Strategy Paper

Managing our Water Resource for Increased Efficiency

by

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Progress Through Science

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Progress Through Science

Trust for Advancement of Agricultural Sciences (TAAS)

GOAL

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

MISSION

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

OBJECTIVES

- To act as think tank on key policy issues relating to agricultural research for development (AR4D).
- Organizing seminars and special lectures on emerging issues and new developments in agriculture.
- To institute national awards for the outstanding contributions to Indian agriculture by the scientists of Indian and other origin abroad.
- Facilitating partnerships with non-resident agricultural scientists visiting India for short period.

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Preamble

Population in most of the tropical developing countries is increasing by leaps and bounds. According to FAO, over 800 million people currently lack adequate food and by 2025 AD the food requirement of an additional 3 billion people will need to be met. Hidden hunger, such as protein and micro-nutrient deficiencies is expected to become increasingly serious, particularly for women and children. Indian agriculture has made a rapid stride achieving self sufficiency in food requirement by recording 5 times increase in production from the base line of 1950-51 through green revolution. Our efforts have also resulted in achieving 10 times increase in horticultural produce, 6 times in milk and 9 times increase in production of fish, from the base level of 1950-51. In India, the cultivated area has remained static at around 142 million hectares for the last 40 years, but production has increased manifold, not only of cereals but also of all other agricultural commodities. This has been possible due to proper policy support and scientific advancements in developing high

[1]Inaugural address delivered at the International Conference on Water Quality and Management for Climate Resilient Agriculture, May 28, 2013 at Jain Hills, Jalgaon, Maharashtra, India

yielding cultivars and farmer-friendly production technologies as well as hard working farmers. It is also a fact that India with 2.4% of the global geographical area and only 4.5% of water resource currently supports about 17% of the human and 11% livestock population of the world.

On the contrary, per-capita availability of land for producing agricultural commodities has declined from 0.48 ha in 1951 to about 0.20 ha in 1981, 0.15 ha in 2000 AD and it is expected to decline further to about 0.09 ha by 2050 AD. For India, water is the key issue to sustain required growth of agriculture in future. Availability of fresh water for agriculture is expected to decline from current level of 80% to about 70% by 2050 AD due to increasing demand of water for industrialization and urbanization. Global-warming will further reduce availability of fresh water to agriculture. Looking into population growth, declining land and water quality, coupled with challenge of climate change, has created much greater concern to feed our ever growing population. Thus, the challenge before us is much greater than before, and has to be addressed with strategic approach utilizing innovations in science and technology.

Emerging Challenges

i) Declining Water Resource

Water is very scarce and valuable resource. Globally, only 0.26% fresh water is available for irrigation and drinking purposes and rest is either saline (7.5%) or not available in useful form. It is estimated that the total world demand for fresh water in the year 2050 would be 1447 billion cubic meter (BMC) as compared to 634 BMC in 2000. Availability of utilizable water is going to decrease from 1020 cubic meter per person in 2004 to 770 cubic meter per person in 2050. In India, currently about 80% of available water is consumed for agricultural production, whereas, this share will be reduced to about 70% by 2025 due to increasing demand of water for industry and drinking purposes. As competition for water for different purposes increases, the need for additional storage as a proportion to total water consumed will increase in future. To meet future food needs, FAO projected a 14% increase of water withdrawals in 93 developing countries and 45 million ha of net expansion of global irrigated area from 2000 to 2030. It is well accepted that even with the fullest economic utilization of water resources, the success of agriculture will continue to be governed by the vagaries of rainfall. Hence, it is imperative to enhance water productivity of both rainfed and irrigated ecosystems for sustainable progress.

