J Raghotham Reddy Memorial Lecture

The Semi-Arid Tropics (SAT) and Climate Change: Research and Policy Solutions

Dr William D Dar

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Science with a human face

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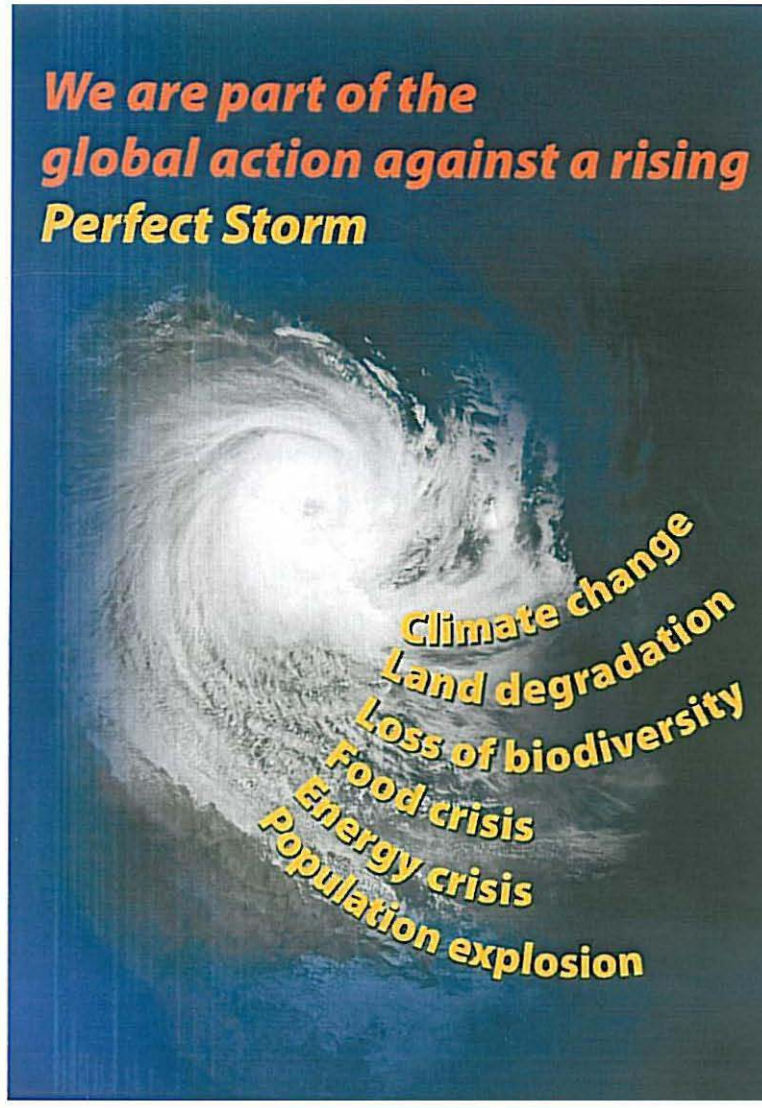
A 'perfect storm' is brewing

The semi-arid tropics (SAT) spans 750 million hectares in 55 developing countries across the globe. The region is home to more than 2 billion people. Of these, 1.5 billion depend on agriculture for a living, with 670 million comprising the poorest of the poor. It also houses nearly 50% of the world's undernourished and more than 70% of its malnourished children.

The SAT is facing a 'perfect storm', with a number of huge problems converging around land issues. Beyond the anticipated population increases, the recent food price spikes, disruptions of financial markets and economic stagnation, energy demands, dwindling biodiversity and effects of climate change create a more difficult environment in which agriculture must operate. At the center of this storm are the poor who depend on the land for survival.

