development Index (IHDI). This was duly reflected in the 2010 UN MDG Summit Outcome Document, advocating for:

- "… Adopting policies and measures oriented towards benefiting the poor and addressing social and economic inequalities;
- Promoting universal access to public and social services and providing social protection floors;
- Implementing social policies and programmes, including appropriate conditional cash-transfer programmes."

In view of the above, establishment of Social Protection Floors (SPF) in developing countries will help reduce inequalities and improve coherence among various programmes generally vertically organized to meet individual MDGs (Herfkens, 2011). The efficacy of the SPFs, however, will greatly depend on the design and management of the programme. For Instance, the Public Distribution System (PDS) of India, one of the oldest and largest food security safetynet programmes in the world, has been successful only in patches. A government-commissioned evaluation of the targeted PDS concluded in 2001 that less than three in five poor households were actually reached by the scheme. The leakage problems also persisted; 58 per cent of subsidized food grains issued from the Central Pool did not reach the target families because of identification errors, non-transparent operation and unethical practices in the implementation of TPDS. In addition, the food subsidy extends only to staple foods but not to fruits, vegetables and other key components of a diverse diet, thus improving the quantity of food accessed by the poor but not necessarily the quality. The final irony is that the costs for the targeted PDS proved to be even higher than for the earlier programme. Let us hope that as India proceeds to enact the Food Bill (Right to Food), these ironies will be ironed out.

Connecting the MDGs with Rio+20

The MDGs have stemmed from a series of landmark global events in the 1990s and can benefit from judicious linkages with other relevant global events in progress or planned in the years ahead. For instance, the Agenda 21 of the Earth Summit, 1992, in Rio, and Rome Declaration of the 1996 World Food Summit of FAO, were precursors of the UN Millennium Declaration in 2000. During the past decade, MDGs have been synergistically interacting with several overlapping national and global initiatives. One such opportunity is to link the

MDG process with the forthcoming Rio+20 Global Conference on Sustainable Development this month (June 2012) and, wherever necessary and feasible, seek new and/or renewed alliances to bring on-track the off-track goals in order to fully achieve all the targets by 31 December 2015 or before.

At the 2011 MDG Summit the Secretary-General, United Nations, BAN Ki-MOON asserted that *"We must also take more determined steps to protect the ecosystems that support economic growth and sustain life on earth. Next year's (2012) United Nations Conference on Sustainable Development — Rio + 20 — is an opportunity to generate momentum in this direction, which is vital for achieving the MDGs. Between now and 2015, we must make sure that promises made become promises kept. The people of the world are watching. Too many of them are anxious, angry and hurting. They fear for their jobs, their families, their futures. World leaders must show not only that they care, but that they have the courage and conviction to act."*

The Rio+20 should critically analyze attainments of the MDGs and assess the outcomes, achievements and impacts. Should an effective and credible mechanism/institution(s) not exist in the ongoing national and international programmes for undertaking judicious evaluations, governments and bilateral and multilateral programmes should urgently institutionalize the M&E process as an integral and dynamic component of development programme. Efficacy of the evaluation process should also be assessed periodically. The successful experiences and models thus identified should be up-scaled and out-scaled toward widespread adoption and adaptation of the best practices.

Twenty years after the first global blueprint for sustainable development was prepared in the famous city of Rio, Brazil, in the same city world leaders, including Prime Minister Dr. Manmohan Singh, will meet on 20 to 22 June 2012 for the Rio+20 Summit to chalk out the earth's future. The new and emerging global economies, BRICS countries, namely, Brazil, Russia, India, China and South Africa, pushing ahead their GDP growths are likely to be seen as greater global players. India, while striving to reduce its high rates of poverty and undernutrition, will also be spotted as a major emitter of GHGs, although on per capita basis, the emission is one-fourth of that for the world as a whole. Thus, with the increasing problems of climate change and environmental degradation, it will be a much more challenging Summit to negotiate the best path for all.

The Rio+20 visualises that the functioning of the Earth system is at risk. The business as usual will fail us. It is urgent that we move onto a sustainable path of development for security and humanity. A well thought interdisciplinary science-based integrated decision making for sustainable development at all levels is needed. Systems of knowledge, defined targets and effective solutions are called for. A new way of doing science and informing policy-makers is needed. At Rio+20 "governments should recognise, analyse and enhance the crucial relationship between policy-making and science, technology and innovation" and help develop a new contract between science and society.

The Rio+20 will be preceded by a Forum on Science, Technology and Innovation for Sustainable Development, which will meet on June 11-15, 2012 in Rio de Janeiro towards

linking science and policy. The Forum shall bring together leading international scientists, policy-makers and other stakeholders to explore the key role of interdisciplinary science and innovation in the transition to sustainable development, to a green economy and to poverty eradication. I am privileged to have been invited to address this Forum and shall be reporting on the highlights in the forthcoming two issues of the NAAS News.

Concluding Remarks

Planet Earth is under pressure as the world population is expected to exceed nine billion by 2050 and the natural resources are shrinking fast. India, with an estimated 1.5 billion people by then, will be the most populous country in the world and would be required to sustain and ensure livelihood security of 16% of the world population from hardly about 3% of the world's land and water resources. Towards 2025, over 50% of the country's population will still be rural, around 50% of the agricultural land will remain rainfed and over 80% of the farm holdings will be small, marginal and submarginal, let alone the intensified volatilities of climate change and market uncertainties. Rising global temperatures, melting markets, soaring food prices and increasing unemployment have significantly added to the pressure.

Keeping the above backdrop in mind, the Millennium Development Goals established by the UN Millennium Summit in 2000, marking a global commitment of an unparalleled magnitude, must be seen as a blessing. Although all the eight separate goals are the pillar of the same grand design, MDG1 to reduce poverty and hunger is critical to the success of the other MDGs. This goal is most complex and difficult to achieve as revealed by country performances. Despite the challenges, the global movement of reducing hunger and undernutrition has shown that there are encouraging signs in several countries and in given countries at provincial, regional and national levels offering hope to achieve the goal by 2015. We must keep our promises to meet the foremost goal, MDG1, which will drive the fulfillment of the other MDGs also.

With only three years to go and a lot more ground to cover, we must doubly speed up the process, especially uptake of judiciously assessed interventions, enactment of concerned policies and scale-up and scale-out of best practices. Can the Fellowship of the Academy unify and focus its efforts to meet this most humane goal 1. I am sure, the answer is 'yes'. We can do it. We must do it.

References

1. Aguayo, V. and P. Menon, 2011. The 1000 Day Window of Opportunity for Improving Child Nutrition in India: Insights form National Level Data. India Health Beat 5(3): pp 4, PHFI and World Bank, New Delhi.

2. Dowling, J.M. and Yap Chin-Fang, 2009. Chronic Poverty in Asia: Causes, Consequences and Policies. Singapore. World Scientific Publishing Co., 560 p.

3. ESCAP, ADB and UNDP (authors), 2012. Accelerating Equitable Achievement of the MDGs: Closing Gaps in Health and Nutrition Outcomes. Asia-Pacific Regional MDG Report 2011/12 in collaboration with UNFPA, UNICEF and WHO, 104 p.

4. FAO, 2009. A Reference for Designing Food and Nutrition Security Policies: The Brazilian Fome Zero Strategy. Coordinated by FAO Regional Representative for LAC, Jose Graziano da Silva. FAO Regional Office for Latin America and the Caribbean. Chile. 2009. www.rlc.fao.org, pp 5-9.

5. FAO, 2010. The State of Food Insecurity in the World: Addressing food insecurity in protracted crises. The Food and Agriculture Organization of the United Nations, Rome, 58 p.

6. FAO, 2011. The State of Food Insecurity in the World: How does international price volatility affect domestic economies and food security? The Food and Agriculture Organisation of the United Nations. Rome, 50 p.

7. Government of India, 2011. Millennium Development Goals India Country Report 2011. Central Statistical Organisation, Ministry of Statistics and Programme Implementation, Government of India. www.mospi.nic.in, 131 p.

8. Graziano da Silva, J., 2007. Zero Hunger Programme: Major Lessons for Scaling Up. Paper presented in Taking Action for the World's Poor and Hungry People. Beijing, pp 1-15.

9. Herfkens, E., 2011. Enhancing the Millennium Development Goals: Reducing Inequalities and Improving Coherence through Social Protection Floors. Background paper prepared for the Social Protection Floor Advisory Group. *www.ilo.org/public/english/protection/spfag/.../sfp-mdg.pdf, 25 p.*

10. IFPRI, 2011. Global Food Policy Report. International Food Policy Research Institute. Washington D.C., 114 p.

11. Kwasi Fosu, A., 2011. Growth, Inequality, and Poverty Reduction in Developing Countries: Recent Global Evidence. WIDER Working Paper. UNU-WIDER, 54 p.

12. Ligon, E. and E. Sadoulet, 2007. Estimating the Effects of Aggregate Agricultural Growth on the Distribution of Expenditures. Background paper for the World Development Report 2008. (http://siteresources.worldbank.org/INTWDR2008/Resources/2795087-1191427986785/LigonE&SadouletE_EstimatingEffectsOfAggAgGr.pdf), 23 p.

13. Menon, P., A. Deolalikar and A. Bhaskar, 2009. India State Hunger Index : Comparison of Hunger Across States. IFPRI. Washington D.C., 32 p.

14. Peter Svedberg, 2007. Child Malnutrition in India and China. 2020 Focus Brief on the World's Poor and Hungry People. IFPRI Washington, D.C., pp 4.

15. NCF, 2006. Serving Farmers and Saving Farming: Towards Faster and More Inclusive Growth of Farmers' Welfare. National Commission on Farmers. Ministry of Agriculture. Government of India. New Delhi, 277 p.

16. Singh, R.B., 2011. Towards An Evergreen Revolution: The Road Map. National Academy of Agricultural Sciences. New Delhi, 61 p.

17. Swaminathan, M.S., 2012. Remember Your Humanity – Pathway to Sustainable Food Security. New India Publishing Agency, New Delhi, 208 p.

18. Times of India, May 12, 2012. Far from Target, House Junks Debate on MDG. New Delhi.

19. United Nations, 2008. Millennium Development Goals Indicators – The UN Official List of MDG Indicators 2008: http://mdgs.un.org/unsd/mdg/Host.aspx?Content=Indicators/OfficialList.htm.

