Germinating the seeds of success in the semi-arid tropics

A Compendium of Speeches and Presentations
by William D Dar
January–December 2005

International Crops Research Institute for the Semi-Arid Tropics

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ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

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William D Dar

Director General, ICRISAT

Biographical Sketch

William D Dar is Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) near Hyderabad in Andhra Pradesh, India, since January 2000. ICRISAT is one of 15 nonprofit, nonpolitical centers within the umbrella of the Consultative Group on International Agricultural Research (CGIAR).

Since January 2005, Dr Dar has had the distinction of being the first Filipino to be Chair of the Alliance Executive of the Alliance of Future Harvest Centers, an international body that governs the collective functioning of individual CGIAR centers. Dr Dar is a Member of the UN Millennium Task Force on Hunger. Prior to joining ICRISAT, he served as Presidential Advisor for Rural Development, and Secretary of Agriculture in the Philippines (equivalent to Minister of Agriculture), the first ever alumnus of the University of the Philippines Los Baños (UPLB) to become one. Before this, he was Executive Director of the Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD) and Director of the Bureau of Agricultural Research (BAR) of the Philippine Department of Agriculture (DA). He also served on the managing boards of the Australian Center for International Agricultural Research (ACIAR) and the CGIAR's International Maize and Wheat Improvement Center (CIMMYT) as well as of ICRISAT. Moreover, he was Chair of the Asia-Pacific Association of Agricultural Research Institutions (APAARI) and the Coarse Grains, Pulses Research and Training (CGPRT) Center based in Indonesia.

Dr Dar received a Doctor of Philosophy (Ph.D.) in horticulture from the University of the Philippines Los Baños and an M.S. (Agronomy) and B.S. in agricultural education from Benguet State University (BSU) in La Trinidad, Benguet, Philippines. He taught at BSU for 11 years and rose from the ranks to become full Professor and Vice President for Research and Extension.

He has received a number of awards and honors—Ten Outstanding Young Men (TOYM) of the Philippines, Outstanding Young Scientist of the Year, Crop Science Society of the Philippines' Achievement Award for Research Management and Outstanding Science Administrator given by the Philippines Department of Science and Technology. He was also awarded as Distinguished Alumnus of UPLB and Most Outstanding Alumnus of BSU. In November 2002, PCARRD honored him with its highest and most prestigious award, the Symbol of Excellence in R&D Management. On April 2003, Dr Dar was conferred the honorary degree of Doctor of Science by the Mariano Marcos State University (MMSU) in Batac, Ilocos Norte, Philippines. On October 2003, the Vietnamese Government honored Dr Dar with the, "For the Sake of Agriculture and Rural Development in Vietnam Award" while the Philippine Bureau of Agricultural Research awarded him with a Plaque of Recognition for his outstanding performance as its first director. He is also the recipient of the "Anahaw Leaf Award" for being the Most Outstanding Alumnus of the Ilocos Sur Polytechnic State College (ISPSC) High School Class of '69. In April 2004, the Central Luzon State University in the Philippines awarded him the Golden Grain Award, commending him for his "deep concern and intense advocacy for the promotion of a global yet equitable program for food security and reduction of poverty through pioneering scientific and technological innovations".

Since leading ICRISAT, Dr Dar has intensively advocated a *Grey-to-Green Revolution* in the dry tropics of Asia and sub-Saharan Africa through *Science with a Human Face*. Towards this, he spurred the development of a new vision, mission and strategy for the Institute. In pursuing it, he has strengthened strategic partnerships with an array of stakeholders – NARS, ARIs, NGOs, development agencies and the private sector.

These initiatives led to a stronger ICRISAT working for a food-secure SAT.

In 2004, ICRISAT led by Dr Dar, won for the fourth time the King Baudouin Award (the most prestigious in the CGIAR) together with CIMMYT, IRRI, IWMI and other national systems in the CIMMYT-led Rice-Wheat Consortium for the Indo-Gangetic Plains. Earlier in 2002, again under his leadership, the Institute together with ICARDA had bagged the award for developing new chickpea varieties with higher tolerance to drought and heat, greater resistance to pests and diseases that provide stable and profitable yields. ICRISAT is the only CGIAR center to have bagged this award four times. In 2003, ICRISAT underwent two external reviews from the CGIAR, acknowledging outstanding science quality and sound management under Dr. Dar. These reviews gave the impetus for ICRISAT to carve out a new strategy for its transformation and renewal as a premier center of scientific excellence for the people of the dry tropics in the 21st century. In the same year, ICRISAT stood second among the 15 CGIAR centers in terms of financial health indicators developed by the World Bank. The turnaround for the Institute was possible because of his effective and human-oriented leadership. As a demonstration of the strong faith in his leadership in turning ICRISAT around, the Governing Board awarded Dr Dar a new five-year term starting January 2005.

Foreword

This is an important book, important to laymen and to those interested in science and its human facet. It tells the story of how ICRISAT, and with it the hopes and dreams of thousands of poor, are being fulfilled.

The world is seeing many changes in agriculture. We face a number of critical issues such as hunger, poverty, land and environmental degradation, climate change, and AIDS. These speeches offer an assessment of the landscape in the semi-arid tropics of Asia and sub-Saharan Africa to a level of detail that is quite remarkable. They provide a clear picture of how agriculture in the semi-arid tropics has changed and lay out a clear vision to deliver sustainable development with the current and expected pressures on land use, and against a background of these changes.

Willie Dar's speeches span a gamut of topics ranging from water strife to biopiracy and pulses to partnerships. Commitment and initiative are what many readers will discover in them.

The speeches also provide the basis for addressing a host of important scientific issues. The links between small scale and large scale are made clear – how alterations to individual patches of vegetation impact on the wider landscape. The speeches address hard questions about poverty and hunger, the cause and effect, pattern and process.

That effective leadership is what it takes to steer an institute and its fortunes are clear. The speeches also illustrate that how the team performs and what the future holds is as much in the hands of employees as leaders.

The compendium is a very important chronology of achievements of an institute that has overcome testing times to emerge a winner. It has lessons that every organization should replicate for success.

Dr Shawki M Barghouti

Adviser, Agricultural and Rural Development
The World Bank

Prospects and Opportunities for Improving Peanut Quality and Utilization Technology

Presented at the International Peanut Conference 2005 on Prospects and Emerging Opportunities for Global Peanut Technology, 9-12 Jan 2005, Kasetsart University Bangkok, Thailand.

Distinguished guests, colleagues from the scientific community and my dear friends, good morning.

I would first like to thank the Kasetsart University for inviting me to speak before you today. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) aims to improve the livelihoods of the rural poor of the semi-arid tropics in Asia and sub-Saharan Africa (SSA). It does this through impact-oriented research on five crops, one of which is peanut or groundnut.

Globally, peanut ranks sixth among oilseed crops and thirteenth among food crops in terms of importance. It is a cheap source of high quality edible oil, easily digestible protein, vitamins and minerals. It also produces high quality fodder. It is grown over 26.4 million hectares and yields 37.1 million metric tons.

Peanuts bring the much-needed income and provide nutritional security to poor and marginal farmers in the semi-arid tropics (SAT). In many parts of sub-Saharan Africa, it is considered a woman's crop because they grow it and use the income for the family.

From 1993 to 2003, the area planted to peanut grew annually by 2.2%. During the same period, production grew annually by 2.9% and productivity by 0.74%. Asia accounted for 58% of the area sown to the crop and 67% of production compared to 38% and 25% in sub-Saharan Africa, respectively.

Production gains in sub-Saharan Africa have mainly accrued through expansion in area. Although productivity has been growing annually, it is insufficient to sustain the crop's long-term economic competitiveness compared to other oilseed crops and cheaper sources of edible oil.

Over the years, the use of peanut oil has declined, but its consumption as food has increased. Therefore, developing high quality peanuts for food and confectionery fetches greater benefits to peanut farmers in developing countries.

In Shandong, China, peanut is a highly efficient crop with a yield potential of 17.3 tons per hectare (t ha^{-1}). In large plots, yields can exceed 9.6 t ha^{-1}. Compared to the average global yield of 1.4 t ha^{-1}, this yield gap is very huge. Scientists in developing countries therefore face the challenge of

bridging this gap in order to make peanut more economically competitive.

You may ask, how do we do this effectively? The answer lies in first selecting an appropriate research strategy by identifying and prioritizing constraints limiting the realization of potential yields.

We should also identify research gaps, estimate the probability of success and analyze returns on research investment. We can reap the optimum benefits of peanut production when genetic enhancement is complemented with sound production practices. Our production technology must suit poor and marginal farmers and aim at bringing sustainable productivity.

Improving peanut quality is a very complex area of research. Its requirements differ with usage and consumer groups. While physical factors can easily be handled through conventional breeding, nutritional quality and sensory factors such as taste and flavor are not easy to breed for.

At ICRISAT, we do Science with a human face by tailoring our research programs to benefit the poor. Doing Science with a human face gives us the impetus and determination to substantially contribute to the attainment of the Millennium Development Goals (MDGs), specifically those that deal with poverty, hunger, gender and health. ICRISAT has made giant strides in peanut research in partnership with national programs and advanced research institutes. Going beyond the successes of conventional breeding, we are harnessing novel approaches like biotechnology to further enhance productivity and improve the quality of peanut as a food crop.

We are now testing the world's first transgenic peanut on our campus using virus coat protein and replicase genes that are resistant to the Indian Peanut Clump Virus (IPCV). After three years of contained field trials, we are now ready to go for farmers' field trials in India.

Besides this, other transgenics ready for testing are lines resistant to the groundnut rosette virus in sub-Saharan Africa and to the peanut bud necrosis virus in Asia. The other constraints being addressed by transgenics at ICRISAT are aflatoxin, foliar diseases and drought.

Likewise, genetically transformed plants with chitinase gene from rice have shown promise against *Aspergillus flavus*, the aflatoxin-producing fungus and leaf spots in initial bioassays. Other candidate genes in transgenics include gluconase from pea and defensins with antifungal properties.

Plants transformed with drought responsive elements from Arabidopsis are showing great promise in our initial experiments. We are developing another transgenic peanut or 'Golden peanut' that can produce beta-carotene to tackle malnutrition in the semi-arid tropics. We are doing this under the auspices of CGIAR's Harvest Plus Challenge Program.

There are tremendous opportunities for using molecular markers in improving peanut. Work is in progress to identify Quantitative Trait Loci (QTLs) for traits of economic importance. Our colleagues gathered here must make concerted efforts to create a dense linkage map of cultivated peanut.

Let me now dwell on another strategic issue — international trade in peanut. Aflatoxin contamination limits the export of peanut from developing to developed countries. This adversely affects the livelihood opportunities of poor farmers in developing countries. Hence, post-harvest handling of peanut is very crucial in ensuring its export quality.

Let me emphasize that most peanut improvement programs lay great emphasis on managing aflatoxin contamination. ICRISAT is working intensively in this research area to improve peanut's export quality and to benefit poor farmers. We must keep in mind that the World Trade Organization (WTO) and trade-related aspects of Intellectual Property Rights (IPR) are changing the face of global agriculture. This compels us to keep poor farmers upfront while planning for the future. Consistent with Science with a human face, we must customize peanut production technology to suit the needs and capabilities of poor farmers.

Applied and adaptive research must be done in combination with upstream research to ensure that their benefits reach poor farmers. Farmer participation in priority setting and technology development ensures greater utilization of improved varieties among them. Since the food and confectionery uses of peanut are increasing, the requirements of food processors and consumers, particularly those from peanut importing countries, must also be considered.

In most developing countries, the non-availability of seeds of improved varieties remains a major bottleneck in improving peanut productivity. Moreover, old landraces and varieties are widely used. This situation is compounded by the private sector's lack of interest in seed multiplication and distribution. Likewise, the public sector cannot meet the expectations of poor peanut farmers.

It is therefore time for civil society to step in and help solve the perpetual shortage of peanut seeds. We must train and mobilize farmers' organizations and other non-governmental organizations (NGOs) to produce and distribute high quality seed to meet local demand.

I am confident that all of you gathered here today will deliberate on these vital issues and evolve a new paradigm of global partnerships in peanut research and development.

We can do it!

Thank you and good day.

Creating Opportunities, Improving Livelihoods

Valedictory address, Entrepreneurship Awareness Camp in Biotechnology, 1-3 Feb 2005, Jawaharlal Nehru Technological University (JNTU), Hyderabad, Andhra Pradesh, India.

Distinguished guests, ladies and gentlemen,

I am sure that you would all have benefited immensely from the knowledge shared at this three-day Entrepreneurship Awareness Camp jointly organized by the Jawaharlal Nehru Technological University and ICRISAT. The idea is to nurture the entrepreneurial spirit, develop future business leaders and show the way for opportunities available in the biotechnology sector. I thank the experts who shared their thoughts and wisdom with all of us.

Biotechnology has high growth potential. The biotech industry is expected to grow by 26% annually with investments close to $227 million in the next couple of years. Given India's demography, varied flora and fauna, huge agricultural sector, vast reservoir of scientific talent, wealth of R&D institutions and centers of academic excellence in biosciences, opportunities for research and development of agri-biotech products applicable worldwide are aplenty.

ICRISAT is a non-profit, apolitical international organization that is devoted to science-based agricultural development. It is one of the 15 Future Harvest Centers of the Consultative Group on International Agricultural Research (CGIAR). It strongly believes that biotechnology is a valuable tool in eliminating global hunger, poverty and malnutrition, since it provides modern ideas and techniques to complement agricultural research.

The results of ICRISAT's work in genetic transformation are very promising. The world's first transgenic groundnuts resistant to the Indian Peanut Clump Virus and rosette are in their third year of contained field trials at ICRISAT. Also, the world's first transgenic pigeonpea resistant to pod borer is now in its second year of contained field trials. In the case of the world's and ICRISAT's first transgenic chickpea too, the first year of contained field trials is ongoing.

Partnership-based research remains the hallmark of our research programs. Genuine partnerships between international organizations, local research institutions and civil society to produce usable research are crucial. For instance, the convergence of public and private research in sorghum, pearl millet and pigeonpea hybrid parents at ICRISAT has brought substantial benefits to Indian farmers. I must add here that more than 541 improved varieties of the mandate crops developed by us in partnership with national agricultural research systems (NARS) have been released in 72 countries since 1975.

The Agri-Science Park (ASP) is the means by which ICRISAT commercializes technology to help farmers in the SAT through partnerships with the private and public sectors. It is a convergence of agricultural partnerships, innovations and products for the poor.

Commercialization at ICRISAT involves developing international public goods (IPGs) for the poor; developing in-house technologies under public domain; facilitating the public use of third-party technologies; initiating effective public/private/NGO partnerships and also emphasizing biosafety through a non-profit approach. The ASP consists of the Agri-Biotech Park of the Genome Valley, the Agri-Business Incubator (ABI), a Hybrid Seeds Consortium and the SAT Eco-Venture.

The Agri-Business Incubator, a collaborative venture between ICRISAT and the Department of Science and Technology (DST), Government of India, helps entrepreneurs incubate technologies developed through agricultural research. In other words, ABI facilitates technology consultancy, business facilitation and training. Technology consultancy involves the transfer of agricultural knowhow from ICRISAT's research findings, or from other national and international providers. Business facilitation consists of pre-feasibility studies, project appraisal, market research and techno-economic feasibility studies. ABI can also assist by networking with bankers, venture capitalists and bureaucrats, and can also help organize events and trade shows. Training, as in the case of this event, involves entrepreneurship development programs, skill upgrades and business management training courses.

The incubator offers the best business opportunity, thereby minimizing risk. In short, ABI is the preferred destination for anchoring agri-business start-ups. At present, it houses four incubatees – Rusni Distilleries Private Limited, Bioseed Research India Limited, Seedworks India Private Limited and Sesslertom and Hyglass Chemicals.

ICRISAT has had a year-long association with JNTU, a premier technological institute in Andhra Pradesh with over 200 engineering colleges affiliated to it. The JNTU's Entrepreneurship Development Cell too is funded by the DST to disseminate entrepreneurship among students and to create more job generators rather than job seekers. In other words, both JNTU and ICRISAT efforts are directed towards biotech-driven entrepreneurship development.

The ICRISAT-ABI world class incubation facility is waiting for entrepreneurs like you. Be part of our venture. Together we can sow the seeds of success.

Thank you.

Institutional and Organizational Innovations for Watershed Management: Collective Action and Property Rights for Poverty Reduction in Dryland Areas

Inaugural address, IFPRI (CAPRi)–ICRISAT Project Inception Workshop, 3-4 Feb 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Ladies and gentlemen,

Pervasive poverty, degradation of agro-ecosystems and declining sustainability are major concerns for agricultural development where people depend on exploiting natural resources for their livelihoods.

The International Crops Research Institute for the Semi-Arid Tropics and its partners have taken the lead in developing new complementary innovations to tackle developmental constraints in the drylands of the semi-arid tropics. Ongoing research at ICRISAT has identified the critical role collective action and property rights can play in poverty reduction in two distinct but complementary areas – market access for dryland crops and community-based watershed management.

Collective action may be broadly defined as action taken by a group (either directly or on its behalf through an organization) in pursuit of a member's perceived shared interest, while property rights are the capacity to call upon the collective to stand behind one's claim to a benefit stream.

Let me highlight the crucial role collective action plays in enabling organizations to make their vision a reality. At the

Annual General Meeting of the CGIAR in Mexico in October 2004, the Center Board Chairs Committee (CBC) and Center Directors Committee (CDC) had developed a 10-point guiding principle for collective action among CGIAR centers. Among the principles are foremost allegiance to the poor; actions based on the principle of partnership among equals; mutual respect; transparency; problem solving via best possible means; priority setting based on open and transparent practices; accountability to and conflict resolution through the collective action governing mechanism; identification of clear specifications and researchable objectives; and shared standards and practices. These principles are applicable to watershed management as well, as is illustrated below.

Today, integrated watershed management (IWM) transcends traditional integrated technical interventions for resource conservation to include multiple interventions that support and diversify livelihood options for smallholders, which in turn helps them withstand market-induced risks and climatic variability. Thus IWM requires active community participation for implementation and sustenance.

Collective action in watershed management has the potential to internalize transaction costs and externalities that limit the success of individual efforts towards resource management. Despite its promising potential, much remains to be done to understand how local institutions evolve and deal with externalities and transaction costs, what roles external agencies could play and how such local institutions can be sustained and contribute to poverty reduction.

Issues of Collective Action in Watershed Management

- A watershed creates interdependence between resources and resource users over time and space.
- Investments in watershed technologies require a relatively longer planning horizon.
- Costs and benefits from watershed development efforts are determined by the stock of resource use, rights and entitlements of individual holders and the ability to exclude others from benefiting from such investments.
- The interdependence among resource users requires interventions mediated through targeted policies and institutional incentives that encourage cooperation and collective action.
- The biophysical diversity and social complexities in a watershed call for complex policy and institutional arrangements.

The Benefits

Among the benefits that flow from collective action are improved technology update; better returns (higher prices) for the produce through collective marketing; improved access to markets and better prices to integrate subsistence producers into the market economy; empowerment of invisible stakeholders (women and small farmers); lowered cost of inputs; and assured equitable distribution of benefits.

Following are the derminants of the success of collective efforts:

- According to Stockbridge et al. (2003), the success of collective efforts of farmer organizations is the result of homogeneity, size, choice of services, commercial activities, self-reliance and autonomy, finance, skills and education, participation, organizational structure and governance, legislation and focus.

- High transaction costs and adverse selection in marketing limit the access of small farmers far removed from marketing points to markets for products, inputs and services.

- The challenge lies in understanding how competitive and viable marketing groups evolve; how policies can assist in their emergence; and how the groups can improve access to credit, inputs, information on prices and enhance business skills.

- Lessons from the Adarsha Watershed: Some of the drivers of collective action were community felt need (acute water stress), shared goals and common interest, good local leadership, private benefits and equity, a coalition of equal partners with a shared vision, transparency and social vigilance, farmers participation in technology evaluation and capacity building.

However, more research is needed to understand why certain types of groups fail and others succeed; how user communities can play an active role in the process and how the distribution of costs and benefits affects this process; what determines user participation; and how new kinds of institutional arrangements can be developed to regulate groundwater use so that the benefits from collective action can be sustained.

Thank you.

Sorghum Hybrids Production and Development

Inaugural address, Training course on Sorghum Hybrids Production and Development, 7-11 Feb 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Ladies and gentlemen, good morning.

I welcome all of you here today to the training program on Sorghum hybrids production and development. In recent years, we have seen a major growth in public-private sector partnerships in the service of agricultural research and development. This convergence of research is highly essential because no single organization can address the enormous developmental issues of the semi-arid tropics.

ICRISAT's primary goals are to enhance the livelihoods of the rural poor engaged in agriculturally-related enterprises and to protect the environment in the SAT. We plan to achieve these to goals by:

- Collecting and managing the germplasm of ICRISAT's five mandate crops (sorghum, pearl millet, groundnut, pigeonpea and chickpea) and minor millets
- Developing improved genetic materials and high-yielding parents/varieties
- Developing improved soil and water management practices for sustainable production and natural resources conservation

- Assisting partners in NARS with improved policy formulations for higher crop productivity and commercialization
- Developing and sharing knowledge and expertise with partners and stakeholders.

In India, about 4.5 million out of 10 million ha under sorghum are planted with more than 50 hybrids. The majority of these are from the private sector and 60-80% of these are based on ICRISAT-bred parental lines or on parental lines developed from germplasm improved by ICRISAT. Coming to the global scenario, over 45 million ha were under sorghum cultivation in 1972/73 when ICRISAT was established, producing about 58 million t. Its productivity was 1.3 t ha^{-1}. In recent years, the area under sorghum has drastically declined in Asia, while it has increased in Africa, leaving the total world's area under the crop unchanged. However, total global production has increased by about 10%. Productivity in the Americas has been greater over time than in Africa and Asia. This has largely been the result of the availability of genetically improved cultivars and better agronomic practices, thanks to the efforts of agricultural scientists.

ICRISAT is proud of its strong sorghum improvement programs in Patancheru (India) for Asia, in Sotuba (Mali) for West and Central Africa (WCA) and in Nairobi (Kenya) for Eastern and Southern Africa (ESA). Our scientists are involved in developing improved varieties in Africa and improved hybrid parents in Asia through partnership research with national program scientists both in the public and private sectors. The NARS scientists in the public and private sectors use these products, test them for adaptation to local conditions and release/market the final products (varieties/hybrids) for general cultivation by farmers. In addition to being partners in research, private sector seed companies are also contributing funds for public research in sorghum improvement through the ICRISAT-Private Sector Sorghum Hybrid Parents Research Consortium.

The lines/hybrid parents that are shared with scientists in the national programs and the varieties/hybrids released/marketed by NARS and private sector seed companies need to have high yield potential and resistance to pests and diseases.

Realizing the importance of knowledge and skills in developing improved hybrid parents to develop hybrids and in maintaining genetic purity, public and private sector scientists in NARS requested ICRISAT to organize an intensive course on hybrid parents development and hybrids production. ICRISAT immediately responded to this request.

To date, ICRISAT has organized six such courses, in Egypt, Myanmar and four at ICRISAT-Patancheru. A multidisciplinary team of scientists at ICRISAT is involved in conducting this course. I understand the participants – both from the private and public sectors – are from Egypt, Iran, The Netherlands and India. I am sure all of you will benefit from this course and will have collected all the knowledge essential to conduct sorghum hybrid parents' research and development for use in your program. I wish you all an enjoyable and productive course.

Have a good day!

Natural Resource Management and Institutions: The Links between Property Rights, Collective Action and Natural Resource Management

Inaugural address, Training course on Natural Resource Management and Institutions: The Links between Property Rights, Collective Action and Natural Resource Management, 7-11 Feb 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Ladies and gentlemen,

I extend you a warm welcome to this training course on Natural Resource Management and Institutions. At the outset, let me thank our partners, the International Food Policy Research Institute (IFPRI) led by Dr Ruth Meinzen-Dick who is visiting us after a very long time, our national partners led by Dr Raju from the Institute for Social and Economic Change (ISEC), Dr Chandrakanth from the University of Agricultural Sciences (UAS), the International Water Management Institute (IWMI), the International Livestock Research Institute (ILRI) and the World Wide Fund (WWF). I would also like to welcome the participants from Bangladesh, Bhutan, Ethiopia, India, Indonesia, Mongolia, Nepal and Sri Lanka and the resource persons representing different institutions.

Many of you are probably visiting ICRISAT for the first time or after a long time. ICRISAT has undergone several changes over

the last five years. More dynamic processes are in place now, collective action is yielding results and Team ICRISAT is all geared up to improve the livelihoods of millions of poor in the semi-arid tropics of sub-Saharan Africa and Asia. In short, we are doing Science with a human face.

It is not without reason that I stress on the words "collective action". ICRISAT has consciously endeavored to forge partnerships with community-based organizations, civil society members, national research institutions, national and state governments, advanced research institutions, international organizations and private entrepreneurs. Collective action is also crucial to the attainment of the Millennium Development Goals (MDGs). The MDG of halving the number of poor people in the world by 2015 as well as achieving improved gender equity cannot be achieved without collective action.

ICRISAT has vast experience in the area of integrated watershed management and we have worked closely with a number of communities in Asia. Based on the lessons learnt, our watershed team has developed an innovative farmer participatory integrated watershed development consortium. A new paradigm has been brought about through the model. I can proudly say that our watershed project is a flagship project that adopts the integrated genetic and natural resource management (IGNRM) approach and acts as a gateway for research technologies to reach farmers as well as enhance livelihoods.

The benefits that we have realized through collective action with our partners in the consortium have been impressive. They outweigh those realized through individual efforts. Therefore, the message is clear: sustainable management of natural resources and poverty reduction demand collective action.

Let me go into detail about ICRISAT's case. When we moved away from the compartmental approach to a holistic or systems approach, the first benefit was that scientists started working in functional and effective teams. Secondly, when the time came to address issues under diverse community watersheds, ways had to be devised to ensure enhanced community and organizational participation. With the goal being common, tangible benefits were soon visible.

The course you will be undergoing here is unique in a number of ways. CAPRi and ICRISAT have joined hands to tackle the issue of NRM by bringing together international knowhow in the area. I understand that CIDA has sponsored a number of Asian participants for this course. The result of collective action on a regional scale is evident here itself.

I wish you very fruitful deliberations and collective learning during the week. I am sure you will enjoy the eco-friendly ambience at ICRISAT and get acquainted with our other activities. You will also get first hand experience during your visit to the Adarsha Watershed at Kothapally.

Let us vow to collectively march towards our goal of reducing poverty in the developing world.

Thank you.

Water as a Catalyst for Development

Inaugural address, World Wide Fund (WWF) Global meeting, 21 Feb 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Ladies and gentlemen, good morning.

I extend a warm welcome to all the participants for this important meeting organized by WWF, our important partner in tackling the problems of food security, poverty, degraded environments, and conserving biodiversity. Dr Biksham Gujja and his team here and ICRISAT together strive to address the most important issue of water management and sustainable development in dryland areas.

The semi-arid tropics of the world covers parts of 55 developing countries spread over 11.1 million km^2, home to 1/6th of the world's population. Of these, 350 million live on less than US$1 a day. The foundation of their livelihoods is food security, which is inextricably linked to the sustainable management of natural resources.

ICRISAT's research strategy revolves around four Global Themes: Biotechnology; Crop improvement; Agroecosystems; and Markets, Policy and Impacts, reflecting our priorities in Asia and sub-Saharan Africa. Our vision is to improve the well-being of the poor people of the SAT through agricultural research for impact.

Water is a scarce natural resource directly associated with basic human needs. The ever swelling population, increase in the absolute number of poor together with greater incomes have led to a substantial rise in the demand for food.

So alarming is today's water and food situation that the Ministerial Declaration signed at the Second World Water Forum identified "Securing food supply" as a key global challenge for the 21st century. The Millennium Development Goal on hunger seeks to halve the number of poor and hungry by 2015. The 2002 World Summit on Sustainable Development (WSSD) included agriculture in its Water supply and sanitation, energy, health, agriculture and biodiversity (WEHAB) framework to tackle the world's most pressing development challenges. These are the same challenges now considered by the MDGs.

Overexploitation of natural resources is causing environmental degradation in the SAT. Land degradation is a serious threat to the economic and physical survival of mankind. Key issues including escalating soil erosion, declining soil fertility, loss of biodiversity, salinization, soil compaction, agrochemical pollution, desertification and water scarcity are crying for attention.

The looming water crisis is already apparent. Over-exploitation of water resources, mainly for agriculture, has created environmental disasters. Alternative approaches have to be found to produce food, given the limited water supplies and already degraded lands. In addition, global warming is likely to affect water availability. In fact, it is believed that a staggering one billion of the world's poorest living in the SAT will be affected by water scarcity by 2025!

ICRISAT's research attacks water scarcity on two fronts. The first utilizes natural resource management research to improve rainwater utilization through watersheds and water conservation techniques. The second employs plant breeding and biotechnology research to improve water-use efficiency (WUE) and drought tolerance in crop genotypes.

Conventionally, the emphasis has been on increasing water supply rather than on reducing demand by enhancing efficiency. There is an urgent need to reverse this approach. A paradigm shift in water management for all uses including agriculture is inevitable.