In India, the surface water potential is about 180 million ha m and the ground water resource is about 44 million ha m. With annual precipitation of about 400 million ha m, the average annual natural flow is about 188 million ha m. The annual requirement of fresh water is estimated at 105 million ha m by the year 2025 AD which is nearly equal to the ultimate water resource's level of the country. Out of this, 77 million ha m has been considered for irrigation purpose. In terms of area, the ultimate irrigation potential of the country has been assessed at 155 million ha (58 million hectare from major/ medium projects, 17 million hectares from surface water minor irrigation projects and 80 mha from ground water projects). Although, India has the largest irrigation system in the world, its water use efficiency has not been more than 40 per cent. If it continues like this, the water crisis would result in reduced production and productivity, which would affect our food and nutritional security. This calls for more productive use of water and more crop yield per drop of water.

Currently only 38% of cultivated area is irrigated and more efforts are needed to cover additional area to enhance productivity. Policies in the past have invariably been for the creation of water potential, whereas, utilization of created potential and enhancement of irrigation efficiency received little attention. Thus, with current level of efficiency, even after exploitation of all the available resources, more than

50 per cent area may still remain rainfed. With increasing population, economic prosperity, industrialization and climate change, pressure on water resources available for agriculture may be much greater. This scenario will demand increasing water use efficiency and water productivity in agriculture, both under irrigated and rainfed systems. Studies have shown that improving water productivity by 40% on rainfed and irrigated land could reduce the need for additional withdrawals over the next 25 years to zero.

ii) Climate Change: A Challenge

Climate change, a cause of concern globally, is likely to have an impact on agricultural crops, due to erratic rainfall, more demand for water, and enhanced biotic and abiotic stresses. The GCM models predicted that the Indian Sub-continent will be warmer by about 1.50°C during the middle of current century, and the second half of the winter will be warmer than the first half. It is also predicted that the Indian sub-continent would receive about 6% more rains which could be irregular and rather more intense. There will be some reduction in the incident radiation and increase in the concentration of CO2 and other green house gases. According to the emission inventories, that different governments submitted to the United Nations Frame Work Convention on Climate Change, agriculture accounts for around 15% of global GHG emission. Increase in deforestation in developing countries for agricultural purpose could raise its contribution between 26-35%. However, all these changes will only be harmful, as enhanced CO2 concentration may enhance photosynthesis in C3 crop species but increased temperature may increase water use and hasten the process of maturity. Innovations and strategic approaches may convert weaknesses into the opportunities. Increased temperature will have more effect on reproductive biology and reduced water may affect the productivity but adaptive mechanisms like time adjustment and productive use of water shall reduce the negative impact. These challenges could be addressed through identification of the genes tolerant to high temperature, flooding and drought, development of nutrient efficient cultivars and production system for efficient use of nutrients and water. The adoption of conservation agricultural technologies and good agricultural practices directed to improve resource-base and quality and vegetative cover, commissioning of cattle dung based bio-gas plants and proper management of cattle breeds and feeds to reduce emission of GHG and development of stress-tolerant varieties of field, fruit and tree crops, could be important climate change related mitigation and adaptation technological interventions. This would need reorientation of research agenda to address emerging challenges due to climate change. We must also enhance our knowledge to address all challenges into opportunity. Concerted efforts with effectiveness and efficiency will be essential to meet the ever increasing demand of food, fibre, fuel and energy for increasing populations in all developing countries.

Crop Management Options

i) Water Productivity and Water Use Efficiency

Water productivity denotes the output of goods and services derived from the unit volume of water. It demonstrates how efficiency of water use can be enhanced to maximize yield. With increasing water scarcity, the water productivity will have to be measured in terms of energy, protein and carbohydrate production to maximize the production in terms of these parameters. There is no single definition of water productivity that suits all situations. However, under all situations, the productivity of water could be enhanced either by saving water use by cutting of non-productive water loss or by increasing the productivity per unit process depletion (crop transpiration in agriculture) or other beneficial depletion and by allocation of water to higher value uses. Relocation of water from low value to higher value uses would generally not result in any direct water savings but can directly increase the economic productivity of water. Suitable water application methods, varieties and management practices will have to be evolved to achieve this goal. Use of liquid form of fertilizers through fertigation appears to be promising for deeper application with sizeable input saving. For example, in 'Arka Anmol' mango, fertigation with 75% of recommended dose of fertilizer resulted in yield at par with that of 100% dose.