20. UNICEF, 2009. Tracking progress on Child and maternal nutrition: A survival and development priority. United Nations Children Fund. New York, 119 p.

21. United Nations, 2011. The Millennium Development Goals Report 2011. UN. New York, 67 p.

Climate Smart Agriculture towards an Ever-Green Economy

Prof. R.B. Singh

President
National Academy of Agricultural Sciences

Context

Amidst the outstanding agricultural and overall economic progress made in the country during the past 50 years or so, a few major events and trends have emerged in the recent years with significant implications for science-led transformation of agriculture towards an economically vibrant, socially secure and environmentally sustainable India.

Firstly, the National Food Security Bill (NFSB) is on the Parliament's anvil for the last about two years. On several counts, the Government is keen to have the Bill passed soon. The proposed Bill will give 67 percent of India's population (numbering nearly 840 million people based on current total population) five kilograms of rice, wheat and coarse cereals per month at heavily subsidized prices, while those in the poorest category (numbering around 250 million) will receive 35 kilograms of foodgrains. Enactment of the Bill stipulates that the Rights will be met essentially from home-grown grains. The implications are obvious – accelerated, enhanced and sustained (climate-resilient) national food and agricultural production.

Secondly, the overall GDP annual growth rate for the year 2012-13 has slipped to 5 percent from a growth rate level of 8 to 10 percent witnessed during the past 15 years or so. Thus, even the trickle down theory of many economists will have little meaning for poverty alleviation.

Thirdly, the negative impact of climate change is increasingly visible not only in depressing agricultural productivity but also in increasing variability and volatility in total production. Given the global dimension of climate change, the production uncertainties will enhance the intensity and frequency of food price spikes. All these will hurt the poorest and the hungriest the most. Unfortunately, one-fourth of the world's such deprived people have their homes in India.

At such a challenging juncture, I am honoured to share my views on our march towards an evergreen economy under the fast changing climate during the celebration of the 20th Foundation

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Presidential address delivered at the 20th General Body Meeting of the National Academy of Agricultural Sciences held at New Delhi on June 5, 2013.

Day of National Academy of Agricultural Sciences (NAAS). As the Academy has attained its adulthood today, we are faced with formidable challenges and uncommon opportunities. Having had served the science and society with distinction during its early and teen years, I am sure, the Academy will continue to brighten our paths ahead. As in the past, harnessing and augmenting the great treasure of knowledge, human capital and leadership that we have built, and invoking the rigour of science, I am doubly confident that we will not only overcome the challenges, but would succeed also in capturing the opportunities. I wish you all a Very Happy Foundation Day.

The Day coincides with World Environment Day (WED). This year's theme of the WED is "Think. Eat. Save. Reduce Your Foodprint". The central message of this theme is to be food smart, resource smart and environment smart. Happily, my Address echoes similar sentiments.

Scope of the Address

The concept of the term "Climate Smart Agriculture" (CSA), particularly in context of sustainable agriculture, has evolved in recent years, especially since the Global Conference on 'Climate Change, Food Security and Agriculture' held in 2010. According to FAO, "CSA seeks to support countries in securing the necessary policy, technical and financial conditions to enable them to sustainably increase agricultural productivity and incomes, build resilience and the capacity of agricultural and food systems to adapt to climate change, and seek opportunities to reduce and remove GHGs in order to meet their national food security and development goals. CSA is site specific and takes into consideration the synergies and tradeoffs between multiple objectives that are set in diverse social, economic, and environmental contexts where the approach is applied. CSA builds upon sustainable agriculture approaches, using principles of ecosystem and sustainable land/water management and landscape analysis, as well as assessments of resource and energy use in agricultural and food systems. Innovative financing mechanisms that link and blend climate and agricultural finance from public and private sector are a key means for implementation of CSA, as are the integration and coordination of relevant policy instruments. The adoption of CSA practices at scale will require appropriate institutional and governance mechanism to facilitate the dissemination of information and ensure broad participation" (FAO, 2012a).

The Green Economy concept was adopted at the Rio+20 as "green economy in the context of sustainable development and poverty eradication will enhance our ability to manage natural resources sustainably and with lower negative environmental impacts, increase resource efficiency and reduce waste". "Green Economy with Agriculture" was the key FAO message for Rio+20 (FAO, 2012b). Thus, CSA, which encompasses sustainable agriculture, enhanced productivity, need for adaptation and GHG mitigation with their associated technological, policy and investment implications, is the way to an evergreen future.

One of the planetary boundaries is that the world must feed itself. Although globally the availability of food is no longer a problem, the perpetuating high incidence of poverty has rendered food economically inaccessible to nearly 1 billion people who remain hungry and another billion are malnourished. Given the high rates of population and income growths

and accelerating urbanization, food demands for quality, quantity and diversity will intensify. FAO estimates that mostly in developing countries food production has to increase by 60 percent between now and 2050 to meet the demands, whereas the production resources, especially land, water, biodiversity, and fossil fuels are shrinking and becoming more fragile (FAO, 2012b).

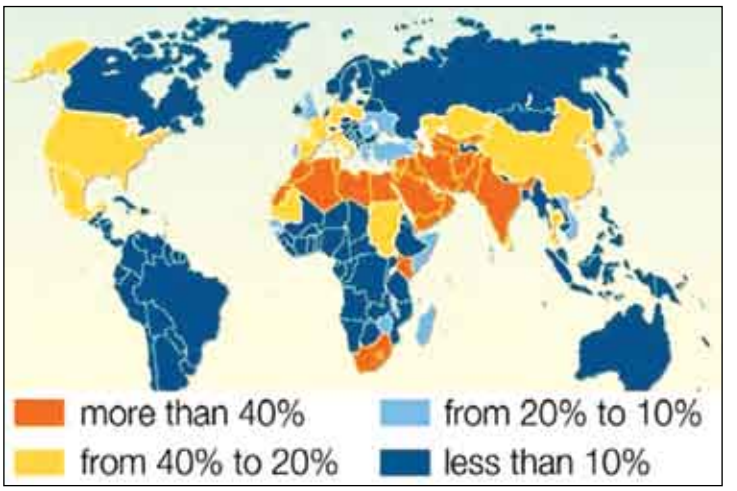
Accelerated and sustained production of food and agriculture in an agriculturally important country, like India, is a must for alleviating hunger and poverty, particularly in rural areas and for achieving assured livelihood security and equitable economic growth (World Bank, 2008). Despite the Green Revolution ushered in the 1960s and the impressive overall economic growth rate achieved by India during the last decade or so, the perpetuating high incidences of poverty and food insecurity are indeed enigmatic. It is still more paradoxical that 60 percent of the hungry and undernourished are smallholder farmers and another 20 percent are landless rural labours, the remaining 20 percent inhabit urban areas. This unacceptable situation can most effectively be addressed essentially through a vibrant, productive, and employment-friendly agriculture (along the entire value chain, from plough to plate).

While the demand for food both in terms of quality and quantity is high and increasing, the natural resource base of agricultural production, encompassing land, water and biodiversity, is shrinking and degrading fast. Moreover, competition for the resources is intensifying. The problem is further exacerbated by the increasing frequency and intensity of climate shocks and by global climate change and extreme weather fluctuations. The global warming due to rising concentration of greenhouse gases (GHGs) causing higher temperature, disturbed rainfall pattern resulting in frequent drought and flood, and sea level rise are already adversely impacting agricultural productivity and stability. In the long run, water availability will decline and uncertainty of the availability will increase considerably, putting 30% of global crop production at risk by 2025 (Fig. 1), let alone the volatile fluctuations in production.

The above climate change volatilities have greatly enhanced vulnerability especially of the food insecure people and resource-poor farmers and are growing threats to agriculture. Low-income rural populations that rely on traditional agricultural systems or on marginal lands are particularly vulnerable. It is projected that nearly 2 billion people in developing countries will be affected adversely due to climate change in the future. Recognising that poverty and hunger are the greatest polluters, the route to the Greener Future and Green Economy is to green the grey areas of chronic deprivation.

The challenge before us therefore is to develop need-based CSA processes duly supported by effective policies and institutions conducive to enhanced and sustained productivity by synergising necessary productivity enhancement, adaptation and mitigation measures. With this backdrop, my Address will briefly describe: (i) impact of climate change and the associated major stresses (extreme temperature, flood, drought, salinity, pests and diseases) on food and agriculture, (ii) climate smart technologies and strategies, and (iii) policy and institutional supports required for developing climate smart agriculture (CSA) towards an evergreen economy.

Fig. 1. *Water availability : 30% of crop production at risk by 2025*



Source: World Economic Forum (2011)

Impact of Climate Change and of Associated Stresses on Agriculture

Trend of Change and Impact on Agricultural Production

The Fourth Assessment Report of IPCC (2007) had brought out the global and regional impacts of projected climate change on agriculture, water resources, natural ecosystems and food security (Table 1). Crop and livestock production may increase in mid to high latitudes and decrease in tropical and sub-tropical areas, comprising majority of the developing countries. With the likely climatic changes, in vast areas, agriculture production will decrease and production variability will increase, suggesting spatial adjustments in cropping patterns.