Since every 1% increase in agricultural productivity translates into an average decrease of absolute poor by 6 to 8 million, agriculture is the engine for overall economic growth and empowerment of the poor in the SAT. Yet farmers here face substantive risks -- very short growing seasons, separated by very hot and dry periods during which crop growth without irrigation is difficult; poor natural soil fertility; incidence of pests


We are part of the
global action against a rising
Perfect Storm
Climate change
Land degradation
Loss of biodiversity
Food crisis
Energy crisis
Population explosion

and diseases that are often difficult to control; a dearth of local infrastructure and national policies that do not adequately and effectively promote agricultural growth and development. Since such risk-entailed dryland rainfed agriculture is practiced on approximately 80% of the world's agricultural area and yet, generates 60-70% of the world's staple food, addressing the needs of rainfed farming is critical in improving the livelihoods of resource poor in the SAT.

Rockström (2009) has proposed a framework based on nine planetary boundaries which define the safe operating spaces for humanity with respect to the Earth system and are associated with the planet's biophysical systems or processes. Of the boundaries, three – climate change, rate of biodiversity loss and interference with the nitrogen cycle – have transgressed their threshold limits. This, according to him, could have irreversible consequences such as abrupt environmental changes and be detrimental to human development.

The SAT poor are highly vulnerable to both current and future climate change impacts, given their high dependence on agriculture, strong reliance on ecosystem services, rapid growth and concentration of human and livestock populations and relatively poor health services. The factors limiting increased agricultural production and sustainability are only expected to worsen with the frequency and intensity of extreme events (tropical cyclones, floods, droughts and heavy precipitation).

Nearly 80 million hectares of India's net sown area is rainfed, with 40% of the foodgrains coming from it. Over 80% of coarse cereals, 55% of upland rice, 77% of oilseeds and 65% of cotton are cultivated under rainfed farming.

However, productivity levels of crops like millets, pulses, and oilseeds at farmers' level continue to remain low. Though potential yields of up to 2 tonnes per hectare are possible, the yield gaps are exacerbated by vagaries of climate and the southwest monsoon playing truant. Hence the need to restore the eroding confidence of the Indian farmer in agriculture.

There is a strong urgency to acknowledge and include agriculture prominently in climate response since both are inextricably tied together. Today agriculture contributes about 14% of annual greenhouse gas emissions, and forestry another 17%. A recent study on climate change by the International Food Policy Research Institute (IFPRI) warns of an addition of 25 million more malnourished children in 2050 without serious mitigation or adaptation; a fall in irrigated wheat yields (by 30%) and irrigated rice yields (by 15%) in developing countries in 2050; and increased prices of wheat by 90%, rice by 12% and maize by 35% in 2050.

Climate change is already inevitable, but in the absence of robust adaptation strategies, will almost certainly exacerbate food insecurity. Millions of people in countries that already have food security problems will have to give up traditional crops and agricultural methods as they experience changes in the nature of the seasons, for which, over time, they have developed coping strategies that have enabled them to survive.

Climate change also threatens poverty reduction efforts because poor people depend directly on already fragile ecosystems for their well-being. They also lack the resources to adequately defend themselves or to adapt rapidly to changing circumstances, and more importantly,

their voices are not sufficiently heard in international discussions, particularly in climate change negotiations. Environmental effects such as desertification and rising sea levels triggered by climate change can lead to increased conflict for resources, which in turn can displace people.

Technical solutions

Climate change being a threat multiplier, adaptation and mitigation strategies need to be urgently integrated into national and regional development programs. Developing countries need to participate in a globally integrated approach to this problem. Policies on adaptation include changes in land use and timing of farming operations, adaptive plant breeding and crop husbandry technologies, irrigation infrastructure, water storage and water management. Mitigation measures may include better forecasting tools and early warning systems, improved crop and livestock management practices including improved input use efficiencies (such as ICRISAT's microdosing), crop systems diversification and improved water management.

Policy solutions

More investments in agricultural research and infrastructure

Considering the role of agriculture in the social and economic progress of developing countries, and the vulnerability of agricultural systems to the impacts of climate change, a

renewed agenda for agricultural research, more aggressive investments in and better management of agricultural research and knowledge can make significant improvements in food security goals. A progressive policy environment should also include more investment in infrastructure and education and research that improves understanding and predictions of the interactions between climate change and agriculture.

