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Presidential Address

Response for Resilience: Happy Agriculture

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Today, the National Academy of Agricultural Sciences (NAAS) has completed 25 years of its existence, and I take this opportunity to heartily congratulate the learned Fellowship on the day. This Academy is indebted to the vision of Late Dr B.P. Pal and Prof. M.S. Swaminathan for its origin. From a humble beginning from the precincts of the IARI, the Academy has emerged as a vibrant national level body, and at present has earned the distinction of an Academic Platform, dedicated to the cause of agriculture and agricultural science in the country. Over the years, the Academy has contributed significantly in shaping agricultural science policies through its various initiatives from time-to-time it has brought out more than seventy policy papers, organized several seminars, congresses and held brainstorming sessions on several topical issues for sustainable agricultural growth and development. From the two local NAAS chapters based at Ludhiana and at Hyderabad in 1998, the Academy has spread its wings to 14 regional chapters across the country.

I deem it an opportune moment to sincerely acknowledge esteemed former Presidents, officer bearers, Executive Council and the distinguished Fellowship, who have devotedly rendered their services in various capacities, and their untiring efforts have raised the Academy to where it stands today. The Academy has gained from the experience and the wisdom of the scientists, intellectuals, academicians and policy planners' from the national and international institutions through interactions during many occasions. Today, we remember our dear Esteemed Fellows, who have left an indelible mark through their significant contributions in the development of Indian agriculture, but are no more amongst us!

Preparedness and response strategy to manage extreme events

Monsoon aberrations in terms of onset, distribution and withdrawal of rainfall, adversely impact agriculture both in rainfed and irrigated areas of the country. Rainfed areas, constituting nearly 58% of the net cultivated area and accounting for 40% of the country's food production, and even providing support to 40% of human and 60% of livestock population, are the most affected areas owing to monsoon failures. It has been estimated that even when full irrigation potential is being realized, nearly 70 million ha of the cultivated area will continue to be under rainfed farming. The widespread failure of monsoon in 2009, and thereafter increased frequency of occurrence of extreme events, reiterates the need for better preparedness, planning and response to mitigate adverse climate impacts.

In the year 2014, and the ongoing 2015, we have encountered many aberrant climate events. The frequency and intensity of which were unprecedented. In 2014, there was a late-and-deficient monsoon, incessant floods in Jammu and Kashmir, cyclone *Hudhud* on the east coast;and in the year 2015, major agricultural states were lashed with hailstorm just before the harvesting of crops. Weather conditions have become unpredictable and extreme. These make agriculture very vulnerable as agriculture depends on the weather. There is a consensus amongst the scientific fraternity that aberrant climate is a sequel of global warming. Over the centuries, there have been enumerable natural disasters that resulted in unbearable losses of humans and properties, but the fast frequency at which these events are happening in India and in other parts of the world, is a cause of concern. Advanced planning and preparedness can reduce the extent of damage, and would be a help in faster restoration of life and property to normal pattern.

At present, the concern is not only of a growing population but also of economic and environmental losses due to natural and manmade disasters. This necessitates a multi-disciplinary approach for risk management to reduce vulnerability and to improve access to services, information, education and empowerment for combating the situation.

The National Policy on Disaster Management by the Government states that the country is vulnerable, in varying degrees, to several forms of disasters, both natural as well as manmade. It mentions that there are five distinct regions in the country that are vulnerable-Himalayan region, the alluvial plains, the hilly part of the peninsula, desert area and the coastal zone. While Himalayan region is prone to earthquakes and landslides, plains are affected by incessant floods almost every year. And the desert part is affected by droughts; while coastal zone is susceptible to cyclones and storms. The relationship between development and disaster risk is clearly described in the recent UNDP

Report on disaster risk reduction. About 75% of the world's population lives in the areas that were at least affected once by earthquakes, tropical cyclones, floods or drought between 1980 and 2000. Data indicate a clear link between developmental status and disaster impact; there is also evidence that disaster risk accumulates historically through inappropriate developmental interventions related to urbanization etc. The need of the hour is formulation of Disaster reduction policies that have a two-fold aim to: "*enable societies to be resilient to natural hazards and ensuring that development efforts do not increase vulnerability to those hazards*" The occurrence and impacts of natural calamities led the *United Nations General Assembly* to designate 13th October as the International Day for Natural Disaster Reduction as part of its proclamation of the *International Decade for Natural Disaster Reduction* to build disaster resilient communities and nations.