Table 1. Principal conclusions of the IPCC Fourth Assessment Report

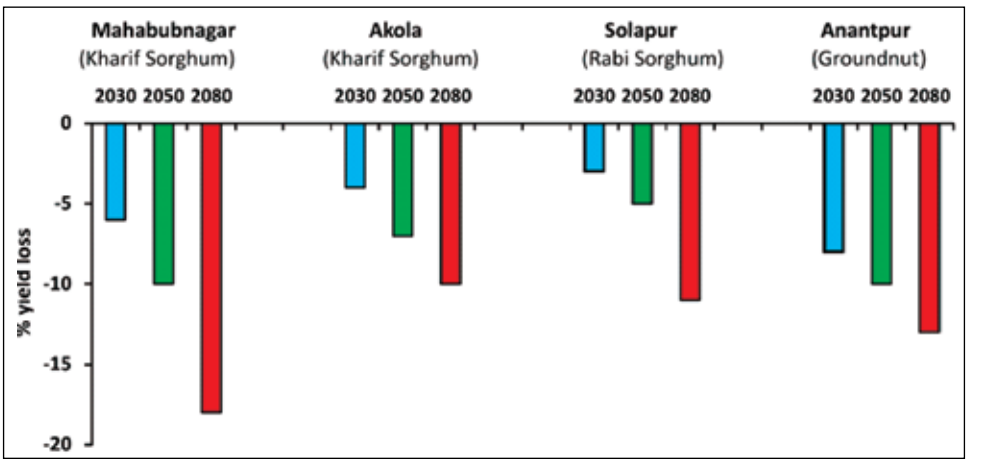
Climate change impact and direction of trend	**Probability of trend***	
	Recent decades	**Future**
Warmer and fewer cold days and nights over most land areas	Very likely	Virtually certain
Warmer and more frequent hot days and nights over most land areas	Very likely	Virtually certain
Frequency of warm spell/heat waves increases over most land areas	Likely	Very likely
Frequency of heavy precipitation events increases over most land areas	Likely	Very likely
Areas affected by drought increases in many regions	Likely	Likely
Intense tropical cyclone activity increases in some regions	Likely	Likely

**Probability classes: likely >66% probability of occurrence; very likely >90% probability of occurrence; virtually certain >99% probability of occurrence.*

Source: IPCC, 2007

India, which after a couple of decades is expected to become the most populous country in the world, is predicted to be one of the more vulnerable countries to climate change, particularly in view of its huge population being dependent on agriculture and the continuing high incidence of poverty and food insecurity. This setting will put excessive pressure on the dwindling natural resources and the mediocre coping mechanisms. The Semi-Arid Tropic districts will suffer the most. As depicted in Fig. 2, in four SAT districts in India productivity losses in selected crops will increase from 5% to 18% during 2030 to 2080 if no effective mitigation measures are undertaken.

Fig. 2. *Predicted productivity loss for major crops in Indian SAT*



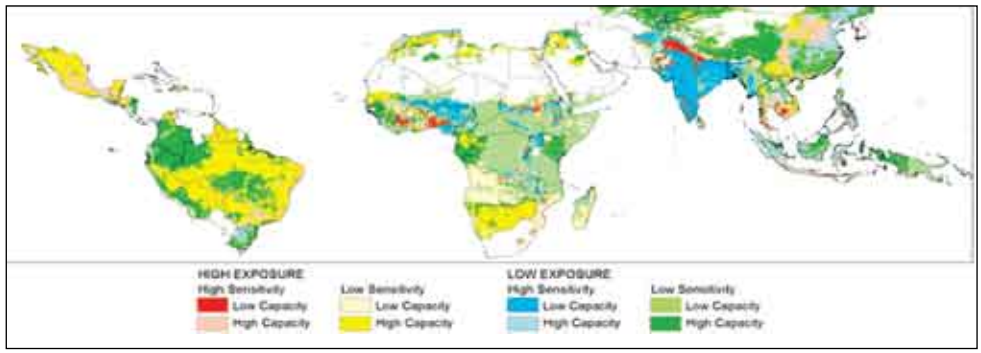
Source: ICRISAT, 2012

Global climatic changes can affect agriculture through their direct and indirect effects on crops, soils, livestock and pests. Increase in atmospheric carbon dioxide has a fertilization effect on crops with C_3 photosynthetic pathway and thus promotes their growth and productivity. Increase in temperature, depending upon the current ambient temperature, can reduce crop duration, increase crop respiration rates, alter photosynthate partitioning to economic products, affect the survival and distribution of pest populations, thus developing new equilibrium between crops and pests, hasten nutrient mineralization in soils, decrease fertilizer use efficiencies, and increase evapo-transpiration.

Indirectly, there may be considerable effects on land use due to snow melt, availability of irrigation water, frequency and intensity of inter- and intra-seasonal droughts and floods, soil organic matter transformations, soil erosion, changes in pest profiles, decline in arable areas due to submergence of coastal lands, and availability of energy.

Freshwater availability in South Asia is likely to decrease. Even the most optimistic studies indicate that South Asian agriculture will be particularly hard hit by climate risks (Fig. 3). During the last 130 years, the region has faced more than 26 droughts. Nearly 70% of the land is

Fig. 3. *South Asia faces increasing challenges due to climatic risks*



Source: Erickson et al., 2011 cited in Aggarwal, P.K. et. al. (2011).

drought-prone, 12% flood-prone and 8% cyclone-prone. While frost is common in northern regions, heat is a frequent incidence at many places.

Seven out of nine food crops could deteriorate in yield with just 1-2°C of warming by 2030. Overall crop yields are expected to decrease upto 30% in the region by mid-21 century. The most dramatic negative impacts are expected in the arid zones and flood affected areas, where agriculture is already at the edge of climate tolerance limits. Crop models indicate that average yields in 2050 may decline by about 50 percent of wheat, 17 percent for rice, and about 6 percent for maize from their 2000 levels. The Indo-Gangetic plain, which produces one-fifth of the world's wheat, is likely to be especially adversely impacted. This alone could threaten the food security of 200 million people. Globally, over 1.4 billion will be affected by the increasing frequency of drought and decreasing precipitation. According to an IFPRI study (Nelson *et al*, 2010), an increase of between 8.5 and 10.3 percent is expected in the number of malnourished children in all developing countries, relative to scenarios of perfect climate change mitigation.

The main driving force for the climate change is the increasing anthropogenic emission of greenhouse gases and their accumulation in troposphere. The decreasing number of cold days and increasing number of hot days resulting in temperature increase is already globally discernible. The warming trend in India over the past 100 years has indicated an increase of 0.60°C. Also discernible is increased water stress and reduction in number of rainy days. The projected impacts of these changes are likely to further aggravate yield fluctuations of many crops.

Indian agriculture is highly diverse with almost all major globally recognised agro-climatic and agro-ecological systems represented in the country. The soil, hydrological and agro-biodiversity regimes are likewise highly diverse and variable. Despite a substantial growth in the irrigated area, about 65% of the Agriculture is rainfed and highly vulnerable to the increasing climate change uncertainties and abiotic stresses. The frequency of occurrence of drought, over the years, has increased in the Semi Arid Tropic (SAT) region (Table 2).

Table 2. Frequency of droughts in twenty-year periods (droughts are computed based on long-term averages) in four SAT districts, India

Period	Andhra Pradesh		Maharashtra	
	Anantapur	Mahabubnagar	Akola	Solapur
1971-1990	9	5	6	7
1991-2009	8	7	9	11

Source: ICRISAT, 2012

The yield of major cereal crops is likely to be reduced due to decrease in grain filling duration, increased respiration, increased crop water demand, and/or reduction in rainfall/ irrigation supplies. Increase in extreme weather events such as floods, droughts, cyclones and heat waves will also adversely affect agricultural biodiversity. Cold waves and frost events could decrease in future due to global warming and this would lead to a decreased probability of yield loss associated with frost damage in northern India in crops such as mustard and vegetables, and even wheat. Besides yield, produce quality would also be affected.

Ding, *et.* al (2003) studied drought pattern and farmers' coping strategies in poverty-afflicted rural China and found that although drought can occur at different seasons, rice farmers suffer heavy losses by drought occurring during July and September, depressing rice production by about 9-64%. The production losses of wheat, cotton, maize and beans could also be substantial. The stress caused seasonal reduction in food consumption, which often dropped below the recommended level of calories intake particularly by the poor. Percentage loss in values for all crops at household level was 33%.

Livestock will also be adversely impacted by climate change. Increased water scarcity will suppress feed and fodder production and nutrition of livestock. Increased temperature would increase lignification of plant tissues reducing the digestibility. The heat stress in dairy animals will adversely affect their reproductive performance. Global warming would increase water, shelter, and energy requirement of livestock for meeting projected milk demand. Moreover, major impacts will be on vector-borne diseases through expansion of vector populations into cooler areas. Changes in rainfall pattern may also influence expansion of vectors during wetter years, leading to large outbreaks of diseases.

As regards fisheries, increasing sea and river water temperature is likely to affect fish breeding, migration, and harvests. The increased temperature and tropical cyclonic activity would affect the capture, production and marketing costs of the marine fish. The higher sea surface temperature will increase the coral bleaching.

Since agriculture makes up roughly 14 percent of India's GDP, a 4.5 to 9.0 percent negative impact on production implies a cost of climate change to be roughly at 1.5 percent of GDP per year. Despite a fall in the share of AgGDP, from about 55% in 1950-51 to about 14% now, the role of agriculture remains crucial on counts of nutritional and employment security. Enhancing agricultural productivity, therefore, is critical for ensuring household level food

and nutritional security and for alleviation of extreme poverty. In the absence of mitigation and adaptation strategies, the consequences of long term climate change could be even more severe on the livelihood security of the poor. Moreover, while the men and women both will be adversely impacted by the climate change, the women are projected to suffer more. With the increasing feminization of agriculture, this differential impact should be addressed judiciously.

Impact on Water and Soil

Water: Demand for irrigation is bound to increase with increased temperature and higher amount of evapo-transpiration. This may also result in lowering of groundwater table at some places, especially where electricity power is made almost free. Regarding overall water availability, the melting of glaciers in the Himalayas will increase water availability in the Ganges, Bhramaputra and their tributaries in the short run but in the long run the availability of water will decrease considerably. A significant increase in runoff is projected in the wet season that, however, may not be very beneficial unless storage infrastructure could be vastly expanded. This extra water in the wet season may increase frequency and duration of floods.

The water balance in different parts of India will be disturbed and the quality of ground water along the coastal track will be further affected due to intrusion of sea waters, exacerbating the salinity and water quality issues. Irrigation demand for agriculture in arid and semi-arid regions is likely to increase by 10% for offsetting the impact of temperature increase.

Soil: Organic matter content, which is already quite low in Indian soils, particularly in the north, would become still lower. Quality of soil organic matter may also be affected. The residues of crops under elevated CO_2 concentration will have higher C:N ratio, and this may reduce their rate of decomposition and nutrient supply. Increase of soil temperature will increase N mineralization but its availability may decrease due to increased gaseous losses through processes such as volatilization and de-nitrification. In physical terms, extreme changes in rainfall volume and frequency, wind velocity, and soil erosion will become more severe.