Water management

Almost 95% of the developing countries' water withdrawals are used to irrigate farmlands. Therefore water policy to make more efficient use of water for agriculture is crucial. This involves understanding water flows and water quality, improved rainwater harvesting and water storage and diversification of irrigation techniques. Such considerations will need to be framed in the context of rapidly expanding populations that are predicted to exacerbate inter-sectoral competition for abstracted water supplies. Robust irrigation infrastructure may be necessary to cope with climate change risks in the short to medium term. Maintenance of existing infrastructure too deserves early attention.

Land-use practices

Land-use policies to encourage diversification and natural resource management, including protection of biodiversity, are critical. Erosion control and soil conservation measures, agroforestry and forestry techniques, forest fire management and better town planning are some steps that can be initiated to blunt the impacts of climate change. Reducing

and sequestering terrestrial greenhouse gas (GHG) emissions are possible by enriching soil carbon, farming with perennials, climate-friendly livestock production, protecting natural habitat and restoring degraded watersheds and rangelands.

Weather and climate services

The role of weather and climate services and products in developing adaptation solutions is crucial. Stock-taking of available climate information in developing countries to ascertain where the systematic observation needs are most pressing, collaboration between national and international providers of climate information and users in all sectors and generating awareness among different user communities of the usefulness of such information are essential. Climate change assessment tools are needed that are more geographically precise, that are more useful for agricultural policy and program review and scenario assessment, and that more explicitly incorporate the biophysical constraints that affect agricultural productivity. Packaging this data for its effective use and rescuing historical meteorological data are equally important. In this respect, the National Meteorological Services in the developing world must be encouraged and enabled to become fully integrated into research and development initiatives.

Engagement of the private sector

Policies that encourage holistic approaches including the engagement of the private sector should feature in any national and international approach to address climate

change and facilitate the transition to a low-carbon economy. The private sector can invest in clean new technologies and develop innovative market mechanisms to combat climate change, particularly the dangers from GHG emissions.

Capacity-building and collective action

Policies that enhance the effectiveness of rural institutions at the local, national and international levels will be a central concern as they seek to speed up the pace of agricultural adaptation. Unless steps are taken to initiate and strengthen cooperation among academic and research institutions, regional and international organizations, and NGOs to provide opportunities for strengthening institutions, dealing with climate change impacts may be cumbersome. Involving local communities, education on climate change and raising public awareness are key to combating climate change.

Economic diversification

Economic diversification to increase the economic resilience of and to reduce reliance on vulnerable sectors is crucial. Reducing dependence on climate-sensitive resources is an important adaptation strategy that must be promoted. Improved food security through crop diversification, developing local food banks for people and livestock, and improving local food preservation need to be encouraged.

Database of adaptation options

Given the diversity of agro-ecological zones and their inherent problems, it is also essential to assemble, document and disseminate a comprehensive and action-

oriented database of adaptation options of different farming and livelihood systems and agro-ecological zones.

Access to credit and crop insurance

Since farmers are often constrained by access to credit, policies that enable better access to credit (micro-finance) and agricultural inputs in order to intensify integrated production systems need attention. Catastrophic or weather-risk insurance and index insurance (insurance linked to a particular index such as rainfall, humidity, or crop yields rather than actual loss) can be used as new climate risk management tools in developing countries.

Gender diversity

While underscoring the vulnerability of poor women to climate change, policies that cater to the rural poor and recognise the important role of women in agricultural production should be acknowledged. By virtue of the valuable knowledge in water, forest and biodiversity management that women have acquired over the years, and their important role in supporting households and communities to mitigate and adapt to climate change, their contribution to the identification of appropriate adaptation and disaster mitigation processes could be very useful. Women's environmental resources, knowledge and practices can be key elements in climate change processes.