Impacts on Agriculture

Agriculture is the most prone sector to rainfall variations, either deficit or excess, in particularly when it coincides with susceptible/critical crop growth stages. According to a FAO study, globally agriculture sector including crops, livestock, fisheries and forestry absorbs approximately 22% of the economic impact caused by the medium and large scale natural hazards and disasters in the developing countries.

Sharp fluctuations in agricultural output in India are mainly attributed to South-West monsoon. Some part of the country experience failure of monsoons almost every year, and most states encounter drought once in two to five years, and there are years when floods and droughts both attack together. About 16% of the country's total area and 68% of the sown area is drought prone and annually about 50 million people in the country undergo crisis owing to drought. In the past decade, the country experienced two all India droughts (2002 and 2009), and drought in several states in 2012 (Table 1).

Table 1: Occurrence and impact of drought/drought- like conditions in the recent- past

Year	Departure % in S-W monsoon rainfall	Impact
2002	-22	All India drought, 29% area affected, 19.1% decline in *kharif* foodgrain output
2004	-12	Mid season drought
2009	-21	All India drought, 59% area affected, 7% decline in *kharif* foodgrains output

Year	Departure % in S-W monsoon rainfall	Impact
2011	+4	Terminal drought in AP
2012	-8	Drought like situation in Karnataka, Gujarat, Punjab and Haryana
2013	+10	Normal/ excess rainfall in rest of India, but drought/ deficit rainfall in Bihar and Jharkhand in July to mid-August and subsequently affected by floods
2014	-12	Delay in onset of monsoon affecting progress in crop sowings across several states, Decline in foodgrain output estimated at 7-8 million tonnes

The 5th Report of the Intergovernmental Panel on Climate Change mentioned that the last three decades have been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was apparently the warmest 30 year period of the last 800 years in the Northern Hemisphere. Globally averaged combined land and ocean surface temperature data showed a warming of 0.85 [0.65 to 1.06] °C over 1880 to 2012. For the longest period when calculation of the regional trends is sufficiently complete (1901 to 2012), almost the entire globe has experienced the surface warming. Atmospheric concentrations of GHGs are at levels that are unprecedented since at least 800,000 years back. Concentrations of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have all increased since 1750 (40%, 150% and 20%, respectively).

In the recent past, agriculture across the country was affected due to unforeseen changes in weather and sudden occurrences of extreme weather events (Table 2). Drought happens due to shortage in rainfall; begins with slower onset of monsoon and unfolds over a prolonged period. Approach and mechanisms for anticipating disasters differ significantly. Development of early warning systems is essential to manage cyclones and heavy rainfall storm events.

Table 2: Occurrence and impact of extreme weather in the recent years

Year	Extreme event	Impact
2002	Cold wave	Extensive damage to horticulture crops in Punjab (Hoshiarpur), vegetable crops in Rajasthan and mustard in Haryana
2003	Heat wave	Estimated loss of 6 million tonnes in wheat from north India
2006	Floods	Extensive damage to field crops in Rajasthan and Andhra Pradesh