Term efficiency is usually a dimensionless ratio but in case of water use efficiency, it is not. This will vary with scale as well as the purpose for which it is being quantified. In case of steel industry, it will be the amount of water required to produce one tonne of steel. In case of agriculture, the water use efficiency at the field level will amount to crop output in physical terms i.e. crop yield in kilograms divided by amount of water consumed or in monetary terms i.e. crop yield multiplied by its price divided by amount of water used. In other words, crop per drop. The water productivity will, therefore, be a function of price, which the economic product commands in the market. Thus, while banana will have a higher productivity in terms of Kg/ha-mm, the grapes will have a higher productivity in terms of Rs./ha-mm. Hence, improving water productivity is equivalent to obtaining more value from each drop of water.

ii) Water Productivity through Crop Improvement

The productivity of water irrespective of environment will be governed by those factors which minimize the water losses from the soil system and improve the transpirational water use by the crops. The water may be lost from the soil system by evaporation, deep percolation below root zone, run off and utilization by weeds. Thus, the management practices which are directed to conserve the water by reducing these losses would increase the proportion of water used by the crops in transpiration. The crop productivity will depend on the development of leaf area to intercept radiant energy and role of photosynthesis to convert it into dry matter. However, distribution of assimilates within the plant will determine the proportion of the total dry matter that is harvested as economic yield. Thus, to improve productivity of water in water deficit environment, one must increase the water passing through the crops in transpiration (T), increase water use efficiency (W) and or increase the proportion of total dry matter going to grains, i.e., harvest index (H).

The water productivity with respect to evapotranspiration (WPET) varies considerably for different crops. The WPET ranged from 0.6 to 1.9 kg/m3 for wheat; between 1.2 and 2.3 kg/m3 for maize; 0.5-1.1 kg/m3 for rice; 7-8 kg/m3 for forage sorghum and between 6.2 and 11.6 kg/m3 for potato under experimental condition. However, the values of large scale field level water productivity are lower than experimental level data. There are also large variations in productivity of water under different environmental conditions. The modern rice varieties have about a three-fold increase in water productivity as compared to tall traditional varieties due to their improved harvest index. The similar is the case with modern dwarf wheat and other drought tolerant genotypes developed through improved plant breeding and biotechnology, wherein the partitioning efficiency of total biomass to economic yield has been improved remarkably.

The potential production rates of C3 plants is around 200 kg dry matter/ha/day and those of C4 plants between 200-400 kg dry matter/ha/day, while CAM (Crassulacean acid metabolism) plants are known for their very high water use efficiency. Pineapple, aloe vera and fodder cactus are good examples of cultivated CAM plants. In general, stomata in water stressed plants remain open during early morning hours when energy load on crop canopy is low and close as solar radiation and vapour pressure deficit of air increases during mid-day hours of day. This interaction is manifested to an extreme in the evolution of CAM in some succulents when stomata remain open during the night and close during the day. Such adaptations are important from carbon and water economy point of view, but their real benefit in field and fruit crops is yet to be understood in greater detail and exploited.

To mitigate the impact of drought and heat tolerance in the climate change scenario, the putative traits which could be beneficial over long time scale should include phenology, osmotic adjustment, rooting characteristics and assimilate transfer from vegetative parts to grains. The importance of these and other traits and their simplified manifestations in other simple measurable plant characteristics (leaf relative water content, canopy temperature, transpirational cooling-canopy minus air temperature difference, use of potassium iodide solution as foliage desiccant for assimilate transfer) have been standardized and utilized in screening crop germplasm for drought tolerance in field crops. Molecular markers and QTL's (Quantitative traits loci) identified for osmotic adjustment and rooting characteristics in rice could open the way for easy screening of genotypes for these traits in other crops. The induction of mRNAs suggests that there is a molecular control that might be manipulated genetically, thus altering the development of desiccation tolerance of young seedlings and embryos. Use of *dreb* gene for drought tolerance in cereal crops is offering good potential through genetic engineering approach.