Contributing to value chains

Policies that contribute to value chains in the agricultural sector and smallholder farmer participation in these

value chains is fundamental to efforts to deal with climate change.

The CET opportunity

The emerging market for carbon emissions trading (CET) offers new opportunities for farmers to benefit from land uses that sequester carbon. Policies that encourage and enhance participation in carbon emission trading schemes must be put in place.

ICRISAT's role

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) serves the poor of the semi-arid tropics in Asia and sub-Saharan Africa (SSA). It recognizes that vulnerable rural communities need to adapt to climate change, beginning with enhancing their ability to cope better with the rainfall variability associated with current climates.

To help farmers in sub-Saharan Africa cope better with climate variability, ICRISAT currently facilitates a NEPAD-endorsed consortium for 15 national, regional and international partners titled *Investing in rainfed farming systems of sub-Saharan Africa: Evaluating the agricultural implications of current climatic variability and planning for future climate change*. ICRISAT is currently partnering with meteorological services, CGIAR centers and climate science specialists in several projects pertaining to climate risk management in Asia and Africa. There are currently 10 such projects taking place in SSA. Equally important is the identification and promotion of crop, soil and water management innovations

that not only optimize the efficiency of use of water stored in the crop root zone, but which also minimize the impacts of both current and future climate-induced risk.

ICRISAT has developed and continues to develop tools and technologies enabling the resource poor to improve livelihoods. It uses sophisticated techniques of predicting and forecasting the monsoons in the context of climate change; enables collective action and rural institutions for agriculture and natural resource management; upscales and outscales its community watershed management model; rehabilitates degraded lands and diversifies livelihood systems for landless and vulnerable groups and initiates government support for water saving options.

Climate-ready crops

ICRISAT already has on hand crops that are adapted to high soil and air temperatures; knowledge and understanding of flowering maturities; information on genetic variation for water use efficiency; short duration varieties that escape terminal drought and high yielding and disease-resistant varieties. For instance, we have developed short-duration chickpea cultivars (Figure 1) ICCV 2 (Shweta), ICCC 37 (Kranti) and KAK 2 and short-duration groundnut cultivar ICGV 91114 (Figure 2) that escapes terminal drought. We recently developed a super-early pigeonpea line that flowers in 32 days and matures in about 65-70 days (Figure 3). We have integrated shrubs and trees into traditional annual cropping systems to help reduce the impacts of winds and to protect soils from erosion.

Figure 1. The Director General examines ICRISAT's new heat-tolerant chickpea variety.

ICRISAT has developed crop varieties that resist pests and pathogens such as downy mildew-resistant pearl millet hybrid HHB 67-Improved in India (Figure 4); wilt-resistant high-yielding pigeonpea ICEAP 00040 in Tanzania, Malawi and Mozambique and rosette-resistant groundnuts in Uganda, to name a few. The stay-green character in sorghum lines is one of the traits associated with terminal drought tolerance. ICRISAT's stay-green sorghum cultivars (Figure 5) can be grown in postrainy season. Fodder of stay-green plants is more nutritious for cattle.

Guiding our crop adaptation work are tools such as INSTAT and GENSTAT, MARKSIM and APSIM/DSAT that analyze