Climate Smart Agriculture: Technologies and Strategies

As mentioned earlier, CSA which sustainably increases productivity, enhances resilience (adaptation), and reduces/removes greenhouse gases (mitigation) is a critical process for achieving national food security and development goals. And, this can be attained through the congruence of water smart, energy smart, carbon smart, nitrogen smart, weather smart and knowledge smart moves and programmes.

Sustainable Productivity Enhancement

A three pronged approach is called for bridging the serious yield gaps. Firstly, by saving and consolidating the productivity gains already achieved, secondly, by extending the gains

to areas which are yet to benefit from technological transformations and where significant yield gaps exist, and thirdly, by achieving newer and higher productivity levels – piercing the yield ceilings through mustering modern technologies and resource management practices.

The approach must be to create rich and dynamic knowledge domains to rationalise input use, enhance input-use efficiency, thus cutting down on the excessive use of water, fertilizers and other agrochemicals. In other words, produce more from less. This is very much in line with FAO's call "Save and Grow", and one can often substitute knowledge for purchased inputs. In this context, changing land-use practices such as the location of crop and livestock production, crop rotation, especially inclusion of legumes in the rotation, sequence and duration, rotating or shifting production between crops and livestock, and altering the intensity of fertilizer, water and pesticide application can help increase yield and at the same time reduce risks from climate change in farm production.

Serious attempts towards water conservation and harvesting and improvement of irrigation accessibility and water use efficiency, coupled with fertilizer and overall input-use efficiency will be highly essential for agricultural production management. Farmers have to be trained and motivated for adopting on-farm water conservation techniques, micro-irrigation systems for better water use efficiency, selection of appropriate crops, etc. Principles of increasing water infiltration with improvement of soil aggregation, decreasing runoff with use of contours, ridges, vegetative hedges and reducing soil evaporation with use of crop residues mulch could be employed for better management of soil-water.

As we meet here in the Indian Agricultural Research Institute (IARI) campus, the original seat of the Academy, permit me to mention that the Institute has again shown the way forward to CSA. The recent release of the marvellous Pusa Basmati 1509 (Fig. 4) is a milestone development towards "more from less" and "save and grow". Being a 115 to 120 day high yielding quality rice, its per day, per litre water, and per kg fertilizer productivity is the highest in the contemporary world of Basmati or scented rices. This is easily a brilliant example of genetic alchemy for convergent economic, environmental and social transformation. This genetic improvement will further consolidate India's position as the world's leading rice exporter, particularly of high quality aromatic rice, currently valued at US$ 3.3 billion. These developments must also induce creation, implementation and institutionalization of niche and differentiated production. It is gratifying that the Hon'ble Chief Minister of Punjab, the foremost Basmati rice growing State, has taken suitable policy decisions and actions to popularise this new option.

Pusa Basmati 1509 saves at least five precious irrigations and this saved water could be deployed for producing an excellent wheat crop in the subsequent season for free (in context of water) – "save and grow" in true sense. The Institute has also come up with an equally brilliant complementary development in form of wheat variety HD 2967 (Fig. 5), yet another miracle wheat. It is an exceptionally high yielding and widely adapted variety possessing multiple resistance to rust, especially yellow rust, and, most importantly, is resistant to extreme weather fluctuations, especially heat and cold as revealed during the past wheat season which

Fig. 4. *Pusa Basmati 1509*

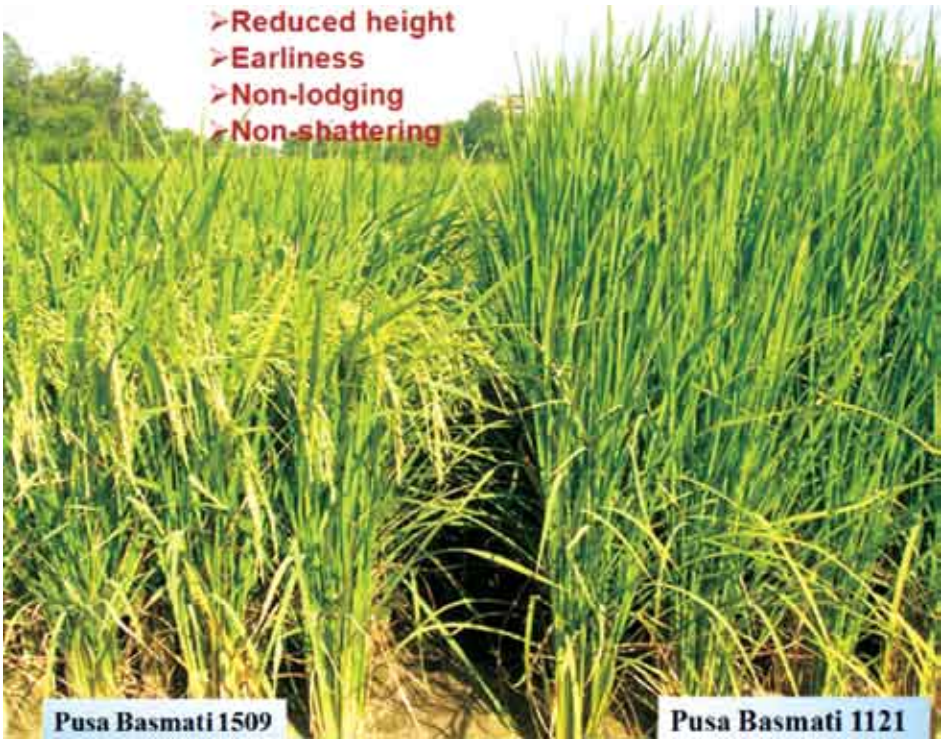
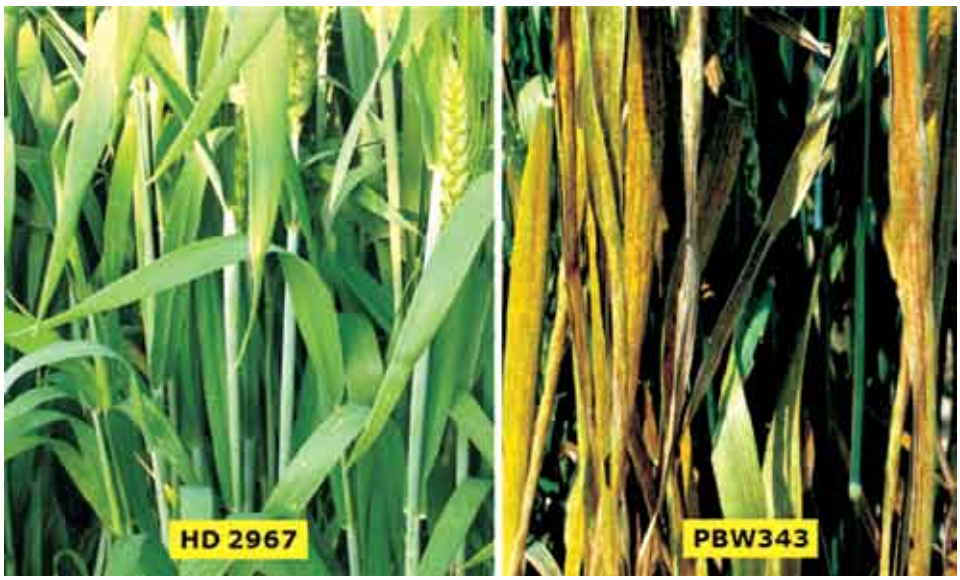


Fig. 5. *Wheat HD 2967 – Resistant to Yellow Rusts*



was rather erratic. Further, fortunately, 60 day mungbean varieties capable of yielding about 1 t/ha on an average are available. Using conservation agriculture techniques, depending on soil moisture and water availability, a catch crop of mungbean between wheat and rice is a distinct possibility, augmenting the nitrogen and carbon economy, income growth and, above all, protein nutrition.

Adaptation

Being weather-dependent, agriculture is directly affected by climate change, hence adaptation to climate change is crucial for food and agriculture security. Developing and adopting cultivars tolerant to flood, drought, heat and salinity stresses, and to biotic stresses to modifying crop management practices, improving water management, adopting new farm techniques such as resource conserving technologies (RCTs), crop diversification, and effective weather forecasts coupled with crop insurance comprise adaptation strategies. Germplasm with greater oxidative stress tolerance may be exploited for designing varieties resistant/tolerant to several biotic and abiotic stresses.

The Rice-What System : Triggered by the semi-dwarf, input responsive, and phoinsensitive HYVs of rice and wheat, the Green Revolution created a new rice-wheat intensification process. But, the process due to poor adoption of recommended practices, coupled with inappropriate policies, had adversely affected land, soil and water resources and aggravated the abiotic stresses. In India, the rice-wheat system occupies about 10 m ha of the most productive land in the Indo-Gangetic Plains (IGP). Enhanced productivity and sustained agro-ecological security of this system must be one of the highest priorities of the government. This is particularly important as the climate change is already having visible adverse impacts in this region posing a serious threat to sustainability and productivity.

The vast Indo-Gangetic Plain can be divided into four agro-ecological regions: the Western or Trans-Gangetic, Higher Gangetic, Middle-Gangetic and Lower-Gangetic Plains. The minimum temperature and rainfall have been increasing from the Western to the Lower Plains. The predominant vulnerability and corresponding adaptation strategies could be summarised as in Table 3.

Table 3. Vulnerability of the rice-wheat system due to climate change and potential adaptation strategies in the Indo-Gangetic Plains

Vulnerability mechanism	Adaptation strategies
High temperature-induced sterility in rice	Heat-tolerant rice cultivar
Rise in temperature, especially during grain filling	Adjusting sowing date, heat-tolerant cultivar, better weather forecast
Declining soil organic matter	Residue management
Rising salinity and alkalinity	Salt-tolerant cultivars
Increased pest and diseases	Improved pest management and pest resistant varieties
Late sowing of wheat	No-till wheat

Shortage of irrigation water	Water-saving technologies (laser land levelling, direct-seeded rice, no-till rice and wheat)
Frequent drought in some areas	Water-saving technologies (laser land levelling, direct-seeded rice, no-till rice and wheat)
Frequent flood in sub-regions 3 & 4	Water-saving technologies (laser land levelling, direct-seeded rice, no-till rice and wheat)
Rain and storm during maturity of rice and wheat (especially in sub-region 4)	Adjusting planting date, better weather forecast, crop insurance
Water logging and excess soil moisture in wheat	Crop diversification, no-till wheat
Widespread frequent flood in some areas	Better weather forecast, crop insurance, flood-resistant cultivar

Stress-tolerant Varieties : Plant adaptation to stress involves key changes in the 'central dogma', the '-omic' architecture, adaptive changes in genes, proteins and metabolites after individual and multiple environmental stresses. Basic understanding of physiological and molecular bases of stress management will help adopt effective crop-stress protection strategy and develop more robust varieties for high-risk environments. Advances in reverse genetics, genomics-phenomics relationships, and bioinformatics would enable systems-biology/ systems-level modelling and development of computational models. Such an approach could be exploited to strengthen plant fitness to changing climates and varying stresses.