Although in India, most of water diverted to agriculture is used for growing staple food crops and only about 10% of the agricultural water is used for horticultural crops. The improvement of water productivity of horticultural crops has potential of reducing water requirement in terms of providing unit energy, unit protein and other nutrients as well as economic returns. As majority of the horticultural crops are perennial in nature, they invariably have deep and extensive root system, capable of extracting water from deeper layers and large canopy to harvest optimum natural resources. Hence, they have better productivity than field crops.

Farm Management Options

On individual farms, higher water productivity requires selection of appropriate crops and cultivars and proper soil and water management technology, improved planting methods. All cultural and agronomic practices that reduce the soil evaporation, run off, deep percolation, transpiration by weeds, application of mulches, micro-irrigation could improve water productivity. Efficiency of irrigation can be increased by converting intensive irrigation into extensive irrigation. Deficit irrigation, in which less water is applied than that required to meet full crop water demand, results in small reduction in photosynthesis and yield as compared to relatively more concomitant reduction in transpiration and crop water use, leading in turn to high water use efficiency.

In flood system of irrigation, selection of proper crop geometry and switch-over from border to furrow system of irrigation results in 30-60% saving of water and significant increase in productivity, especially in case of wide spread crops such as mustard and cotton. Similar benefits for improving productivity of water could be realized from improved planting methods (sunken and raised bed, raised bed furrow irrigated system (FIRB), broad bed furrows (BBF), terracing and water harvesting and recycling, synchronization of water applications with the most sensitive growth period of crops, holistic approach of watershed and improved drainage for water table control).

Pressure irrigation system along with fertilizer application (fertigation) resulted in remarkably high water use efficiency and yield and thus high productivity of water. Sprinkler and drip systems of irrigation, in case of some field and horticultural crops, especially under water scarcity and poor ground water quality, have helped in increasing yield and saving of water.

The micro-irrigation scheme implemented by the Government of India was evaluated covering about 3900 farmers spread over 26 districts in the states of Andhra Pradesh, Haryana, Karnataka, Maharashtra, Orissa and Tamil Nadu. The study revealed that farmers invariably introduced high value horticultural crops like grapes, banana, strawberry, citrus, mango, cashew-nut and coconut after installing the drip system. There was yield increment for crops like banana, grapes, citrus, pomegranate which ranged from 41% (grapes) to as high as 141% (pomegranate). Economic analysis of 695 beneficiary farmers and 76 non-beneficiary farmers indicated that the cost was recovered in a period of less than three crop seasons. The study also revealed the benefit:- cost ratio being more than 2.5:1 for most of the cases. Keeping in view these benefits, Ministry of Agriculture launched a national mission on micro-irrigation in 2010, which aims at increasing water use efficiency, crop productivity, and above all farmers' income.

Rainfed cultivation is still practiced over 60% of cropped area throughout the country. Selection of appropriate horticultural crops based on land, soil and climatic conditions is the first step for horticultural development in the rainfed areas. Based on drought-tolerance, the horticultural crops can be classified as follows: Hardy (bael, ber, boradi, aonla, gonad, custard apple, apricot, date palm), less hardy (avocado), moderate (coconut, fig, apricot, breadfruit, cashewnut, chestnut, chironji) and susceptible (apple, arecanut, banana, cherries). Horticultural developmental activities through perennial fruit orcharding have already paid high dividends, bringing stability in fragile ecosystems (e.g. apple in Himachal Pradesh, mango and cashew-nut in the Western Ghats in Maharashtra and large cardamom in Sikkim). The niche potential of marginal mountain lands, if properly nurtured with scientific horticultural practices can bring fortunes and can convert the non-viable subsistence farming to economically viable farming. The success story of the Konkan region in the Western Ghats in commercialization of mango, cashew, black pepper, etc. demonstrates the possibility of converting once barren hilly tracts into economically viable regions. Success stories of seed spices and medicinal and aromatic plants in the arid zones of Rajasthan and Gujarat are pointers in the right direction. Holistic approach of watershed management, water harvesting for ground water recharge in grey areas and life-saving irrigation or supplemental irrigation can enhance productivity to the extent of 20-30% and could be helpful in increasing cropping intensity and livelihood security of farmers in the rainfed ecosystem.

i) Augmenting Poor Quality Waters

In future, reclamation and proper use of brackish and sewage water could be an additional option for increasing water productivity and resource use efficiency both in field and fruit crops.