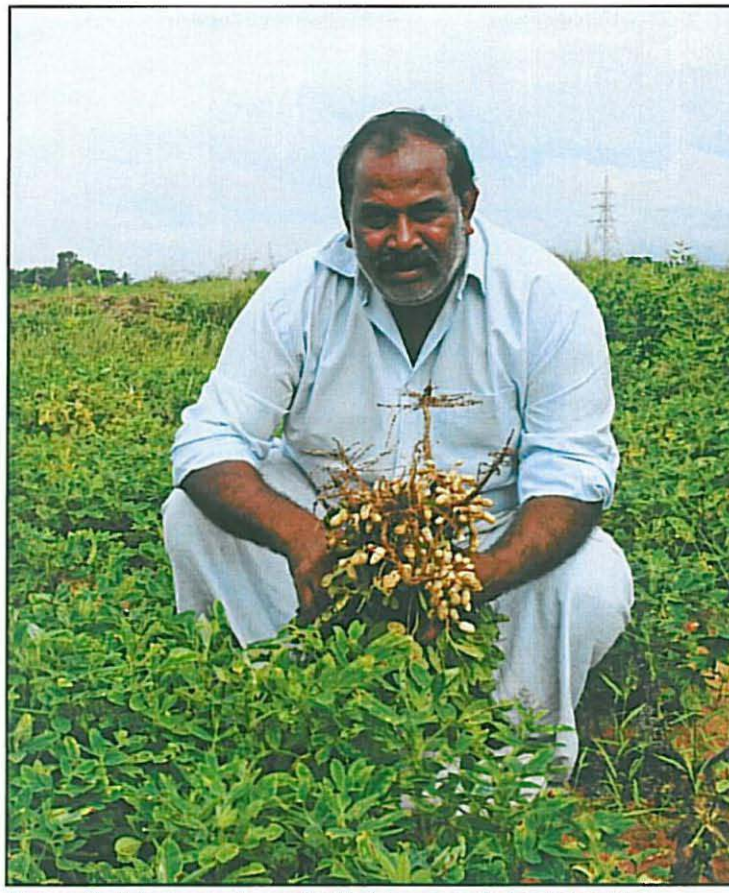


Figure 2. A farmer pleased with his crop of short-duration groundnut cultivar ICGV 91114 that escapes terminal drought.

climate data and produce high-quality information and products tailored for agricultural applications and to quantify the relationships between climate, crop, soil and water resources.

Figure 3. ICRISAT's new super-early pigeonpea line.

Figure 4. Downy mildew-resistant pearl millet hybrid HHB 67-Improved.

Figure 5. ICRISAT's stay-green sorghum cultivars can be grown in the postrainy season.

Since ICRISAT's mandate crops are already more adapted to heat and high soil temperatures, our breeding strategy factors these harsh and dry conditions while developing improved varieties. What we need to better understand is the physiological mechanism underlying heat tolerance; identify wider gene pools to develop crops with wider adaptability; and develop more effective screening techniques of germplasm for desired traits. ICRISAT's genebank holds more than 119,000 accessions from 144 countries that will help safeguard and exploit genetic diversity in order to enhance adaptation.

Biofuel production

ICRISAT is also responding to the challenges by exploiting the potential of 'pro-poor' opportunities for biofuel production. Its BioPower initiative encourages more investments in bio-energy crops and systems to provide a major impetus for sustainable development; empowering the dryland poor to benefit rather than be marginalized, so that farmers can better cope with stresses, climate change or otherwise. The current activities include developing higher-yielding sweet sorghum varieties for food, fuel, feed and fodder; pilot-scaling pro-poor commercial startup company partnerships in sweet sorghum bioethanol production and research-to-development alliances for pro-poor Jatropha plantation development for biodiesel.

Conclusion

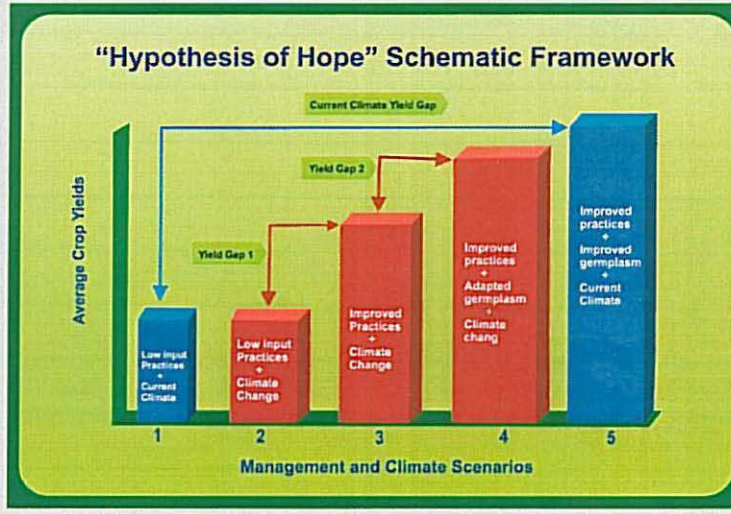
If developing countries in the SAT are to contribute meaningfully to efforts toward adaptation and mitigation of climate change impacts, they will need the strengthened capacity that comes with development. A conducive and comprehensive policy environment that enhances opportunities for smallholders given the climate change scenario, needs to encompass all levels – farm, basin, regional, national and global. It must include adaptation and mitigation strategies, more investment in agricultural research and extension, rural infrastructure, and access to markets for small farmers, among other things. The bottom line is to ensure that they develop resilient ecosystems, resilient crops, resilient livestock and resilient communities.