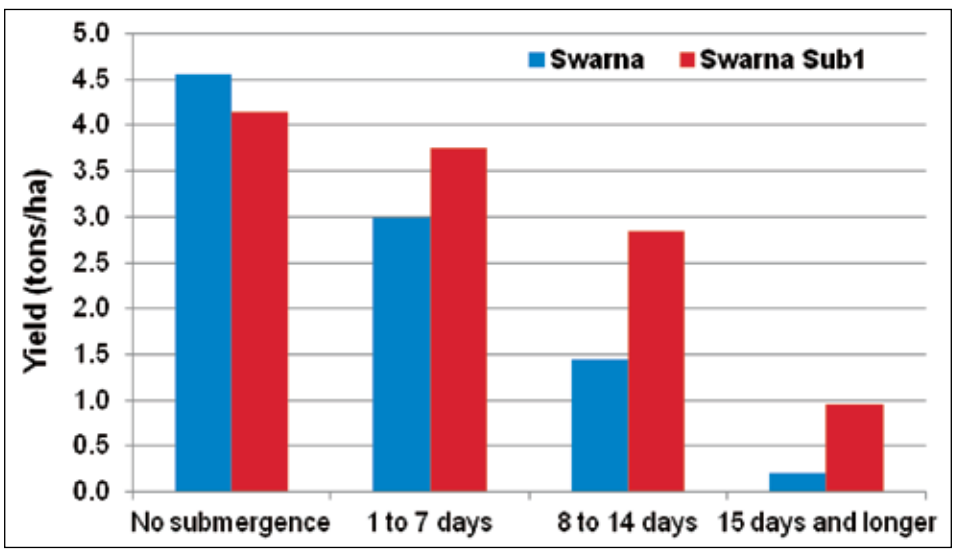
Breeding crop varieties tolerant to various abiotic and biotic stresses and combining desirable yield and other agronomic characters is the most effective way to develop climate resilient agricultural system. A good number of QTLs for abiotic stress tolerance have been identified in several crops. For instance, Sub1, an exceptionally strong QTL, conferring submergence tolerance in diverse genetic backgrounds of rice under different environments, is being widely utilised in flood-prone rice growing areas (Fig. 6). A marker-assisted backcrossing

Fig. 6. *New Sub1 lines after 17 days submergence in the field at IRRI*

(MAB) approach was developed at the International Rice Research Institute (IRRI) and in several national programmes, including India, to introgress Sub1 in mega varieties which are already popular with famers and consumers, such as Swarna, TDK1, and Samba Mahsuri in India.

Swarna-Sub1 has already been released for commercial production and is significantly contributing to enhanced and sustained production under flooded conditions with 2-4 weeks of submergence, out-yielding the original intolerant Swarna by about 30-35%. A recent study in Eastern UP and Odisha provinces had shown that Swarna-Sub1 has yield advantage of 0.7 (23%) and 1.5 tons/ha (95%) over Swarna when length of submergence has 1 to 7 and 8 to 14 days, respectively (Fig. 7). Despite most families in the surveyed area in Odisha were affected, only 9% had adopted Swarna-Sub1, where as in Eastern UP the adoption rate was 35% (Yamano, T, et al. 2013). Thus, the adoption rate of Swarna-Sub1 in both the provinces and other such areas should be promoted to save the huge losses suffered recurrently in the flood-prone areas. The National Food Security Mission (NFSM) has included Swarna-Sub1 in its eastern India programs in 2010. About 38,000 tons of seed were distributed, reaching an estimated 1.3 million farmers in 2012 alone.

Fig. 7. *Yields of Swarna and Swarna-Sub1 under submergence in eastern India*



Source: Yamano, T. et al., 2013

Other submergence tolerance genes distinct from Sub1 have also been identified and their use will help in diversifying the genetic base and tolerance to varying submergence conditions. Moreover, genes conferring drought as well as salinity tolerance have been pyramided with the submergence tolerance genes, rendering Swarna tolerant to multiple stresses (IRRI-STRASA project).

Diversification : The rice-wheat system has often been hard particularly on underground water resources, especially due to high water requirement of rice. Crop diversification out of rice to save water without sacrificing farmers' income should be a viable option. In this context the newly available determinate high yielding (about 2.5 t/ha) and short duration (120-125 days) pigeonpea genotypes developed at IARI and elsewhere can fit in a pigeonpea-wheat cropping pattern with economic returns analogous to those from the prevalent rice-wheat system, plus a huge bonus in terms of soil fertility, reduced water consumption and enhanced human nutrition. The system could be still more productive and sustainable with drip irrigation for the pigeonpea crop. Notwithstanding the bright prospect, I may forewarn that determinate pigeonpeas are highly prone to pod borers and the stipulated cropping pattern will not work unless cost-effective and environment-friendly pest management practices are available and widely-adopted. Other such options should be developed as per the location-specific settings.

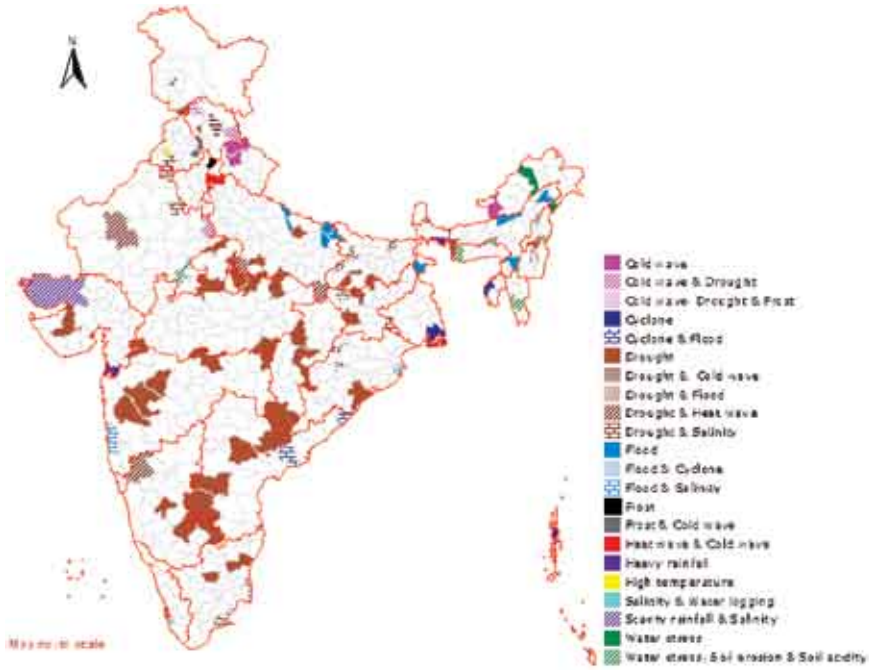
Needless to assert, under the above circumstance, GM/GE pigeonpea, as Bt cotton, should prove a boon. But, paradoxically, the good science is being throttled and kept away from serving the humanity. The pigeonpea genome has already been mapped by our scientists. It will almost be a crime not to benefit from this pioneering world leadership in science and technology. The Academy must rise to the occasion and take science and technology to those who need it the most, especially the huge population of the poor and the hungry. I must thank the Fellowship for its strong support to this cause.

National Initiative on Climate Resilient Agriculture (NICRA) : The National Initiative on Climate Resilient Agriculture (NICRA) project of India, encompassing : (i) strategic research to address long-term climate change, (ii) demonstration of innovative and risk management technology in different parts of the country, (iii) funding competitive research, and (iv) capacity building of different stakeholders for greater awareness and community action, is an exemplary step. This initiative covers diverse sectors of agriculture from agronomy to livestock involving different departments and stakeholders. The action researches are implemented in a structured way starting from identification of vulnerable districts, involving the Krishi Vigyan Kendras (KVKs) (Agriculture Knowledge Centres) choosing representative village cluster(s) for intervention selecting interventions in a participatory mode (community approach), and monitoring of the efficacy of the interventions. Some of the interventions implemented are: direct seeded rice, staggered community nursery, community seed bank, weather literacy, residue incorporation and custom hiring for farm implements, among others. Additional proven interventions such as alternate wetting and drying in rice cultivation (only where assured irrigation available), use of biofertilizers, use of leaf colour chart, deep placement and coating of urea etc. could also be scaled-up.

While aggregate macro level data and trend are helpful in formulating broad policy frameworks and options, micro level vulnerability mapping is a must for initiating effective actions at the ground level and for assigning priorities for investment and action. The NICRA has undertaken this task and already mapped most vulnerable 100 districts. The mapping must penetrate lower levels – sub-district, block and village in order to target the most vulnerable and needy.

The following four technology assessment modules have been designed and are being linked in the priority 100 spots (Fig. 8) to assess their efficacy (Venkateswarlu, 2013).

Fig. 8. 100 Districts selected for Technology Assessment



Source: Venkateswarlu B., 2013.

"**Module I:** Natural resources : Interventions related to soil health, in-situ moisture conservation, water harvesting and recycling for supplemental irrigation, improved drainage in flood prone areas, conservation tillage where appropriate, artificial ground water recharge and water saving irrigation methods.

Module II: Crop Production :Drought/temperature tolerant varieties, advancement of planting dates of rabi crops in areas with terminal heat stress, water saving paddy cultivation methods (SRI, aerobic, direct seeding), frost management in horticulture through fumigation, community nurseries for delayed monsoon, custom hiring centres for timely planting, location specific intercropping systems.

Module III: Livestock and Fisheries : Use of community lands for fodder production during drought/floods, improved fodder/feed storage methods, preventive vaccination, improved shelters for reducing heat stress in livestock, management of fish ponds/tanks during water scarcity and excess water, etc.