Groundwater constitutes the most important source of supplemental irrigation in arid and semi-arid regions in India. Unfortunately, the water in 32-84% of the aquifers surveyed in different states of the country has been observed to be of poor quality. In India, Punjab, Rajasthan, Haryana, U.P., M.P., Gujarat and Karnataka ground waters have been found to be highly concentrated with salts. Considerable research has been carried out to utilize poor quality water in alternate and mixed mode with fresh canal water in field crops. More work is still needed to harness brackish water in horticultural crops by using pressurized system of irrigation. In general, the chloride-rich saline waters are more harmful than sulphate dominated waters. However, there exists great scope for using brackish water by drip irrigation in horticultural crops. Brackish water in future could also be used for inland aquaculture through diversified agriculture.

A large number of river stretches are severely polluted as a result of discharge of domestic sewage. Treatment of domestic sewage and subsequent utilization of treated sewage for irrigation can prevent pollution of water bodies, reduce demand for fresh water in irrigation sector and result in huge savings in terms of nutritional value of sewage in irrigation. Although lot of sewage treatment plants have been established by Govt. of India but they are not in proper operation for reclamation of sewage water for its safe use in irrigation.

Indiscriminate use of waste water loaded with toxic elements and harmful pathogens pollutes our natural resources and impairs human health. The problem is more serious in vegetables and fodders grown in peri-urban areas by using sewage waters which need urgent attention by scientists and policy-makers. Both water quantity and nutrients contained in urban and peri-urban wastewaters make them attractive alternative water source for agriculture and aquaculture. Treated wastewater from off-site treatment plants can be reused for irrigation of parks and gardens, agriculture and horticulture, tree plantation and aquaculture, if these exist or can be established not far from the wastewater treatment plants. To prevent potential negative impacts on human health and environment, the importance of wastewater reuse in urban and peri-urban agriculture has to be recognized and clear policy guidelines for their proper treatment and reuse need to be established.

ii) Promoting Green-house and Plasticulture:

The green-house technology and use of plasticulture using drip system of irrigation alongwith fertigation is one of the most modern technologies at present to grow high value crops with remarkable saving in water use. However, the design of green house has to be location specific. Due to controlled environmental conditions, the high value crops and nurseries of off-season fruits and vegetables can be grown throughout the year under protected conditions with water economy of 40-50%. Green-house technology has been successfully used in the hilly states of north and north eastern states as well as in water scarcity states like Maharashtra and Karnataka by optimizing the energy, water and fertilizer application in high value floriculture and vegetable crops. Rain water harvesting and its reuse in drip system of irrigation and artificial recharging of ground water has been used quite successfully in Karnataka.

The utilization of plastic mulch along with dripline underneath has been very successful in controlling soil evaporation and water use by weeds. High value crops like strawberry followed by another crop of chilies under the same plastic cover using as soil mulch has been found very remunerative in water scarcity areas of Haryana with almost total control on soil evaporation which is about 60-65% of total ET in this region. Similar high degree of water economy has been achieved by fitting drip lines under plastic mulch for growing several horticultural and vegetable crops in other parts of India. Studies have reported almost 30-40% increase in yield of tomato by using straw and polythene mulch. Similar encouraging results have been reported in case of groundnut, cotton etc.

iii) Diversification and Intensification:

Options for improving productivity and economic efficiency of water further lies in the production of timbers, energy plantation, agro-horticulture system, silvipasture and growing of low water requiring medicinal plants as intercrops or sole crops. The shifting from field crops to low water requiring fruit crops and medicinal plants has got tremendous scope to improve productivity of water as well as more remuneration to farmers. The low water requiring fruit crops like ber (*Zizyphus zuzuba*), aonla, custard apple, pine-apple, pomegranate and tamarind are drought-tolerant hardy fruit crops. If they are supplemented with drip system of irrigation covered with plastic mulch, very little watering at critical phase of growth could give good yield of fruits with very high water use efficiency. The drip system of irrigation followed in pomegranate fruit crop in Maharashtra during water deficit period (March to mid June) with just 20-30% wetted area gave 4.5-5.7 t/ha fruit yield by consuming just 3560-5322 litres of water. Similarly, *in situ* water harvesting of rainfall through run off collection from the micro-catchments with 0.5%, 5% and 10% slope ensured 300-1000 mm run-off supplement in different fruit crops with average annual rainfall of 360 mm on sandy catchment area around Jodhpur (Rajasthan), India.

The design criteria indicating percent slope and size of catchment for different fruit crops has been devised for sandy and rocky catchments of Jodhpur region of Rajasthan, India. The catchment size should be such that the runoff from it, at one recharge, does not ordinarily exceed the moisture storage capacity of the soil profile under the tree canopy. Similarly, pitcher irrigation has been found very useful to establish young fruit plants, especially melons in areas having little rainfall or no irrigation facilities. In the State of Madhya Pradesh, different medicinal plants grown in agro-forestry/ agro-horticulture system gave very high cost-benefit ratio.

iv) Integrated Farming System

Farming system as a concept takes into account the components of soil, water, crops, trees, livestock and other resources, keeping farm family at the centre. Integrated farming systems are, therefore, more productive, profitable and sustainable. For centuries, Indian farmers have been raising crops and livestock for better livelihood.

Water conservation based IFS models by integrating field and horticultural crops + livestock + biogas plants is quite prevalent in several parts of India. In Chitrakoot (MP), farmers do grow crops, medicinal plants and raise livestock. These practices do help in better resource utilization, employment generation, livelihood security and welfare of small land holders for holistic rural development. Such models need to be replicated in other parts of the country for conservation of soil and water resources and increasing productive and economic efficiency of water and other costly inputs in a mission-mode for the welfare of rural community. Also attention is needed to help the farmers in value addition, processing and marketing of produce to reduce losses and attract remunerative prices of their produce, thus increasing farmers' income.

Future Strategy

Out of several available on-farm water management strategies, providing irrigation at the most sensitive stages of growth, use of well designed surface, sub-surface or pressure systems of irrigation, mulching, fertigation, plasticulture, conjunctive use of sewage and brackish waters and the holistic approach of watershed development would help in increasing water productivity. It is needless to mention that role of integrated approach of farming system, value addition, processing and marketing is immensely important as they help in increasing productivity, profitability, employment, habitat conservation and livelihood security of small and marginal farmers.

Addressing the concern of efficient water use would need well articulated future Road Map to move forward. Following are some specific suggestions worth consideration:

i) Water be treated as a national asset. National water policy should, therefore, aim to have water on concurrent list to be governed by the Central Government or else State level disputes would always hamper future agricultural growth.

ii) Like other inputs, water be also priced in order to ensure judicious use of this valuable natural resource. Policy of providing free water to farmers is counter productive and not in the national interest.

iii) Current practice of flood irrigation must be discouraged as a matter of national priority. Instead, water use efficient practices may be promoted, including micro-irrigation practices (Example: Narmada Canal in Western Rajasthan).

iv) Policy of "*khet ka pani khet main*" be adopted by encouraging bunding of fields. On-farm water conservation must be an aim of NAREGA, RKVY etc., and farm bunding be considered a priority goal under approved activities of these ambitious national schemes.

v) Thrust in agricultural diversification, especially involving horticulture, agro-forestry, silvi-pastoral approaches, requiring less water compared to food crops, should form major strategy leading to considerable saving of valuable water resource.

vi) Strategy for conjunctive use of brackish water (upto an extent of 20 per cent) in canal command areas of central and north-western states, receiving less than 500-700 mm precipitation, be put into practice through enabling policy interventions.

vii) Extensive public awareness campaign to promote water use economy by all concerned is urgently needed.

viii) Good watershed management practices need to be promoted through active community involvement and by forming water user associations.

ix) Outscaling of innovations that save water such as conservation agriculture, plastic mulching, direct seeded rice, alternate furrow irrigation, micro-irrigation, fertigation etc. be given priority attention through much needed policy, research and development related initiatives.