Given the serious and persistent problems of water scarcity in the drylands, using water as an entry point and as a catalyst of development should be uppermost in our minds. Watersheds are a logical entry point for managing natural resources to increase productivity and contribute to sustainable development. They not only protect the environment but also improve livelihoods in the SAT.

ICRISAT and the NARS have developed and evaluated an innovative farmer-centric integrated watershed management model with technical backstopping by a consortium. The approach is holistic and based on farming systems and diversified livelihood opportunities to cater to the needs of the socially marginalized and landless. The Adarsha Watershed in Kothapally in Andhra Pradesh has attracted farmers, policymakers and development investors due to the tangible and non-tangible benefits it has generated, some captured by individual farmers and some by the entire community. The benefits have been in the form of reduced runoff and soil loss, improved groundwater levels, improved land cover and vegetation, increased productivity and changes in cropping patterns. This watershed team and WWF have joined hands to tackle the critical water shortage problem in the tropics at micro and macro levels through on-farm research as well as policy advocacy.

Water scarcity is the most critical constraint in dryland agriculture. Therefore, the following interventions are urgently required for agriculture to emerge as a market-oriented, commercially viable and ecologically sustainable means of producing food, fibre and raw materials while at the same time protecting the environment:

- Adoption of an efficient watershed management approach
- Drought proofing through harvesting and storage of rain water

- Recharging of depleted groundwater aquifers and strong regulations on groundwater extraction
- Pricing of water and power to reflect their opportunity costs
- Government support for water-saving options
- Specification and enforcement of clearly defined water rights in watershed communities
- Enabling stronger collective action in resource management
- Enhancing the scientific and technological support to watershed programs.

The World Wide Fund, ICRISAT and our partners are addressing these issues and have developed joint proposals. Development of agriculture in dryland areas requires investments both to develop the resource base as well as to enhance land productivity.

Watershed development programs have demonstrated their potential to contribute to both these objectives. Participatory watershed development programs spearheaded by ICRISAT in Andhra Pradesh, Madhya Pradesh, Rajasthan and Gujarat have shown that investments in these programs can result in handsome returns and can also reduce poverty in dryland areas.

There is an urgent need to scale up such initiatives with a plan to cover all the dryland areas in the country within a span of 10 years. The program requires massive investment and technical supervision to create the desired impact in a reasonably short period. Effective procurement back-up for dryland crops, inclusion of coarse grains in the public distribution system or substituting a food stamp scheme for the public distribution system and a more farmer-friendly crop insurance scheme can complement the watershed development programs.

However, the benefits accrued could be undone without policy and institutional support from the government. There is an urgent need to put in place water-saving technologies as well as interventions for efficient and sustainable use of water resources. School curricula should include the need for proper management of water resources. While addressing food security and poverty issues, we also need to consider water needs for the environment as well as biodiversity conservation.

ICRISAT, WWF and other stakeholders can together find a win-win proposition using watershed management as an entry point for improving the livelihoods of the poor in the semi-arid tropics.

The vision of reducing poverty, hunger and malnutrition and ensuring sustainable livelihoods can be achieved by a multi-pronged strategy comprising:

- Water as a catalyst for development
- Re-orienting public policies that rationalize subsidies on agricultural inputs, and cover more crops under the minimum support scheme
- Diversification and selective specialization
- Marketing and commercialization
- Institutional innovations
- Improved infrastructure
- Better targeting of developmental interventions
- Focused research
- Building pro-poor partnerships and linkages.

I once again welcome all the participants to this meeting and hope you have fruitful deliberations.

Thank you.

The Future Harvest Alliance: Let Us Infuse Life and Make it Work

Opening remarks, Centers Deputy Directors Chair (CDDC) meeting, 28 Feb 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

First, as the Director General of ICRISAT, let me welcome you all to Patancheru. Please feel at home in the natural ambience of the SAT environment. Dr Dyno Keatinge will ensure that you all have a pleasant stay with us in ICRISAT.

Second, let me address you now not as the Director General of ICRISAT but as the Chair of the CDC or the Alliance Executive of the newly formed Alliance of Future Harvest Centers of the CGIAR. The Centers, now the Alliance, is one of the three pillars of the CGIAR System, the other two being the Science Council and the other CG members or stakeholders financing the CG. The Alliance is a homegrown initiative of the Centers and is forming part of the CGIAR reform process. The mission of the Alliance is to contribute more effectively and efficiently to the mission of the CGIAR.

This meeting is important since it is the first time that the Alliance Executive has requested a meeting of the Science Group of the CDDC with the vital task of reviewing the latest version of the System Priorities Document developed under the supervision of the Science Council, an important ally in the system. Most of the scientists from the Alliance were involved in preparing this document. The group will make its recommendations to the CDC through the Chair, which will in turn be discussed, improved upon and approved by all the Directors General in an e-mail discussion. As Chair of the Alliance Executive, I will then formally submit the revised document to the Science Council for its consideration.

I take this opportunity to welcome to this meeting the Executive Secretary of the Science Council, Dr Ruben Echevarria. His presence is symbolic of the close and strong ties between the Alliance and the Science Council.

I am sure you are all aware of the changes taking place within the CGIAR Centers. Old attitudes of competitiveness and mutual antipathy that are not conducive to doing business together are giving way to new methods and practices of cooperation and collective action. These will pave the way for us to work together more effectively, so that the donors are rid of the impression that we are often competing with one another. Thankfully, the funding climate has improved over the last couple of years mainly due to the hard work of the Centers; we must seize this opportunity to demonstrate that we can work in unison and can deliver as well.

Sub-Saharan Africa remains our highest priority for working together more effectively. I call upon the leadership of the International Livestock Research Institute (ILRI) and Africa Rice Center (WARDA) to enhance the process of trying to develop programmatic harmony of the Future Harvest Centers working in sub-Saharan Africa with ASARECA and CORAF/WECARD, respectively. They have been assigned the lead responsibility by the CDC to move the process forward of integrated planning with the sub-regional organizations (SROs). The same goes for the leadership of the World Forestry Center (ICRAF) to accelerate the Kenya country study. These are among the “quick wins” agreed to by the Alliance to be demonstrated in sub-Saharan Africa.

I take this opportunity to again call upon the leadership of ICRAF to help enhance the collective contribution of the Future Harvest Alliance Centers in the sub-Saharan Africa Challenge Program under the leadership of the Forum of Agricultural Research in Africa (FARA). We need to demonstrate our readiness to enhance the complementarity and synergy of Centers in the region to show that they can present a coherent and integrated program.

We are strengthening the various organs of the Alliance. The CDDC will increasingly play a more proactive role in the Alliance. It will be a vital group that gives advice to the CDC/Alliance Executive on how to manage the Alliance. In a way, this meeting is a watershed for this new role.

You are free to hold discussions among yourselves. But everyone in this room please bear in mind one of the ten guiding principles of the Alliance which were formally adopted by all the Centers during the meeting at the International Wheat and Maize Improvement Center (CIMMYT) last year:

OUR PRINCIPAL ALLEGIANCE IS TO THE POOR.

And let me hasten to add that our second allegiance is equally to the Alliance and to our own Centers.

Please allow the ten Principles of the Alliance to govern your actions and voices over the next two days and beyond. Infuse life into the Alliance and make it work, and internalize and practice the Code of Conduct of Centers. I wish you a constructive meeting and look forward to hearing your recommendations tomorrow afternoon.

Thank you.

With your Guidance we Move Forward

Welcome speech, Genetic Resources Policy Committee (GRPC) meeting, 28 Feb 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Dear friends,

On behalf of the ICRISAT management and staff, I welcome Dr Carlos Correa, Chair of GRPC and other distinguished members of the Committee, my colleague in the Alliance of Future Harvest Centers of the CGIAR, Dr Emile Frison, Director General of the International Plant Genetic Resources Institute (IPGRI) and other senior staff from IPGRI and ICRISAT.

I would like to mention about one important initiative from the Centers, the Alliance of Future Harvest Centers of the CGIAR, one of the pillars of the system, which has the mission to contribute more effectively and efficiently to the mission of the CGIAR. I am happy to say that the initiative has made a significant turnaround programmatically and financially.

The GRPC is a very important and independent advisory body, as it debates and provides policy guidelines to CGIAR Centers on issues related to genetic resources. Legal, political and ethical issues relating to genetic resources at the national and international levels (CBD and the International Treaty on PGRFA) are crucial to CG Centers which depend on the GRPC's advice and support to ensure that they follow uniform and equitable policies.

The GRPC also monitors agreements signed by the CG Centers with the Food and Agriculture Organization (FAO) on *ex-situ* collections, and helps in their interpretation, where necessary. It also deals with issues related to Intellectual Property Rights.

I understand that there are more than 1300 genebanks in the world, storing around 6 million germplasm accessions. Although the 11 CG genebanks together hold nearly 10% of the *ex-situ* germplasm accessions (about 600,000 accessions), it is still a huge responsibility.

We at ICRISAT focus on diversity assessment and developing representative core and mini-core collections to enhance utilization by breeders. Most of these accessions have been characterized. Germplasm seeds are conserved under very precise (cool and dry) conditions. Adequate seed of each accession is conserved to meet the requests of researchers and for posterity.

Times have changed and core funds have dwindled; so genebanks find the collection, regeneration, characterization, conservation and exchange of germplasm a drain on their resources. Moreover, donor interest in these activities is limited.

In that sense, the World Bank-funded Global Public Goods (GPG) Phase-I project came as a boon; it provided the much-

needed support to many Centers to upgrade their genebanks and related activities.

The GPG Phase-I project has produced significant outcomes that will have far-reaching impacts in sustainable food production in the future. The CG Centers are in the process of finalizing GPG Phase-II for submission to the World Bank. We need the total support of the GRPC members to help us convince the Bank of the need to fund this project.

We also need clear guidelines from GRPC on policies relating to the unintentional presence of transgenics in *ex-situ* collections. Guidance on the standard Material Transfer Agreement, Access and Benefit Sharing and IPR are crucial to us. The concept of having a "safety triplicate" set of germplasm for long-term storage at Svalbard should be resurrected and an action plan developed.

As indicated earlier, the CG Centers need your guidance and support, and I, as Chair of CDC, would like to assure the GRPC of our fullest cooperation.

I hope you all have a pleasant stay and fruitful discussions.

Thank you.

Working Collectively to Preserve Biodiversity

Welcome address, ICWG-GR meeting, 1 Mar 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Dear friends,

On behalf of the ICRISAT management and staff, let me welcome the members of the ICWG to ICRISAT-Patancheru. I would like to extend a special welcome to Dr Emile Frison, Dr Jane Toll, Coordinator of the System-wide Genetic Resources Program (SGRP), Dr Rory Hamilton, Chair of ICWG Executive Committee, members of the Executive Committee and senior scientists from IPGRI and ICRISAT.

Among the System-wide programs, SGRP serves as a binding force for activities related to the genetic resources of all the 15 Centers to facilitate policy, public awareness, information, knowledge sharing and capacity building. Its activities cover genetic resources of crops, livestock, fisheries and forests. This meeting aims to review the progress, priorities and proposals for new activities and provides the basis for setting work plans for the future while at the same time achieving greater coherence within the system.

I just mentioned the SGRP's binding role. Now I would also like to reiterate how the Centers can engage constructively in fulfilling the mission of the Alliance of Future Harvest Centers, which is to contribute more effectively and efficiently to the mission of the CGIAR. The objective of the Alliance is to serve as a collective and unified voice for the Centers and more importantly, strengthen existing collective action and create opportunities for integrated collective action.

The System-wide Information Network for Genetic Resources (SINGER) has in the past decade been involved in enhancing information exchange among Centers and sharing data and information on genetic resources.

Concerted efforts by SGRP, ICWG and the CDC led to the World Bank allocating US$13.6 million for the GPG Phase-I project to upgrade genebank activities. The project is entering the penultimate year, and I am happy to learn that most Centers have shown considerable progress and the World Bank is satisfied with the achievements. Plans are afoot for a mid-term review.

The SGRP/ICWG are in the process of finalizing the GPG Phase-II proposal on "Upgrading the CGIAR Genetic Resources System: A New Paradigm for the Rehabilitation of Global Public Goods" for submission to the Bank. I am sure you will have elaborate discussions on developing a full proposal for the second phase. As Chair of CDC, I would like to emphasize that the new phase should showcase system-wide collaboration and collective action to impress upon the World Bank that the activities are not Center-oriented but system-oriented, with a very high probability of developing IPGs.

I believe that SGRP/ICWG activities must move beyond the 'service' function mould, and involve research and science to guide the users in enhanced utilization of genetic resources. Future areas of research could include:

- Providing core and mini-core subsets to users for evaluation and selection of useful germplasm
- Better characterization (both morphological and molecular) of germplasm to help users select appropriate materials

- Use of genomics and gene mining in diverse germplasm
- Collection in endangered areas to preserve genetic resources.

This 6-day meeting promises to be enlightening, with sessions covering the Global Crop Diversity Trust, PGFRA and Global Public Goods projects, in addition to the workshop on SGRP Policy. These should help in identifying key issues.

There are new challenges ahead for the SGRP. I am confident that by working together as an Alliance, we can deal with them more effectively and efficiently. I wish you fruitful deliberations at this meeting.

Thank you.

Improving Livelihoods through Sustainable Natural Resources Management

Inaugural address, TATA-ICRISAT-ICAR Project Review and Planning Workshop, 22 Mar 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Ladies and gentlemen, good morning.

I warmly welcome you all to ICRISAT for this important Review and Planning Workshop of the TATA-ICRISAT-ICAR Project on Combating Land Degradation and Increasing Productivity in Madhya Pradesh and Eastern Rajasthan. The objectives of the project are to address crucial issues such as land degradation, sustainable use of natural resources and increasing agricultural productivity of farmers in order to improve rural livelihoods.

The project is unique in the sense that it is a consortium of research institutions (national and international), corporate trusts, government departments (state and central), NGOs and most importantly, farmers. The stakeholders, all focused on the mission of improving rural livelihoods, joined hands, with ICRISAT facilitating the formation of the consortium.

The project, which has been implemented over the last three years, possesses the following distinctive features:

- Tangible economic benefits have improved stakeholders' participation. The level of participation has moved from contractual to consortium mode. Now is the time to achieve the collegiate mode that would enhance stakeholder involvement in decision-making.

- The project has provided research fellowships to young researchers to bring in the use of advanced tools of science such as GIS and remote sensing. I understand that a Ph.D student from the Institute for Social and Economic Change (ISEC) is being supported with a fellowship to study the Effect of subsidies on overexploitation of water use. M tech students are being supported to carry out studies on Monitoring use of groundwater with remote sensing and GIS.
- To increase its visibility, the project has undertaken a media fellowship. A reputed newspaper reporter has independently taken up studies on this project. Feedback from different benchmark locations of the project areas has been published.
- In addition to adopting a holistic farming systems approach, ingrained in the project are issues of health and sanitation, women, children and the landless. Panchayat Raj Institutions (PRIs) too have become partners in the consortium.

Since the project lays emphasis on minimizing land degradation and enhancing productivity, ICRISAT in partnership with the Central Research Institute for Dryland Agriculture (CRIDA), state agricultural universities (SAUs) and other consortium partners, has adopted an integrated watershed management model with technical backstopping. Soil and water conservation measures have demonstrated intensification and extension of agriculture in target watersheds as well as enhanced agricultural productivity. This has happened due to the adoption of an integrated genetic and natural resource management (IGNRM) approach that stresses on using improved seed varieties and diversifying cropping using integrated nutrient management (INM) and integrated pest management (IPM) options. What triggered off greater productivity were micronutrient amendments that synergistically increased production per hectare through enhanced rainwater use efficiency.

Our observations over the three years reveal that productivity has increased up to 200% in some cases. We are confident that by the end of the project, production will have doubled in the test areas. Apart from enhanced productivity, greater incomes and livelihood options for the landless, the project has opened up opportunities for watershed micro-enterprises through self - help groups (SHGs).

Our concerted efforts to rehabilitate degraded lands not only increased incomes but also reduced land degradation and conserved biodiversity. More importantly, the project has ensured that common property resources are able to fulfill the purpose they are intended for i.e., supplying feed and fuel needs.

Over the years, our partners have extended their activities to more watersheds. I am pleased to note that the consortium has been able to scale-up its activities and that our NGO partners, the Bharatiya Agro-Industries Foundation (BAIF) and Samaj Pragati Sahayog, are doing their best. I would like to make a special mention of how with exceptional support from the Government of Rajasthan, we have been able to scale-up the watershed activity in target districts and also spread it to surrounding areas with BAIF as a lead NGO.

The challenge now lies in consolidating the results we have achieved so far. This will lead us to the goal of minimizing land degradation and increasing agricultural productivity in the target areas.

Let me emphasize why scaling-up is so important. Not only does it provide an opportunity to refine strategies but it also facilitates the emergence of new areas for research. Onsite and offsite impacts of such initiatives need to be carefully examined so that harmony can be achieved at the benchmark level and benefits can be realised on an eco-regional scale.

You would have certainly noticed the very eco-friendly ambience at ICRISAT. I urge you to enjoy the same during your free time. Thank you for your excellent support. I can assure you that Dr Wani and his team will make your stay at ICRISAT memorable.

I am sure that the deliberations over the next two days will help you fulfill the objectives of the project and ensure that it becomes a model for public-private partnership between research organizations and industry, and most importantly, links farmers to markets with the aim of improving rural livelihoods and protecting the environment.

Thank you.

Nipping Water Strife in the Bud

Welcome address, Policy Dialogue meeting on Water conflicts in India, 22 Mar 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Distinguished panelists and guests, participants, friends, ladies and gentlemen, good morning.

Today is considered important as it is World Water Day! I welcome all of you to ICRISAT on this very crucial dialogue on resolving water conflicts organized by WWF, our important ally and partner in attacking the problems of water shortage. ICRISAT works in 48 developing countries with the goals of ensuring food security, eradicating poverty and protecting the environment. With water becoming increasingly scarce and developing new sources of water becoming prohibitively expensive for developing countries, more national conflicts are rearing their ugly heads, pitting people, industry, urban centers and agriculture against each other.

Though history suggests that cooperation over water has been the norm, it has not been the rule. We see it in the case of the water conflicts between states in India that share river basins, such as Karnataka and Tamil Nadu, which border the Cauvery river. In other parts of India, people have been killed in riots over water. In short, water is the cause of enough violence and conflict to threaten social and political stability.

The challenge to governments and international bodies is to recognize the new geography and causes of water-related conflict. Steps such as efforts to increase the productivity of water use (output per unit of water); measures such as drip irrigation, shifts in cropping patterns, water impounding ponds, recycling and reusing wastewater, and water-thrifty household appliances enable cities and farming regions to do more with less water. In addition, stronger policies are needed to regulate groundwater use, to price irrigation and urban water in ways that encourage thrift instead of waste and to protect rivers and lakes from degradation.

But most importantly, governments must act early and constructively before conflicts blow up into major conflagrations. Water user associations could contribute to more efficient use of water, improved water delivery to farmers when they need it and better management of irrigation systems.

In India, the federal government plays a crucial role in defining and establishing the overall framework and guidelines for state-level operation and implementation of programs to improve water allocation and its efficient use and management. The National Water Policy was revised in 2002 to address the newly emerging issues of water availability, quality and inter-sectoral distribution. The key to defusing potential conflicts over water is a reform of this policy to ensure the most efficient use of available water supplies.

ICRISAT and NARS have developed and evaluated a farmer-centric holistic and participatory watershed management program with technical backstopping by a consortium. Clear impacts of this approach in the Adarsha Watershed in

Kothapally have attracted farmers, policymakers and development investors. Once individuals were able to realize the benefits of soil and water conservation, they participated in other community activities in the watershed by becoming members of various organized groups such as user groups to operate and maintain water-harvesting structures.

Participatory watershed development programs spearheaded by ICRISAT in Andhra Pradesh, Madhya Pradesh, Rajasthan and Gujarat have shown that investments in these programs can result in handsome returns and can also reduce poverty in the dryland areas.

ICRISAT continues to build on its comparative advantage of efficiently and strategically utilizing germplasm collection for the improvement of staple SAT crops, especially for drought. HHB 67, a popular early-maturing pearl millet hybrid, was jointly developed by the Haryana Agricultural University (HAU) and ICRISAT. Now marker-assisted backcrossing is being used to develop versions of the same with improved levels of drought tolerance. Among our other achievements are the extra-short duration chickpea variety ICCV 2 and pigeonpea hybrid ICPH 8 that escape terminal drought. ICRISAT is also harnessing biotechnology to develop new varieties that are drought tolerant. Our goal is to attain more yields or more production per drop of water.

The time has come for us to shift to a new paradigm. There is an urgent need to work towards increasing the efficiency of water use. Water literacy in society must be improved. More importantly, let us rid ourselves of the notion that water is a free and infinite resource.

I am sure that the very crucial study that you have initiated on 70 cases of water conflicts in India will serve as an eye-opener to policymakers and lead to the devising of conflict resolution mechanisms that are so essential in this water-starved world.

I wish you fruitful deliberations at this dialogue.

Thank you.

Plant Genetic Resources as a Means to Sustainable Agriculture

Paper presented at the National Conference on Biopiracy: A Threat to National Wealth of Biological Resources, 22-23 Mar 2005, Department of Botany, Osmania University, Hyderabad, India.

Abstract

Traditional germplasm resources of crops are vital to crop improvement. Their assembly and access to them are important. There are presently over six million germplasm accessions held in over 1300 genebanks across the world. This paper discusses how one of the CGIAR genebanks — the Rajendra S Paroda Genebank at ICRISAT-Patancheru — has utilized its germplasm collection for sustainable agriculture. ICRISAT's genebank conserves genetic resources of sorghum, pearl millet, chickpea, pigeonpea, groundnut and six small millets; holding 114,870 accessions of these crops from 130 countries.

The germplasm in ICRISAT's genebank has been donated by various institutes and organizations worldwide. Two hundred and thirteen fresh germplasm missions were made in 62 countries securing 33,194 germplasm accessions. The germplasm accessions receive high priority and attention for regeneration, characterization, conservation and distribution. The focus of our research is on diversity assessment and on developing representative core and mini-core collections to enhance utilization by breeders. Most of these accessions have been characterized. Germplasm seeds are conserved under very precise (cool and dry) conditions. Adequate seed of each accession is conserved to meet the requests of researchers and for posterity.

The ICRISAT genebank has been supplying over 40,000 germplasm samples annually to scientists globally. About 30% of these samples have been shared with scientists of the Indian national program, resulting in the release of 544 varieties (478 from breeding lines and 66 from basic germplasm) supplied from ICRISAT.

ICRISAT has restored crop germplasm to several countries including India. In the last five years, on request from the National Bureau of plant Genetic Resources (NBPGR) in India, 44,822 accessions of germplasm held at ICRISAT genebank were restored to them.

This paper also discusses concerns of biopiracy of germplasm resources and associated knowledge.

Introduction

The realization that some of the natural resources on earth are finite and vulnerable led to the drafting of the Convention on Biological Diversity at the Earth Summit in Rio in 1992. Biological diversity – or biodiversity – refers collectively to the variety of life forms on earth. Biodiversity forms a "web of life" of which human beings are an integral part and upon which they fully depend. Plants, including food crops, are an important part of this biodiversity, vital for nourishing and sustaining humankind.

At the Rio summit, both developed and developing countries formalized their pledge to check the rapid loss of biodiversity and sustain this critical resource for the present and future generations. Plant Genetic Resources (PGR – synonymous with germplasm) are the most important component of this biodiversity. They contribute substantially towards achieving the global objectives of food security, poverty alleviation, environmental protection and sustainable development. They are critical components of plant breeding efforts aimed at increasing food security — both for short-term gains as well as for long-term increase in productivity. The success of crop improvement solely depends on the availability of diverse genetic resources.

Purposeful efforts to explore, collect, exchange and conserve germplasm resources started in the 1920s. Over the years, genebanks have been established in a number of countries and the number of accessions conserved in genebanks now exceeds the six million mark (FAO 1998).

Traditionally, farmers save seeds from one season for planting in the next. Seed storage under controlled temperature in genebanks is a recent innovation that helps conserve germplasm for longer periods. *Ex situ* conservation involves seeds stored in genebanks; *in situ* conservation is done in farmers' fields and in the wild; and *in vitro* conservation is done under laboratory conditions, mostly for non-seed bearing plants.

The CGIAR

The Consultative Group on International Agricultural Research (CGIAR) is an association of public and private members supporting a system of 15 Future Harvest Centers that work in more than 100 countries to achieve sustainable food security and reduce poverty in developing countries through scientific research and research-related activities in the fields of agriculture, forestry, fisheries, policy and environment.

The CGIAR seed collections are a unique resource, available to all researchers. Seed contributions have helped lay the foundations of recovery by jumpstarting agricultural growth in countries emerging from conflict (such as Afghanistan, Angola, Mozambique and Somalia) and those recovering from natural disasters. A recent study showed that of more than one million seed samples distributed over the past 10 years, 80% or more went to universities and national agricultural research systems where scientists are developing new crop varieties that give higher yields, have improved nutritional value, use less water, need lower amounts of fertilizers, and have natural resistance to insect-pests, diseases and climatic vagaries.

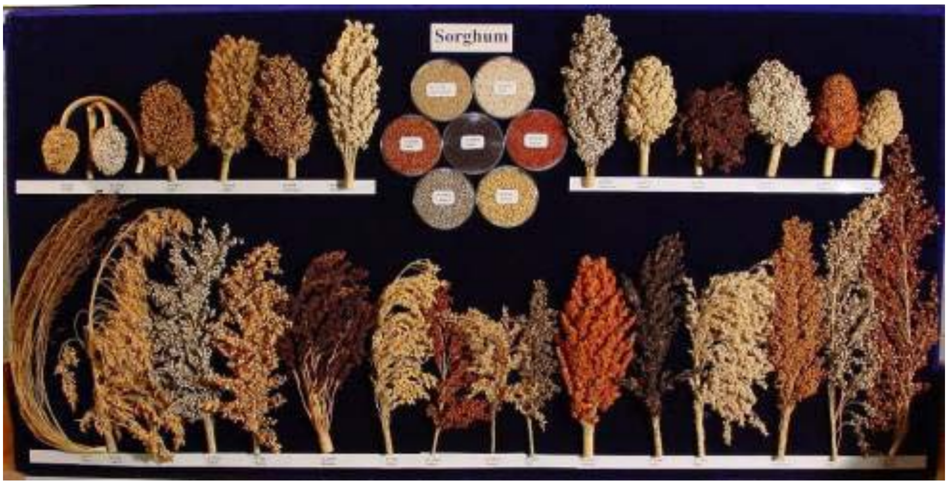
The CGIAR and the Genebanks

CGIAR scientists play major roles in collecting, characterizing and conserving plant genetic resources. Eleven centers together maintain about 600,000 germplasm samples of crop, forage and agroforestry genetic resources in the public domain, of which almost 533,000 are designated in-trust for the world community under agreements with the Food and Agriculture Organization (FAO) of the United Nations.

ICRISAT has the world mandate for the germplasm collection, characterization and conservation and distribution of sorghum, pearl millet, chickpea, pigeonpea and groundnut; and the genetic enhancement of these crops. It also deals with germplasm collection, characterization, conservation, and seed distribution of six small millets: finger millet, foxtail millet, kodo millet, little millet, proso millet and barnyard millet.

1. Germplasm Assembly in the ICRISAT Genebank

When ICRISAT was established in 1972, efforts began to assemble the germplasm of the mandate crops that existed with various research institutes in India and other countries. The Rockefeller Foundation had assembled over 16,000 sorghum germplasm accessions from major sorghum areas, and ICRISAT acquired 11,961 accessions of this collection in 1974 that existed in India and USA, besides 2,000 pearl millet accessions. ICRISAT also obtained 2,000 accessions of pearl millet collected by the Institut Francais de Recherché Scientifique pour le Development en Cooperation (ORSTOM) in francophone West Africa.



The germplasm material of chickpea and pigeonpea originally collected and assembled by the former Regional Pulse Improvement Project (RPIP), a joint project of the Indian Agricultural Research Institute (IARI), the United States Department of Agriculture (USDA) and Karaj Agricultural University in Iran, formed the initial collection. Sets of this germplasm, which were available in several agricultural research institutes in India and Iran, and at the USDA, were donated to ICRISAT in 1973. ICRISAT also acquired over 1,200 chickpea accessions from the Arid Lands Agricultural Development (ALAD) program in Lebanon. Similarly, much of the groundnut germplasm was received from the Indian groundnut research program (now the National Research Center for Groundnut, Junagadh), and USDA. In all, 32,307 accessions (12,042 of sorghum, 3,320 of pearl millet, 5,401 of chickpea, 5,054 of groundnut; 3,889 of pigeonpea and 2,601 of small millets) were donated by various research institutes in India (Table 1). This comprises 28.3% of the entire holding at the ICRISAT genebank (Table 2).