Year	Extreme event	Impact
2009	Cyclone ‘Aila’	Coastal flooding of agricultural areas in West Bengal, Odisha and excess rainfall in north and north eastern states
2010	Cyclone ‘Laila’	Flooding in coastal areas of Andhra Pradesh
2012	Cyclone ‘Nilam’	Flooding in coastal areas of Andhra Pradesh
2013	Cyclone ‘Phailin’	Extensive damage to horticulture and paddy in Odisha and Andhra Pradesh
2014	Unseasonal rains and hailstorm	Damage to horticultural crops in Maharashtra, Karnataka, Madhya Pradesh etc.
	Cyclone ‘Hud-hud’	Extensive damage to horticulture and paddy in Odisha, Andhra Pradesh and damage to several field crops in Chhattisgarh and Uttar Pradesh due to unseasonal rainfall
2015	Unseasonal rains	Extensive damage to *rabi* crops in Maharashtra, Telangana, Andhra Pradesh, Madhya Pradesh, Punjab, Rajasthan and western Uttar Pradesh

Core principles of assessment, prevention, mitigation and preparedness are the parts of disaster-risk reduction measures. Enhancing resilience of Indian agriculture to cope with climate variability and climate change is imperative to secure livelihood of millions of small and marginal farmers in the country. Devising appropriate adaptation strategies would enable farmers to cope better with aberrant climate along with efficient use of natural resources.

Climate-smart agriculture (CSA) is an integrative approach to address interlinked challenges of food security and climate change, that explicitly aims to sustainably increase productivity and income, build resilience for climate change, and reduce greenhouse gas emissions for enhancing national food security and developmental goals. More productive and resilient agriculture will need better management of natural resources, land, water, soil and genetic resources through conservation agriculture, integrated pest management, agroforestry and sustainable food security.

Realizing the impact of climate change, the Government of India has prioritized climate change research, and a major project *National Initiative on Climate Resilient Agriculture (NICRA)* has been initiated in 2010-11 as a multi-institutional, multi-disciplinary network project. Through the project, On-farm participatory demonstrations of available technologies have been implemented in 100 most vulnerable districts. Interventions used under this are: resource conservation practices and technologies for natural resource management, and efficient use of resources and inputs for improved crop, livestock and fisheries production.

Four coping strategies for preparedness to climatic risks are disaster preparedness, mitigation practices, contingency planning and responses and disaster risk mainstreaming. A crisis management plan at the National level was put in place in 2012. In this context agriculture contingency planning is one of the major strategies of preparedness to manage aberrant weather. Some of the initiatives taken by the ICAR are as follows.

District level contingency plans for weather aberrations

Widespread drought in 352 districts across the country during 2009 impelled the Central Government for preparing district level contingency plans for climate risks in agriculture. A standard template was designed and contingency plans were formulated for drought and other extreme weather events by the ICAR-Central Research Institute for Dryland Agriculture in collaboration with the multi-disciplinary team of scientists at the 45 State Agricultural Universities. Till date 580 district level Contingency Plans are available for implementation by the State Governments. Suggested contingency measures for delayed monsoon include adoption of short duration and drought-tolerant cultivars; crop replacement with low-water requirement crops; adoption of crop combinations; suitable grain or fodder crops and cultivar choices for advancing *rabi* planting where *kharif* crop failed due to severe drought.

Climate smart practices and technologies

Pilot implementation of appropriate technologies in farmers' fields on real time basis is underway in 28 states under the technology demonstration component of the NICRA in 130 climatically vulnerable districts, exposed to drought and other extreme events. The overall focus under the project is to enhance resilience of farms and farming community to override climate aberrations to ensure sustainability over a period of time. Sustainability is the immediate goal in highly intensive production systems facing natural resource degradation. Therefore, the main aim of the technology demonstrations is not on enhancing productivity but is on the intervention, which can cope with vulnerability and improve natural resource use efficiency.

Successful interventions are: *in-situ* moisture conservation practices, *ex-situ* rainwater harvesting to provide life saving/ critical irrigations; drought tolerant and short duration crop cultivars; alternate contingency crops such as millets, oilseeds and pulses in case of delayed monsoon onset; community staggered nurseries, water saving direct seeding methods in paddy; crop diversification and climate resilient intercropping systems for delayed planting etc. The favourable impact of these practices was evident from the participatory demonstrations in the - prone states, Maharashtra, Karnataka, Andhra Pradesh, Gujarat, Rajasthan, Madhya Pradesh, Bihar, Jharkhand and western Uttar Pradesh. To minimize damage due to excess rainfall, farmers in the NICRA adopted villages in Madhya Pradesh used broad bed furrow planting method in soybean and realized 40% yield advantage as compared to flat bed sowing.