Recent TAAS Publications

- Public-Private Partnership in Agricultural Biotechnology - Second Foundation Day Lecture, delivered by Dr. Gurdev S. Khush, Adjunct Professor, University of California, Davis, USA, October 17, 2005.
- Farmer-Led Innovations for Increased Productivity, Value Addition and Income Generation - Brainstorming Session, October 17, 2005 - Highlights & Recommendations
- Strategy for Increasing Productivity Growth Rate in Agriculture" - Strategy Paper by Dr. R.S. Paroda, August, 2006.
- Brainstorming Session on "Models of Public-Private Partnership in Agricultural Biotechnology ", April 7, 2007 - Highlights & Recommendations.
- National Symposium on Quality Protein Maize for Human Nutritional Security and Development of Poultry Sector in India and Presentation of the Third Dr. M.S. Swaminathan Award for Leadership in Agriculture, May 3, 2008 – Proceedings and Highlights.
- Overcoming the World Food and Agriculture Crisis through Policy Change, Institutional Innovation and Science– Fourth Foundation Day Lecture, delivered by Dr. Joachim von Braun, Director General, International Food Policy Research Institute, Washington, March 6, 2009
- Brainstorming Workshop on “Emerging Challenges before Indian Agriculture - The Way Forward”, March 6, 2009 - Proceedings & Recommendations.
- Brainstorming Workshop on ’Strategy for Conservation of Farm Animal Genetic Resources’ 10th – 12th April, 2009 – Ranchi Declaration.
- Brainstorming Workshop on “Climate Change, Soil Quality and Food Security”, August 11, 2009 – Proceedings & Recommendations.
- Millions Fed: Proven Successes in Agricultural Development, January 19, 2010 (Translation in Hindi jointly published by IFPRI, APAARI and TAAS)
- National Seminar on “Quality Seed for Food Security through Public-Private Partnership”, April 13-14, 2010 – Proceedings & Recommendations
- TAAS Foundation Day Lecture on “Climate Change and Food Security: From Science to Sustainable Agriculture” by Dr. Mahendra M. Shah, May 7, 2010
- NSAI Foundation Day Lecture on “Revitalizing Indian Seed Sector for Accelerated Agricultural Growth”, October 30, 2010
- Brainstorming Session on Prospects of Producing 100 million tons of Wheat by 2015 and presentation of Fifth Dr. M.S. Swaminathan Award for leadership in Agriculture - Proceeding & Highlights December 18, 2010
- National Dialogue on Building Leadership in Agricultural Research Management, Hyderabad, August 27 - 28, 2010 - Proceedings & Recommendations
- Stakeholders’ Interfae on GM Food Crops, May 19, 2011 - Recommendations
- TAAS Foundation Day Lecture on “Harnessing Knowledge for India’s Agricultural Development” by Dr. Uma Lele, August 12, 2011
- The Sixth Dr. M.S. Swaminathan Award Lecture on "Challenges and Opportunities for Food Legumen Research and Development" by Dr. M.C. Saxena, January 25, 2012
- Proceedings and Recommendations of Farmers’ Led-Innovation. December 23-24, Hisar, Haryana, 2011
- Proceedings and Recommendations of Global Conference on Women in Agriculture. 13-15 March, 2012 New Delhi; India.
- The Seventh Foundation Day Lecture on "Ensuring Food and Nutrition Security in Asia: The Role of Agricultureal Innovation" by Dr. Shenggen Fan, DG, IFPRI. January 11, 2013
- A Brief Report on Seventh Dr. M.S. Swaminathan Award presented to Dr. William D. Dar, DG, ICRISAT, Hyderabad. June 24, 2013