ICRISAT initiated activities to add new germplasm of its mandate crops from areas that were not adequately represented in the collection. Between 1975 and 2004, a total of 213 joint missions were launched in 62 countries, from which 33,194 accessions (9,011 of sorghum, 10,841 of pearl millet, 4,228 of chickpea, 3,873 of pigeonpea, 2,776 of groundnut and 2,465 of small millets) were collected. ICRISAT also works on the genetic improvement of its mandate crops. A large number of breeding lines or germplasm selections are developed and evaluated at important locations. The promising/improved germplasm lines were also registered in the genebank and conserved for future utilization. Currently 3,905 accessions (549 of sorghum, 1,336 of pearl millet, 286 of chickpea, 1,619 of pigeonpea, 114 of groundnut and 1 of finger millet) that are in fact improved breeding lines, resistant sources of various stresses or cultivars, have been registered in our genebank (Table 3).

2. Germplasm Management

Phenotypic characterization and evaluation: Agronomic and morphological characterization is necessary to facilitate the utilization of germplasm. To achieve this, germplasm accessions of all the crops were sown in batches over the years and characterized for morphological and agronomic traits. Germplasm screening against biotic and abiotic stresses were conducted in collaboration with various disciplinary scientists. Grains were tested for nutritional value. Germplasm sets were evaluated over locations jointly with NARS scientists in India, Nepal, Thailand, Indonesia, Ethiopia, Kenya and more intensively with NBPGR. The results of joint evaluations have led to a better understanding of the germplasm material.

Regeneration: Regeneration was carried out to meet the increased seed requirements of: (1) accessions that had reached a critical low level of seed stock/viability; (2) accessions required for medium-term storage (MTS) or long-term storage (LTS); and (3) germplasm repatriation, particularly to the NBPGR. Some of the germplasm accessions that do not produce seeds under ICRISAT-Patancheru climatic conditions (some wild *Arachis* species) are maintained vegetative in the greenhouse. Some other accessions (wild *Cicer* species) need long day length and cool weather to grow and produce seeds. These species are also regenerated in greenhouse facilities.

Conservation: Germplasm conservation requires cleaning the seed material, drying to minimal seed moisture content, storing in cool and dry conditions and regular monitoring of seed health during storage. Seeds in the ICRISAT genebank are stored in medium-term storage (MTS 40°C, 20–30% RH) in aluminum cans. A recent monitoring of the health of seed conserved for 10–25 years (MTS) indicated greater than 75% seed viability for the majority of the accessions. Accessions with declining seed viability (less than 75% seed germination) are regenerated on priority and old stock is replaced with fresh seeds. Germplasm accessions are also conserved in long-term storage (LTS -20°C) after packing in vacuum-sealed aluminum foil pouches. Before packing, the seeds are dried to about 5% moisture content in a walk-in-drying room (100 m^3 size; 15°C and 15% RH) facility. At present, about 70% of the FAO designated germplasm is in the LTS facility.

Enhancing germplasm use for improved food security: Only a very small part of our germplasm collection is being used by plant breeders in crop improvement programs because of the lack of information on traits of economic importance, which often shows genotype x environment interactions and requires replicated multilocational evaluations. This is very costly and resource-demanding. To overcome this, our research now focuses on studying the diversity of germplasm collection and developing core collections, which are about 10% of the entire collection, but represent almost the complete diversity of the species. In the case of crops with a very large number of accessions and core subset, ICRISAT scientists have developed a strategy to select a mini-core collection (Upadhyaya and Ortiz 2001), which is 10% of the core collection (ie., 1% of the entire collection) and contains the diversity of the entire collection. From the germplasm collection in the ICRISAT genebank, we have already developed a core collection of sorghum (2,247 accessions, Grenier et al. 2001); pearl millet (1,600 accessions, Bhattacharjee 2000); chickpea (1,956 accessions, Upadhyaya et al. 2001); groundnut (1,704 accessions, Upadhyaya et al. 2003); pigeonpea (1,290 accessions, Reddy et al. 2004); and finger millet (622 accessions, Upadhyaya et al.; in press). We have also selected mini-core collections of chickpea (211 accessions, Upadhyaya and Ortiz 2001) and groundnut (184 accessions, Upadhyaya et al. 2002).

A large number of mini-core collection sets of chickpea and groundnut have been sent to different countries on request. The collections are evaluated and useful parents are selected for use in breeding programs. At ICRISAT, we have identified 21 new sources of early-maturity, 158 sources of low temperature tolerance at germination, 18 sources of drought resistance-related traits, specific leaf area and SPAD chlorophyll meter reading in groundnut, and 28 sources of early-maturity, 16 sources of large-seed size in kabuli type and 10 sources of drought resistance-related traits in chickpea. We also identified 15 valencia, 20 spanish and 25 virginia type germplasm lines in groundnut with high yield, good shelling percentage and 100-seed weight through multilocational evaluation of the Asia region core collection (Upadhyaya et al.; in press). These new sources performed better than or similar to the best control cultivars for particular trait(s) but were diverse from the known sources. Their use will broaden the genetic base of cultivars. Similarly, the chickpea mini-core developed at ICRISAT (211 accessions) was evaluated at the Indian Institute of Pulses Research (IIPR), Kanpur, during the 2002-03 and 2003–04 seasons to identify desirable germplasm for use in the improvement programs.

3. Molecular Characterization of Germplasm

Characterization of germplasm with molecular markers can help improve their utilization. This information can be used to predict shared pedigree or geographical origin of individuals and to find population structures that influence the analysis of functional characterization, such as associations between markers and phenotypes. It can further form the basis for mining and cloning of agronomically important genes.

Chickpea: Two sets of germplasm have been analyzed for molecular diversity. The first set comprising of 96 accessions was analyzed for ascochyta blight, and the second of 89 accessions for botrytis gray mold. The molecular diversity in these sets was assessed by studying polymorphisms at about 30 mapped simple sequence repeats (SSR) markers. The number of alleles detected per marker ranged from 7 to 32. The genetic relationships among genotypes within each set indicated that the sources of resistance for each of these diseases might be genetically diverse.

ICRISAT is actively participating in the Generation Challenge Program (Generation-CP) launched by the CGIAR and aimed at enhancing the use of genetic resources through application of biotechnological tools.

Groundnut: Twenty-three SSR and three resistance gene analogue (RGAs) markers were screened across 22 genotypes with differing levels of resistance to rust and late leaf spot. Twenty-four markers were polymorphic and 12 of these showed a high level of polymorphism. This is the first report of such high levels of genetic polymorphism in cultivated groundnut. Multi-dimensional scaling and cluster analyses revealed three well-separated groups of genotypes corresponding to differing botanical types and disease response groups.

Documentation: The vast germplasm data gathered on chickpea and pigeonpea germplasm has been summarized and presented in the form of catalogs (Pundir et al. 1988, Remanandan et al. 1988). During the last 15 years, we have had a very purposeful collaboration with NBPGR, in germplasm exploration and evaluation at a number of potential locations. The success stories were reviewed, discussed and published as ‘Collaboration on Genetic Resources’ (ICRISAT 1989). The data on joint germplasm evaluations were analyzed and we published two catalogs on forage sorghum germplasm (Mathur et al. 1991, 1992), one on chickpea (Mathur et al. 1993a) and two on pearl millet (Mathur et al. 1993b and 1993c).

4. Global Germplasm Supply to Scientists and Institutions

Since 1973, we have supplied 670,057 germplasm samples outside ICRISAT (Table 4). In addition, ICRISAT scientists have shared very large samples of early and advanced generation breeding materials, international nurseries and trials with their counterparts.

5. Impact of Germplasm Supplied to NARS Worldwide

Besides the utilization of germplasm in ongoing research at other institutes, 66 germplasm accessions (30 of sorghum, 7 of pigeonpea, 19 of chickpea, 6 of groundnut, 2 of finger millet and 1 each of pearl millet and barnyard millet) supplied from the ICRISAT genebank have been directly released as cultivars in 44 countries. Pigeonpea germplasm accession ICP 8863 collected from farmers' fields in India was found very promising against fusarium wilt and was purified for the trait. The purified line was high yielding and was released in 1986 as Maruthi for cultivation in Karnataka state, India. This variety is grown over large areas in the adjacent states of Maharashtra and Andhra Pradesh.

Parbhani Moti, a sorghum variety, was released in Maharashtra in May 2002. It is an excellent Maldandi-type (predominant postrainy sorghum landrace in Maharashtra and Karnataka states) with large lustrous grains and high yield. It has been selected from a germplasm collection from Ghane Gaon, Sholapur, Maharashtra, made by ICRISAT genebank staff during 1989.

In addition, from the breeding materials supplied from ICRISAT, 478 varieties and hybrids (172 of sorghum, 75 of chickpea, 111 of pearl millet, 85 of groundnut and 35 of pigeonpea) have been released in 64 countries spread over five continents.

6. Repatriation of Germplasm to NARS Worldwide

The global collections held at ICRISAT serve the purpose of restoring germplasm to the source countries when national collections are lost due to some reasons. We supplied 362 of sorghum accessions to Botswana, 1827 of sorghum and 922 of pearl millet to Cameroon, 1723 of sorghum and 931 of chickpea to Ethiopia, 838 of sorghum and 332 of pigeonpea to Kenya, 1436 and 445 of sorghum accessions respectively to Nigeria and Somalia and 71 pigeonpea accessions to Sri Lanka.

7. Centers of Plant Genetic Resources Diversity and the Concern for Biopiracy

Following the concept of eight centers of plant origin by NI Vavilov, Zeven and Zhukovsky (1975) suggested 12 megagene regions of plant diversity. These included the (1) Chinese-Japanese region, (2) Indochinese-Indonesian region, (3) Australian region, (4) Hindustani region, (5) Central Asian region, (6) Near Eastern region, (7) Mediterranean region, (8) African region, (9) European-Siberian region, (10) South American region, (11) Central American and Mexican region and (12) North American region. Besides these regions being a rich source of diversity of crop, medicinal and aromatic plants, they have also accumulated a whole lot of traditional knowledge on their usage. However, there is always the danger of the plant materials and the traditional knowledge being wrongly appropriated. This is what we call biopiracy, and it

usually occurs through the patenting of intellectual property right to a biological entity, active agent or to the knowledge associated with the utilization of crop genetic resources. Legally, three fundamental conditions need to be fulfilled before a patent can be granted. These pertain to:

- Novelty: The claimed invention must be new and unique
- Human ingenuity: Showing that the invention is something which another person in the field would not ordinarily have done
- Utility: Granting a patent must require the invention to be commercially useful in some way.

Several instances of attempted biopiracy have come to light in the recent past, such as Basmati rice from India and Pakistan, Jasmine rice from Thailand and several medicinal and aromatic products from India.

Possible ways of minimizing biopiracy: The FAO's International Treaty on Plant Genetic Resources for Food and Agriculture has the ability to protect traditional knowledge of plants and rights to ensure equitable participation in the sharing of benefits of plant genetics. Unfortunately, few high-income countries have ratified the treaty thus far. The creation of the Traditional Knowledge Digital Library and linking it to the International Patent Classification System through a Traditional Knowledge Resource Classification System is an important conceptual step towards minimizing biopiracy (Mashelkar 2001). It could follow with appropriate material transfer and benefit-sharing mechanisms when products are created based on community knowledge. The village-level documentation of crop cultivars, locally used medicinal herbs, wild foods and other biodiversity resources; and of their use, and conservation and management practices envisaged in the legal framework might take the form of a Peoples Biodiversity Register (PBR) (Ghate et al. 1999). The precise documentation of PBR may serve to promote sustainable management of biodiversity resources and to impose certain conditions of benefit sharing in case some biological product of their domain is patented.

The role of International Agricultural Research Centers in minimizing biopiracy: Most of the germplasm accessions at the 11 IARC genebanks are designated and held in-trust for the world community under agreements with the FAO. The terms of the agreements signed between the FAO and CGIAR Centers stipulate that the germplasm within the in-trust collections will be made available without restriction to researchers around the world, on the understanding that no intellectual property protection can be applied to the material. Seed samples are thus made available by individual centers under a standard Material Transfer Agreement (MTA). Under MTA, recipients agree not to take IPR on the germplasm material received and the subsequent recipient is also bound by the same conditions.

8. Conclusion

Crop genetic resources have contributed enormously towards sustainability of agriculture and alleviation of poverty. These are being assembled and conserved at several genebanks for posterity. Using raw germplasm resources, a large number of crop varieties and hybrids have been developed and released for cultivation. New strategies on core and mini-core collections were developed to further enhance utilization of germplasm in research. The emerging problem of biopiracy of germplasm resources and associated knowledge are the real concerns that need to be dealt with appropriately.

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Table 1. Germplasm accessions in the Rajendra S Paroda genebank, ICRISAT, donated by institutes in India until 2003.

Crop	Number of accessions
Sorghum	12,042
Pearl millet	3,320
Chickpea	5,401
Pigeonpea	3,889
Groundnut	5,054
Small millets	2,601
Total	**32,307**

Table 2. Germplasm holdings in the Rajendra S Paroda Genebank, ICRISAT, Patancheru, December 2004.

Crop	Active collection	Base collection	Accessions held in-trust
Sorghum	36,774	31,669	35,836
Pearl millet	21,594	15,150	21,329
Chickpea	17,258	15,984	16,970
Pigeonpea	13,632	10,266	12,712
Groundnut	15,419	6,820	14,419
Finger millet	5,949	4,620	4,979
Foxtail millet	1,535	1,054	1,535
Proso millet	842	576	835
Little millet	466	384	462
Kodo millet	658	630	656
Barnyard millet	743	487	743
Total	**114,870**	**87,640**	**110,476**

Table 3. Germplasm accessions in the Rajendra S Paroda genebank that were bred/developed/selected at ICRISAT until 2003.

Crop	No. of accessions
Sorghum	549
Pearl millet	1,336
Chickpea	286
Pigeonpea	1,619
Groundnut	114
Finger millet	1
Total	**3,905**

Table 4. Distribution of germplasm samples from the Rajendra S Paroda genebank, to scientists outside ICRISAT, 1974-2004.

Crop	1974-79	1980-85	1986-91	1992-97	1998-2004	Total
Sorghum	23,120	61,988	107,358	42,103	13,931	248,500
Pearl millet	7,829	13,425	48,387	13,470	6,129	89,240
Chickpea	17,214	46,197	29,477	14,184	13,738	120,810
Pigeonpea	10,834	12,442	19,664	14,501	8,897	66,338
Groundnut	7,114	17,684	30,750	25,489	12,937	93,974
Finger millet	2,762	5,487	5,688	8,460	6,222	28,619
Foxtail millet	3,353	2,281	2,906	680	1,464	10,684
Proso millet	676	2,183	1,980	234	244	5,317
Little millet	186	739	409	116	636	2,086
Kodo millet	657	547	708	64	33	2,009
Barnyard millet	679	880	604	61	250	2,474
Total	**74,424**	**163,853**	**247,931**	**119,362**	**64,481**	**670,051**

Improving Livelihoods and Food Security in Asia through Sustainable Management of Natural Resources

Presented at the 5th Regional conference on Environment and Development on The Future of the Sierra Madre: Responding to Social and Ecological Changes, 13 Apr 2005, Cagayan Valley Program on Environment and Development, ISU-Cabagan, 3328 Isabela, The Philippines.

Ladies and gentlemen,

Rainfed agriculture constitutes the livelihood base for the vast majority of rural inhabitants in developing countries. It is a source of food security, employment and cash income. It is estimated that about 80% of the world's agricultural land is rainfed, contributing to about 58% of the global food production.

Approximately 2 billion people inhabit the drylands across the globe. Studies indicate that Asia has the largest area under drylands and is home to over 1.5 billion people. It is characterized by limited natural resources, erratic rainfall, land degradation, soil erosion, poverty and a burgeoning population. A global assessment of the extent and form of land degradation reveals that 57% of the total dryland areas occurring in two major Asian countries, namely China (178.9 million ha) and India (108.6 million ha), are degraded. If current production practices persist, Asian countries will face a serious food shortage in the near future.

Given this scenario, the mission of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is to help the poor of the SAT through Science with a human face and partnership-based research, and to increase agricultural productivity and food security, reduce poverty and protect the environment in SAT production systems.

ICRISAT generates international public goods through its research and in partnership with others, particularly the national agricultural research systems. Every effort is made to ensure that research knowledge and products developed by the Institute are actively disseminated and used for the benefit of people in the developing world, and for society in general. ICRISAT believes that access to its outputs should be fair and equitable.

Among the international public goods derived from our research in agroecosystems are improved participatory research methodologies for natural resource management (NRM), improved simulation modeling capacity and its application in smallholder farmer systems research and methodologies for watershed development and soil fertility management. The Institute has adopted an integrated genetic and natural resource management approach to improving the livelihoods of the millions of poor, which combines water management and crop management, beginning with the management of soil and water leading to the development of other resources. The potential technologies are scaled-up and scaled-out to create a self-supporting system essential for sustainability and development in the dry regions.

A new model has emerged from the lessons learnt from watershed-based research conducted by ICRISAT-NARS. Based on this experience, the SAT have been given a new deal with a farmer-centric integrated watershed management model, whose components include a farmer participatory approach, use of new science tools, a holistic systems approach to improving livelihoods, a consortium of institutions for technical backstopping, nucleus watersheds where farmers conduct strategic research with technical guidance from scientists, low-cost soil and water conservation measures and structures, a combination of traditional and new knowledge, emphasis on individual farmer-based conservation measures, continuous monitoring and evaluation by stakeholders and the empowerment of community individuals.

The model was applied at selected benchmark locations in Asia to enhance and sustain productivity and to develop environment-friendly soil and water resource management practices. On-station benchmark locations served as sites for strategic research and on-farm benchmark watersheds served as farmer-managed sites for farmer participatory refinement and evaluation of sustainable natural resource management options under varying socioeconomic and biophysical situations. The on-farm watersheds were provided technical backstopping from ICRISAT and other consortium institutions.

The targeted production systems in Asian ecoregions with assured rainfall were the eastern Deccan plateau in India and parts of central Myanmar, northeastern Thailand, northern Vietnam, southern China and the dry areas of Indonesia and the Philippines.

Among the interventions that ICRISAT uses to make a difference in the lives of the poor are new scientific tools such as remote sensing, geographical information systems (GIS), digital terrain modelling for estimating runoff and soil loss and crop simulation modelling for the analysis of long-term potential productivity in watersheds. These tools provide the capabilities for extrapolating and implementing technologies to other larger watersheds. Our use of crop growth simulation models such as APSIM and DSSAT provide an opportunity to simulate crop yields in a given climate and soil environment.

For instance, in partnership with the National Remote Sensing Agency (NRSA), Hyderabad, India, ICRISAT is using Indian Remote Sensing Satellite (IRS-1B/-1C and -1D) data to develop and manage watersheds and to monitor the impact of interventions made.

Our studies on crop productivity and resource use adopting an integrated watershed approach for soybean-chickpea sequential and soybean/pigeonpea intercrop systems revealed that the improved broadbed and furrow (BBF) system recorded an average 0.1 t ha^{-1} more grain yield than the flat landform. The BBF system gave greater crop yield, lower total runoff, stored 15 mm more rainfall in the soil profile and had greater deep drainage than the flat landform treatment, especially in shallow soil.

The objectives of improving rural livelihoods, ensuring the sustainable utilization of existing resources and adding value to rural produce are achieved by convergence of activities in the watershed. Income-generating options for the landless and women at Kothapally and other benchmark watersheds have included the setting up of village seed banks through self-help groups, value addition through seed material, product processing such as *dhal* making, grading and marketability, poultry rearing for egg and meat production and vermicomposting.

To control erosion and restore the productivity of degraded soils in the watersheds, engineering techniques are taken up in conjunction with biological control measures. These comprise *in situ* and *ex situ* conservation measures. The green-blue water (rainfed systems combined with supplemental irrigation) continuum has proved to be more effective in terms of improving overall water use efficiency.

Let me now come to how ICRISAT's integrated nutrient management (INM) deals with nutrient constraints. In Tad Fa Watershed in northeastern Thailand, use of legumes in the cropping system is a viable alternative to overcoming nutrient constraints, especially when chemical fertilizers are expensive. Legumes like bean (*Vigna umbellata*), black gram (*Vigna mungo*), sword bean (*Canavalia gladiata*) and sunnhemp (*Crotalaria juncea*) were evaluated on farmers' fields at Ban Koke Mon near Ban Tad Fa, where the ICRISAT benchmark watershed is situated, to quantify nitrogen fixation and the benefits of legumes using 15 N abundance and 15 N isotope dilution methods. The cropping systems of Ban Koke Mon are similar to those of Ban Tad Fa.

We at ICRISAT have adopted integrated pest management (IPM), the coordinated use of pest and environmental information to design and implement pest control measures that are economically, environmentally and socially sound. Indigenous methods like shaking pod borers from pigeonpea and using them for pest management, adopting pest-tolerant varieties and biocontrol measures using Helicoverpa nuclear polyhedrosis virus (HNPV) are part of the Institute's strategy of optimizing crop productivity in watershed interventions. Studies have shown that in 65% of the 17 farmers' field trials in Kothapally, in addition to giving higher crop yields (3.47 t ha^{-1})

over farmers' practice (2.33 t ha^{-1}), IPM substantially reduced investment.

Apart from breeding drought-resistant crops/varieties and using high-value crops such as medicinal plants to increase productivity and incomes, ICRISAT trains farming communities in developing micro-enterprises such as vermicomposting, preparing bio-fertilizers, setting up village-based seed banks, and livestock-, fisheries-, horticulture- and poultry-based activities which help curb migration to urban areas in search of employment during the off-farm season.

Availability of good quality seed is critical for farmers to increase crop productivity, and ICRISAT believes in empowering farmers and self-help group members in running village-based seed banks under the technical guidance of consortium partners. Under the APRLP-ICRISAT-ICAR project, two village-based seed banks became operational in 2003 in Kurnool district of Andhra Pradesh.

Rehabilitating common grazing lands and wastelands is another crucial activity under watershed management. For instance, under the Tata-ICRISAT-ADB Project in Gokulpura village in Rajasthan, community participation to rehabilitate 45 ha of open grazing land on undulating terrain by erecting a stone wall fencing, planting useful grasses, bench terraces, contour trenches and silt trap pits for *in situ* soil moisture conservation led to improved fodder availability and the rehabilitation of flora and fauna.

Overall, the impacts of ICRISAT's technology interventions at Adarsha watershed have been in the form of increased productivity, shift in cropping pattern and crop diversification, improved greenery, improved groundwater levels, reduced runoff and soil loss and increased incomes. The increased availability of water and better employment opportunities in watershed development-related activities have contributed to the diversification of income opportunities and reduced vulnerability to drought and other shocks.

Among the new initiatives that ICRISAT has taken up are empowering stakeholders (farmers, partners, NGOs, government departments and policymakers) through capacity building, disseminating on-station and on-farm technologies in watersheds; conducting farmers' days, field days, farmer awareness programs, training courses/programs; preparing and distributing training material, information brochures, bulletins and pamphlets on various watershed-based technologies in English and regional languages; and putting in place ICT-enabled farmer-centered learning systems.

At present the ICRISAT-led consortium is developing a scaling-up methodology for the integrated watershed management model in 190 villages in India, China, Thailand and Vietnam with financial support from the ADB, Sir Dorabji Tata Trust, DFID and NARS.

As a Filipino I am proud to share my successes with you. I have steered ICRISAT out of troubled waters and we have come out winners, reaping the seeds of success we have sown in the semi-arid tropics. For the fourth time, ICRISAT won the King Baudouin Award during the CGIAR Annual General Meeting in Mexico. We shared this award with CIMMYT, IRRI, IWMI and other national systems in the Rice-Wheat Consortium for the Indo-Gangetic Plains. With our fourth King Baudouin Award, ICRISAT is now unequalled in the CGIAR system.

ICRISAT has clearly demonstrated that rainfed agriculture can be harnessed to contribute to the global food basket. Its potential can be tapped through effective natural resource management through watersheds. Holistic farmer-centric and up-scalable approaches can ensure 'win-win' solutions and help increase productivity of rainfed agriculture. ICRISAT has proved that strong community institutions, participatory approaches, technical support and standard watershed technologies together have the potential to lift the landless poor and small farmers living in the rainfed areas out of the poverty trap.

We in the Philippines are living in a time of crisis, but we can overcome it by going that extra mile in helping our country. The CVPED has contributed significantly through education and research to the sustainable management of the Sierra Madre Mountain Range. What is needed is timely response to sociological and ecological changes. This is possible through policy harmonization, the operationalization of the Sierra Madre Biodiversity Corridor, the involvement of local people, fostering partnerships for rural development and biodiversity conservation and watershed management, among other things. I think it is possible with a little bit of determination.

Let me tell you that when I took over the reigns at ICRISAT, things were not all that rosy. But I was determined to turn around the institute. All it called for was a vision and the determination to see it through.

Thank you.

The Role of Youth in Rebuilding the Philippines

Delivered during the 27th annual commencement exercises of the Isabela State University, 16 Apr 2005, Cabagan, Isabela, the Philippines.

To the graduating students and their parents, the faculty, staff and guests of the Isabela State University, good morning.

I am extremely grateful to President Romy Quilang for inviting me to be the speaker in today's commencement exercises of a premier educational institution such as the Isabela State University-Cabagan. As a son of the North, I feel reinvigorated everytime I come to this region to meet my fellow Ilocanos.

It is a pleasure to see that ISU-Cabagan has come a long, long way since its days as the Cabagan National Agricultural School, then the Cagayan Valley Institute of Technology and finally a full-blown state university.

President Quilang requested me to inspire the new graduates and share words of wisdom to guide them on their road to success. I will therefore focus my speech on the graduates in the context of rebuilding the Philippines, which today faces gigantic challenges in fighting poverty, hunger, crime, corruption and social conflict.

We now live in a global village — a world of free markets, and a wired society of competing economies. Relentless forces, such as huge capital flows, advances in information and communication technology and the gene revolution are changing the way we live.

You belong to the youth that comprises almost one-third of the population. In terms of numbers, your attitudes, values and chosen profession can indeed shape and make a big difference to your country's development. I therefore challenge you to pursue a mission of rebuilding the Philippines. You can do this by helping lift our rural poor from the quagmire of hopelessness and poverty.

How will you succeed in your chosen profession to help the poor? Allow me to share my own experiences. Not so many years ago, I too listened to a commencement speaker at the Benguet State University, my alma mater. I patiently listened throughout the speech, wondering what was in store for me. But deep inside, I felt I had a mission to pursue.

I wanted to be a leader serving the rural poor, and I was determined to succeed. I then set my sights on a career in the public service, starting as a government farm management technician.

Hard work and patience paid off as I eventually became Professor VI and Vice President for Research and Development at the Benguet State University. I then moved to the Department of Agriculture as the first Director of the Bureau of Agricultural Research (BAR). ISU should also be proud to have contributed to the esteemed league of BAR Directors in the person of Dr William Medrano.

From BAR, I became the fifth Executive Director of the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD). Later on, I became Secretary of Agriculture and then Presidential Adviser on Food Security and Rural Development.

Through these experiences, I began to develop a deeper sense of commitment to pursue my dream. It strengthened my resolve to serve the rural poor not only in our country but other developing countries of the world as well.

In time, I came to serve ICRISAT, the International Crops Research Institute for the Semi-Arid Tropics, as its fifth Director General. I am now in my second term as ICRISAT's Director General. Concurrently, this year, I was also chosen to lead the Future Harvest Alliance Executive of 15 Centers under the CGIAR.

ICRISAT serves 48 countries of the dry tropics of the world — home to about 300 million people who are the poorest of the poor. Our mission is to improve agriculture in the dry tropics, spearheading a Grey to Green Revolution that is guided by Science with a human face.

While a Grey to Green Revolution makes us turn adversities into opportunities in the dry tropics through agricultural research for impact, doing Science with a human face means that we harness science and technology and innovations as a means to serve the rural poor, not as an end in itself.

You may ask, what is the formula for a successful leader and manager? Let me devote the last part of my speech on what I call Formula 10 for effective leadership and management.

1. Chart a Vision and Develop a Game Plan

A leader must be able to provide a clear vision of a transformed future. By vision I mean strategy and goal setting. It is more than simply having a plan. Vision is a passionate commitment to creatively bridge the gap between the present and the desired future.

2. Communicate Your Vision

A vision is meaningless unless it is shared with others. A leader must possess a wide range of communication skills. This includes articulating issues, listening to others and synthesizing diverse perspectives of constituents.

3. Harness Good People

Outstanding people make outstanding organizations. Human resources are the most essential in building great institutions. Consequently, outstanding people give confidence to a leader in delegating authority and responsibility. I am proud to lead an organization with excellent people. This is manifested by more than 40 awards that ICRISAT has received during the last five years.

4. Build a Strong Team

Leaders develop dynamic networks, relationships and a culture that builds a strong team in the organization. Building a strong team enables a leader to mobilize followers who are eager to cooperate for the greater good. Team spirit makes an organization greater than the sum of its parts. It enables a vision to be realized.

5. Make Sound Decisions and Take Risks

True leaders have the courage to act. They take risks and make tough decisions. Without taking risks, leaders cannot move their organizations forward. Thus, leaders must be willing to make bold moves and embrace the seemingly impossible, including failures.

6. Admit Mistakes and Apologize when Needed

A leader who is a risk taker allows room for mistakes. Hence, a leader should quickly recognize mistakes, apologize and rectify the situation. Outstanding leaders learn from their mistakes and make amends. I don't hesitate to say "I'm sorry" if I know I made a mistake.