Small farm mechanization through custom- hiring under NICRA

Average operational land holding size is estimated at 1.16 ha; about 80% of land holdings are with small and marginal farmers, owning <1 and 1-2 ha holdings, respectively. In such situations, fuel efficient mechanization brings in timeliness and precision to agricultural operations, greater field coverage over a short period, cost effectiveness, efficiency in use of resources and applied inputs, conservation of available soil moisture under stress conditions and adequate drainage of excess rains and floodwaters. Custom hiring centres (CHCs) have been established in 100 NICRA villages.

Space technology

Integration of remote sensing, geospatial information system (GIS), satellite communication and internet is the fundamental to decision support system that plays a vital role in disaster mitigation. The satellite imageries help in providing accurate information about cyclonic location, its intensity and land fall. GIS can be used as a decision support system for identifying and integrating, monitoring and predicting hydrological hazards, which are the major environment risks for Indian agriculture. During *Hudhud* forewarning about the cyclone enabled the state machinery to respond and take requisite measures regarding evacuation of people to safe places etc. Integration of science and technology in disaster risk reduction and management holds the key towards creating not only a resilient agriculture but a resilient society as well.

Conservation agriculture

This is based on the principle of providing continuous soil cover (crop residues, cover crops), minimum soil disturbance, and crop rotations, and has a high potential to increase productivity while protecting natural resources and environment. Over the past few years, adoption of zero-tillage has expanded to cover about 2 m ha in the country.

Conservation agriculture (CA) provides a truly sustainable production system; while conserving also enhances natural resources efficiency and increases variety of soil biota, fauna and flora (including wild life) in agricultural production systems without loss in yields. Such resource conserving technologies restrict release of soil carbon thus mitigating increase of CO_2 in the atmosphere. Greater emphasis on water harvesting and improving the efficiency of regional as well as farm water use efficiency could help face uncertain rainfall.

The major challenge in adoption of conservation agriculture technologies is lack of farm development, standardization and adoption of farm machinery for seeding with minimum soil disturbance; proper development of crop harvesting and management systems with residues and development of continuously improving site-specific crops, soil and pest management strategies that would optimize benefits from new systems.

Development and testing weather index based insurance products

Index insurance has been presented as an important tool that can allow smallholders better manage climate risks; enabling investment and growth in agricultural sector. A Weather-based Crop Insurance Scheme (WBCIS) is being implemented as a component of the National Crop Insurance Programme (NCIP), which covers main crops – cereals, millets, pulses, oilseeds and commercial / horticultural crops. Crops have been selected and notified by State Governments, under various climatic risks categories, such as droughts, prolonged dry-spells, excess rainfall, temperature extremes, high humidity, hailstorms, cloudburst and high wind.

The All- India Coordinated Project on Agrometeorolgy (AICRPAM) at the ICAR-CRIDA evaluated weather indices in groundnut for designing insurance product to analyze long-term yield and weather conditions at four locations – Anantapur, Bengaluru, Anand and Ludhiana. Crop insurance and weather index based insurance schemes are being offered by the Government through Agricultural Insurance Company of India. The WBCIS has been implemented in 19 states, covering 19 million farmers with a total pay-out of Rs 4,078 crore. Since 2010-11 *rabi* season, modified national agricultural insurance scheme is being implemented with a coverage of 1.6 million farmers and payout of Rs 1,719 crore.