Module IV: Institutional Interventions : Institutional interventions either by strengthening the existing ones or initiating new ones relating to seed bank, fodder bank, commodity groups, custom hiring centre, collective marketing group, introduction of weather index based insurance and climate literacy through a village weather station will be part of this module."

Built-in flexibility in the design and implementation of the modules provides for dynamic adjustments to address issues as they appear. Another important feature of this programme is that it is comprehensively documenting perceptions of local farmers, indigenous coping mechanisms and the associated knowledge in all the 100 districts towards attaining a sustainable climate resilient agriculture.

Mitigation

In India, Agriculture accounts for about 17% of the GHG emissions against 22% by the Industry and 58% by the Energy sectors. In the Agriculture sector, the contribution of livestock is 63%, rice 21%, agricultural soils 14%, residue burning 2% and manure management 1%. It accounts for over 80 pcercent of water withdrawal in the country. Obviously, major mitigation strategies would encompass: livestock feeding and enteric fermentation management, especially development of probiotics and feed supplements; improved methods of rice cultivation to reduce methane emissions; efficient use of water, fertilizers and other inputs and crop management; conservation of land, water, biodiversity and other natural resources; conservation of energy and development and production of renewable energy sources; development and wide adoption of conservation agriculture and carbon sequestration practices; and formulation and implementation of science-informed policies coupled with suitable incentives for effectively adopting adaptation and mitigation measures.

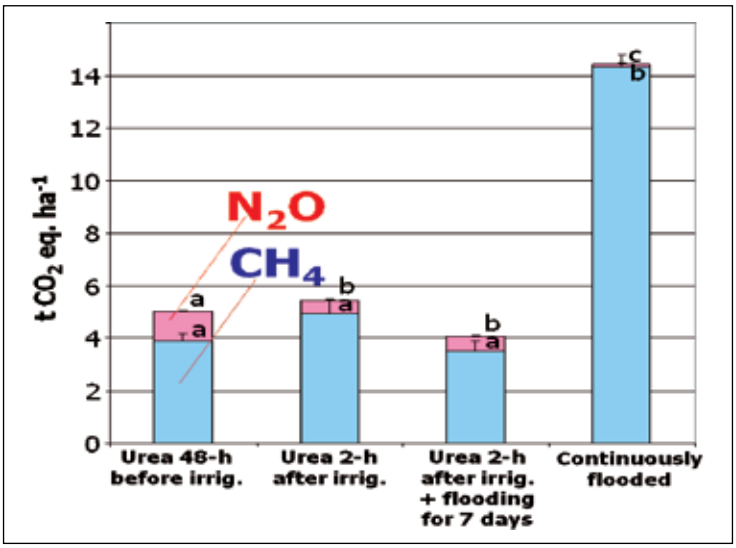
Climate change mitigation options fall into two broad categories : (i) increasing removals of GHG primarily through carbon sequestration and (ii) reducing emissions, which in the case of crops effectively means reducing N_2O emission by improving efficiency of N use, and in case of rice paddies and ruminants it relates basically to reducing methane emissions.

Among crops, rice cultivation is the main source of GHG emission, especially CH_4 = 21CO_2 eq and N_2O = 298 CO_2 eq. As depicted in Fig. 9, methane is the predominant emission under alternate wetting and drying (AWD) water management, ranging from about 2.8 t CO_2 eq. ha^{-1} to 4.5 t CO_2 eq. ha^{-1}, whereas under continuous flooding, only methane is emitted, averaging about 14.2 t CO_2 eq. ha^{-1}. Only under AWD, N_2O is emitted, ranging from 0.2 to 0.5 t CO_2 eq. ha^{-1}. The studies from IRRI on GHG emissions on flooded rice (Ladha, 2013) have thus revealed that :

- Water management is most crucial for CH_4 and N_2O emissions especially in paddy rice,
- N fertilizer has no effect on CH_4 and N_2O in rice-rice under continuous flooding,
- CH_4 is only emitted under continuous flooding,
- CH_4 emissions decreased and N_2O increased with alternate wetting and drying or marginal flooding, and
- N fertilizer rates affect N_2O emissions under marginal flooding.

Based on the above findings, for mitigating methane emission from rice cultivation, the following strategies could be adopted: (a) altering water management, particularly promoting mid-

Fig. 9. Global Warming Potential of CH_4 and N_2O under alternate wetting and drying



Source: Ladha, J.K., 2013

season aeration by short-term drainage and intermittent drying; (b) improving organic matter management by promoting aerobic degradation through composting or incorporating it into soil during off season drained period; (c) using rice cultivars with few unproductive tillers, high root oxidative activity and high harvest index; and (d) applying fermented manure like biogas slurry in place of unfermented farmyard manure.

As mentioned earlier, livestock are the main emitter of methane. Methane emission from ruminants can be reduced by altering the feed composition to reduce the percentage which is converted into methane without compromising the milk and meat yield. Under the project on Reducing Emissions from Livestock Research Program (RELRP), manipulations of both genetic potential and feed are being pursued. Three biological control methods are being examined for their ability to reduce methane production from livestock.

As regards nitrous oxide, the most efficient management practice to reduce the emission is site-specific nutrient management (SSNM). The emission could also be reduced by nitrification inhibitors such as nitraphyrin and dicyandiamide (DCD). There are some plant-derived organics such as neem oil, neem cake and karanja seed extract which can also act as nitrification inhibitors.

Likewise, mitigation of CO_2 emission from agriculture can be achieved by : (a) Increasing carbon sequestration in soil through manipulation of soil moisture and temperature; (b) Setting aside surplus agriculture land, and restoration of soil carbon on degraded land; and (c) Adopting soil management practices such as reduced tillage coupled with mulching, manuring, residue incorporation, improving soil biodiversity, and micro aggregation, which can enhance carbon sequestration in soil.

Conservation Agriculture (CA) is being increasingly promoted in context of sustainable agriculture and climate smart agriculture, including as a mitigation measure. It comprises three basic components : (i) reduced tillage, (ii) retention of crop residues on soil surface, and (iii) crop diversification (rotation, intercropping, relay cropping etc.). Notwithstanding the role of conservation agriculture in water and energy saving and in improving soil conservation and soil organic carbon, soil carbon sequestration has probably been "oversold" as a climate change mitigation measure. As recently reviewed by Clare Stirling of CIMMYT at the South Asian CCAFS meeting, March 2013, a Brazilian study on the impact of reduced tillage on soil carbon content had revealed that while 26 years of continuous no-till increased soil C in upper layers, it decreased soil C in lower layers. Under conventional tillage, carbon content was fairly even. Stirling underscored that the serious impacts of trace gases (N_2O) have been overlooked. She asserted that overemphasis has been placed on modest C gains in arable soils which has diverted attention from larger climatic change issues, such as : soil organic carbon loss from high-C soils (forests, grasslands, peats), and inefficient N use and N_2O emission. The message she gave was that for climate change mitigation in crops – think N. Mitigation measures should follow best management practices and aim to optimise fertilizer N use efficiency.

In India, good opportunities exist for scaling up and scaling out several of the above options. The country already has an extensive research information to reduce field level emissions in rice cultivation and is supporting complementary policy option and actions for promoting new forms of fertilizers (neem coated urea, customized fertilizers, etc.), alternative systems of rice intensification and direct seeded rice. Further, vast degraded lands (120 m ha) exist in the country which can be brought under tree cover to promote carbon sequestration. Upcoming major schemes on promotion of renewable energy and energy efficient equipment in agriculture and irrigation, and support for CA systems in irrigated regions are encouraging moves. R&D outputs like probiotics and feed supplement to reduce emission in intensive dairy systems deserve due support.

The GHG mitigation potential of the most promising technologies and their constraints are summarised in Table 4. Some technologies such as intermittent drying, site-specific N management can be easily adopted by the farmers without extra investment whereas other technologies need economic incentives and policy support.

Table 4. Potential and constraints of greenhouse gas mitigation options

Option	Mitigation potential	Constraints
Methane from rice field		
Intermittent drying	25-30%	Assured irrigation
Direct-seeded rice	30-40%	Machine, herbicide
System of rice intensification	20-25%	Labour, assured irrigation
Methane from ruminants		
Balanced feeding	5-10%	Small holding, awareness
Feed additives	5-10%	Cost, biosafety, incentives to use probiotics and feed supplements

Option	Mitigation potential	Constraints
Nitrous oxide from soil		
Site-specific N management	15-20%	Awareness, fertilizer policy, lack of availability
Nitrification inhibitor	10-40%	Cost, appropriate equipment, training and absence of incentives for deep placement of N fertilizers

Source: Pathak et al. (2010)

Adaptation-led Mitigation

Despite adaptation being so very important for developing climate-resilient agriculture and food security, only mitigation issues had predominated in the UNFCC. However, after the CoP13 in Bali, adaptation is also being considered forcefully. With the increasing emphasis on food security, the developing countries have succeeded at global fora and negotiations in putting adaptation firmly at the table. Adaptation needs should be carefully assessed. At the same time, mitigation potentials should also be assessed with food security and rural poverty in sight. Also, the global commitment to mandatory mitigation from 2020 should be kept in mind. In my view, adaptation and mitigation are two mutually reinforcing pillars of climate resilient agriculture. Most developing countries are often confronted with the problems of low-yield, low-income and instable production. Under these settings, science and innovations should focus on adaptation strategies to enhance productivity, resources use efficiency and income growth, and adaptation-led mitigation. India's agriculture, agro-ecologically diverse as it is, should be assessed for its carbon, methane and N footprints across agro-ecologies and differentiated adaptation-mitigation plans should be prepared. In particular, dynamic relations of rice ecologies and livestock farming in context of GHG emissions should be analysed.

Emphasising that CSA is not a specific technology, but is a highly location-specific process addressing specific socio-economic and agro-ecological situations, in India since agriculture is the main driver of alleviation of food insecurity and poverty, adaptation assumes greater urgency. Adaptation strategies will include activities like genetic restructuring, altered agronomic practices, diversification, integrated farming systems, efficient use of natural resources etc to meet the micro (farm level) as well as macro level situations.