7. Be Trustworthy and Care about Others

Visions are based on core values. For good leaders, the means are just as important as the end. They pursue reforms with integrity, taking right actions for the right reasons. They know that trust and credibility are central to leadership.

8. Be Humble Yet Firm

In our culture, humility, especially among leaders, is a highly regarded virtue. In a broader sense, humility enables leaders to have a modest estimate of their own worth. It also enables them to submit themselves to others without being weak. I am a humble son of the soil, but I am also firm as a leader.

9. Never Give Up

Never give up. Work hard. These are at the heart of successful leadership. The best leaders love what they do and put their hearts into it. Leaders make commitments and are determined to see them through.

10. Have a Sense of Humor

Good leaders laugh with others and at themselves. They maintain a healthy sense of balance and perspective. They know that humor often diffuses a tense situation. I usually laugh with my colleagues, especially to unfreeze a tense situation.

With these words, I wish you well and good luck. I am confident that you will soon join the ranks of leaders who will help rebuild the Philippines and serve our poor people.

With God's help, I am sure that you will all succeed.

There is indeed hope and pride in the Filipino.

Agbiagkayo ken naimbag nga aldawyo amin apo!

Leaders Develop New Leaders

Delivered at the Leadership Training for Future Leaders of Research and Development (R&D) and Educational Institutions, 10-11 Jun 2005, Central Luzon State University, Science City of Muñoz, Nueva Ecija, the Philippines.

President Rudolfo Undan, President Emeritus of CLSU, Dr Fortunato Battad, other leaders in agriculture and educational institutions, my dear friends, ladies and gentlemen, good afternoon.

I have always believed that the final test of a leader is for him or her to leave behind in other men and women the conviction and the will to carry on. That is what I would like to elucidate on today, as I stand before you, leaders and future leaders in agriculture and educational institutions.

I am happy to note that this two-day training program for leaders of R&D and educational institutions is in total congruence with the mission of our higher educational institutions to develop quality human resources and technologies for people empowerment, global competitiveness and sustainable development.

As Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), I have learnt that leadership is not about more followers. It is about producing more leaders who can take up from where you left. It has to do with motivating people, engaging and igniting their minds as well as their hearts.

Personally, my first term at ICRISAT has been full of prospects where I could go as far as I could dream. Today, ICRISAT is practically on top of the CG System, and much more in the Alliance of Future Harvest Centers of the CGIAR. I am now the Chair of the Center Director's Committee (CDC), now the Alliance Executive, giving me the opportunity to lead and influence the CGIAR system. It is indeed a comforting thought that our actions can greatly impact on the lives of the poor people in the developing countries of the world.

Hunger and poverty continue to be global tragedies that call for concerted and persistent efforts to eliminate them. The Millennium Development Goal of halving hunger by 2015 builds on the various attempts to cut the proportion of people who go hungry from the current 852 million every day. The UN Millennium Project's Task Force on Hunger, of which I am a member, gave me the opportunity to contribute my ideas.

The Task Force had the challenging job of identifying interventions and policy measures needed to achieve the hunger goals. These included investments to improve agricultural production, enhancing the nutritional status of the hungry, improving productive safety nets, promoting rural markets, providing off-farm employment and restoring and conserving natural resources crucial for food security.

Let me come to my own motherland and its poverty. Today, the Filipino people are tired of the mess they are forced to live in. Millions have left the motherland and their families to seek employment around the world. Those who stay behind are forced to eke out a living. It is not just material poverty that has gripped the Philippines today; there is a serious dearth of effective and moral leadership too. If our nation is to regain its past glory, this group can contribute a big deal to make it happen again. With your new attitudes and skills and the desire to help your country get out of this situation, you are expected to take the lead in ushering in major changes in your respective areas. You can generate hope from the prevailing situation in the country. I am sure this training course will energize and develop strong problem-solving, decision-making and visionary leaders from among you.

As Peter Drucker says, leaders are made, not born. But how they develop is crucial for organizational change. Those who are willing to work at developing themselves and becoming more self-aware can most certainly evolve over time into truly transformational leaders.

An effective leader does not need to be a leader in the typical sense of the word. What makes him effective is that he ask

— what needs to be done and what is right for the enterprise, develop action plans, take responsibility for decisions and for communicating, focus on opportunities rather than problems, run productive meetings and think “we” rather than “I.”

All of you gathered here today have it in you to change circumstances. Rise and take the bull by its horns and face the challenges head on. Most importantly, lead by example. I speak from personal experience.

Had I been a passive onlooker to the goings on at ICRISAT when I took over the reigns in 2000, I would not have succeeded in steering the ship to calm waters. ICRISAT would not have recovered from the crisis it was mired in. I believed that what we wanted was possible. Finally, it was not the material rewards that mattered but the development of the institution that counted. Reversing the hopeless situation called for dialogue, engendering respect, sparking collaboration and more importantly, inspiring initiative. Ever since the turnaround, there has been no looking back.

Today I can proudly say that my leadership and our collective efforts have paid off. ICRISAT has made a big turnaround and is scaling new heights. For the fourth time, and no other Center can equal this feat, we won the most prestigious King Baudouin Award during the CGIAR Annual General Meeting in Mexico last year. We shared this award with CIMMYT, IRRI, IWMI and other national systems in the Rice-Wheat Consortium for the Indo-Gangetic Plains. The world’s first two transgenic groundnut products are in their third year of contained field trials at ICRISAT. Also, the world’s first transgenics pigeonpea and chickpea are now in their second year of contained trials.

I have recounted my experiences to you. This is where the inspiration and motivation stop and the perspiration (provided by you) begins. You have all the talents and resources. Your main challenge is to inspire and serve as good examples that others can emulate. Your vision must touch the heart of every Filipino, in turn inspiring him to tread the same path. I am sure that with a little bit of determination and innovation and going that extra mile, you can become the country's highest achievers. I wish you all the best in your endeavors and I believe you will all succeed.

Rise, my countrymen! Stop not till the goal is achieved!

Thank you.

Empowering Small Farmers

Delivered on Recognition Night, 107th founding Anniversary of the Department of Agriculture, 23 Jun 2005, The Philippines.

DA Secretary Arthur Yap, Former Secretaries of Agriculture, Mr R C Jain, our friends and partners from the agriculture sector, other distinguished guests, good afternoon.

It is a great honor for me to be part of this celebration of the 107 years that the Department of Agriculture has been of service to the farmers and fisherfolk of this country. I would like to thank Secretary Yap for recognizing the outstanding achievements of former Secretaries of Agriculture. I humbly accept this honor and dedicate and share it with the small farmers/fisherfolk. Thank you also for giving us the opportunity to renew our ties with the Department, and the chance to strengthen our commitment to the agricultural growth and development of our country. Likewise, I would like to take this opportunity to honor as well, all the men and women of DA who have remained committed to and remain the vanguards of the Department, weathering the different changes and challenges in the sector.

I am proud to say that I have been a part of the DA family for many years, first as the Director of the Bureau of Agricultural Research, then as the Secretary. Since I became the Director General of ICRISAT, I have intensively advocated a Grey to Green Revolution in the dry tropics of Asia and sub-Saharan Africa through Science with a human face. This is science and technology primarily dedicated to helping the small farmers in the drylands of the world. The reason I'm sharing this with you is that I believe that the lessons I learned in ICRISAT could help the DA chart its course in spurring agricultural growth and development and ultimately improving the lives of small farmers and fisherfolk.

Serving the small farmers and fisherfolk has always been my mission and passion. Though I am now based in India, there is a continuing effort on my part to promote the best practices in research management and dryland agriculture to help achieve our goals for the empowerment of small farmers, especially those who are located in the upland and dry areas.

By providing farmers support such as a conducive policy environment, research, extension and credit services, rural infrastructure and the right investments, we are enhancing their transformation from subsistence agriculture to a commercial one. We are building their capacities to enable them to produce more and better products and compete in the market-oriented agriculture that the Department is espousing. It is in the establishment of these basic support systems where the small marginal farmers/fisherfolk get the opportunity to be empowered and can make use of the new technologies that the R&D institutions have developed.

I come from a farming family. I know the hardships that small farmers/fisherfolk are going through today. My life's work has evolved in looking for ways to help them improve their lives.

Though I am not with the government right now, I would like to assure you that I will continue to be of help and would still champion their plight.

This is a pledge I make before you tonight. My life is dedicated to the upliftment of the small farmers/fisherfolk. May the Department of Agriculture do its share by formulating a pro-poor agriculture program dedicated to these farmers.

Thank you and MABUHAY tayong lahat!

Genetic Resources Enhancement for the Poor of the Semi-Arid Tropics*

Centenary lecture delivered at the Centenary Celebrations of the Tamil Nadu Agricultural University, 29 Jul 2005, Coimbatore, Tamil Nadu, India.

Ladies and gentlemen,

It is an honor to be here today to celebrate the centenary year of the Agricultural College and Research Institute of your prestigious university. Whether it is imparting education to students as you do or empowering poor farmers in the semi-arid tropics as ICRISAT does, both institutions are striving to serve the poor in their own ways. The imperative of every man, woman and child having enough food to eat is a sentiment that unites people throughout the world and institutions such as yours and mine.

The semi-arid tropics (SAT) where the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) operates includes parts of 55 developing countries: most of India and parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa and a few countries in Latin America. These areas are characterized by unpredictable weather, long dry seasons, inconsistent rainfall and soils that are poor in nutrients. The SAT supports over 1.4 billion people, of whom 560 million are classified as poor. Of these, 70% live in rural areas (Ryan and Spencer 2001).

Poverty, food insecurity, child malnutrition and gender inequalities are widespread in SAT regions, where rainfed agriculture constitutes the source of food security, employment and cash income for the vast majority of rural inhabitants. Therefore, the greatest challenge lies in increasing the productivity of water used for agriculture, leaving more water for the users and the environment, in other words, getting more crop per drop (Ryan and Spencer 2001). This is possible

* The speech was delivered by Dr CLL Gowda, Global Theme Leader on Crop Improvement, Management and Utilization for Food Security and Health, ICRISAT, on behalf of Dr William Dar.

by improving the productivity of the crops that support livelihoods of the poor through the development of seed-based and natural resource management technologies and the technologies for product diversification to broaden utilization options.

Creating wealth in the rural SAT and generating science-based agricultural technologies that improve crop yields, increase incomes and reduce degradation of dwindling natural resources such as biodiversity, land and water are vital. ICRISAT is committed to improving the productivity of sorghum, pearl millet, chickpea, pigeonpea and groundnut along with national agricultural research system partners through genetic and integrated genetic and natural resource management and socio-economic research since these crops are staple for millions of poor in the SAT.

ICRISAT's dynamic genetic enhancement priorities and strategies are guided by the changing scenario of agriculture. Improved yield potential is its most important breeding objective, followed by genetic improvement of resistance/ tolerance to diseases, insect-pests and abiotic stresses, adaptation and quality of grain and fodder. It recognizes that traditional germplasm resources are vital to crop improvement; hence its RS Paroda Genebank conserves genetic resources of sorghum, pearl millet, chickpea, pigeonpea, groundnut and six small millets; holding 114,870 accessions of these crops from 130 countries. It has been supplying over 40,000 germplasm samples annually to scientists globally, of which about 30% have been shared with scientists of the Indian national program, resulting in the release of 544 varieties. ICRISAT's global collection also serves the purpose of restoring germplasm to source countries when national collections are lost due to natural and human-induced calamities. A number of germplasm accessions/selections are released as superior varieties through partnership research. Also, 66 germplasm accessions supplied from the ICRISAT genebank have been directly released as cultivars in 44 countries.

Since some genetic resources are not agronomically acceptable in their original form, their suitability is improved through genetic enhancement processes and techniques, and cultivar options are guided by reproductive and pollination control systems. The end products are guided by the requirements of producers, industry and end users.

At ICRISAT, simple recurrent selection is being used to improve *ms*3 and *ms*7 genetic male-sterility sorghum populations to develop trait-based gene pools. Pedigree selection in segregating populations derived from planned crosses is the major breeding method used to develop pure line varieties. Being a highly cross-pollinated crop, pearl millet allows exploitation of heterosis. Various forms of recurrent selection have been used to develop open-pollinated varieties (OPVs). The availability of several alternative cytoplasmic male-sterility (CMS) systems and their restorers has enabled large-scale commercial exploitation of single-cross hybrids in India. Pedigree breeding has been used in populations developed by recurrent selection, albeit on a limited scale, to develop hybrid parents. In the case of groundnut, the pedigree method is most commonly used. A combination of pedigree and bulk methods is generally used for selection after hybridization in chickpea. The backcross method is used only occasionally to incorporate one or few traits from a germplasm line, sometimes a wild species, to a well-adapted variety. Rapid generation advancement in greenhouse following a single seed descent (SSD) method is generally used to develop recombinant inbred lines (RILs).

In pigeonpea, selection to capitalize on tremendous genetic variability within landraces has been very effective in developing high-yielding popular varieties. Population breeding, mutation breeding, mass selection and bulk pedigree methods have also been used with limited success. Limited natural outcrossing has also been successfully exploited to increase yield and stability through the development of commercial hybrids using genetic male-sterility. Currently, CMS is being used to develop and commercialize hybrids.

ICRISAT focuses on partnership-based research to develop improved varieties and hybrid parents at ICRISAT-Patancheru for Asia, and finished products at other ICRISAT locations in Africa. Partnership efforts by scientists at ICRISAT and in NARS programs have led to the release of 474 different cultivars in Africa, Asia and the Americas.

At ICRISAT, we have successfully bred improved early-maturing sorghum varieties that have been adopted by subsistence farmers. ICSV 111, which is very popular among farmers in Ghana, Cameroon, Chad and Nigeria for its tolerance to *Striga*, excellent brewing qualities, short duration and high yield potential, and Macia (SDS 3220) that has greatly benefited farmers in Mozambique and Botswana, are examples of ICRISAT's success stories. Several ICRISAT-bred improved sorghum hybrid parents have been extensively used by both public and private sector research organizations to develop and market hybrids in Asia. More than 30 hybrids, based on ICRISAT-bred parents, have been released in India and China.

The adoption of another ICRISAT-private sector partnership hybrid, VJH 540, with its high yield potential, increased from 650 ha in 1997 to 1,42,000 ha in 2003 in rainy season areas in major sorghum growing states in India, as evidenced from increased seed sales of this hybrid from 6.5 t in 1997 to 1420 t in 2003 (personal communication, Yogeshwara Rao, Vikki's Agro-Tech Ltd. Hyderabad). ICTP 8203, the earliest-maturing commercial open-pollinated pearl millet variety developed by recombining five progenies selected from a landrace from northern Togo (Rai et al. 1990), was rapidly adopted in Maharashtra and is cultivated on a limited scale in Karnataka, Andhra Pradesh and Rajasthan.

The application of a Panicle Harvest Index selection procedure in the Bold-Seeded Early Composite (BSEC) led to the development of an open-pollinated variety ICMV 88904 (released as ICMV 221) that outyielded the popular open-pollinated variety ICTP 8203 by 15% across 21 trials in nine locations (Witcombe et al. 1997).

The success of the iniari group of materials led to a targeted collection of this germplasm, followed by intensive evaluation that led to the constitution of an extra-early-maturing

B-composite (EEBC), making it the earliest-maturing pearl millet population developed to date. Its selected version (ICMP 94001) has been shown to outyield EEBC unselected bulk by 12%, with only 13% less grain yield than the commercial HHB 67 (Rai et al. 1998). The development of hybrid HHB 67, however, remains the greatest landmark in breeding early-maturing pearl millet cultivars.

Coming to groundnut, several short-duration cultivars have been developed with multiple tolerance/resistance. ICGV 86015 has wide adaptability and was released in Pakistan as BARD 92, in Vietnam as HL 25, in Nepal as Jayanthi and in Sri Lanka as Tikiri. ICGV 91114 is gaining popularity with farmers in drought-prone areas of Anantapur in Andhra Pradesh and Saurashtra in Gujarat while ICGV 89104 is resistant to seed infection by *Aspergillus flavus*.

Reduction in time to flowering and maturity has substantially contributed towards increasing and stabilizing chickpea productivity in the tropics. This was done by identifying a major gene efl-1 for earliness. More than 50 short-duration and Fusarium wilt-resistant cultivars have been released so far by national programs in several countries with ICRISAT's help. History was made when kabuli adaptation was extended to the tropics for the first time with the release of ICCV 2 as Swetha (and another desi variety Kranthi) in Andhra Pradesh in 1989, increasing chickpea area in Andhra Pradesh five-fold and production thirteen-fold during 1993-2002.

Through ICRISAT's development of the first hybrid (ICPH 8) pigeonpea variety and hybrid seed production technology, private and public sectors in India have been able to develop hybrid cultivars. Teams of ICRISAT and NARS have identified varieties suited to specific production systems.

Coming to disease resistance, ICRISAT has developed several grain mold-resistant male-sterile sorghum lines with good potential for developing grain mold-resistant hybrids by using trait-based breeding (Reddy et al. 2004). Downy mildew (DM), ergot, smut and rust are some of the diseases of pearl millet that have received research attention. Due to the development of large-scale and cost-effective screening techniques, availability of sources with high levels of resistance and relatively simpler genetic inheritance, several OPVs and hybrids of pearl millet with high levels of resistance have been developed and adopted for cultivation. Recent developments in molecular marker-assisted breeding (MAB) have enabled more effective host-plant-based DM management. For instance, an extra-early-maturing hybrid (HHB 67) developed by Haryana Agricultural University and currently grown on more than 0.4 million ha, has been showing signs of its increasingly susceptibility to DM.

A number of foliar diseases-resistant groundnut varieties have been developed, of which ICGV 86590, ICG (FDRS) 10 (ICGV 87160), ICG (FDRS) 4 (ICGV 87157) and ICGV 86699 are highly popular among farmers.

Fusarium wilt (FW), Ascochyta blight (AB) and botrytis gray mold (BGM) are important diseases of chickpea, particularly in the SAT. Availability of simple and effective field screening techniques and many highly resistant sources have led to excellent progress in breeding FW-resistant cultivars. Germplasm accessions with moderate resistance to AB have also been identified. The resistance is controlled by many quantitative trait loci (QTLs). Thus, efforts have been made to enhance the level of resistance by accumulating resistance genes from different sources. Recent breeding efforts have led to the development of lines with good agronomic characters and moderate levels of BGM resistance.

Since sterility mosaic and Fusarium wilt are the major pigeonpea diseases, breeding varieties with dual resistance was given priority, of which Asha (ICPL 87119), Laxmi (ICPL 85063) and Maruti (ICP 8863) are good examples.

Let me now dwell on our work in insect pest resistance. Sorghum varieties and hybrid parents resistant to shoot fly, stem borer and midge have been developed. Midge-resistant white grain varieties developed at ICRISAT have been released in Australia. Several shoot fly-tolerant male-sterile lines and stem borer-resistant male-sterile lines have been developed with good potential to develop shoot fly-resistant hybrids (Reddy et al. 2004). Jassid-resistant and multiple resistance and/or tolerance to *Spodoptera*, leaf miner, jassid and thrips groundnut breeding lines have been developed at ICRISAT.

In the case of pod borer in chickpea, several germplasm accessions/breeding lines/cultivars with moderate resistance and accessions of annual and perennial wild *Cicer* species with higher levels of resistance have been identified. In pigeonpea, we have developed varieties tolerant to *Maruca* and *Helicoverpa*. Attempts are being made to transfer insect resistance from wild relatives of pigeonpea.

Micronutrient malnutrition, primarily the result of diets poor in bio-available vitamins and minerals, causes blindness and anaemia (even death) in more than half of the world's population, especially among women and pre-school children. Pre-breeding research was carried out at ICRISAT as a part of the CGIAR's Challenge Program on HarvestPlus project to explore the prospects of breeding for micronutrients and ß-carotene-dense sorghum and pearl millet under high-yielding background. A golden pearl millet germplasm with 1.3 ppm ß-carotene has been identified.

Considerable progress has been made in salinity tolerance research at ICRISAT-Patancheru in terms of assessing genetic variability, identifying tolerant germplasm lines, varieties, hybrid parents and breeding lines and identifying possible mechanisms of salinity tolerance that could enhance breeding efficiency.

The Government of India's recent policy on blending petrol and diesel with ethanol means an additional 4000 million liters of ethanol are needed, apart from 1000 million liters per annum for other purposes. Molasses, the traditional source of raw material for ethanol production with a contribution of 2000 million liters per annum (Gowda et al. 2005) is unlikely to meet actual demand in the long run. Distilleries and sugarcane-based industries are showing increasing interest in using sweet sorghum as an alternative to make up for the possible deficit.

ICRISAT renewed its sweet sorghum research initiated in 1980 to help meet this demand for ethanol. Four promising lines were evaluated in the All India Coordinated Sorghum Improvement Program (AICSIP) during the 2004 rainy season and two have been promoted for advanced testing during the 2005 rainy season. Also, four sweet-stalk varieties and Seredo found promising in ICRISAT trials have been contributed to AICSIP for preliminary multilocational testing during the 2005 rainy season. A Special/Sweet Sorghum Hybrid (NSSH-104) developed from an ICRISAT-bred male-sterile (seed) parent and SSV 84 is being recommended for release for commercial cultivation by the National Research Center for Sorghum (NRCS), Hyderabad.

With growing health awareness, people in urban and peri-urban areas are prefering low-fat/oil foods. Scientists at ICRISAT have developed large-seeded relatively low-oil groundnut varieties such as Asha, which is popular among farmers in Gujarat and Maharashtra since it can be used for both oil extraction and confectionery uses.

ICRISAT has a high throughput applied genomics laboratory and uses marker-assisted selection as a potential method to hasten and improve precision and effectiveness of crop improvement. Molecular markers have been identified for stay green trait and resistance to shoot fly and *Striga* in sorghum, downy mildew resistance and terminal drought tolerance in pearl millet. Research is on to identify markers for root mass and resistance to Ascochyta blight, botrytis gray mold and *Helicoverpa* pod borer in chickpea; and Fusarium wilt resistance and fertility restorer genes in pigeonpea.

Two hybrids having parental lines bred by marker-assisted selection for downy mildew resistance have been developed at ICRISAT. In January 2005, one of them, HHB 67-2, was released for commercial cultivation by the Haryana State Varietal Release Committee. This is the first public sector-bred marker-assisted pearl millet breeding product to be released and is the crowning achievement of 15 years of investment in pearl millet MAB by ICRISAT, the Indian national program, UK-based partners and the UK's DFID Plant Sciences Research Program.

ICRISAT has pioneered transformation technologies for all its mandate crops. The first transgenics from ICRISAT is the transgenic groundnut for resistance to the Indian peanut clump virus (IPCV) that employed the coat protein and replicase genes from the virus itself. Transgenics have been developed in pigeonpea and chickpea with resistance to *Helicoverpa armigera* by using the Bt Cry1Ab and cry1Ac genes derived from the bacterium *Bacillus thuringiensis*. This material is currently undergoing contained field testing. During the coming years, ICRISAT and its Indian NARS partners will jointly test them before deployment. Besides this, groundnut rosette virus (GRAV), peanut bud necrosis virus (PBNV) and peanut stem necrosis disease are being addressed through transgenic approaches. Work is also on to develop transgenics in groundnut and chickpea for tolerance to abiotic stresses such as drought and low temperatures where the transgenics carrying the transcription factors like DREB and proline-overproduction genes are currently being tested in greenhouse studies. In cereals, transgenics have been developed for resistance to stem borer in sorghum and are currently under greenhouse testing.

Future research on genetic enhancement needs to focus on developing technologies that stabilize current yield levels, such as host-plant resistance to biotic and abiotic yield constraints, crop-product diversification and value-addition and developing cultivars suitable for non-traditional uses apart from food and forage. Forging partnerships between public sector research organizations and private sector industries in developing research products suitable to these alternate uses should receive major attention.

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Unlocking the Potential of Rainfed Agriculture: ICRISAT's Vision and New Paradigms

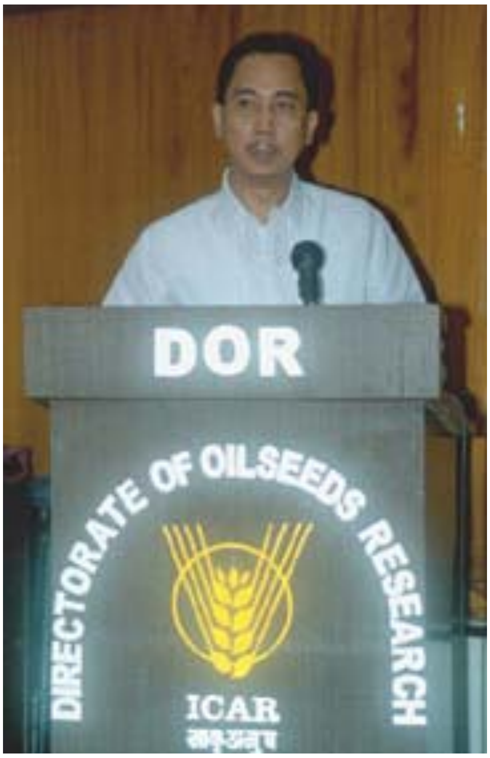
Foundation Day Lecture, 1 Aug 2005, Directorate of Oilseeds Research, Rajendranagar, Hyderabad, Andhra Pradesh, India.

Ladies and gentlemen,

I am honored to be with you on the occasion of the Foundation Day celebration of the Directorate of Oilseeds Research, one of our most valuable partners. On behalf of ICRISAT and its stakeholders, I thank Dr DM Hegde, Project Director, for inviting me to deliver the Foundation Day address today. This gives me an excellent opportunity to share my views on combating poverty, hunger and malnutrition, especially in the semi-arid tropics of South Asia.

ICRISAT's goal is to harness the power of technology for development, food security, poverty alleviation and environmental protection, targeted at poor rural families in general and women in particular. We call it doing Science with a human face. We have several partners and stakeholders in this mission, with the Indian Council of Agricultural Research (ICAR) being the host in the country. Since its inception in August 1977, ICRISAT has been a close partner of the Directorate of Oilseeds Research in their common endeavor to improve the productivity and sustainability of rainfed agriculture, where most of the oilseed crops are grown.

Groundnut, which was added to ICRISAT's mandate in 1976, provided a common platform for both the institutions to work together closely in moving towards creating a 'yellow revolution' in the country. Although, the 'yellow revolution' is yet to fully materialize, we are close to it. However, we must learn from the lessons and experiences of other 'revolutions' in agriculture so that our journey remains free of pitfalls and the poor are not ignored. The Green Revolution, which saved the world from hunger, bypassed 700 million ha of land worldwide, and 800 million poor people are still waiting for another technological breakthrough to improve their livelihoods. 'Subsistence' rainfed agriculture must become 'substance agriculture' to provide food security to future generations. The traditional mindset towards rainfed agriculture needs to change drastically. Rainfed agriculture needs to be a vehicle for economic, social and eco-friendly change in rural societies of not just South Asia but also other regions where it is practiced.



A majority of the population in developing countries lives in rural areas, with agriculture being the major source of livelihood. Agricultural production in these countries is largely done in the dry tropics. For example, the rainfed ecosystem in India covers nearly 66% of the net cultivated area, supports 40% of the population, contributes 44% to the national food basket and supports two-thirds of the livestock population of the country. The dry tropics are very fragile and suffer from inherent low soil fertility, low and erratic rainfall and poor physico-social infrastructure. Rainfed farming systems are quite complex with a wide variety of crops, cropping systems, agroforestry and livestock production. Farmers' dependence on livestock as an alternative source of income is very high. Issues such as growing global warming, increasing water shortages and a burgeoning population will not improve the situation unless addressed urgently. Further, liberalized trade policies demand competitive and productive agriculture with high quality of produce. Dealing with these challenges requires a globally coordinated and multi-institutional effort.

The Challenges

Among the major challenges in rainfed ecosystems, stubborn poverty, food insecurity, drought, water scarcity, low rainwater use efficiency, low crop productivity, high instability, land degradation, declining soil health, acute fodder shortage and poor livestock productivity are critical. Lack of infrastructure, unfavorable policies and poor socio-economic conditions of farmers further complicate matters. Given the nexus between drought, land degradation and poverty, the absence of proper water and nutrient management strategies prevents dryland farmers from achieving desired levels of food security.

Current estimates indicate that substantial areas in Asia will be severely desertified if not properly managed, and that by 2020, many Asian countries might face serious food shortages. Sustainable resource use is therefore central to food security, which involves the ability to meet both food and non-food requirements to sustain human and other resources over time. Sustainable resource use and food security together depend on ways in which resources are used in production and exchange, in the generation of income and in subsequent patterns of consumption and investment.

The causes of hunger are complex and include violent conflict, environmental factors and discrimination based on gender, ethnicity, age and other factors. Hunger is both a cause and an effect of poverty.

I am a member of the UN Millennium Project's Hunger Task Force that has identified interventions and policy measures needed to achieve one of the Millennium Development Goals of halving hunger by 2015. Among the measures suggested are:

- Move from political commitment to action
- Reform policy and create an enabling environment
- Increase agricultural productivity of food-insecure farmers
- Improve the nutrition of vulnerable groups that have chronic and hidden hunger
- Reduce the vulnerability of the acutely hungry through productive safety nets
- Make markets work for the poor and increase incomes of the food insecure
- Restore/conserve natural assets of the food insecure.