A climate change "Hypothesis of Hope" for the Semi-Arid Tropics

ICRISAT's scientists have used a range of proven models to provide insights on the potential impact of climate change on crop productivity. Out of this, ICRISAT has identified yield gaps that ICRISAT must address in seeking solutions to both current and future climate-induced production risks as crop management practices and adapted crop varieties are used under current climate and climate change scenarios.

The first and last columns show the yield gaps between low input and improved practices and germplasm under the current climate. The three columns in between show yield gaps with various crop management practices and adapted germplasm under climate change. Column 2 indicates lower yields due to climate change if farmers continue using low inputs. Columns 3 and 4 show that better yields are possible even with climate change if farmers utilize improved crop management practices and climate-adapted crops. On the whole, high yields are still possible under climate change if farmers combine improved practices with climate-adapted crop varieties.

Hence policymakers should take notice that better formulated and targeted policies that facilitate and support the adoption of agricultural innovation today assume even greater urgency. Not only will they improve the welfare of rural population today but will do a great deal to mitigate the impacts of future climate change.



Notes

William D Dar, PhD, is the Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) near Hyderabad in Andhra Pradesh, India, since January 2000.

Dr Dar has had a long and distinguished career as an educationist, agricultural scientist, administrator, and humanitarian in his native Philippines and abroad in the Asia Pacific region and sub-Saharan Africa.

He holds the distinction of being the first Filipino and Asian to be Director General of ICRISAT. He was Chair of the Committee on Science and Technology (CST) of the United Nations Convention to Combat Desertification (UNCCD) from 2007 to 2009.

Prior to joining ICRISAT, he served as Presidential Adviser for Rural Development, and Secretary of Agriculture in the Philippines (equivalent to Minister of Agriculture). Before this, he was Executive Director of the Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD), Director of the Bureau of Agricultural Research (BAR) of the Philippine Department of Agriculture (DA) and Vice President for R&D and Professor of Benguet State University (BSU), Philippines.

Dr Dar has received a number of awards and honors, including the 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 the Outstanding Alumnus of UPLB, BSU and the Ilocos Sur Polytechnic State College. In November 2002, PCARRD honored him with its most prestigious award, the Symbol of Excellence in R&D Management. He was recipient of the 2007 Outstanding Professional of the Year Award in the field of agriculture awarded by the Professional Regulation Commission (PRC) of the Philippine Government.

He has received several honorary doctorates -- Doctor of Science from the Mariano Marcos State University in the Philippines (2003), Doctor of Resource Management from Benguet State University (2007), and Doctor of Technology from Isabela State University (ISU) in the Philippines (2008).

In 2009, he was conferred the Father Jose Burgos Award, Ilocos Sur's most prestigious award for his outstanding achievement in the field of agriculture. In recognition of his outstanding contribution to pulses research, he was honored with the Indian Society of Pulses Research and Development (ISPRD) Lifetime Achievement Award.

Dr Dar is a man on a mission and a champion of the poor. He led ICRISAT into renaissance, excellence and relevance with the motto "Science with a Human Face". His transformational leadership has turned ICRISAT into a forward looking institute.