Policy and Institutions

Major Policy Changes Needed to Save the Planet Earth

In June 1992, one hundred and ten Heads of Governments discussed the state of environment at a world platform and prepared a plan for the Earth's future. For the first time, world politicians and civil society came to realize that "climate change" and "greenhouse gases" are problems and impact real people across the world.

Since 1992, several global, regional and national policies and programmes to save and conserve the environment, and to grow simultaneously, were launched with varying successes.

Global conventions, such as those on desertification, biodiversity and climate change were held. Several countries established corresponding national programmes. For instance, India launched some of the major national programmes such as the National Biodiversity Authority, National Rainfed Area Authority and National Initiative for Climate Resilient Agriculture to meet the challenges.

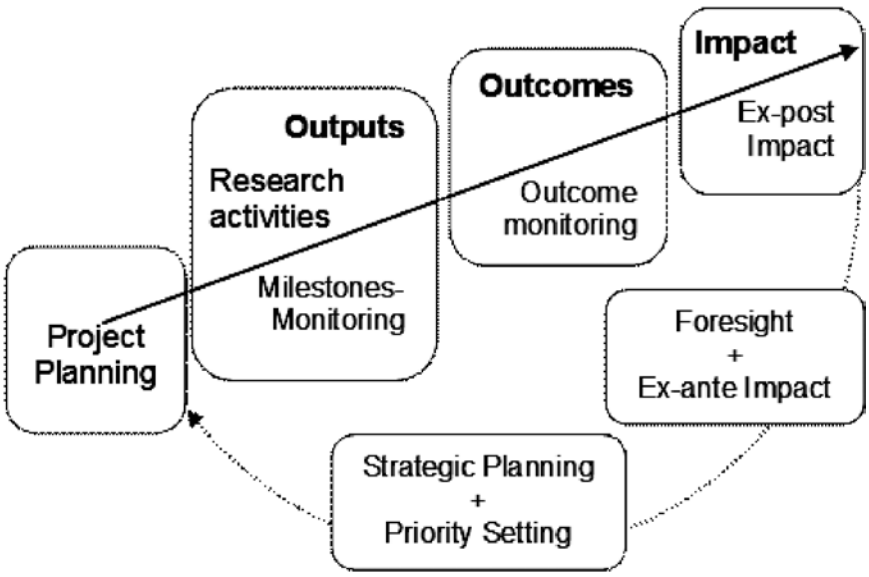
Despite the veritable developments and the increased scientific understanding of environmental degradation, the demographic, social, economic, ecological and environmental problems have exacerbated. The Pressure on Planet Earth has intensified. In order to critically review the situation since Rio 1992 and to develop necessary policies, action plans and global alliances, the United Nations held the Global Conference on Sustainable Development 20 years later in the same city of Rio de Janeiro from 20 to 22 June, 2012. Its agenda recognized that the humanity will face threats to water, food, biodiversity and other critical resources which will continually intensify economic, ecological and social crises.

Nobel Laureate Professor Elinor Ostrom, Planet Under Pressure Chief Scientific Advisor, had observed that "the concept of the Anthropocene heralds a profound shift in perception of our place in the world. Given the mounting evidence of the sheer scale of global changes we are witnessing, the scientific community has a responsibility to urge public officials, citizens, and private firms in all countries to focus on the need for major policy changes to avoid irreparable damage to our planet." The conference on Planet Under Pressure : New Knowledge Towards Solutions was organised three months before the Rio+20 in London from 26-29 March 2012. Its Declaration had echoed Prof. Ostrom's sentiments and comprised invaluable input for the Rio+20.

The Rio+20 prepared a blueprint to keep the humankind within safe natural boundaries. In this context, it organized a five-day Forum on "Science, Technology and Innovation for Sustainable Development" from June 11 to 15, 2012, in Rio de Janeiro, and the outcome of the Forum was internalized in the Rio+20 Declaration. The main topics included: Human Wellbeing and Population Trends; Sustainable Consumption and Production; Climate and Other Environmental Changes; Food Security; Water Security; Urban Environment and Wellbeing; The Contribution of Biodiversity and Ecosystem Services to Sustainability; Indigenous Knowledge and Science: From Recognition to Knowledge Co-production; Disasters; Energy; and Green Economy and Rethinking Social and Economic Models. The Green Economy plank emphasised improved human well-being and social equity, whilst significantly reducing environmental risks and ecological scarcities.

Impact Pathways

Climate Change and Agriculture and Food Security (CCAFS) programme of the CGIAR, in South Asia, headquartered in New Delhi, has recently been institutionalising the Impact Pathway approach in the national and regional programmes as reproduced below (CCAFS, 2013). The approach allows establishment of explicit pathways to outcomes and impact, and a sense of shared purpose among implementers. The approach helps identify and consolidate synergies among programmes and better understand the needs of end users and next users.



The impact pathway approach is likely to provide a vision of the following questions:

- What was the situation like before the programme started? What were the unmet needs and requirements of next users and end users?
- What are the next users now doing differently?
- How are programme outputs disseminating (scaling out)?
- What political support is nurturing this spread (scaling up)?
- What are the end users doing differently?
- What are the benefits they are enjoying as a result of the programme?
- Are some end users groups benefiting more or less than others?

India and CCAFS in partnership can derive significant mutual benefits. For instance, there are the areas in which CCAFS has been working in some parts of India and there is a good scope to out-scale and up-scale CCAFS Climate Smart Village (CSV) initiative in several parts of the country through the National Initiative on Climate Resilient Agriculture (NICRA) programme. Likewise, CCAFS has been implementing index based insurance in Vaishali district, Bihar of India and there is ample scope for collaboration in this sector with AIC. CCAFS has been partnering with IFFCO Kishan Sanchar Limited (IKSL) in providing agro-advisories in climate smart villages in Bihar and IKSL will further expand areas for this work. On request, the IKSL will assist in piloting similar activity in other countries in South Asia.

NICRA can emerge as an international model and can establish partnership with other international programmes, such as CCAFS for undertaking training on downscaling climate

scenarios and climate analogues; applying Decision Support System for defining R&D priorities, capacity building and data sharing; evolving protocols and toolkits for climate smart villages; and conducting case studies on mainstreaming climate resilient agricultural activities into regional development plans.

Mainstreaming Climate Smart Agriculture into National Policy

Socio-economic divides and inequalities, worsening under the changing climate and intensifying biotic and abiotic stresses, are main hurdles in reducing hunger and poverty in developing countries. Location-specific and community-based activities to develop climate smart agriculture thus deserve greater attention. Science must continuously enrich development by providing rigorous scientific evidences which will sensitize policy makers and help institutionalize science-policy interface at national, regional and global levels. National capacities for multi-disciplinary and participatory research, knowledge generation, building databases, science-informed policy-formulation, strategic planning and program implementation will need to be strengthened. A scientific approach and understanding what drives adoption or dis-adoption or mal-adoption should help guide the national system in making more informed choices and decisions on guiding policies and investments.

Efficacies of different policies related to climate resilient agriculture and effectiveness of their implementation should be critically assessed. Policies such as those on Agriculture, Disaster Management, Food Security, Water, Land etc. should be synergistically converged at different levels, particularly at the grassroots, such as at the level of the climate-smart villages. Institutional adjustments and inter-ministerial convergence are needed to ensure judicious implementation. Development of climate smart agriculture (CSA) should be mainstreamed into the national policy with suitable investment and financing provisions.

The GOI has taken several initiatives to meet the challenges. It launched the National Action Plan on Climate Change in 2008, and the National Mission for Sustainable Agriculture (NMSA) in 2010. The thrust areas of NMSA include: Dryland Agriculture, Access to Information, Biotechnology and Risk Management. Some of the National Missions are directly impacting the CSA movement. For instance, the National Mission on Micro Irrigation impacts both adaptation and mitigation as well as sustainable intensification, and promotes linkages among concerned CSA interventions.

Community based actions, including land allocation and reallocation within the village, managing local water bodies to better cope with drought, and providing weather forecasts and other related information to cope with adverse events, such as drought, prove extremely helpful in coping with the adverse effects. For instance, Chinese rice farmers cope with drought by adopting: (i) spatial diversification: village committee distributes land to farm households in such a way that each household has a land portfolio consisting of different qualities of land, which helps to reduce the production risk through diversification of land type, (ii) income diversification: 39% of income is from farm cultivation, of which half is from rice; 15% from animal husbandry and 46% from a range of non-farm activities, (iii) cultivation flexibilities: farmers cope with drought by postponing rice transplanting timing and adjust

planting of other crops, and (iv) adjustment in agricultural input by reducing chemical use (Ding, *et al.*, 2003).

The Crisis Management Plan of the GOI (2012) reported that annually 50 million people are exposed to chronic drought. Sixteen percent of India's land area is drought prone and 68% of the land area sown is exposed to drought. The Southwest monsoons account for 86% of rainfall occurring in 100-120 days. Thirty three percent of land receives less than 750 mm of rainfall, and is classified as chronically drought prone. Rainfall is erratic in four out of ten years. Per capita water availability is rapidly declining due to population and urban growth, industrialization, cropping intensity and depleting groundwater. Unfavourable rainfall pattern and frequency of occurrence of extreme events such as drought and temperature events are becoming highly discernible over the years. It is estimated that 5700 sq. km of coastal area in India will be lost due to 1 m sea level rise, displacing 7.1 million people resulting in significant economic losses.

The ongoing programmes need to be strengthened and the CSA framework and the pathways may internalise the following experiences gained in several countries (FAO, 2012b).

- Assessing the current situation, defining the baseline (business as usual) and alternative development pathways.
- Understanding barriers to adoption of CSA practices which may include technological, institutional, financial, services and market constraints.
- Information on existing and expected social, economic and environmental development settings as assessed through deploying effective and realistic indicators. As variability and vulnerability have been increasing, efficacy of various CSA practices should be assessed and both autonomous adaptation and adaptation to abnormal weather fluctuations and to extreme variations should be strengthened by ensuring access to reliable information and appropriate CSA practices. Agricultural insurance, based particularly on weather indices deserve priority attention. Managing climate risk.
- Defining coherent policies (technical, institutional and economic priorities) and policy levers for adoption of cost-effective adaptation and mitigation measures for sustainable food and livelihood security.
- Guiding investment based on cost benefit analyses of various adaptation and mitigation practices.