The Opportunities and Approaches

An integrated approach of genetic and natural resources management (IGNRM) — a combination of better natural resources management and crop improvement — is essential to improve and stabilize crop and livestock productivity in a sustainable manner. IGNRM leads to improved livelihoods through higher incomes, lower risks, improved production technologies and crop varieties, better soil and water management and better environment protection. Of all the farming systems in South Asia, the crop-livestock systems are believed to have the highest potential for improving livelihoods in a sustainable manner.

The success of any research and development project in agriculture hinges on its being demand driven, the participation of all sectors of society in planning and implementation, tangible and equitable economic benefits for peoples' empowerment, a holistic approach to problem solving, the support of all stakeholders, access to modern technologies and back-up research support.

At ICRISAT, our research agenda consists of four thematic areas: Crop improvement; Biotechnology; Agroecosystems; and Markets, policy and impacts.

Crop improvement: In addition to improving yield and local adaptation which are always important in genetic enhancement programs, there is now greater emphasis on improving the nutritional quality of cereals of rainfed agriculture ie., sorghum and pearl millet. With increasing availability of wheat and rice, other cereals are losing their ground. These nutritionally-rich ‘orphaned’ cereals need to be promoted as health foods in urban areas in order to increase their consumption. They provide not just nutritional security but also income to poor farmers who cultivate them. Biofortification with vitamins such as Vitamin A and minerals such as iron (Fe) and zinc (Zn) will make them an excellent health food for both rural and urban populations and increase their utility. Their industrial uses in the animal feed industry, starch and beverages etc., should be explored to make them commercially viable.

Harnessing biotechnology for the poor: Biotechnology-assisted germplasm enhancement (marker-assisted selection and genetic transformation) activities at ICRISAT contribute to solutions for some of the complex problems that have remained intransient to conventional methods. Integration of biotechnology tools and conventional breeding methods in crop improvement will lead to greater efficiency of the latter. Similarly, transgenics in groundnut for resistance to virus diseases has been produced and is being evaluated under controlled field conditions for its performance. Efforts are being made to introduce through transgenics, DREB gene to enhance drought and salinity tolerance; and chitnase gene for aflatoxin resistance in groundnut genotypes. ICRISAT is also working towards biofortification by enhancing beta carotene levels in groundnut.

Other areas receiving attention include biofortification with Vitamin A and resistance to drought, aflatoxin and foliar diseases in groundnut. Biosafety aspects of genetically modified crops are also being studied.

Agroecosystems development and management: In the absence of proper land, water and nutrient management strategies, rainfed dryland farmers are unable to achieve desired levels of food security. Despite significant genetic gains made in crop improvement programs, the potential of improved genotypes remains unrealized due to limited or poor soil productivity and lack of water. An integrated and holistic approach is essential to harness the benefits of natural resources and improved genotypes and their synergies/ interaction to improve productivity and its stability in rainfed agriculture.

Markets, policy and impacts: Strategic assessments of commodity and market trends, input supply and access constraints as well as an understanding of the dynamics and determinants of poverty continue at ICRISAT in order to inform and direct future investment in research for the benefit of poor farmers. These have assumed much greater importance in the post-globalization era where only efficient agricultural production systems will survive. To provide a level playing field to poor farmers in rainfed agriculture given such competition, necessary policy changes and access to capital resources are required. Constraints to the uptake, adoption and utilization of deliverables will need to be fully understood so as to develop technologies that are economically viable and farmer- and environment-friendly.

Crop-livestock Systems

Of all the farming systems in South Asia where poverty is concentrated, crop-livestock integrated systems have the highest potential for improving livelihoods in a sustainable manner. The demand for livestock products is growing rapidly in most developing countries but shortage of feed and fodder is a major constraint facing small-scale farmers in effectively meeting the demand. Since the mandate crops of ICRISAT, particularly sorghum, pearl millet, groundnut and pigeonpea provide 10-15 t ha^{-1} of high quality fodder, their value for livestock is given special attention in our crop improvement programs. ICRISAT together with the International Livestock Research Institute (ILRI) and national partners is now working on several projects related to fodder quantity and the quality of these crops.

Public-private Sector Partnership: The Way for the Future

Consortium of private sector: No single organization can effectively address the complex developmental issues in agriculture alone. The roles of public and private sectors and their relationships are changing, bringing synergy of joint efforts. The consortium of private seed sector companies in sorghum, pearl millet and pigeonpea is now generating US$ 470,000 annually from membership contributions to support seed-based technology at ICRISAT. From a small beginning in crop improvement, the consortium approach is now spreading to other areas. These include the Biopesticide Research Consortium for integrated pest management and research and the Sweet Sorghum Consortium for Ethanol Production. All the private sector partnerships at ICRISAT are coordinated under a single institutional program called the Technology Innovation Center (TIC).

Agri-business Incubator (ABI): The Agri-business Incubator helps novel agri-business ideas bloom. It was initiated at ICRISAT with corpus funding from the Government of India, coupled with our technologies and infrastructure. Rusni Distilleries Pvt Ltd, the first client, is collaborating to generate raw material to produce potable alcohol and fuel alcohol from sweet sorghum varieties developed by ICRISAT. The second client, Bioseed Research India Pvt Ltd, is working on research projects related to the application of biotechnology for the development of superior cotton hybrids. Some of the other technologies under consideration are the generation of biodiesel from Jatropha and Pongamia, hybrid paddy and development of biopesticides.

Virtual Academy for the Semi-Arid Tropics

Information and knowledge can play a pivotal role in preparing farmers to respond better to climatic uncertainties, natural calamities and changing market conditions besides enabling them to manage drought, diseases and pests effectively. The Virtual Academy for the Semi-Arid Tropics (VASAT), a coalition led by ICRISAT, is focused on sharing appropriate information and knowledge with farm communities and their intermediaries through the innovative interface of Information and Communication Technologies and distance learning.

To unlock the potential of rainfed agriculture and directly impact on rural poverty, strategic assessment of future scenarios for agriculture and livelihood options, enhanced technology utilization, commercialization of dryland crops, product diversification and value addition, micro-level assessment of the dynamics and determinants of poverty, identification of new institutional arrangements for research and development and effective targeting of spillovers based on institutional experience will be essential. However, the impact of the technology can only be fully realized if poor farmers and all other stakeholders are full-fledged partners in technology development and dissemination. To rekindle the hopes of the poorest of the poor in new technologies and in the future, patience and persuasion will be required. Different levels of technologies will be needed so that farmers can choose the ones best suited to them. At ICRISAT, we follow the bridge-broker-catalyst paradigm while implementing a research and development agenda for rainfed agriculture.

Coming back to enhancing oilseeds production in India, more so groundnut, it must be mentioned that there hasn't been much progress in making use of molecular markers in its improvement. Emphasis is required on identifying QTLs for traits of economic importance. A dense linkage map of cultivated groundnut is needed, which is possible through concerted research efforts of the global scientific community.

Increasing the economic competitiveness of the crop and maximizing returns to each farmer is possible if groundnut production technology is customized to suit the needs and capability of each farmer. Applied and adaptive research is as important as upstream basic research to ensure that the benefits of investments in research and development reach small farmers. Last but not the least, farmer's participation is essential in priority setting and technology development; farmer participatory varietal selection will ensure greater acceptance of new varieties among the farming community.

Thank you.

Working in Partnership for the Greater Good

Inaugural speech, Consultation Meeting on Hybrid Parents Research, 30 Aug 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Dear friends, good morning.

It gives me great pleasure to welcome you all here on the occasion of this Consultation Meeting on Hybrid Parents Research in Sorghum, Pearl Millet and Pigeonpea. This is the first of such deliberations involving ICRISAT and the private and public sectors represented by All India Crop Coordinators, since the strengthening of the Consortia in 2004. We are happy to mention that this model of partnership between us has become a showcase in the CGIAR system.

Hybrid parents research is just one aspect of ICRISAT's global research program that is guided by our new vision of the "improved well being of the poor of the semi-arid tropics through agricultural research for impact". ICRISAT is committed to the attainment of the mission of helping the poor of the semi-arid tropics through Science with a human face and partnership-based research and to increase agricultural productivity and food security, reduce poverty and protect the environment in SAT production systems.

ICRISAT believes that pathbreaking scientific achievements are possible when different organizations work in tandem, consolidating their strengths and synergies. We have a history of successful long-standing working partnerships with scientists from the public sector (ICAR and State Agricultural Universities) and private sector companies in several research areas. These broadly fall under ICAR-ICRISAT partnership projects, need-based special projects and the ICRISAT-private sector hybrids parents research consortia in sorghum, pearl millet and pigeonpea.

Sorghum and pearl millet constitute the only crop options for small farmers in many parts of the semi-arid tropics. Within Asia, India with 7.4 million t and China with 2.9 million t dominate the production scene despite a decrease in area (–2.9% and –5.6% respectively). Coming to pearl millet, India produces more than 7 million t. Pigeonpea, the major protein source for millions of poor people in Asia, is cultivated not only for its grain but also to enrich soil fertility. In 2000-02, India produced 2.4 million t of pigeonpea, nearly 87% of the global share.

At ICRISAT, we follow trait-based breeding in sorghum, utilizing both the racial and geographical diversity of the germplasm to develop broad-based hybrid parents. These have been utilized by both public and private sector scientists. I understand that more than 50 hybrids based on these hybrid parents and/or their derivatives are marketed in India — a factor that significantly contributed to cultivar diversity and stable production. Since the food use of sorghum is gradually declining in India, producers are often confronted with reduced market demand. It is to broaden the market that ICRISAT in partnership with several of you, undertook two major projects – the DFID- and CFC/FAO-funded projects on 'Developing market linkages for use of sorghum in poultry feed'. We are also working on 'Enhancing the use of sweet-stalk sorghums in ethanol production'. This expanded utilization has transformed sorghum from a subsistence crop into what I would like to call "a crop of substance". Pearl millet too is a component of the CFC/FAO-funded project on 'Enhanced utilization of grain in poultry feed' that will hopefully improve the crop's market share. Since an organization cannot individually tackle these major challenges, partnership-based research is the way forward.

Coming to pearl millet, both population improvement with recurrent selection and breeding improved lines by pedigree method have resulted in improved hybrid parents with high grain yield and resistance to downy mildew. Thanks to the partnership between us, breeding at ICRISAT has kept pace with the constantly evolving downy mildew pathogen. Our strong ties have enabled us to bring more than 70 hybrids into the market, with at least 60 of them based on ICRISAT-bred parental lines, or on proprietary parental lines developed from ICRISAT-bred improved germplasm, leading to wider cultivar diversity and enhanced productivity in India.

Developing high-yielding and bold grain hybrid parents in general, large grain, shoot fly- or grain mold-resistant hybrid parents in sorghum and high-yielding and downy mildew-resistant parental lines in pearl millet in diversified genetic backgrounds will continue to be ICRISAT's major research thrusts. However, our research will take into account the emerging requirements of farmers and the industry, for which we would like to elicit your complete support.

ICRISAT has developed a CMS-based hybrid breeding system in pigeonpea after 30 years of research, helping exploit heterosis to boost stagnant productivity. The breakthrough has stimulated interest in hybrid development among pigeonpea scientists in both public and private sectors. I am sure that with your support we will be able to develop potential hybrid parents, and the commercial cultivation of hybrid pigeonpea could become a reality. Improvement of hybrid parents for high grain yield and resistance to diseases (eg., sterility mosaic virus, wilt) and *Helicoverpa* among insects, will form the thrust areas for hybrid parents research in pigeonpea at ICRISAT. However, these research areas may further need to be focused based on your inputs.

ICRISAT's current efforts to harness the energies and resources of private sector seed companies to produce public research goods that can be utilized by all, including public sector scientists, has its origin in the year 2000, when the ICRISAT-Private Sector Hybrid Parents Research Consortia in sorghum and pearl millet was formed. It was expanded to include pigeonpea in 2001.

These three consortia now boast of a membership of 33, with a few common members across 3 crops. I have learnt that all three consortia are working very well, thanks to the leadership of seed companies which could envision the real value and power of partnership research to deliver improved technologies to farmers/seed producers. I take this opportunity to appreciate your role in delivering desired technologies — be they improved breeding products or management practices — to farmers at their doorsteps.

New scientific tools are increasingly being used to enhance the precision and pace of genetic enhancement of crops. Molecular markers associated with shoot fly and stem borer resistance and tolerance to terminal drought in sorghum and resistance to downy mildew and tolerance to drought in pearl millet are being developed. Here I would like to mention the success of our marker-assisted selection, which has led to the development of the downy mildew-resistant version of the early-maturing hybrid HHB 67, which was released early this year in Haryana as HHB 67-2. I am happy to note that *Bt* transgenics for resistance to stem borer in sorghum and *Helicoverpa* in pigeonpea are well on their way.

I am very pleased with the way sorghum, pearl millet and pigeonpea programs have evolved in recent years to accommodate the changing demands of farmers, entrepreneurs and consumers. Partnerships have yielded benefits. But let us not be complacent; let us constantly work hard to upgrade our skills in order to maintain and improve the quality of science and products that go to farmers, much more the rural poor. Trust and faith are the essence of team spirit and comradeship, and I am sure that you will nurture and promote this spirit among yourselves. Let me reiterate, the fruit of faith is love, the fruit of love is service, the fruit of service is peace, and the fruit of peace is prosperity.

Though I will not elaborate on research issues that you will be addressing during this meeting, I would like to dwell on a few other issues. Firstly, as I mentioned earlier, several sorghum and pearl millet hybrids developed are based on ICRISAT-bred parents or their derivatives that have contributed to significantly improving productivity. I am glad to learn that the consortia have finalized the questionnaire to assess the impacts of these hybrids in terms of area, profits from seed production, commercial crop cultivation and cultivar diversity. I hope this joint study will serve as a guide for future research.

Secondly, ICRISAT has made a good beginning in identifying salinity-tolerant and micronutrient dense parental lines in sorghum and pearl millet. This is meant to extend their cultivation to harsh and saline areas and to combat malnutrition (due to micronutrient deficiency), particularly in pregnant women and children. Breeding for soil salinity tolerance and micronutrient dense crops is now a priority research area in the CGIAR system.

Thirdly, it is well known that *Helicoverpa* is a major menace in pigeonpea. Our combined skills and resources can lead to a breeding strategy and an action plan to breed resistant parental lines to contain this menace. The Department of Biotechnology (DBT) of the Government of India has started a program for Public-Private Partnership. We should use this opportunity to enhance research collaboration in biotechnology, especially *Bt* pigeonpea.

Let us together endeavor to carry out partnership research to deliver products to benefit resource-poor farmers, consumers and sorghum, pearl millet and pigeonpea entrepreneurs. I once again welcome all of you to this meeting and wish you good luck in your deliberations.

Thank you.

Poverty Reduction through Pulse Crops

Foundation Day lecture, 5 Sep 2005, Indian Institute of Pulses Research, Kanpur, Uttar Pradesh, India.

Ladies and gentlemen,

I am honored to be with you today on the Foundation Day celebration of the Indian Institute of Pulses Research (IIPR). On behalf of ICRISAT and its stakeholders, I thank Dr Masood Ali, Director, IIPR, and one of our most valued partners, for inviting me to deliver this address.

The goal of the International Crops Research Institute for the Semi-Arid Tropics is to harness the power of technology for development, food security, poverty alleviation and environmental protection, targeted at poor rural families. We call this doing Science with a human face. We have the global responsibility for improving the livelihoods of the poor in unfriendly environments — the dry tropics — where inherent low soil fertility, low and erratic rainfall and poor physico-social infrastructure make farming a herculean task. Farming systems in such areas are quite complex.

ICRISAT conducts research on its mandate crops that strike a rich balance between carbohydrate-rich cereals, protein-rich pulses and oil-rich groundnut. It uses the latest technologies in breeding, biotechnology, resource management practices, social science, technology promotion and impact assessment to ensure that the benefits of its research reach the poorest of the poor.

The crop improvement team at ICRISAT works in a multi-dimensional and multi-disciplinary mode and our scientists have made remarkable progress. The four CGIAR King Baudouin Awards we have won is recognition of how effectively ICRISAT has fulfilled its mission of delivering Science with a human face, along with its partners.

Though the Green Revolution saved the world from major catastrophe, it bypassed millions of poor people living in the dry areas. Due to the skewed policies of the Government and absence of high-yielding varieties and improved natural resource management technologies, legumes were either eliminated from favorable cropping systems or relegated to marginal environments. Although cereal monocropping (eg., rice-wheat in the Indo Gangetic Plains of South Asia) was economically profitable (owing to the heavy subsidies on water, fertilizer and pesticides), it led to several ecological problems. In many cases there was a plateauing of yield, no response to inputs and increased weeds, pest and disease problems. This necessitated a relook at cereal monocropping and the reintroduction of legumes in the system to reverse the trend of low crop productivity. Increased cultivation of legumes in cereal-based systems will not only raise total productivity, including nutrition, but also stabilize rainfed agriculture. Therefore, both IIPR and ICRISAT have a common responsibility to improve the adaptation and productivity of pulses.

The annual pulse production of 15.23 million t in India falls short of demand, and huge quantities of pulses are imported, spending huge foreign exchange reserves. Imports have also led to increased prices, thus taking pulses out of the reach of poor farmers who were depending on them for protein nutrition. This situation can be addressed by (i) developing improved varieties with high yield potential and stability (having necessary resistance to pests and diseases and tolerance to drought); (ii) increasing the area under pulses in traditional areas, and by finding new niches; (iii) enhancing their productivity under stress environments; (iv) reducing harvest and storage losses; and (v) increasing opportunities for value addition and marketing at different levels of production.

Legumes easily grow with minimum tillage and provide high quality protein in food and feed. Crop diversification with legumes as components of intercrop, crop rotation or relay cropping is one of the strategies to maximize agricultural productivity and farm incomes.

Improving the yield and adaptation of our mandate crops is one of the major goals of ICRISAT. In addition to traditional crop improvement efforts, we are now using tools of biotechnology to enhance efficiency, effectiveness, speed and precision of plant breeding. The success in breeding for increased crop productivity in marginal areas, however, requires complex multi-disciplinary and multi-sector collaborative approaches. Hence ICRISAT lays emphasis on IGNRM approaches to sustainably enhance crop production and productivity.

ICRISAT has also identified cytoplasmic male sterility system (CMS) in pigeonpea after 30 years of intensive research. The CMS-based hybrid production has stimulated excitement

among many partner institutions, especially in India, which has the largest area under pigeonpea in the world. The CMS genetic materials and hybrid production technologies were shared with various ICAR institutions and private seed companies. Eight private sector seed companies have joined this partnership effort.

The improved varieties of pigeonpea developed by ICRISAT and Indian program partners have also been showing promise. The extra-short-duration pigeonpea cultivar ICPL 88039 with greater grain yield potential than the local cultivar UPAS 120 was found best suited for rotation with wheat in the Northwestern Plains of India. Several on-farm trials in Haryana, Punjab and western Uttar Pradesh indicated that the cultivar yielded around 2 to 2.5 t ha^{-1}. Being a legume crop, it also increases yields in the following (rabi) wheat crop. Farmers in Uttar Pradesh (Gaziabad, Meerut and Bulandshar) were highly impressed with it, and by the end of the 2004 rainy season, approximately 1700 ha were under ICPL 88039, almost replacing UPAS 120.

ICRISAT has also helped many NARS partners in strengthening their chickpea breeding program capacity. To date, ICRISAT has made available over 33,000 segregating populations and over 131,000 advanced breeding lines to partners in 105 countries. Twenty-five chickpea varieties have been released in India from ICRISAT-bred materials, 14 of which were under breeder seed production during 2003/04.

One of ICRISAT's significant contributions has been the development of early-maturing Fusarium wilt-resistant varieties of both desi and kabuli chickpea. For example, in Andhra Pradesh the adoption of short-duration varieties led to a 5-fold increase in area and a 13-fold increase in production from 1993 to 2002. More significantly, chickpea productivity increased from less than 500 kg ha^{-1} in 1993 to about 1300 kg ha^{-1}, the highest in the country and 40% higher than the average national productivity (865 kg ha^{-1}).

Since large kabuli seeds have a premium in the market, the present breeding program is centered around breeding extra-large-seeded high-yielding varieties that mature in about 125 days, whose cultivation will enhance the income of farmers.

Biotechnology-assisted germplasm enhancement activities can contribute to solutions for some of the complex problems that have remained intransient to conventional methods. Integration of biotechnology tools and conventional breeding methods in crop improvement have led to greater efficiency of the latter. Recently, the first downy mildew-resistant hybrid of pearl millet (HHB 67-2) developed through marker-assisted selection was released in India, particularly in Haryana and Rajasthan.

Seed is an important component of farming in rural households in the Deccan Plateau, India. In districts like Anantapur where approximately 8.0 million ha of groundnut are grown every year, no single agency can meet seed demand. For instance, cultivar ICGV 91114 was most preferred by farmers here, and demand for seed exceeded supply. Therefore, a village-level farmer participatory seed multiplication system was established successfully to provide quality seed. Twenty-five enthusiastic farmers/self-help groups in five villages were identified to multiply ICGV 91114 seed during the 2004/05 postrainy season. A total of 30 acres (12 ha) were sown and about 2 to 2.5 t ha^{-1} pod yield was obtained.

Transgenics have been developed in pigeonpea and chickpea with resistance to *Helicoverpa armigera* and are currently undergoing contained field testing. During the coming years, ICRISAT and its Indian NARS partners will jointly test them before deployment. Besides this, groundnut rosette virus (GRAV), peanut bud necrosis virus (PBNV) and peanut stem necrosis disease are being addressed through transgenic approaches. Work is also on to develop transgenics in groundnut and chickpea for tolerance to abiotic stresses such as drought and low temperatures.

Crop-livestock integrated systems have the highest potential for improving livelihoods and incomes in a sustainable manner. The demand for livestock products is growing rapidly but shortage of feed and fodder is a major constraint facing small farmers. Since the mandate crops of ICRISAT, particularly sorghum, pearl millet, groundnut and pigeonpea provide 10-15 t ha^{-1} of high quality fodder, their value for livestock is given special attention in our crop improvement programs. ICRISAT scientists together with the International Livestock Research Institute (ILRI) and national partners, are now working on several projects related to fodder quantity and the quality of these crops.

To develop better adapted grain legume varieties and production technologies, the involvement of farmers in decision making and implementing management options is expected to bring permanent impact. One such project, 'Farmers' participatory improvement of grain legumes in rainfed Asia', is on in India, Vietnam, Nepal and China.

ICRISAT is a strong believer in partnership-based research. Following are the highlights of the IIPR-ICRISAT collaboration:

- New groundnut variety ICGV 91114 was identified as a replacement for TMV 2 in Anantapur
- New groundnut variety GG 7 and integrated disease management technology were introduced in Saurashtra region of Gujarat
- Improved varieties ICGV 86590 and ICGS 76 were recommended for Orissa
- New variety ICGS 76 and a technical package were recommended for groundnut cultivation in tribal areas
- A specific technical package for chickpea seed production and distribution in Rajasthan was developed
- Improved chickpea varieties DCP 92-3 and JG 315 and IPM for pod borer were recommended in Bundelkhand region
- Improved pigeonpea variety DPL 62 and Narendra Arhar 1 were identified for Bundelkhand, in addition to an economic dose of fertilizer application for legumes.

I would like to mention here that the research collaboration between scientists from Indian national programs and ICRISAT is an excellent example of fruitful partnership. Our joint research endeavors have led to wilt-resistant Maruti pigeonpea reviving the crop in central India and hybrid pigeonpea adding 30% in yield while being more resistant to drought than traditional varieties.

By adopting integrated pest management (IPM) techniques, pigeonpea and groundnut farmers in southern India have greatly reduced the use of insecticide in pilot test areas, up to 100% on some farmer's fields. A vital breakthrough was achieved in identifying the causes of sterility mosaic, leading to the development of technologies for disease diagnosis and development of resistant varieties for hot spots in Karnataka. The variety 'AP Kaju' or Asha (ICGV 86564) is all set to hit the markets in Gujarat. These are but a few of the achievements of combined efforts.

Unlocking the potential of rainfed agriculture to impact on rural poverty will require an assessment of future scenarios in the areas of agriculture and livelihood options, enhanced technology utilization, commercialization of dryland crops, product diversification and value addition, micro-level assessment of the dynamics and determinants of poverty, identification of new institutional arrangements for research and development and effective targeting of spillovers based on institutional experience.

However, the impact of the technologies can only be realized if poor farmers and all other stakeholders are partners in technology development and its dissemination. Swifter agricultural growth and a structural shift towards legumes are the key to poverty reduction. Let us work together to achieve this objective!

Lastly, if only governments of developing countries would significantly increase their investments in dryland agriculture to the level of irrigated agriculture and there is the right policy support for dryland agriculture, we are optimistic that poverty can be reduced to half by 2015 and a food secure environment will ensue in the semi-arid countries of the world.

Thank you.

ICRISAT & ICAR: Realising Synergies in Groundnut Research

Opening remarks, ICAR-ICRISAT Groundnut Scientists Meet, 3-4 Oct 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Dr Dube, Dr Basu, Dr Nigam, scientists of the All India Coordinated Research Project on Groundnut and colleagues from ICRISAT, good morning.

Let me first welcome you all to ICRISAT campus and to this meeting. Shyam Nigam tells me that many of you are visiting our campus for the first time. I hope your stay is comfortable and you will have very productive interactions with ICRISAT scientists. We have a beautiful campus whose serenity I am sure you will enjoy.

This meeting is very significant as it brings together ICRISAT and its strongest partner, the Indian Council of Agricultural Research (ICAR), to review the status of groundnut and plan for its future in India. We highly value our joint ventures with ICAR institutions, universities and NGOs in India. ICRISAT is a firm believer in the power of partnerships. If partnerships are harnessed properly, synergies of unprecedented scale can be realized. I am also very happy to note that the longstanding and highly successful partnership between the groundnut team at ICRISAT and the AICRP-GN team is going from strength to strength. Groundnut research programs in both institutions have evolved together and complimented each other — the former with its global focus and the latter with its Indian focus. Some of the significant achievements of this partnership are:

- Ongoing repatriation of groundnut germplasm to NBPGR
- Joint ICAR-ICRISAT release of 8 groundnut varieties
- Joint SAU-ICRISAT release of 6 groundnut varieties
- 4 releases from ICRISAT-supplied breeding populations
- Promotion of groundnut cultivation in the spring season.

Since 1979, besides several hundreds of germplasm lines including sources of resistance to abiotic and biotic stresses, ICRISAT has enriched the Indian national program by supplying 5064 segregating populations, 7972 advanced breeding lines and 190 sets of international trials to collaborators. In the AICRP-GN trials in 2004, 37% of the new entries contained ICRISAT-supplied germplasm or breeding lines in their pedigrees.

However, I must mention that in spite of these major achievements in AICRP-GN, groundnut is slowly losing its place to other crops among oilseeds in India. I hope that during the course of your deliberations, the reasons for this decline will be identified and plans made to overcome them through research and development.

About 80% of the groundnut production in the country comes from rainy-season cultivation. Since productivity and production fluctuate with rainfall and its distribution, we will have to develop strategies to insulate this crop from the vagaries of the monsoon. Groundnut is reported to have the lowest varietal replacement rate in India. The seed system needs to be strengthened considerably for farmers to have access to good quality seed of improved varieties. The Government of India is concerned about the low annual growth rate in agriculture. The Planning Commission under the chairmanship of the Prime Minister, has proposed enhancement of the varietal replacement rate to boost growth in agricultural production.

Since groundnut is grown mostly by poor and marginal farmers with little or no input other than labor, planning for research and development strategies must factor in the requirements of this section. Often, scientific developments and technologies fail to make any impact on the livelihoods of the poor as their socio-economic and cultural conditions are not taken into consideration while planning for technology development. There is a lesson in this for all of us. New biotechnological tools need to be employed to hasten the pace and efficiency of improving groundnut crops. At the same time, we need to reach out to poor and marginal farmers with technologies that are already available so that past investments in research are not frittered away. However, these technologies may require further fine-tuning for acceptability.

Later this year, the Joint ICAR-ICRISAT Policy Advisory Committee will review the progress of ICAR-ICRISAT collaborative research projects; I am sure the Groundnut group will come out with flying colors.

I wish you highly successful and productive deliberations during the meeting.

Thank you and good day.

From Commitment to Action in Medak District

Delivered at the launching of the project on "Enhancing Rural Livelihoods Through Integrated Agricultural Development in Medak District", 7 Oct 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

His Excellency the Governor of Andhra Pradesh, Shri Sushilkumar Shinde, Mr Venkatesham, Dr Vani Mohan, distinguished guests and my dear colleagues at ICRISAT.

This day marks another milestone in ICRISAT's partnership with the Government of Andhra Pradesh. It is a partnership that has blossomed over the years to yield fruits to farmers in the semi-arid tropics.

I take this opportunity to welcome Shri Sushilkumar Shinde, who has kindly consented to inaugurate the Project on Integrated Agricultural Development in Medak District and to visit ICRISAT.

I am proud to say that ICRISAT's research has germinated on Indian soil, with generous support from the Government of India. Also, its dynamic relationship with the Indian Council of Agricultural Research and its institutes has, like vintage wine, matured over the years. The results of our joint research have transformed the lives of resource-poor farmers in the dryland areas.