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Dr. Rajendra S. Paroda is an accomplished plant breeder and geneticist by profession and an able research administrator. He has made significant contributions in the field of crop science research. He is known for modernization and strengthening the national agricultural research system (NARS) in India as well as in Central Asia and the Caucasus. He was instrumental in establishing the Asia-Pacific Association of Agricultural Research Institutions (APAARI) and the Asia-Pacific Seed Association (APSA), while serving with FAO in early ninties. Since, 1992, he is continuing as Executive Secretary of APAARI. He was elected as the first Chairman of the Global Forum on Agricultural Research (GFAR) and served from 1998-2001. Dr. Paroda was also the Director General, Indian Council of Agricultural Research (ICAR) & Secretary, Department of Agricultural Research and Education (DARE), Government of India during 1994-2001. He has the unique distinction of being the main architect of one of the world's largest and most modern National Gene Bank at NBPGR, New Delhi. He is Fellow of almost all the prestigious Science Academies in India and the Agricultural Academies of Russia, Georgia, Armenia and Tajikistan, besides that of Third World Academy of Sciences (TWAS), Italy. He had been the President of the National Academy of Agricultural Sciences (India) from 1996-2001 and was elected as General President of the prestigious Indian Science Congress Association for the year 2000-2001. In addition, he served as President of more than a dozen agricultural scientific societies in India. In recognition of his meritorious contributions to agricultural research, the President of India conferred on him the prestigious PADMA BHUSHAN in 1998. He also received several prestigious awards, namely, ICAR Team Research Award (1983-84), Rafi Ahmed Kidwai Memorial Prize (1982-83), Federation of Indian Chamber of Commerce and Industry (FICCI) Award (1988), Om Prakash Bhasin Award (1992), Asia-Pacific Seed Association Special Award (1995), Dr. Harbhajan Singh Memorial Award (2001), Dr. B.P. Pal Memorial Award (2003), Borlaug Award (2006) and Agriculture Leadership Award (2008), 1st Dr. A.B. Joshi Memorial Award (2012), Prof. Kannaiyan Memorial Award (2012), Medal from Govt. of Vietnam (2012), Krishi Siromani Samman by Mahindra (2013) and Vaigyanik Drishlikon Society (VDS) Samman (2013). In all, 15 Universities including Ohio State University, Indian Agricultural Research Institute, Scientific Council of Agricultural Academy, Agricultural Universities of Pantnagar, Kanpur, Jorhat, Coimbatore, Hyderabad, Udaipur, Varanasi, Srinagar, Meerut, Bhubneshwar, Punjab and Dharwad have conferred honory D.Sc. (Honoris Causa) degrees on him. Dr. Paroda has also served as a member of many international organizations such as Australian Center for International Agricultural Research (ACIAR), Commonwealth Agriculture Bureau International (CABI), Finance Committee of the Consultative Group on International Agricultural Research (CGIAR), Global Biotech Advisory Council of Monsanto, Board of Trustees of IRRI, Chairman of ICRISAT Board of Trustees and Chairman, Program Committee of GFAR. In view of his outstanding achievements, both American Society of Agronomy and the Crop Science Society of America had awarded Dr. Paroda with their prestigious Honorary Membership in 2001. ICRISAT and Kazakhstan have named their Gene Banks after him. He also served as a member of the World Meteorological Organization (WMO) High Level Taskforce for preparing a Global Framework for Climate Services. As Chairman of the Organizing Committee of Global Forum on Agricultural Research for Development (GCARD), he provided leadership at global level to organize successfully GCARD2 in October, 2012 in Uruguay. His passion, as Chairman, Trust for Advancement of Agricultural Sciences (TAAS), is to link science to society through needed policy reorientation and to work for the overall progress of the resource poor farmers. Since 2010, he has been serving as Chairman of the Farmers' Commission of Haryana State and as member of the Rajasthan State Planning Board. Currently, he is a member of the ICAR Society as well as its Governing Body.

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