Climate Smart Villages : Climate Smart Agriculture must be rooted in climate smart villages. The smartness must be realised at the ground and grassroot level by developing Climate Smart Villages (CSV) through invoking effective partnership of village committees and other stakeholders to assure convergence of innovative agricultural risk and resource management strategies and services. The South Asian CCAFS programme has taken lead in establishing climate smart villages in India (Aggarwal, *et al.*, 2012). The main components of such a climate smart agricultural system at the village/farm level are:

- Weather smart: seasonal weather forecast, ICT-based agro advisories, index-based

insurance, climate analogues

- Water smart: aquifer recharge, rainwater harvesting, community management of water, laser-levelling, on-farm water management
- Carbon smart: agroforestry, conservation tillage, land use systems, livestock management
- Nitrogen smart: site-specific nutrient management, precision fertilizers, catch cropping/ legumes
- Energy smart: biofuels, fuel efficient engines, residue management, minimum tillage
- Knowledge smart: farmer-farmer learning, farmer networks on adaptation technologies, seed and fodder banks, market info, off-farm risk management-kitchen garden

Management of Climate Risk and Agricultural Insurance : Although, India is the 4th largest country in terms of insuring agriculture in the world, and index based insurance is being adopted in many parts of the country, the efficacy of the system is yet to be proven. The main challenges faced are: (i) small and scattered farm holdings, and (ii) remoteness of the farms and paucity of farm level data. To meet these challenges, institutional supports and infrastructure development is required. Several developed countries provide huge support to the farmers either through subsidies and/or directly meeting a portion of costs of insurance. India should also provide such support by strengthening regulatory framework for the insurance scheme, developing reliable and comprehensive data and information systems, building capacity and climate literacy programs, developing viable and cost effective insurance products, and subsidising the insurance and risk financing programmes. As a matter of fact, the National Commission on Farmers (2006) had recommended that a National Agricultural Risk Fund should be established to meet not only the emergency needs but also to institutionalise the risk management process.

Certain climate changes, viz. warming, manifest in a more predictable manner year after year, and thus farmers adopt proven new technologies, a sort of gradual adaptation. But, usually the changes are disruptive and unpredictable. Risk profile of CSA practices should also be understood to be prepared to reduce the vulnerability of farmers to climate risk.

Communication Science and Technology and Partnerships : We are proud of our Fellows and other scientists for their sterling contributions to the Green Economy through ever-greening the agriculture by developing the CSA processes. The development of Pusa Basmati Rice 1509, HD 2967 wheat, the short duration productive determinate pigeonpea and mungbean varieties and the associated agronomic and natural resource management practices is truly an exercise in convergence of what I have earlier said gene smart, water smart, energy smart, climate smart and income smart practices and approaches. However, we have failed both at national and international levels to suitably and adequately communicate these outstanding achievements to the veritable stakeholders – political leaders, policy makers, scientists, development partners, farmers, consumers, and the civil society. Our national research, education and extension systems, the NARIs, must strengthen their communication

science and technology capacities to ensure effective and timely communication of actual and potential impacts of their products and outcomes.

It can hardly be overemphasised that multi- and inter-disciplinary research, technology generation and technology transfer in a partnership mode is the only way to go forward. Notwithstanding the unmindful splitting of SAUs, ICAR may also be required to undertake institutional transformation to ensure effective synergistic integration of activities and sub-systems. Having shown the paths for increasing productivity and environmental security, as mentioned above, National Institutes and Deemed Universities should be empowered to judiciously and rigorously integrate the efforts located within the four walls of the Institute without compromising the proverbial independence and autonomy of individual scientists and centres. The process needs to be critically evaluated with clearly defined accountability of all partners.

As regards farmers, ICT-based agro-advisories have been promoted by private sector in India. IFFCO Kisan Sanchar Limited (IKSL) is one of such initiatives reaching millions of farmers. The service has two major components: push component through which agro-advisory is disseminated to the farming communities (both in voice and text through mobile phones), and the pull component through which farmers are provided advisories on their real time problems in farming. Farmers could ask questions using helpline and get instant advisories/suggestions on farming operations. In this way, a two-way communication is possible between the experts and farmers. In order to enhance sustainability of the services and to bring more benefits to the community, community groups need to be further mobilized and strengthened. The voice messages delivered through mobile phones are a minute each covering diverse areas of farming systems (crop management, animal husbandry, horticulture, plant protection, weather information, market information, human health and hygiene etc) which are contextualized in the local language. Other such initiatives, viz. Digital Green deserve public sector support for content development, training at grassroot level, and for augmenting the feedback mechanisms and the knowledge pool.

Epilogue

Agriculture which impacts as well as gets impacted by climate change, is required to address simultaneously three overarching challenges: ensuring sustained food and nutritional security through sustainable enhanced productivity and income, adapting to climate change (enhancing resilience to climate change), and contributing to climate change mitigation.

A climate-smart and sustainably productive agriculture is therefore a must for assured livelihood security in an agriculturally-important country like India where over 600 million people are directly dependent on agriculture. Enigmatically, a good proportion of farmers are food-insecure and resource-poor and are faced with the increasing climate change volatilities and vulnerability. Thus, an agriculture which will sustainably increase production and resilience (adaptation) and remove greenhouse gases (mitigation) is needed. These three objectives and the related activities interact in a complex manner and cut across a number of stakeholders, seeking synergistic integration of gene smart, water smart, soil and nitrogen smart, energy

smart, carbon smart, weather smart, and knowledge smart development pathways to green the economy.

Given the high location-specificity of agriculture and climate change, baseline information on critical factors and input and output markets will be essential for appropriate decision-making by farmers and other stakeholders. Climate smart village programmes should thus be judiciously piloted and up-scaled. Further, keeping in view the persisting high incidence of food and nutritional insecurity and the intensifying abiotic and biotic stresses, emphasis should be placed on adaptation-led mitigation. Investment in science and research for development and the associated human resources should be suitably enhanced and linked with an effective monitoring, evaluation and impact mapping system. Innovative approaches to social safetynets will be needed to augment household resilience. The science-policy interface must be institutionalised to ensure that the rigour of science sensitizes policy makers and guides the policy process, options, actions, investment, incentives, and even implementation. Development of climate smart agriculture should thus be mainstreamed into the national policy as we move towards an EverGreen Economy.

The Green Economy movement, noble as it is, will be green and evergreen only when the dark shadows of poverty and hunger, often lengthening, are removed for ever. The climate change volatility and high vulnerability has exacerbated the problems. The time is not on our side. The millions of hungry children cannot wait. The Right to Food must be operationalised truthfully. Moreover, overall annual GDP growth rate of 8 to 10 percent in the past has slipped to 5 percent now. The days ahead are not easy. We must act now.

References

1. Aggarwal, P.K., Joshi, P., Campbell, Bruce, Vermeulen, S. and Kristjanson, P. (2012). Adapting South Asian Agriculture to Climate Change and Declining Resources, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

   http://blogs.ubc.ca/foodsecuritypolicyinasia/files/2012/02/Presentation_Aggarwal.pdf

2. Ding, S., Pandey, S., Chen, C. and Bhandari, H. (2003). Drought and Farmers' Coping Strategies in Poverty-Afflicted Rural China. pp 19

3. Erickson et al., 2011 cited in Aggarwal, P.K., Joshi, P., Campbell, Bruce, Vermeulen, S. and Kristjanson, P. (2012). Adapting South Asian Agriculture to Climate Change and Declining Resources, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

   http://blogs.ubc.ca/foodsecuritypolicyinasia/files/2012/02/Presentation_Aggarwal.pdf

4. FAO (2012a). Developing a Climate-Smart Agriculture Strategy at the Country Level : Lessons from Recent Experience. Background paper for the Second Global Conference on Agriculture, Food Security and Climate Change. Hanoi, Vietnam, 3-7 September 2012.

5. FAO (2012b). Greening the Economy with Climate-Smart Agriculture. Background paper

for the Second Global Conference on Agriculture, Food Security and Climate Change. Hanoi, Vietnam, 3-7 September 2012.

FAO (2013). http://www.fao.org/climatechange/climatesmart/en/

6. GOI (2012). The Crisis Management Plan : Drought. Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation. pp 33
7. ICRISAT (2012). Vulnerability to Climate Change: Adaptation Strategies & Layers of Resilience. Policy Brief No. 17. Climate Change Realities and Policy Coherence in SAT India. International Crops Research Institute for the Semi-Arid Tropics Patancheru 502 324, Andhra Pradesh, India. pp 8
8. IPCC (2007). Climate Change 2007: Synthesis Report : An Assessment of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland. pp 104
9. NAPCC (2008). National Action Plan on Climate Change. Prime Minister's Council on Climate Change. Government of India. pp 56
10. NCF (2006). Serving Farmers and Saving Farming. Fifth and Final Report, 4 October 2006. Jai Kisan : Revised Draft National Policy for Farmers. National Commission on Farmers, Ministry of Agriculture, Government of India. pp 50
11. Pathak, H., Bhatia, A., Jain, N. and Aggarwal, P.K. (2010). Greenhouse gas emission and mitigation in Indian Agriculture – A review, In ING Bulletins on Regional Assessment of Reactive Nitrogen, Bulletin no. 19. (Ed. Bijay Singh), SCON-ING, New Delhi, 34 p.
12. Stirling, C. (2013). Opportunities for Climate Mitigation in Conservation Agriculture. Paper presented at Workshop on Impact Pathways for Climate Change, Agriculture and Food Security in South Asia, 26-28 Feb. 2013, Dhaka.
13. Venkateswarlu, B. (2013). NICRA and Linkages Opportunities with CCAFS. Paper presented at Workshop on Impact Pathways for Climate Change, Agriculture and Food Security in South Asia, 26-28 Feb. 2013, Dhaka.
14. World Bank (2008). World Development Report: Agriculture for Development. Washington DC.
15. World Economic Forum (2011). Realizing a New Vision for Agriculture: A roadmap for stakeholders. World Economic Forum, Switzerland, p. 29.
16. Yamano, T., Malabayabas, M. and Gumma, M.K. (2013). Adoption, Yield, and Ex Ante Impact Analysis of Swarna-Sub1 in Eastern India. STRASA Economic Briefs, No. 2 (March 2013). International Rice Research Institute, Philippines. pp 4