ICRISAT has been an active participant in several national and State Government-funded projects, such as those on Jatropha in the rain shadow districts, scaling-up and scaling-out of the watershed technology in 150 units, strengthening the chickpea revolution and hosting the Agri-Science Park, among several others.

The project being inaugurated today will involve a consortium of ICRISAT and partner institutions working with the State Government, such as CRIDA and the Acharya NG Ranga Agricultural University (ANGRAU), much more specifically Medak district.

Medak district is mainly agriculture oriented, with about 78% of the population being involved in agriculture and allied activities. Most of the area is rainfed and about 30% of the gross cropped area is irrigated.

The project's objective is to improve the livelihood and income opportunities of farmers in Medak district using a multifaceted and holistic approach involving participatory community-based watershed management, integrated pest management, ICT, capacity building, links to markets and improving delivery systems.

Evidence is accumulating that greater returns can now be achieved by investing in marginal lands and drylands like in Medak district. Results from India and China suggest that government investments in less favored areas have greater poverty-reducing effects, as well as greater productivity effects than investments in better endowed areas. I am sure that the project we are beginning today will serve as a good opportunity to prove this once again.

The world faces a major conundrum: food has never been more abundant, yet millions of people go hungry. Achieving the UN Millennium Development Goals through agricultural research is therefore high on our agenda. This we strive to achieve by interventions to improve soil health; expanding small-scale water management; improving access to seeds and other planting material; diversifying on-farm enterprises with high-value products and establishing effective agricultural extension service and links to markets.

Some of the technologies that are available for adoption by farmers are rainwater harvesting for supplemental irrigation, *in situ* moisture conservation through land farm treatments, micronutrient amendments to increase yields, popularizing improved high-yielding varieties/hybrids, making available high quality improved seed varieties via village-based seed banks, diversification of incomes through biofuel production, diversifying systems through livestock and horticultural stocks and setting up ICT-enabled farmer-centered learning systems. Our joint efforts will ultimately lead to a new model of livelihood enhancement which can be replicated throughout the district.

ICRISAT's work has contributed to improvements throughout the SAT. But this is not enough. We will continue to respond to change while striving towards our vision of a semi-arid tropics free of hunger. We need science and technology for the sustainable development of the dryland areas of Medak district.

Thank you.

Dynamic Networking for Poverty Reduction in Asia

Delivered at the CLAN Steering Committee meeting, 3-5 Nov 2005, Central Luzon State University, Munoz, the Philippines.

Ladies and gentlemen,

It gives me great pleasure to welcome to this meeting the dignitaries on the dais, CLAN Country Coordinators, representatives of The World Vegetable Center (AVRDC) and the International Center for Agricultural Research in the Dry Areas (ICARDA) who are co-facilitators of CLAN with ICRISAT, and those from the International Livestock Research Institute (ILRI), the International Rice Research Institute (IRRI), the Food and Agriculture Organization of the United Nations (FAO), the Asia-Pacific Association of Agricultural Research Institutions (APAARI) and partners from the Philippines national programs.

I also take this opportunity to acknowledge the support from APAARI, and the co-hosts of this meeting, especially the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) and Department of Agriculture-Bureau of Agricultural Research (DA-BAR), who are co-hosts along with the Central Luzon State University (CLSU). The network is alive thanks to your continued interest and support.

The previous CLAN Steering Committee meeting held at ICRISAT in November 2003 was in many ways historic. It laid the foundation for an innovative approach to regional coordination of research and development involving APAARI and three international agricultural research centers. We have now sown the seeds for a novel institutional mechanism for coalition among various partners to enhance food security and improve the livelihoods of resource-poor farmers.

Given the fact that more than two-thirds of the world's poor are in Asia, higher productivity in agriculture is crucial to improve the incomes of the poor. Our objective of strengthening linkages and facilitating collaborative research among members in order to address and solve high priority production constraints to contribute to the development of stable and sustainable production systems is bearing fruit. Partnerships between national and international research institutions provide valuable opportunities for the exchange of improved production technologies and human resource development needed to spur legume production in Asia.

Let me update you on some of the latest developments. The APAARI-AVRDC-ICARDA-ICRISAT joint project submitted to the Asian Development Bank (in March 2004) was not considered for funding due to limited grant funds available with ADB. The situation has not changed in 2005.

Talks are on with the International Fund for Agricultural Development (IFAD) to seek support for the joint project, but it will cover 4.5 countries only, since IFAD does not favor projects involving a large number of countries.

Despite the lack of special project funding for CLAN, all the 3 IARCs (AVRDC, ICARDA and ICRISAT) have worked collaboratively with CLAN member countries to support the exchange of germplasm and breeding material, exchange of scientists' visits, participation in national planning meetings, regional and international workshops, and in training and capacity building.

Some national programs (notably Philippines, China, India, Iran and Vietnam) have received funds from national and bilateral donors to enhance R&D on legumes, and thus enhance impacts in their own countries.

Other national programs should emulate these examples and generate funds locally to take the intermediate and finished products to farmers' fields so that benefits can accrue to them and the country.

CLAN is one of the few R&D networks that has stood the test of time and vagaries of donor funding. This is mostly because of the commitment of scientists and research administrators in member countries. Most of the resources (staff, facilities and funds) come from the national programs, thereby enabling the sustenance of many R&D activities.

The network has been dynamic. It has responded to the needs and aspirations of member countries. It was expanded to include lentil (ICARDA) and mung bean (AVRDC) in 2003. At this meeting, we have included crop-livestock systems to highlight the role of livestock in the livelihoods of farmers in Asia.

Agriculture in Asia keeps throwing new challenges at us. Let us find ways to tackle them. Together, we can improve the well-being of the Asian farmer!

Thank you.

Asian Dryland Agriculture: Ideas, Paradigms and Policies

Paper prepared for the International Conference on "Agricultural and Rural Development in Asia: Ideas, Paradigms and Policies — Three Decades After", 10-11 Nov 2005, Mandarin Oriental Hotel, Makati City, the Philippines.

Introduction

Developments in the dryland[1] region of Asia reflect the pervasiveness of poverty, which is demonstrated by the growing constraints of water, land degradation, continuing concerns about malnutrition, migration due to frequent droughts, lack of infrastructure, poor dissemination of improved technologies and effects of government policies and further economic liberalization. Dryland ecosystems, where most of the world's poor live, are characterized by extreme rainfall variability, recurrent but unpredictable droughts, high temperatures and low soil fertility. Therefore, dryland areas present significant constraints to intensive agriculture.

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[1] *Dryland* refers to the arid, semi-arid and dry sub-humid areas in which the annual precipitation to potential evapotranspiration falls within the 0.05-to 0.65 range (Ministry of Environment and Forests, GOI, New Delhi). Dryland agriculture is also defined in terms of rainfall and irrigated area. It is identified by percentage of cropped area under irrigation of less than 25% and average annual rainfall between 500 mm and 1500 mm. By definition, drylands receive less rainfall and are subject to a more hostile environment. The heart of the drylands is the semi-arid zone, which receives from 250 to 1,000 mm of rainfall each year, and may have one or two short rainy seasons that provide a growing period of 75-179 days.

Vast expanses of dryland regions were bypassed by the Green Revolution. They have failed to attract commercial investments in agricultural technology because markets are small or non-existent. This paper summarizes the major constraints to income growth, food security, poverty alleviation and environmental sustainability, and identifies future strategies and priorities for dryland agriculture in Asia. It highlights emerging issues that threaten the sustainability of agriculture and future sources of growth.

Development planners and policymakers are increasingly eyeing less-favored dryland regions, where agricultural transformation is yet to take off. Due to issues of equity, efficiency and sustainability, the need to improve the productivity of dryland agriculture has become more compelling, more so as growth opportunities in irrigated areas have been exhausted.

Changes in Recent Decades

More than 60% of Asia's arable land is devoted to rainfed[2] agriculture, ranging from the dry and semi-arid areas of Pakistan, Burma, Thailand and the People's Republic of China to the wet and humid Indonesia and the Philippines.

Using three broad classifications of farming systems defined by Dixon et al. (2001), rainfed farming has been categorized as:

- *Rainfed farming systems in humid areas of high resource potential*, characterized by a crop activity (notably root crops, cereals, industrial tree crops and commercial horticulture) or mixed crop-livestock systems;
- *Rainfed farming systems in steep and highland areas*, which are often mixed crop-livestock systems; and
- *Rainfed farming systems in dry or cold low-potential areas*, with mixed crop-livestock and pastoral systems merging into sparse and often dispersed systems with very low current productivity or potential because of extreme aridity and cold.

[2] According to water resource availability, arable lands are also identified as irrigated, rainfed, moist and dry. Rainfed refers to arable areas that are grown to crops without the benefit of irrigation.

A comprehensive list of major farming systems given in Annexures 1a&b shows the relevant rainfed farming systems in South and East Asia and the Pacific.

Table 1 shows the area, yield and production of cereals in rainfed Asia. A comparative analysis of the 1995 benchmark data with projected estimates for 2025 shows the changing role of rainfed agriculture between 1995 and 2025.

In South Asia, the area under rainfed cereals is projected to be 55.3 million hectares in 2025, an 18.5% decline over the area planted in 1995. The aggregated rainfed cereal yield is projected to be 37% higher than yield in 1995 and the total rainfed production 12% over the production in 1995. In Southeast Asia, rainfed cereal area in 2025 is projected to be 31.4 million hectares, a 5% increase over the area planted in 1995. The aggregated rainfed cereal yield is projected to increase significantly to 2.46, which is 53% higher than the average yield in 1995 and the total rainfed production by 62% over production in 1995.

Among developing countries globally, rainfed cereal area is projected to account for more than 60% of the total cereal production in 2025. More details on the role of rainfed crops are given in Table 2, showing the fractions of total area and production for five cereal grains in rainfed Asia. Additional disaggregations are currently being analyzed for other commodities including sorghum, millets, pulses and legumes.

The Context of Change in Dryland Agriculture

The sources of change in dryland systems emanate from social, economic and environmental forces. These drivers of change are directly or indirectly influenced by policies on incentives, subsidies, prices, legislation, etc. Social changes include labor scarcity and high wage rates, growth in off-farm income opportunities, disease including AIDS and demographic transition to lower human fertility. Environmental changes involve climate change, soil fertility decline, erosion, land scarcity and loss of biodiversity. Lastly, changes in management incorporate increased farm and labor input, land use change, intensification, crop-livestock integration, income diversification and migration.

Challenges Facing Dryland Agriculture

Persistent Poverty

Reducing poverty remains a central challenge in Asia. An estimated 1.85 billion people or 57% of the region's population still lived on less than $ 2 a day in 2003. Of the rural poor, it is estimated that around 380 million (38%) reside in the arid/ semi-arid tropics and another 500 million (50%) in the humid/ sub-humid tropics. Among these agroecological zones, dryland areas have slightly more poor people than do the more irrigated areas (Ryan and Spencer 2001). The UNDP human poverty index (HPI) shows greater poverty in the semi-arid tropics (SAT). HPI for the 36 SAT countries in 1998 was 32%, compared with 24% for all non-SAT countries. HPI has declined by almost 10% since 1995 in the SAT countries compared to an increase of more than 3% in non-SAT ones. Smallholders inhabiting the tropical drylands are unable to extricate themselves from two realities of their ecosystems. There is little or no rain for five months or more in a year. Dryland farming is unpredictable, with periods of intense and exhausting work separated by periods of relative inactivity.

Data from the National Sample Surveys of India indicate that a large number of India's poor depend on dryland regions. Of an estimated 147.5 million rural poor in India (1999-2000), 41% or 60.2 million poor were concentrated in the SAT. By and large, areas with low irrigation have the highest incidence of poverty among all these regions. The less irrigated areas in the humid and SAT zones have a high concentration of the poor social groups comprising of Scheduled Castes and Scheduled Tribes. The rural poor from dryland regions display a relatively low utilization of anti-poverty programs, highlighting the issue of constrained access.

Evidence from ICRISAT's village level studies (VLS) conducted since 1975 provides empirical evidence on the vulnerability of the poor to various risks and shocks, as well as their capacity to access physical, financial and social resources and networks in the drylands. The VLS captured welfare indicators involving the level of human development and the extent of vulnerability and insecurity among individuals or households (Rao et al. 2005).

Water Scarcity

Water is increasingly becoming scarce. In South Asia, international water conflicts are brewing and riots over water have become commonplace. Minor irrigation sources have increasingly become more important than major and medium sources, especially in the drylands. However, very often farmers dig deeper and deeper wells to steal a part of the neighbour's water rather than really adding new water areas. The desire to get away from dryland farming is so intense that they sometimes ruin themselves as well as their neighbours in pursuit of scarce groundwater. As a result, there is a lowering in water tables and reduction in yield from wells.

As water scarcity is the most critical constraint in dryland agriculture, water-related interventions must include: a) adoption of an efficient watershed management approach; b) reducing vulnerability to drought through harvesting and storage of rainwater; c) recharging of depleted groundwater aquifers and strong regulations on groundwater extraction; d) pricing of water and power to reflect their opportunity costs; e) government support for water saving options, eg., drip irrigation or dryland crops; f) specification and enforcement of clearly defined water rights in watershed communities; g) enabling stronger collective action for community development in agriculture and resource management; and h) enhancing the scientific and technological support to watershed programs.

Climate Change

Climate change is expected to have a negative impact on crop and livestock activities, which underpin the livelihoods of most of the poor in dryland areas. Crop yields are projected to decrease and therefore worsen food security or exacerbate hunger. This may force changes in livelihood or coping strategies, especially in the more fragile lands. In periods of distress, the poor may be forced to sell their physical assets, such as small tractors, bicycles, household assets and farming implements. In areas where climate change is leading to more frequent drought and floods, the rural poor may have to regularly draw on these physical assets, thereby undermining the sustainability of their livelihoods over the long term. In addition, where economic diversification is low, income opportunities and hence options for developing alternative livelihoods in response to climatic changes may be limited (Bantilan et al. 2000).

The impact of climate change on agriculture could increase the number of people at risk of hunger. It has been noted, however, that "impending global-scale changes in population and economic development over the next 25 years will dictate the future relation between water supply and demand to a much greater degree than will changes in mean climate" (Vorosmarty et al. 2000). The impact of climate change on food security will be greater in those countries with low economic growth potential but that currently have high malnourishment levels. In developing countries, production losses due to climate change may drastically increase the number of undernourished people, severely hindering progress in combating poverty and food insecurity. (Session on World Food Security, May 2005).

Land Degradation

Land degradation is a serious threat to the economic and physical survival of the dryland farmer. Key issues include escalating soil erosion, declining soil fertility, loss of biodiversity, salinization, soil compaction, agrochemical pollution, desertification and water scarcity. Poor farmers, primarily those with small landholdings, have neither the resources to combat land degradation nor the options to meet short-term disasters, such as drought or pest attacks (ADB 1989).

Nutrition and Health Threats

The magnitude of the nutrition and health problems facing the poor in dryland regions is immense. Micronutrient malnutrition, often called "hidden hunger", has become more conspicuous. More than 840 million people do not have enough food to meet their basic daily energy needs. Far more—an estimated 3 billion—suffer the insidious effects of micronutrient deficiencies because they lack the money to buy enough meat, fish, fruits, lentils and vegetables. Women and children are especially at risk of disease, premature death and impaired cognitive abilities because of diets poor in crucial nutrients, particularly iron, vitamin A, iodine and zinc. A great proportion of the 10 million children in developing countries who die each year of malnutrition are from the dryland regions. Today, micronutrient malnutrition diminishes the health, productivity and well being of over half the global community, with its impact primarily on women, infants and children from low-income families. This hidden hunger results in huge costs to society, greatly impairing national development efforts, reducing labor productivity, lowering educational attainments in children, reducing school enrolments and attendance, increasing mortality and morbidity rates and increasing health-care costs.

Until the late 1980s, no Asian country had experienced a major AIDS epidemic, but by the late 1990s, the disease was well established across the region. UNAIDS reports that in 2003, over one million people were newly infected with HIV in Asia and the Pacific, bringing the total number of people living with HIV/AIDS in the region to 7.4 million. At the end of 2003, as many as 4.58 million Indians were living with HIV/AIDS. The country is projected to overtake South Africa as the nation with the largest HIV-infected population in the world (AIDS Epidemic Update, December 2003). The dryland regions are particularly vulnerable because limited opportunities for earning cash income lead to high levels of mobility and migration in search of better opportunities, with attendant increases in the probability of contracting HIV/AIDS. This poses new challenges for agricultural R&D. At the household level, the immediate impact is on the availability and allocation of labor.

Migration

Among many factors causing uncertainty is migration of people engaged in dryland agriculture. Migration of workers from less favoured areas to more favourable ones has grown over the last few decades. Seasonal, semi-permanent and permanent migration is a predominant coping strategy adopted by the poor in the drylands to get out of the poverty trap. As a matter of fact, informal markets for migrant labour that have developed over time play an important role in balancing the regional supply and demand for casual labor. While informal migrant labor markets continue to increase, their efficiency could be improved and many more poor could benefit from them, if an institutionalized system of collecting and disseminating information about supply, demand and wage rates is put in place from the local to the regional level. State governments may effectively intervene in labor markets and ensure that wage rates are fair and that there is no exploitation through practices such as bonded labor.

Opportunities in Dryland Agriculture

The discussion in this section uses the context of ICRISAT's experience in the dryland semi-arid tropics of South Asia where poverty, food insecurity, child malnutrition and gender inequalities are widespread.

While the Green Revolution in the 1960s and 1970s succeeded in shortening the growing season of irrigated crops, thus allowing farmers to harvest two or more times a year, progress has been much slower in the dry regions. Growth rates in agricultural production and total factor productivity in the drylands have been moderate, if not high. Modern technologies (such as HYVs) are increasingly being used. Agricultural research scientists are combining a variety of measures to allow farmers to reap more than one harvest a year. Quicker growing plants mature before the summer heat and water-harvesting techniques allow concentration of available water where it is most needed. Better water management methods have helped farmers optimize the use of water.

Cropping pattern shifts are taking place and coarse cereals are being replaced by soybean, pigeonpea and lentil, and in some places maize. Significant dietary changes are occurring across all income baskets. This dynamism not withstanding risks, poverty, natural resource degradation and biodiversity loss persist and are projected to worsen under the impacts of globalization, modernization, climate change, disintegrating community organizations and inadequate and ineffective public sector interventions.

The emerging evidence of higher impacts of poverty as well as higher marginal productivity gains from public investments, particularly in roads, markets and research in less favored regions (Fan et al. 2000) suggest the need to prioritize these hitherto overlooked areas in terms of technology, institutions and policy. Evidence from the literature also suggests there have been sweeping changes in the semi-arid village economies in the last few decades (Rao et al. in press), justifying a reassessment of research and development priorities in regions that have been bypassed.

Agricultural Diversification

Diversification with a focus on crop-livestock development is both a coping strategy against risk and an income enhancing opportunity that allows efficient utilization of land, labor and capital over space and time. Since the poor in dryland regions hold a major share of livestock, diversification towards milk and meat reduces interpersonal disparities in income.

Diversification out of staple food production is triggered by rapid technological change in agricultural production, improved rural infrastructure, and diversification in food demand patterns. A recent FAO/World Bank study on farming systems and poverty has suggested that diversification is the single most important source of poverty reduction for small farmers in South and Southeast Asia (Dixon et al. 2001).

Yet, in almost all South and Southeast Asian countries, agricultural policies and institutions have favored self-sufficiency in cereals and the inertia in this system will act as a strong disincentive for diversification unless drastic changes in policies and institutions are adopted. This is illustrated by the fact that the share of cereals in the value of agricultural output has generally remained unchanged in South Asia as a whole. In general, the export prospects are unlikely to affect a majority of farmers even if some specialized production for niche export markets were to take place. Such production would be on a limited scale at least with respect to the total agricultural population. Therefore, the dynamics would largely be driven by domestic demand.

Growing Importance of Livestock

Population growth, urbanization and increasing per capita incomes are fuelling rapid growth in the demand for animal-based foods in developing countries, especially those living in the SAT. Hence, in addition to improving crop production, it is important to seek ways to improve dryland livestock production and crop-livestock systems. Vast tracts of arid and semi-arid lands are unsuitable for crop production but support livestock, especially small ruminants such as sheep and goats, which not only constitute a vital supply of protein but are an important sector of the economy providing livelihood to around 300 million pastoralists worldwide from land that would otherwise be unproductive. In order to fulfill crop needs like manure and animal traction, farmers move towards crop-livestock interaction, where crops and animals are integrated on the same farms. Globally, mixed farming is highly important, producing 90% of the global milk, 54% of cattle meat and 100% of buffalo meat (McIntire et al. 1992).

Trade Liberalization and Commercial Orientation of Agriculture

To keep pace with the changing world trade regime characterized by globalization and commercialization of agriculture and the altering food habits of people in favor of livestock products, fruits and vegetables, dryland farmers will need to have a clear market orientation to make decisions about crops that they should grow. Access to good markets, which can ensure a fair price to the producer, is essential to increase the production and profitability of dryland agriculture. The use of information and communication technology can stimulate creative interaction between farmers and agro-industries and help keep farmers informed about prices prevailing in regulated markets and facilities available to them. Contract farming and other institutional innovations for vertical coordination are emerging alternatives to open markets. Farmer associations could tie up with processing industries and thus share the benefits of value addition.

The World Trade Agreement (WTA) of 1994 led to the setting up of the World Trade Organization (WTO) in place of the

General Agreement on Trade and Tariffs (GATT). This Agreement on Agriculture (AOA) has sought to reform international trade in agricultural commodities by making it obligatory for countries to open their markets to products from other countries and by reducing production and export subsidies to some extent. Prior to this agreement, there existed a paradoxical situation in which there was a thorough liberalization of trade in industrial commodities while the markets for agricultural commodities remained highly protected. To enhance food security, virtually every country aimed at enhancing production of food grain commodities, ignoring the principle of comparative advantage. With the WTA taking the first step towards liberalization and globalization of trade in agricultural commodities, most developing countries are finding it difficult to adjust to the new scenario. However, there is resentment in developing countries that the agreement carried many asymmetries in favor of developed countries. Secondly, some developed countries resort to various methods of protection while implementing the agreement. There are apprehensions that a flood of subsidized imports may harm the interests of small farmers in developing countries in general, and dryland farmers in particular (Gulati and Kelly 1999). So, there is a clamour for exemptions and safeguards to protect dryland farmers who are subject to great risk of crop loss due to biotic and abiotic factors. In any case, reduction in unit cost of production is the best strategy to face the competition in the global market. A strong research and development backup for dryland agriculture will help in better resource use efficiency and competitiveness. The basic question is how dryland agriculture in Asia can be organized or diversified to overcome complex challenges and capture emerging opportunities so that the benefits of globalization, technology, policy and institutional innovations can be harnessed to reduce poverty and resource degradation rather than lead to further marginalization of dryland regions.

NARS and the Private Sector

Dryland dwellers need to be empowered and their capacity built through education, training, provision of technical information and institutional credit to enable them to participate in and contribute to mainstream economic, social and political activities. It is important to build the capacity of supporting institutions and enable institutional learning and innovation. The challenge lies in providing an enabling institutional environment and incentives that will accelerate agricultural growth. National and regional programs with participation by the public and private sectors are essential as actions at the individual level are inadequate to reverse the situation in the drylands.

Partnerships between the public and private sectors have been evolving over time. In the 1980s, for example, ICRISAT played a nurturing role to the fledgling industry and provided breeding material, often through informal networks. During the early 1990s, as private seed industry grew, partnership was enhanced by developing significant research capability and using ICRISAT-bred improved breeding materials. In this process, the private sector became a major channel for delivering ICRISAT-based hybrids to farmers. It was quickly recognized that the private sector presents an effective delivery mechanism for improved technologies and facilitating farm-level adoption. It was observed that the private sector had the advantages of well-established marketing channels and regular monitoring of farmers' choice based on market surveys through seed traders and other networks. With the government providing a supportive policy environment, the private sector can play a major role in developing dryland agriculture by leading in investments in agribusiness, machineries, input enterprises and logistical support systems throughout the complete range of the market chain.

Pathways of Development

Science with a Human Face – an ICRISAT Perspective

ICRISAT's goal is to harness the power of technology for development, food security, poverty alleviation and environmental protection targeted at poor rural families in general, and at women and children in particular. ICRISAT calls this Science with a human face: research not for its own sake, but targeted at specific goals and implemented through genuine partnerships.

The institute serves the needs of the SAT where one-sixth of the world's population lives, half of them (380 million) in absolute poverty. Its mandate areas are marginal lands such as the fringes of the Sahara where starvation and malnutrition are recurrent. At ICRISAT, our global research themes — Markets, Policy & Impacts, Biotechnology, Crop Improvement and Agrodiversity Development — are geared towards helping the poor of the SAT. This is achieved by doing Science with a human face and partnership-based research for development. The challenge lies in achieving the second Green Revolution in less inhospitable rural agroecosystems by transforming adversities into opportunities.

The Grey to Green Revolution – A Paradigm for Development

The Green Revolution of the 60s and 70s, with its package of improved seeds, farm technology, better irrigation and chemical fertilizers, was highly successful in meeting its primary objective of increasing crop yields and augmenting food supplies. It signaled the power of modern technology in enhancing agricultural productivity. Yet its benefits did not percolate to the dry and marginal rural farmlands. These areas, characterized as dry or "grey", yearn for a strategy for change that addresses the powerlessness of the poor, failing which the tragic result will be more food and yet more hunger.

If agriculture can play a role in alleviating hunger, it will only be through pro-poor alternatives like sustainable agriculture, which reduce inequality and make small farmers the center of an economically vibrant rural economy. Recent research responds to criticism that the Green Revolution depended on fertilizers, irrigation and other factors that poor farmers could not afford and that may have been ecologically harmful. While the contributions of international agricultural research centers were crucial to the Green Revolution, it must not be forgotten that it would not have succeeded without the involvement of the national systems, civil society organizations and the private sector.

While the Green Revolution depended on farmers' access to favorable conditions to avoid moisture or nutrients stresses, in the marginal dry tropics productivity gains can also be made by adapting the crop to the environment, through less stress, disease and pest management. This means farmers get more out of their own natural resource endowment and they are better placed in the global market. By managing and optimizing local resources, poor people can turn adversity into opportunity. This way they climb their way out of poverty without depending on costly inputs or external aid.

This new revolution to green the grey areas is not possible without modern tools of science such as biotechnology and information technology. Biotechnology has the potential to substantially increase the rates of return on investments in genetic improvement. Moreover, there are synergies between advances in DNA sequencing, genome analysis and bioinformatics. Information is a vital resource for farmers to take well-informed and timely decisions to make optimal use of available resources, together with new science tools such as GIS and modeling.

While the focus of conventional agricultural research has been on agricultural production which has a direct bearing on food availability, ICRISAT's vision has to extend to encompass the entire gamut of the issue — water, markets, crop-livestock integration in farming systems, commodity vs systems approach, rural livelihoods, institutional innovations, postharvest technology, biotechnology impacts, feminization of agriculture, AIDS and policy.

The Grey to Green Revolution is not just about increasing crop productivity. It has more to do with empowering the poor to build their own capacities, self-confidence and self-reliance by using modern tools for agricultural transformation and economic growth. Appropriate technology holds the key to sustained food security and poverty alleviation in resource-poor developing countries. Growing concerns about environmental degradation and sustainability of intensive agricultural systems have given rise to the consideration of alternative technologies, such as low-input agriculture (use of organic nutrients) and

Integrated Pest and Disease Management, which are environmentally safe and maintain soil fertility. Recent developments in new science offer considerable potential benefits. Through science innovations, dryland agriculture can be a vehicle for economic, social and eco-friendly change in rural societies.

IGNRM: Research and Development Strategy

The most effective way to address the critical challenges in dryland agriculture is to develop problem-based, impact-driven strategies for agriculture and make them available through effective delivery systems. At ICRISAT, participatory and interdisciplinary research evolved towards development of an integrated genetic and natural resource management (IGNRM) approach. This approach takes advantage of an integrated strategy of core competencies to enhance productivity gains with equitable benefits through genetic enhancement and biotechnology, crop breeding, soil and water management, food safety and social science perspectives.

Genetic Enhancement and Biotechnology

Productivity gains are essential to achieve universal food security, poverty alleviation and economic viability. To help developing countries attain food security and reduce poverty and malnutrition, ICRISAT lays special emphasis on the genetic enhancement of five dryland crops—sorghum, pearl millet, groundnut, chickpea and pigeonpea—that are particularly important in the diets of the poor. Through natural selection and countless generations of cultivation by farmers, these crops have been adapted to the SAT. ICRISAT's plant breeding work has led to the release of over 400 improved crop varieties by national programs across Asia and Africa.

Application of biotechnology to dryland agriculture is expected to improve the quality of products, decrease use of chemical pesticides and lead to profitable utilization of germplasm and development novel products. Advances in genomics and bio-informatics will help realize the value of germplasm. We can expect varieties with tolerance to drought and waterlogging and resistance to insect pests; marker-assisted procedures may accelerate these processes. Higher yields and reduction in pesticide use may lead to benefits that may exceed the additional costs of the new products. How soon some of the bio-engineered products may become available after testing and the needed safeguards would depend on the quantum of resources devoted to the effort.