Some Salient interventions

- Custom- hiring centres for farm machinery enabled farmers to access implements to take up climate resilient practices and technologies in NICRA villages. Tribal farmers' of Umrani village in Nandurbar, Maharashtra, faced consistently problem of long dry spells and low yield and hence demonstration of *in-situ* conservation of soil- and -water and sowing across the slope in 10 ha covering 25 farmers resulted in 11-13% increase in soybean yield along with conserving valuable top soil from erosion.

- Delay in onset of monsoon rains coupled with deficit rainfall in July affected adversely transplanting of paddy in Bihar. Demonstration of direct seeding of rice with drum seeder at Saran resulted in timely sowing, saved nearly 25 litres of diesel and 35 man days for transplanting and saving in pumping by 3 hours per ha ;thus reducing cost of cultivation and increasing grain yield by 17%.

- Demonstration of *in-situ* moisture conservation through broad beds prepared across the slope for cultivation of *rabi* sorghum in 4.8 ha at Baramati, Maharashtra, increased crop yield by 3 times 11.3 q/ ha compared to 3.8 q/ha in the untreated control. Use of seed cum fertilizer drill facilitated crop diversification in Satna, Madhya Pradesh with pulses and oilseed crops where rice-wheat is the predominant system.

- Terminal heat stress in wheat drastically affected seed set and reduced grain yield. A key adaptation to avoid this stress is to ensure timely planting of wheat. Hence, demonstration of wheat production for timely sowing, resource conservation and to enhance productivity was taken up. Wheat was sown directly after harvest of rice using zero- till seed drill in 25 ha, involving 105 farmers. Zero-tillage saved on cost of field preparation, on labour and increased grain yield.

- In Kota, Rajasthan, water availability is a major limiting factor for sustaining wheat productivity. Hence, furrow irrigated raised bed (FIRB) system of wheat cultivation was promoted to enhance crop yield (10%) and water productivity in 40 farmers' fields by using FIRB machine. Wheat cultivation with FIRB system saved up to 25% seed,30% of irrigation water and along with saved on time required for irrigation over flat bed system.

The technological developments and timely interventions have enhanced resilience in Indian agriculture while facing abiotic stresses. (Table 3).

Table 3: Agricultural production during sub-normal rainfall years.

Year	Departure % in S-W monsoon rainfall	Agricultural Production (MT)			
		Foodgrain	Milk	Eggs*	Fish
2002	-22	174.77	86.2	39.8	6.2
2004	-12	198.36	92.5	45.2	6.31
2009	-21	218.11	116.4	60.3	7.99
2014	-12	251.12	137.69#	74.4#	9.6#

MT: Million Tonnes; *billions; #2013-14

Farmers need to adapt to changing climate to sustain farm production and their income. Over the years, several practices and technologies have been developed to bring about stability in agricultural production against seasonal fluctuations. Adoption of climate resilient practices and technologies by farmers is more of a necessity than an option. Early warning systems and contingency plans can provide support to regional and national administration as well as to local bodies, and for farmers to adopt. Policies that encourage crop insurance can provide protection to the farmers. Participatory on-farm demonstration of location specific technologies will go a long way in enabling farmers to cope with current climate variability. Adaptation to climate change impacts may be considered in all major policy considerations, development planning activities and capacity building programmes to strengthen coping mechanisms to climate risks.

The Academy has been and would continue to endeavour towards science led agriculture for greater efficiency as well as resilience. The wisdom, expertise, experience and skills of the Fellowship have enabled this institution to provide guidance and inputs in different phases of the agriculture sector. Silver jubilee is an occasion to redeem our pledge to dedicate ourselves to the cause of Indian agriculture.

Thank you

Literature consulted:

Some of the publications of Govt. of India, ICAR, FAO of the UN and CGIAR as Agricultural Statistics at A Glance-2014, Annual Reports-Ministry of Agriculture, Government of India; CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS): Info notes; ICAR-National Initiative on Climate Resilient Agriculture (NICRA) Technical Bulletins; and The Impact of Natural Hazards and Disasters on Agriculture And Food and Nutrition Security. FAO-2015, available on the respective websites were consulted in preparation of the text.