Biotechnologists estimate that products resistant to abiotic stresses and those with better nutritive value may become available in the next three to five years. Once available, the prevailing regulatory regimes would determine the speed of adoption.

ICRISAT's genetic enhancement priorities and strategies are guided by the changing scenario of agriculture. ICRISAT builds on its main comparative advantage, ie, its unrivalled capacity to efficiently and strategically utilize its germplasm collection for the improvement of staple dryland crops, especially for biotic and abiotic stresses, yield, nutritional and quality traits. Our gene bank, one of the largest in the CGIAR system, houses a collection of about 113,500 accessions and wild relatives of the staple food crops of the world's poorest people. Research to find new, useful genes are ongoing. A major comparative advantage of ICRISAT's crop research lies in its quick access to a vast collection of global germplasm and the ability to enhance it for diverse traits in all mandate crops. Research is directed towards reducing cost of production and improving input use efficiency, combined with integration of crop management technologies vital to improving response to inputs and stabilizing production.

Breeding Crops for Better Nutrition

The international research orientation on biofortification for dryland crops is demonstrated in four major research initiatives at ICRISAT:

1. Biofortification for Zn, Fe and Vitamin A in sorghum
2. Biofortification for Zn, Fe and Vitamin A in pearl millet
3. Biofortification for Zn and Fe in pigeonpea
4. Biofortification for Vitamin A in groundnut

These initiatives harness new scientific techniques to enhance the nutritive value of food cereals and legumes. Genetic enhancement of micronutrient density in sorghum and millets will further add to nutritional security. In case of carotene in millets, sources of yellow endosperm have been identified which may even have higher carotene content, and hence higher vitamin A density.

For biofortification of Zn and Fe in pigeonpea*, g*enotypes containing a higher level of protein (up to 32% HPL 8 and HPL 24) have already been developed at ICRISAT that can be employed for enhancement of essential amino acids. Tissue culture methods have been optimized to obtain high frequency (80-90%) shoot regeneration from cotyledonary and leaflet explants of pigeonpea. Transgenic pigeonpeas rich in essential amino acids would form an important component of diets by providing protein and fibre in multiple commodity diets.

For vitamin A in groundnuts, ICRISAT has over 15,000 accessions of cultivated and wild germplasm of groundnut. This forms an important resource for screening of lines for variations in other micronutrients in addition to Vitamin A (eg, iron and zinc). Our vast germplasm resource with different nutritional and adaptation backgrounds is readily available for use in developing transgenic plants with enhanced ß-carotene content. This allows great potential for carrying out strategic nutrition-oriented work on the development, characterization and field evaluation of transgenic plants. ß-carotenoid-enriched groundnuts can potentially enhance the diets of malnourished people in most south and southeast Asian countries where clinical vitamin A deficiency is prevalent. At ICRISAT, tissue culture methods have been developed to obtain high frequency (80-90%) shoot regeneration from cotyledon explants of groundnut. These protocols have been optimized for obtaining transgenic plants of groundnut from cotyledon and leaflet explants by using *Agrobacterium tumefaciens*-based binary plasmids carrying genes of interest. This has been successfully used to obtain a large number of independently transformed transgenic plants with marker genes (NPT II and GUS) and coat protein gene of the Indian Peanut Clump Virus.

Water and Soil as Entry Points

Agriculture and livelihoods in the dryland areas evolved under the influence of biotic (pest and disease incidence) and abiotic constraints. The most binding abiotic constraints are related to water scarcity and poor fertility of soils. The limited availability of fresh water and seasonal variation and unreliability of rainfall render agriculture in the semi-arid regions inherently risky. In dryland systems of the SAT, the constant risk of drought increases the vulnerability of the poor. Since water is vital for crop growth, low and unreliable rainfall make drought management a key strategy for agricultural development in these regions (Ryan and Spencer 2001). An integrated approach of IGNRM — a combination of better natural resources management and crop improvement — is essential to improve and stabilize crop and livestock productivity in a sustainable manner. IGNRM leads to improved livelihoods through higher incomes, lower risks, improved production technologies and crop varieties, better soil and water management and better environment protection. What is needed is increased Government investment in natural resource management in dryland areas with a greater focus on watershed management-based livelihood improvement approaches. Priority water-related interventions include:

- Adoption of an efficient watershed management approach
- Reducing vulnerability to drought through harvesting and storage of rainwater
- Recharging of depleted groundwater aquifers and strong regulations on groundwater extraction
- Pricing of water and power to actually reflect their opportunity costs
- Government support for water saving options
- Specification and enforcement of clearly defined water rights in watershed communities

Enhancing the Scientific and Technological Support to Watershed Programs

ICRISAT's research attacks water scarcity on two fronts. The first utilizes natural resource management research to improve rainwater utilization through watersheds and water conservation techniques. The second employs plant breeding and biotechnology research to improve water-use efficiency and drought tolerance in crop genotypes.

ICRISAT and the NARS have developed and evaluated an innovative farmer-centric integrated watershed management model with technical backstopping by a consortium. The approach is holistic and based on farming systems and diversified livelihood opportunities to cater to the needs of the socially marginalized and landless. The Adarsha Watershed in Kothapally in Andhra Pradesh has attracted farmers, policymakers and development investors due to the tangible and non-tangible benefits it has generated, some captured by individual farmers and some by the entire community. The benefits have been in the form of reduced runoff and soil loss, improved groundwater levels, improved land cover and vegetation, increased productivity and changes in cropping patterns. This watershed team and World Wide Fund (WWF) have joined hands to tackle the critical water shortage problem in the tropics at micro and macro levels through on-farm research as well as policy advocacy.

Enhancing soil quality compliments water use efficiency. Inadequate attention to controlling soil erosion has led to rampant soil degradation in dryland areas. Coupled with this, poor crop residue management has resulted in depletion of soil organic carbon status. Therefore, sustaining crop yields even at current levels has become a challenge in many areas. ICRISAT's Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) strategies deal with nutrient constraints and coordinated pest and environmental information to design and implement pest control measures that are economically, environmentally and socially sound. Given the fragile nature of natural resources in the SAT, there is a need to develop technologies which do not create too much of pressure on natural resources and which help replenish resources used up in the process of production. This will ensure that the stock of natural resources is intact over time.

Biological control of pests helps farmers save on pesticides and protects their health and the environment. For instance, ICRISAT introduced among farmers the use of a small insect, the mud wasp, to control pod borer. IPM integrates biological control, breeding for resistance, cultural control and judicious use of pesticides in a robust and viable system that sharply cuts the use of chemicals.

Food Safety

Aflatoxins are toxic to both humans and animals. It appears in many agricultural products, especially groundnuts (peanuts). Consumption of aflatoxins by human beings can lead to liver cancer. They also affect poultry, and when present in cattle fodder, the yield and quality of milk. Aflatoxin causes marked deterioration in kernel quality followed by decay in seeds and non-emerged seedlings, finally leading to aflaroot disease. Contaminated groundnuts cannot reach lucrative international markets and exports may decline due to stringent quality requirements of importing countries. Recent studies conducted by ICRISAT in southern India reveal aflatoxin levels as high as 40 times the permissible limit. ICRISAT has established effective partnerships to tackle this problem. Until recently, the cost of testing for mycotoxins exceeded US$ 9 per sample, using imported qualitative kits, and over US$ 100 through third-party certifiers. As part of a DFID-funded project, ICRISAT developed an inexpensive ELISA-based tool, reducing the cost of testing per sample to under US$ 1. Results of this innovation have already been transferred to the private sectors in India and Africa. In India, Janaki Feeds Company now saves a considerable amount annually since they began using the technology to monitor aflatoxin and ochratoxin contents in animal feeds as part of their quality control system.

Social Science Perspectives

ICRISAT pioneered an effort to develop a longitudinal panel database, which could be used for tracking development pathways and testing several theories and policy impacts. The Village Level Studies (VLS) which were carried out during 1975 to 1985, created a reliable long-term panel data set.

The second generation VLS, which commenced in 2002, has proven to be a powerful tool in providing insights into changes in rural livelihoods over the last 20 years. NARS partners in ICAR and agricultural universities in India are now applying VLS tools, approaches and methods across diverse locations in India. This broadens the coverage of VLS to not only include SAT environments but also other agro-climatic regions in India, thus making it a powerful tool for decision-making. The findings of the VLS revived in 2002 have many implications for policymakers, researchers and development agencies. Key findings include shift in cropping patterns from food crops to commercial crops, decline in livestock numbers, decline in income from farming due to persistent drought, increased dependence on non-farm work, migration, services, business and other occupations to support families. The findings also reflect the forces of globalization and national policies that influence input and output prices and the profitability of agriculture. Many policy interventions are needed in favour of dryland agriculture in the SAT to correct the policy bias and to enhance public investments to alleviate poverty. Evidence from VLS

featured the importance of regional specificity and participatory priority identification to develop innovative strategies for the complex dryland environment.

Complimentary case studies on social capital and social networks reveal complex interactions underlying the impact of agricultural research and technology uptake process considering the vulnerability of households, their asset base, intervening institutions and livelihood strategies. Monitoring and evaluation tracking reveal that social capital (referred to as the ability and willingness to form social networks and the ability to form relationships of trust) is an important means by which the poor, marginalized, vulnerable, women and the socially excluded gain access to resources, economic opportunities and expansion of choice.

Innovation Systems: Strategic Alliances

Recognizing that the participation of different institutions is critical to generate required outputs to achieve shared goals, ICRISAT's research work is attuned to, and integrated with partners' needs and priorities, supporting a mutual sharing of information and technology. ICRISAT institutionalizes a systematic and dynamic approach to building and maintaining strong partnerships. It acts as a catalyst, bridge and scientific contributor— helping advanced research institutions adapt and deliver their novel techniques and information to solve pressing problems of the SAT. The roles of public and private sectors and their relationships are changing, bringing synergy of joint efforts. All the private sector partnerships at ICRISAT are coordinated under a single institutional program called the Technology Innovation Center (TIC). Partnership efforts by scientists at ICRISAT and in NARS programs have led to the release of 474 different cultivars.

Agri-Science Park @ ICRISAT

The Agri-Science Park @ ICRISAT (ASP) is the means by which ICRISAT commercializes technology to help farmers in the SAT through partnerships. The Agri-Science Park consists of an Agri-Biotech Park (ABP), Agri-Business Incubator (ABI), a Hybrids Parents Research Consortia and the SAT Eco-Venture. The consortium undertakes collaborative research with private, public and government entities. Consortium partners provide annual grants to ICRISAT to fund hybrid parents' research on sorghum, pearl millet and pigeonpea. Consortia member partners have access to research products before non-members.

The Agri-Biotech Park is the venture in which mature businesses can establish facilities to tap into ICRISAT's upstream research expertise and use its world-class infrastructure either on a contract basis or through joint ventures. The scientific resources and support services available in the ASP include access to an international body of expert scientists, genetic transformation and applied genomics laboratories, bioinformatics facility, and assistance on IPR and biosafty issues.

The Agri-Business Incubator enables startup agri-business companies to tap ICRISAT's scientific and managerial support resources to grow and develop into viable ventures. Funded through a collaborative project between ICRISAT and the Department of Science and Technology, Government of India, the ABI provides technology exchange, feasibility studies, networking and training.

Public-Private Partnerships in the Seed Sector – Hybrid Seeds Consortium. The recognition of the private sector as a valuable research for development partner led to the formation of the Sorghum and Pearl millet Hybrid Parents Research Consortia, the first of its kind in the entire CGIAR system. Under this arrangement, each member contributes a small research grant each year for sorghum and pearl millet research for a five-year period. This arrangement was very effective as evidenced by 16 PS seed companies becoming consortia members for sorghum, 18 for pearl millet, with 11 being common for both the crops by the end of 2003. A significant aspect was that the products developed with consortia grants were available freely to the public sector and to non-consortia PS companies.

SAT Eco-Venture is the agricultural eco-tourism initiative being developed in collaboration with the Andhra Pradesh Department of Tourism.

Biopesticide Consortium

A dialogue with the private sector biopesticide industry in India has resulted in the endorsement of the Biopesticides Research Consortium (BRC). The BRC is meant to develop, promote and commercialize the use of biopesticides by farmers. ICRISAT and its national partners have been working on bacterial isolates, fungi and entomopathogenic viruses to manage insect pests and diseases. The partnership research will validate protocols for low-cost, commercial-scale production of microbial biopesticides developed at ICRISAT, and will promote agricultural practices that enable protection of crops at a low cost. The private sector partners will market the biopesticides. The response of the private sector to the BRC has been encouraging, and to date 10 biopesticide manufacturers have become members.

Watersheds Development Consortium

In order to increase incomes and improve livelihoods of dryland farmers and the landless in Asia, ICRISAT, NARS and NGOs together developed an innovative farmer participatory consortium model for integrated watershed development (Wani et al. 2003). The model builds on the strength of the consortium partners, tangible economic benefits, equity, empowerment and participatory approach to achieve its objectives while at the same time minimizing land degradation and protecting the environment. The consortium has been expanded to include public and private enterprises to provide forward and backward linkages to increase rural incomes, increase empowerment opportunities and enhance production.

The ICRISAT-led watershed consortium entered a partnership in four areas to augment funding for research to effect accelerated/ improved incomes and livelihoods of resource-poor framers through: (a) scaling-up an innovative participatory consortium; (b) facilitating the cultivation and processing of medicinal and aromatic plants; (c) production of bio-diesel; and (d) strengthening PS research to serve farmers.

VLS-university Alliances

The Village Level Studies of ICRISAT were used by the academic community all over the world to develop and test theories of economic behaviour of farmers in developing countries. It yielded several publications, policy insights and research recommendations for the benefit of farmers, researchers and policymakers. The modules of the latest VLS were soon adopted by the National Centre for Agricultural Economics and Policy Research, New Delhi, for the Social Science Information Repository studies in 10 states of India, covering 55 villages. The revival of VLS has attracted the collaboration of researchers from Oxford University, Cambridge University, INRA, France and several researchers from USA, Canada, Japan (Institute of Developing Economies, Chiba, Tokyo University, Hitotshubashi University, etc.). ICRISAT proposes to extend these methodologies to other locations in India (to include the collaborators of NCAP) and further to other countries of South Asia like Sri Lanka, Bangladesh and Nepal.

Information Technology (VASAT)

The recent revolution in information and communication technology (ICT) has led to the tremendous decline in the cost of using ICT, making it quicker and feasible, particularly in rural areas. ICT and the Internet have opened great possibilities to provide agricultural extension, price information and other matters of interest to farmers at a reasonable cost. Farmers in the drylands can now have access to expertise in resolving crop-related constraints. The Virtual Academy for the Semi-Arid Tropics (VASAT) is a coalition that aims to mobilize communities and intermediaries of the dry tropics by sharing information, knowledge and skills related to climate literacy, drought preparedness, best practices in dryland agriculture and other relevant issues. It is done through the innovative interface of ICTs and distance learning. A number of private sector initiatives that use IT for rural development are active partners in South Asia and corporate foundations are partners with ICRISAT in West and Central Africa. For example, a course on drought-preparedness among youth was recently delivered in 40 different sites and covered 30,000 learners. Another innovation that extends outreach to more clientele in the dryland region of Asia is the Global Open Agricultural and Food University (GOAFU), a new CGIAR initiative enabling the delivery of technical content and training across well-established Open Universities globally. The university's goal is to strengthen the capacity of postgraduate students, researchers and other working professionals in food and agriculture in order to enhance agricultural development, poverty reduction and food security.

Reorienting Policy

Food security and productivity growth in agriculture in Asia are increasingly dependent on improved utilization of new technology and productivity growth in rainfed areas. If future technology growth is to benefit the poor, the overlooked potential of the rainfed areas must be explored, and suitable strategies and policies designed to stimulate productivity growth. Reorientation of public policies and better targeting of development interventions to dryland farmers are called for since they relate to key factors constraining agricultural productivity.

Any policy initiative that talks of supporting dryland agriculture starts from an implicit recognition of policy bias in favour of irrigated agriculture. Policy support to the development of dryland agriculture should address the adverse policy outcomes suffered by dryland farmers.

The following list of policy recommendations were formulated based on an analysis of micro-level (VLS) data and a nationwide poverty analysis using the National Sample Surveys of India. The studies provided the basis for identifying major policy issues that need to be addressed to strengthen livelihoods in the dryland regions.

Higher public investment in technology and infrastructure. Since low levels of input use and low productivity levels characterize dryland agriculture, it is important to step up the level of private and public investment in improved technologies. Farm and non-farm incomes in the drylands are constrained by deficient infrastructure. Constraints in seed availability and other input supply also emphasize the importance of an effective public and private sector in reaching the rural poor. Results cited earlier show that the marginal returns to investment in infrastructure and technology in dry areas are higher than those in irrigated areas. Investment in rural infrastructure particularly will have a direct impact on food security.

Addressing chronic trade deficits in pulses and oilseeds. Shortage of pulses and oilseeds and import dependency are chronic problems, especially in India. While the Technology Oilseeds Mission (1986) helped reduce edible oil imports for some years, there has been a steady growth in edible oil imports since the 90s. As these crops are predominantly grown in the drylands, a renewed emphasis on oilseeds and pulse production can help reduce the unnecessary imports.

Rationalize subsidies on agricultural inputs. Fertilizer subsidy is a major issue. While fertilizers can be used in both irrigated and dryland areas, most of them have been used in irrigated crops. Due to nonavailability of moisture, dryland farmers consider it quite risky to apply fertilizers. They are used only in small doses for dryland crops. However, Governments and banks are providing farmers cheap credit for irrigated crops.

Like fertilizers, irrigation water and electricity are two other inputs that are heavily subsidized. For example, the benefits of irrigation investments are shared by the whole society, but unfortunately, farmers in drylands are discriminated by this policy. Non- recovery of irrigation capital costs is the first among the many policies that were discriminatory. The existing policy of subsidies on agricultural inputs needs to be reviewed and its direct and indirect impacts on different categories of farmers carefully assessed. There is a need to streamline the delivery system to ensure that the benefits from subsidies are widely and equitably distributed. To attain this objective, it is imperative that dryland farmers receive a higher priority in the allocation of funds for subsidies on farm inputs.

Cover more crops under minimum support price schemes. Rainfed crops suffer substantial discrimination in the Government's procurement and public distribution policies (PDS). Although minimum support prices are announced for rainfed crops as well, they are seldom backed by procurement operations. The heavily subsidized PDS and rice and wheat market in India, for example, have eroded the competitiveness of coarse cereals and altered market price ratios. Substituting PDS with a food stamp system leaves beneficiaries the option of buying grains of their choice. Unless these policy initiatives are taken up vigorously, rainfed crops and farmers growing them may be further marginalized, forcing them to seek livelihood options outside agriculture.

Covering more households under crop and livestock insurance. With the cost of cultivation rising and given the risks and uncertainties of dryland agriculture, every farmer is concerned about the investment he makes and the returns he expects. Another major policy initiative needed is crop insurance in dryland areas. The National Agricultural Insurance Scheme has just been launched by the Ministry of Agriculture of India. Its coverage should be extended to all dryland farmers at subsidized premiums.

Higher inflow of institutional credit to dryland agriculture. The amount of institutional credit provided to dryland farmers per hectare is markedly lower than that in irrigated areas. It has been observed that dryland agriculture is profitable over a period of 3 to 5 years even though in any one year it may be a losing concern. Therefore, a new cyclical credit policy is required to meet all the credit requirements of the dryland farmer during this period, even if he becomes a defaulter in one or more years.

Coping with globalization and marginalization. Market reforms that encourage integration and liberalization of import and export markets, production efficiency and competitiveness of agricultural products within the domestic and international markets are becoming an important policy issue in the agricultural sector. Considering dryland agriculture's role as a means of livelihood for millions of poor people, enhancing its competitiveness by cutting the unit cost of production is critical for the survival of many smallholder farmers.

Facilitating migration. Seasonal semi-permanent and permanent migration is a predominant coping strategy adopted by the poor to escape poverty. Informal markets for migrant labor (in SAT villages of India) play an important role in balancing the regional supply and demand for casual labor. The efficiency of informal migrant labor markets could be further improved if an institutionalized system of collection and dissemination of information on supply, demand, and wage rates is provided in select dryland regions. Wage rates for female workers are substantially lower (50%) than that of male workers; policies to address this imbalance are needed.

Conclusion

Though the Green Revolution transformed many regions in Asia, it did not reach the poor in the drylands. Poverty, population explosion, water scarcity, land degradation, migration and other health constraints persist. Low productivity of dryland agriculture coupled with a changing global environment further threatens to marginalize agriculture and livelihoods in the drylands of Asia. These areas require approaches that differ from the Green Revolution strategy.

A broad vision for dryland agriculture would involve reducing poverty, hunger, and malnutrition, and ensuring sustainable livelihoods for everyone. This vision can be achieved through a multi-pronged strategy to accelerate the pace of development of dryland agriculture. The development of drylands requires synergies among technologies, marketing systems, input supplies, credit, policies and institutions. Broadbased sustainable growth and development in Asia's drylands is the key to addressing rural poverty in this region.

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Table 1. Rainfed total cereal area, yield and production in Asia, 1995. Figures in parentheses are baseline compared with projections to 2025.

Country	Area (m ha)	Yield (mt ha -1)	Production (m mt)	Rainfed Area (%)	Rainfed Production (%)
South Asia	67.9 (55.3)	1.20 (1.65)	81.5 (91.24)	54.1	36.2
India	62.3 (49.8)	1.20 (1.63)	74.6 (81.4)	62.2	42.7
Pakistan	00.8 (00.9)	0.60 (0.93)	00.5 (00.8)	07.4	02.3
Bangladesh	01.9 (01.6)	1.35 (2.03)	02.6 (03.3)	24.9	13.5
Other S Asian countries	02.9 (03.0)	1.35 (2.16)	03.9 (06.5)	43.5	39.2
Southeast Asia	29.8 (31.4)	1.61 (2.46)	47.9 (77.8)	60.8	45.0
Indonesia	05.6 (05.9)	1.70 (2.44)	09.6 (14.5)	38.1	23.3
Thailand	08.8(09.1)	1.52 (2.08)	13.3 (19.0)	80.7	70.4
Malaysia	00.3 (00.3)	1.45 (1.78)	00.4 (00.5)	35.9	25.6
Philippines	03.9 (04.5)	1.49 (2.46)	05.9 (11.2)	60.1	50.8
Vietnam	03.6 (03.5)	1.68 (3.19)	06.0 (11.3)	48.8	33.5
Myanmar	05.3 (05.7)	1.87 (2.80)	010 (16.0)	85.3	79.8
countries	02.2 (02.4)	1.22 (2.22)	02.7 (05.3)	92.9	88.8
East Asia	27.1 (30.5)	3.54 (4.59)	95.7 (133.47)	29.5	26.1
China	26.2 (29.6)	3.59 (4.65)	94.0 (137.5)	29.6	26.3
S Korea	00.2 (00.1)	3.29 (6.01)	00.6 (00.8)	16.1	12.5
Japan	00.2 (00.2)	3.28 (3.72)	00.7 (00.8)	09.7	07.5
Other East Asian countries	00.6 (00.6)	1.57 (1.70)	01.0 (1.00)	36.2	24.8

Source: Rosegrant et al. 2002.

Table 2. Fractions of rainfed to total area and production of total cereal grains in Asia, 1995 and 2025.

Crop/region	Area		Production	
	1995	2025	1995	2025
China	.30	.31	.26	.26
India	.62	.52	.43	.31
South Asia (excluding India)	.22	.21	.14	.14
Southeast Asia	.61	.61	.45	.47
Developing countries	.62	.62	.43	.43
Developed countries	.82	.81	.77	.74
World	.69	.68	.58	.56

Source: Rosegrant et al. 2002.

Fig 1a. Major farming systems in South Asia.

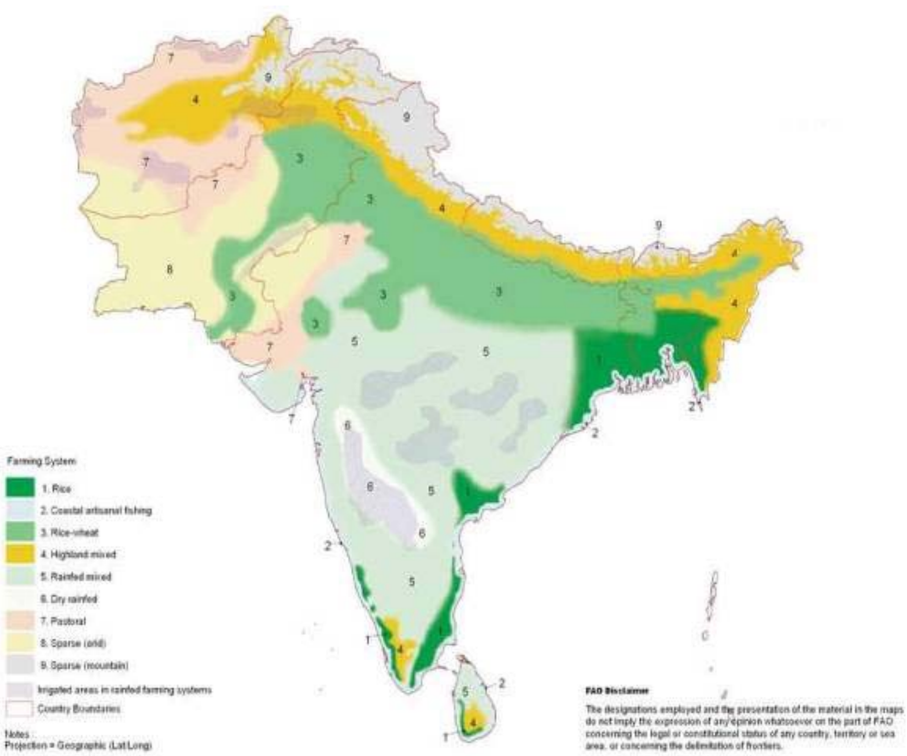
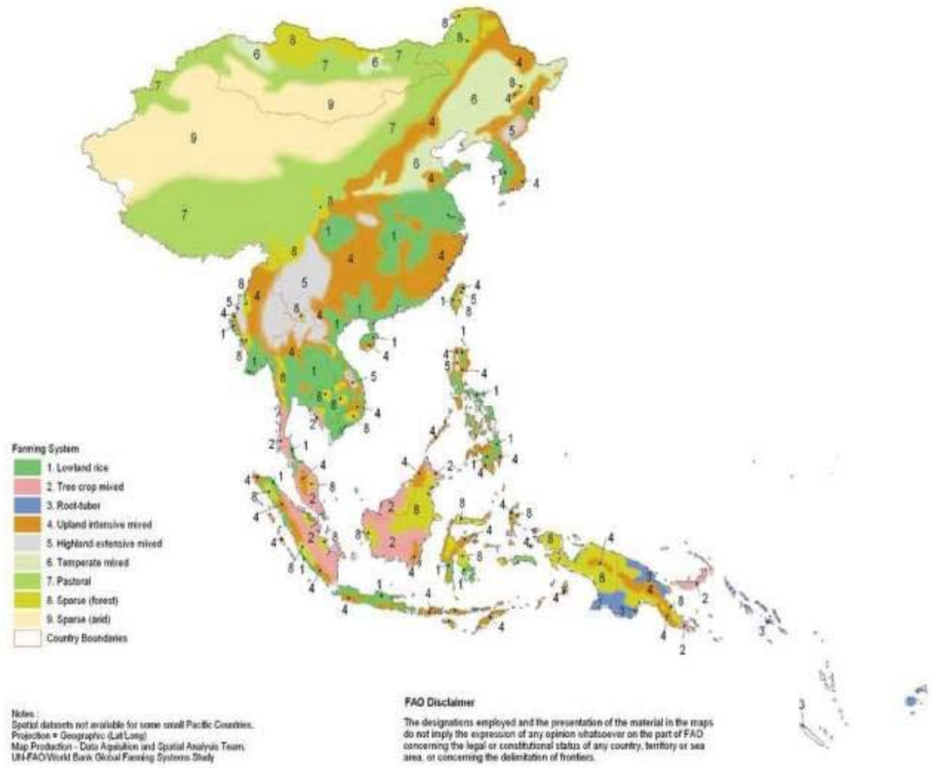


Fig 1b. Farming systems in East Asia and the Pacific.



Annexure 1a

Major farming systems in South Asia.

Farming systems	Land area (% of region)	Agric. popn. (% of region)	Principal livelihoods	Prevalence of poverty
Rice	7	17	Wetland rice (both seasons), vegetables, legumes, off-farm activities	Extensive
Coastal Artisanal Fishing	1	2	Fishing, coconut, rice, legumes, livestock	Moderate - extensive
Rice-Wheat	19	33	Irrigated rice, wheat,vegetables, livestock including dairy, off-farm activities	Moderate - extensive
Highland Mixed	12	7	Cereals, livestock, horticulture, seasonal migration	Moderate - extensive
Rainfed Mixed	29	30	Cereals, legumes, fodder crops, livestock, off-farm activities	Extensive (severity varies seasonally)
Dry Rainfed	4	4	Coarse cereals, irrigated cereals, legumes, off-farm activities	Moderate

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Farming systems	Land area (% of region)	Agric. popn. (% of region)	Principal livelihoods	Prevalence of poverty
Pastoral	11	3	Livestock, irrigated cropping, migration	Moderate - extensive (expecially) drought induced)
Sparse (Arid)	11	1	Livestock where seasonal moisture permits	Moderate - extensive (especially) drought induced)
Sparse (Mountain)	7	0.4	Summer grazing of livestock	Moderate (especially in remote areas)
Tree Crop	Dispersed	1	Export or agro-industrial crops, cereals, wage labor	Moderate (mainly of agricultural workers)
Urban based	<1	1	Horticulture, dairying, poultry and other activities	Moderate

Annexure 1b

Major farming systems in East Asia and the Pacific.

Farming systems	Land area (% of region)	Agric. popn. (% of region)	Principal livelihoods	Prevalence of poverty
Lowland Rice	12	42	Rice, maize, pulses, sugarcane, oilseeds, vegetables, livestock, aquaculture, off-farm work	Moderate
Tree Crop Mixed	5	3	Rubber, oil palm, coconut, coffee, tea, cocoa, spices, rice, livestock, off-farm work	Moderate
Root-Tuber	2	<1	Root crops (yam, taro, sweet potato), vegetables, fruits, livestock (pigs and cattle), off-farm work	Limited
Upland	19	27	Rice, pulses, maize, sugarcane, intensive mixed oilseeds, fruits, vegetables, livestock, off-farm work	Extensive

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Farming systems	Land area (% of region)	Agric. popn. (% of region)	Principal livelihoods	Prevalence of poverty
Highland	5	4	Upland rice, pulses, maize, oil Extensive Mixed seeds, fruits, forest products, livestock, off-farm work	Moderate
Temperate Mixed	6	14	Wheat, maize, pulses, oil crops, livestock, off-farm work	Moderate
Pastoral	20	4	Livestock with irrigated crops in local suitable areas	Extensive, especially drought - induced
Sparse (Forest)	10	1	Hunting, gathering, off-farm work	Moderate
Sparse (Arid)	20	2	Local grazing where water is available, off-farm work	Extensive
Coastal Artisanal Fishing	1	2	Fishing, coconut, mixed cropping, off-farm work	Moderate
Urban based	<1	1	Horticulture, dairy, poultry and other work	Limited

Working Together for a Hunger-free World*

Delivered on the 70th anniversary of the Guangxi Academy of Agricultural Sciences, Nov 17-20, Nanning, China

Ladies and gentlemen, good morning.

I am honored to be here today as a special guest on the occasion of the 70th anniversary of the Guangxi Academy of Agricultural Sciences.

The ICRISAT-China alliance has been constantly evolving; new avenues for joint research are being explored. Pigeonpea has served as the crop that has cemented our ties. At one time, it had completely disappeared from the Chinese landscape. ICRISAT has been instrumental in reviving the crop in Guangxi and Yunnan provinces. At the Guangxi Academy of Agricultural Sciences, the main research emphasis has been on fodder production, grazing and soil conservation, while at the Insect Resources Institute, the aim was to exploit the crop's potential for soil conservation.

Newly-developed ICRISAT pigeonpea lines have shown great promise for different cropping systems in China. Short-duration varieties have shown high adaptation in southern China. At present, Guangxi and Yunnan provincial governments have made elaborate plans to multiply seed of promising lines. Currently, the area under pigeonpea is estimated to be around 50,000 ha.

The world faces a major conundrum: food has never been more abundant, yet millions of people go hungry. Achieving the UN Millennium Development Goals through agricultural research is therefore high on our agenda. We strive to achieve these by interventions to improve soil health; expanding small-scale water management; improving access to seeds and other planting material; diversifying on-farm enterprises with high-value products; and establishing effective agricultural extension service and links to markets.

ICRISAT strongly believes in the power of partnerships. We believe that the results of scientific breakthroughs, transferred

* The speech was delivered by Dr KB Saxena on behalf of Dr William Dar.

across borders and adapted to local conditions, can go a long way towards creating a hunger-free world. Genuine partnerships between international organizations, local research institutions and civil society to produce usable research are crucial. I must add here that more than 541 improved varieties of the mandate crops developed by us in partnership with national agricultural research systems have been released in 72 countries since 1975.

ICRISAT's goal is to harness the power of technology for development, food security, poverty alleviation and environmental protection, targeted at poor rural families. We call this doing Science with a human face. We have the global responsibility for improving the livelihoods of the poor in unfriendly environments — the dry tropics — where inherent low soil fertility, erratic rainfall and poor physico-social infrastructure make farming a challenging task.

While the focus of conventional agricultural research has been on agricultural production which has a direct bearing on food availability, our vision has to extend to encompass the entire gamut of the issue — water, crops-livestock integration in farming systems, commodity vs systems approach, rural livelihoods, postharvest technology, biotechnology impacts, feminization of agriculture, AIDS, etc.

The results of our collaborative efforts with China are there for you to see. Pigeonpea is now grown on the roadsides, hill slopes and riverbanks. Chinese food technologists have developed noodles, snacks and alcoholic drinks from pigeonpea. Among the pigeonpea varieties that have been released in China are ICPL 90008 (released as GUIMU 1), ICPL 87119 (GUIMU 3) and ICP 7035 (GUIMU 4).

Your institution is celebrating 70 years of doing science. It is indeed a momentous occasion and ICRISAT is a proud partner. I wish you all the best in your future endeavors.

Thank you.

Building Communities with Confidence

Delivered at the Silver Jubilee celebrations of the ICRISAT Association for Community Development, 25 Nov 2005, IACD Center, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Dear friends,

It is a pleasure to join this group gathered here to celebrate the silver jubilee celebrations of the ICRISAT Association for Community Development (IACD). It is equally heartening to find determined youngsters wanting to seize their own destinies. Their enthusiasm is very infectious.

The overarching objective of community development and empowerment is to help underserved people accumulate assets and improve their economic well-being. IACD set out to fulfill this objective by building the capacity of communities while at the same time serving as an advocate for healthy and productive communities and their importance to society.

What began as a crèche for children of ICRISAT employees in 1980 has now blossomed into a program that has kept pace with events in the outside world. The tailoring and embroidery classes have injected a new confidence in young women. Supplementing the family income is high on their agenda. The newly-introduced English speaking classes are a rage, I am told. The response to computer classes has been overwhelming. Two students have even found themselves coveted jobs. I would like every program of ICRISAT to donate their disposable computers to IACD so that more students can learn new skills.

These examples are powerful and reassuring. But knowing what works for making these facilities accessible to individuals and communities is crucial. Future gains in our poorest neighbourhoods will depend on our ability to connect to people, to those who are striving to get from where they are to where they want to be.

While the Institute takes great pride in IACD's work, it is you all who make the program what it is. Your belief that if you keep on doing what you've always done, you'll only get what you've always got is precipitating change.

Though private philanthropy can help build capacity, there is no substitute for local initiative, local imagination and local responsibility. To all those here who have benefited from IACD's small initiatives, I have a message. Now you in turn must do things that will benefit those around you.

Shortly before he died, Mahatma Gandhi gave his grandson a written list of the seven biggest reasons of violence and strife. Among these was "Science without humanity." At ICRISAT, it has been our endeavor to do Science with a human face. It is science not merely for its own sake, but for the benefit of humanity. What is being done at IACD is an extension of this philosophy to benefit communities that live around us.

When you embrace change as an inevitable part of life, looking for ways to use new change to make your life richer, easier and more fulfilling, your life will work much better. You will experience change as an opportunity for growth.

Programs like IACD help individuals and communities create their own solutions and seize their own destinies. We know from years of experience that building social capital is important.

Let us use the time and resources we have in a creative manner. Let us make the most of our opportunities to build IACD; to make it a place where the poor can have a better life.

Thank you.

The Alliance of Future Harvest Centers: Convergence and Collective Action for the CGIAR

Speech delivered as Chair, Alliance Executive and Director General, ICRISAT, during the opening session of Centers and Members Day, CGIAR Annual General Meeting, 5 Dec 2005, Marrakech, Morocco.

My most esteemed colleagues, good morning.

Over the past four years, the CGIAR has undergone unprecedented reforms. This has resulted in a re-focused vision and mission, streamlined governance, strengthened scientific advice, coordinated central support and an elevated program profile. The Centers are committed to playing a proactive and constructive role in the reform process.

Toward this end, the Centers established a formal Alliance of 15 Future Harvest Centers. Building on existing governance mechanisms, the Alliance aims to enhance effectiveness and efficiency without creating new levels of bureaucracy in the System, operating at a minimal cost. More importantly, the Alliance itself is an instrument of reform in the CGIAR.

Our primary objective in establishing the Alliance is to facilitate convergence and collective action among Centers. This enables us to:

1. Bring in more partners, knowledge and scientific disciplines to address new priorities
2. Focus on innovative systems and impact pathways rather than commodities, agro-ecosystems, and disciplines
3. Speak with one authoritative voice on global issues
4. Support institutional learning and the synergy of ideas
5. Achieve cost efficiencies in standards and services
6. Eliminate unwanted tensions through contractual and conflict resolution mechanisms.

Collective action also enables stakeholders to enjoy:

1. More focused, multi-faceted programs
2. Streamlined access to and uniform arrangements with Centers
3. More effective application of global public goods
4. Lower transaction costs.

Revisiting Our Collective Action Framework

In July 2004, a framework for collective action was mapped out in a retreat of the Center Directors, Board Chair representatives and partners. The framework is the foundation of the Alliance which is:

1. Built on existing CGIAR practices
2. Informed by analysis of past constraints and a new vision
3. Building on the Principles and Procedures as the platform for best practices in collaboration
4. Guided by the Alliance Board and managed by the Alliance Executive
5. Supported by the Future Harvest Alliance Office.

Milestones of the Alliance

In the past, collective action has been hampered by the complexity of the CGIAR's task environment, issues of governance and management, competition and territoriality among Centers and inadequate resources.

Today, I am happy to report that the Centers are fully engaged in collective action through the Alliance. Moreover, the Alliance has come a long way since it was proposed at the CGIAR Executive Council (ExCo) meeting in September 2004.

Let me share some of our milestones

At the CGIAR's Annual General Meeting in 2004, the Center Boards Committee (CBC) and CDC formally established the Alliance. A set of guiding principles was agreed upon, topped by a declaration that *"the allegiance of the Alliance is first and foremost to the poor."* Likewise, the Center Directors Committee transformed itself into the Alliance Executive (AE).

The CBC and CDC then appointed a team led by Jim Jones, Chair of CIAT, to draft the Principles and Procedures for the Alliance. The Principles and Procedures (P&P) is essentially a roadmap for decision-making, collective action and convergence among Centers.

At a meeting in September, Alliance leaders reviewed the latest version of the P&P document and discussed several important issues. The draft document has been discussed by Centers and reviewed by the World Bank.

The Alliance was also discussed at the CGIAR Executive Council (ExCo) meeting in Stockholm in October. The revised P&P document was discussed by the Board Chairs and Directors General at their meeting here in AGM05. When finalized and approved by Center Boards, the Alliance will request CGIAR members for its inclusion in the CGIAR Charter.

Centers with their partners are developing joint medium term plans (MTPs) for sub-Saharan Africa (SSA). ILRI with ASARECA lead the initiative for Eastern and Southern Africa (ESA). WARDA and CORAF are the leaders for Western and Central Africa (WCA). CGIAR members view the joint MTPs as a showcase for Centers to deliver what is needed. Moreover, the MTPs will serve as vehicles for program alignments in SSA.

To heighten awareness among Centers and stakeholders, we have established an Alliance newsletter. Published quarterly in electronic format, this can be accessed within the CGIAR website. I invite all of you to read our newsletter regularly for latest developments in the Alliance. An Alliance diary for 2006 has also been produced for stakeholders as a symbol of collective action.

The Alliance also gave collective inputs in finalizing the Science Council's (SC) research priorities and a collective analysis of the SC's comments on Center MTPs.

A task force from the Center Deputy Directors Committee (CDDC) drafted an assessment report on the System-wide Ecoregional Programs (SWEPs). The report concluded that the World Bank's funding was very successful, having significantly leveraged additional resources from other donors.

The Alliance together with the Private Sector Committee and Secretariat of the CGIAR jointly organized a workshop in September to explore trends in agricultural research with the private sector.

The rapid adoption of the common policies on Genetically Modified Organisms (GMOs) and Center germplasm collections was made possible through the Alliance. Likewise, it also facilitated the organization of an orientation program for new Board members.

A Steering Committee composed of Alliance leaders, supported by the Future Harvest Alliance Office, has also drafted a grievance and conflict resolution mechanism for Centers.

Alliance Members in Collective Action

While we were building the Alliance, Centers have been working together to pursue the CGIAR mission. Ordered alphabetically, let me share some highlights of the Alliance in collective action.

Centers through the ICT-KM Program will launch *CGXchange*, the new CGIAR Intranet during this AGM. This will enable access to the information resources of the entire CGIAR System. It will also provide a unique set of tools for collaborative work without boundaries throughout the world.

Centers also sent their gender and diversity associates to Bogor, Indonesia, in June, to take stock of their progress on gender and diversity goals and plan for the future.

CIAT with CIMMYT, CIP and ten partners from Latin America collaborate to improve nutrition of the poor, especially children and women. To achieve this, superior crops are being developed and deployed. This initiative strengthens linkages among Latin American agriculture, nutrition and health sectors to the Harvest Plus Challenge Program with Canadian support.

CIFOR worked closely with ICRAF, IWMI and FAO to increase awareness of how floods are often wrongly blamed on deforestation. Floods are also used to justify people's displacement from their lands and forest-based livelihoods. This campaign resulted in over 50 stories in the international media.

CIMMYT and its partners developed an approach to select drought-tolerant maize under controlled drought stress, including participatory varietal testing. Three to five years of using this breeding method in eastern and southern Africa increased average yields in experimental hybrids by 15 to 20%. Over 45,000 tons of maize seed from this work have been distributed in the region.

CIP has developed with ILRI a simple way to make sweet potato more edible for pigs, using a combination of ensilaging and feed supplements. Less energy is needed to prepare the feed, yet the same amount of feed yielded at least 35% more meat. The system had a significant impact on livelihoods in Vietnam and it is currently being extended to Indonesia, China and India.

ICARDA with CIAT, CIMMYT, CIP, ICRISAT, IFPRI, ILRI, IPGRI and IWMI have been engaged as a consortium of Centers to rebuild agriculture in Afghanistan. The consortium has assisted in rebuilding seed systems and key agricultural stations, undertaken germplasm collection and trained Afghan farmers and scientists, thus contributing to rebuilding food security in the country.

ICRAF hosts the Alternative to Slash and Burn program which was recognized for its scientific impact. Embrapa estimates that this program helped prevent 2.5 million hectares of Brazilian forest from being converted to pastures. The recognition was also due to pro-poor policies it shaped which helped avoid conflicts and environmental degradation.

ICRISAT with CIMMYT, CIP, ILRI, IRRI and IWMI hosted a media dialogue promoting CGIAR's *Healing Wounds* initiative in New Delhi, India, in June. *Healing Wounds* helps rehabilitate agriculture in countries devastated by natural disasters and conflicts. For instance, the Alliance is helping rehabilitate livelihoods of tsunami survivors in Asia.

IFPRI's research findings on public-private partnerships offer a means of sharing knowledge and resources for more strategic impact on poverty reduction, food security and agricultural development. To optimize this potential, IFPRI launched a research initiative and organized workshops, including one in New Delhi with ICRISAT.

IITA and its partners conducted a communication campaign on the dangers of mycotoxin contamination, reaching an estimated 10 million people in Ghana, Togo and Benin. Innovative technologies to manage mycotoxins have been developed by IITA, ICRISAT and CIMMYT.

ILRI, IITA and the Systemwide Livestock Program are providing women in northern Nigeria with cowpea and sorghum varieties that keep their goats and families fed throughout the long dry season. The women's goat-rearing groups are growing exponentially as this project empowers women to be income earners and household providers.

IPGRI, the host of the System-wide Genetic Resources Program (SGRP), organized a workshop to put farm animal and fish genetic resources on a higher profile. This was aimed at meeting the Science Council's new thrusts. SGRP also drafted inputs on Center agreements with the International Treaty on Plant Genetic Resources for Food and Agriculture and standard Material Transfer Agreement.

IRRI leads the Rice Knowledge Bank which has established itself as the premier source of rice related training and extension material. The Rice Knowledge Bank had over three million hits in 2005 and 13 country sites. Taking off from this, IRRI and CIMMYT have proposed to jointly establish a Cereal Knowledge Bank.

IWMI leads the Consortium of Spatial Information that includes all Centers. The priority areas are: data management and coordination (IWMI), geographic dimension of crop varieties (CIMMYT), impact assessment (IFPRI), natural resource degradation (ICARDA), integration and training of national agriculture research systems (CGIAR-CSI) and poverty mapping (CIAT).

WARDA's new types of rice for Africa (NERICA) are making big waves. In Benin, it has helped increase school enrollment and reduced child sickness. In Uganda NERICA is the new cash crop supporting education. In Guinea, the area planted to NERICA increased by 50% from 2002 to 2003.

WorldFish Center is working with "The Consortium to Restore Shattered Livelihoods of Communities in Tsunami Affected Nations" alongside other CGIAR Centers. This consortium addresses the root causes of vulnerability and ensures that communities attain better situations than before the tsunami.

Challenges

As the Alliance has taken off, there are a few challenges we must continuously face to further enhance collective action.

*For example, w*e need to systematically document, share and institutionalize our lessons learned from joint efforts.

Second, we must carefully analyze when research is best done individually or collectively by Centers.

Third, we need to develop incentives to encourage collective action by Centers, especially in the current competitive funding environment.

Fourth, we must creatively quantify added value, research synergies, increased efficiency and quality of science and delivery through collective action.

Fifth, we must abide by our principles and procedures, codes of conduct and define roles to guide management for effective inter-Center partnerships.

And sixth, we need to finally agree on transparent and fair conflict resolution mechanisms to maximize productivity and healthy relationships among partner institutions.

Allow me to add that during the recent meeting of the CGIAR ExCo in Sweden, there was a concern among donors that the Alliance Executive may simply add another bureaucratic layer to the CGIAR. To clarify this, the Centers were asked to address the following concerns at AGM05:

- Indicate full and fully-loaded costs of the Alliance Office
- Show that there is full buy-in of the Alliance by every Center
- Clarify how binding AE decisions are on each member and if

the Alliance Board will have full governance authority over the Alliance and

- Describe cost and benefits for the Alliance.

The Alliance is committed to face these challenges through our 2006 work plan. This will be presented by Joachim Voss, the incoming Chair of the Alliance Executive. We will also present our clarification on the last set of issues during the Business Meeting.

As I close, let me thank Meryl Williams and Kerri Wright-Platais for their invaluable support and to all of those who helped us build the Alliance. Meryl has left us last month and we now have Geoff Hawtin on board.

Again, let me emphasize that the Alliance will be a proactive force to help CGIAR in the reform process. We expect that the road to reform will not be smooth. However, we are confident that with your support, the Alliance will surely succeed in helping pursue the CGIAR's mission.

Thank you and good day.

Loyalty to the Goal is Our Guiding Light

Delivered on Loyalty Day, 13 Dec 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Good morning TEAM ICRISAT.

It is believed that an idea is a powerful seed. If you plant it in the soil of knowledge and experience, nurture it with the water of wisdom and integrity, light it with the passion of team workers, a beautiful flower will appear.

Dear colleagues, its that time of the year once again when ICRISAT honors those who have made it the beautiful flower that it has blossomed into today. ICRISAT and its staff are as strong as ever because they share so many values in common: A belief that a team and not the individual makes a great institution, a belief that decency and hard work define a person's worth.

We have honored 165 employees today with Loyalty Awards, of which 64 have stood by the Institute through its ups and downs, completing 30 long years. Thank you for standing by ICRISAT.

There are five main drivers of loyalty: Care and concern that the employer shows for workers; fairness; employees' feelings of accomplishment in their work; satisfaction with daily activities; and management appreciation for employees' ideas and input. ICRISAT has given you these. You have in return given it your everything.

The world is very different now. Organizations like ours hold in their hands the power to abolish all forms of human poverty, to give those living in the semi-arid tropics of Asia and sub-Saharan Africa a better deal. Each of us should see this goal in terms of a mission.

We have defined some missions and completed some. We have surmounted odds. We have fought back magnificently – and in the process have won the admiration of the Governing Board, our donors and our partners. We have together demonstrated that where hard work and loyalty flourish, success will ensue.

This year has been particularly rewarding. The 53rd Governing Board meeting was held in September. The Board hailed ICRISAT for its continued excellence, recognized the high morale of staff and the surplus budget achieved for the third year in a row.

In the past, collective action has been hampered by the complexity of the CGIAR's work environment, issues of governance and management, competition and territoriality among Centers and inadequate resources. Our objective in establishing the Alliance of Future Harvest Centres was to facilitate convergence and collective action among Centers. Today, I am happy to report that the Centers are fully engaged in collective action through the Alliance. While we have made substantial gains building the Alliance, Centers have been working together to pursue the CGIAR mission.

In a very rare circumstance, the Alliance was led by ICRISAT, with Prof. Mokwunye as Chair of the Alliance Board, I as the Chair of the Alliance Executive, and Dr Keatinge as Chair of the Alliance Deputy Executive. Together we have laid the foundation of the Alliance.

Another very crucial exercise — a long-term (2006-2015) envisioning exercise – is on at ICRISAT. Tomorrow is Visioning Day, where distinguished guests will share their perspectives.

In your hands, my dear colleagues, more than mine, will rest the final success or failure of our course. In your hands and not in mine, is the future of this institute.

On Loyalty Day, let us reaffirm our allegiance to ICRISAT and resolve to uphold its vision.

Thank you.

Thinking Differently, Breaking New Ground

Delivered on Annual Day, 15 Dec 2005, ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

Dr Barghouti, Mr Dewan, Dr Ashok, Dr Shehu Ago, Dr Ramakrishna, guests and my dear colleagues at ICRISAT, good morning.

We are honored to have with us today Dr Barghouti, former Director General of ICRISAT, and Mr Dewan, Chief Secretary to the Government of Andhra Pradesh, and our new member of the Governing Board. I welcome you to ICRISAT.

There has never been a more urgent need for making poverty history. And there has never been a stronger call for action from the global community. Progress towards reducing hunger has been slow in the past decade and uneven across regions and countries. The situation in sub-Saharan Africa (SSA) is particularly dire with the number of hungry people increasing by 20% since 1990.

Since the adoption of the Millennium Development Goals in September 2000, poverty has climbed to the top of the global development agenda. The year 2005 saw a wide array of high-level initiatives to address the issue and a new focus on agriculture and rural areas, where most hunger persists.

This year, I am delighted to say that ICRISAT has made important progress in several key directions that have a bearing on hunger and poverty. We have been thinking differently and have broken new ground. This morning, I would like to briefly review the advances we have made and then turn my attention to the future.

ICRISAT is committed to offering the poor in the semi-arid tropics of Asia and sub-Saharan Africa unparalleled opportunities so that they can develop their potential. Our success is measured by the impacts of our research. ICRISAT's research products are a range of public goods and means of enhancing individual, community and societal capacity to translate these into substantial benefits for the rural poor.

For instance in Ethiopia, *Mariye* was the most widely adopted chickpea variety followed by *Shasho.* The *kabuli* chickpea variety *Chefe* released in 2004 and *Sasho* are expected to spread rapidly. Two fusarium-wilt resistant chickpea varieties (ICEAPs 00040 and 00053) promoted for adoption in Babati, Tanzania, have yielded about 67% higher yields and cut production costs by 26% compared to local landraces.

Microdosing technology promoted in West and Central Africa (WCA) has increased millet productivity from 50 to 120% and incomes from 44 to 134%. Nearly thirteen thousand farm families are using the technology.

The Desert Margins Program has entered the second stage, with 1,500 African Market Garden units installed in 8 Sahelian countries, benefiting an estimated 10,000 farm families.

Another area of ongoing focus has been the testing of biotechnology products in Asia and SSA. We are conducting contained field trials of transgenic groundnut for resistance to the Indian Peanut Clump Virus (IPCV); transgenic groundnut for resistance to the peanut bud necrosis virus (PBNV); and transgenic pigeonpea for resistance to the legume pod borer with *Bt cry1Ac* gene.

ICRISAT believes in sustaining media networks to support biotechnology promotion. As part of this effort, media seminar-workshops on biotechnology were successfully conducted in New Delhi, Dhaka and Ouagadougou.

In Asia, ICRISAT has pioneered marker-assisted breeding leading to pearl millet hybrids resistant to downy mildew. HHB 67-2, a joint product of the Haryana Agricultural University and ICRISAT, has been released for cultivation in India.

Collaboration across intellectual and institutional boundaries will be a condition for success in the next phase of the innovation economy. Science is showing us the way. The most exciting new areas of research are drawing together specialists from multiple disciplines. In pooling their expertise, they create entirely new fields. Many of the most important opportunities before us require skills and resources that no single institution can deliver. Our innovative partnerships with the private sector bear testimony to this. The Agri-Science Park (ASP), ICRISAT's technology commercialization arm, has 9 incubatees in its Agri-Business Incubator. The Agri-Biotech Park, part of the Genome Valley Initiative of the Andhra Pradesh government, hosts five biotech companies.

The Agri-Science Park now has a new entrant, the Rudraram Research Institute of Agricultural Sciences, set up to create patentable IPs in molecular biology and agricultural biotechnology. The Bio-pesticides Research Consortium was established with 11 companies pledging about US$ 24,000. The joint venture can potentially help entrepreneurs to enhance their businesses while ICRISAT can meet its objectives of helping farmers of the SAT by providing them with low-cost, eco-friendly technologies to protect crops.

In order to harness funding from corporations, foundations and trusts, ICRISAT has mapped out a strategy and initiated a campaign to intensify resource mobilization in India. We are also undertaking branding initiatives focused on watersheds, the Virtual Academy for the Semi-Arid Tropics (VASAT) and biotechnology.

In the area of ICT4D and e-learning, VASAT's reach has expanded and collaborations are on with other ICT-KM programs. ISRO-India has agreed to provide ICRISAT direct connectivity to support NARS and State Agricultural Universities (SAUs).

The great danger for most of us is not that our aim is too high and we miss it, but that it is too low and we reach it. So let us not limit our capabilities in any way. Because sooner or later, those who win are those who think they can.

Donor visits have become an integral part of our efforts to communicate more effectively to our donors how they help the most vulnerable in our society. I recently had the opportunity to meet World Bank President Mr Paul Wolfowitz and Indian Prime Minister Dr Manmohan Singh. ICRISAT showcased its research facilities when Andhra Pradesh Governor Mr Sushilkumar Shinde came visiting.

ICRISAT launched a Visibility Initiative with colleagues across the Institute to raise awareness among donors and other key ICRISAT stakeholders of our commitments to, and achievements in SSA as well as SSA-Asia synergies. We have strengthened our strategic relationship with The Hindu Group of Publications and other partners.

ICRISAT had a broader role to play this year in the Alliance of Future Harvest Centers of the CGIAR. Prof Mokwunye as Chair of the Alliance Board, I as the Chair of the Alliance Executive and Dr Keatinge as Chair of the Alliance Deputy Executive were successful in laying the foundations of the Alliance.

Now the Centers are taking the lead with their partners in developing joint medium term plans (MTPs) for sub-Saharan Africa. This is being carried out against an accelerated timeline for submission to the Science Council and their eventual implementation. The document of the Principles and Procedures for the Alliance, a roadmap for decision-making, collective action and convergence for all Centers, was adopted and approved by Center DGs and Board Chairs during our meeting in Morocco.

On the financial front, the news is good. Our budget has risen from $21 million when I took over to around $30 million in 2005. We have once again been rated as “superior” by the World Bank for our financial performance in 2004. This has been the result of TEAM ICRISAT’s hard work and the generosity of our donors.

Keeping costs under control has become imperative given the escalating price of oil. Conscious efforts are being made to phase out old vehicles, rationalize the fleet, explore alternate fuel, pool transportation, identify energy-inefficient equipment, establish centralized equipment, etc. With your cooperation, some of these steps are showing results.

The process of empowering ESA and WCA hubs continues. Assistant regional directors are now in place in Niamey and Nairobi. The transition has been reasonably smooth and the authority and responsibility of the regional Directors has been substantially enhanced.

My second term as Director General began in January 2005. It involved clarifying a vision for the institute, goal-setting and moving in the right direction. Our long-term global visioning exercise (2006-2015) began last month with the Asian in-house review and planning meetings. Yesterday was Visioning day, with partners sharing their ideas and viewpoints.

In the past, our success owed much to our industrious workforce, but times and trends and economic forces have changed. In the future, we can no longer only depend on our traditional strengths but must find new skills, new ways, new recipes for success. TEAM ICRISAT should be part of that exciting quest.

As Martin Luther King Jr. once said, “Take the first step in faith. You don’t have to see the whole staircase. Just take the first step.” We should take the first step together. TEAM ICRISAT can do it!

Thank you and good day.

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political, international organization for science-based agricultural development. ICRISAT conducts research on sorghum, pearl millet, chickpea, pigeonpea and groundnut – crops that support the livelihoods of the poorest of the poor in the semi-arid tropics encompassing 48 countries. ICRISAT also shares information and knowledge through capacity building, publications and ICTs. Established in 1972, it is one of 15 Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

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