National Symposium on

Food, Nutrition, and Environmental Security

Towards Achieving SDGs

29-30 August, 2022

Proceedings and Recommendations

Trust for Advancement of Agricultural Sciences (TAAS)

Avenue II, IARI Campus, Pusa, New Delhi 110012
Website: *www.taas.in*

Indian Council of Agricultural Research (ICAR)

Krishi Bhawan, Dr Rajendra Prasad Road, New Delhi 110001
Website: www.icar.org

National Academy of Agricultural Sciences (NAAS)

NASC Complex, DPS Marg, Pusa, New Delhi 110012
Website: www.naas.org.in

Indian Society of Plant Genetic Resources (ISPGR)

NBPGR Campus, Pusa, New Delhi 110012
Website: http://ispgr.nbpgr.ernet.in

International Maize and Wheat Improvement Center (CIMMYT)

Carretera México-Veracruz, Km. 45, El Batán 56237
Texcoco, Mexico
Website: www.cimmyt.org

The Alliance of Bioversity International and CIAT (BI&CIAT)

Via de San Domenico,1, 00153, Rome, Italy
Website: www.alliancebioversity.org

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Patancheru 502324, Telangana State, India
Website: www.icrisat.org

International Rice Research Institute (IRRI)

DAPO Box 7777 Metro Manila, Philippines
Website: www.irri.org

National Symposium on Food, Nutrition and Environmental Security: Towards Achieving SDGs

29-30 August, 2022

Proceedings and Recommendations

Organizers

Trust for Advancement of Agricultural Sciences
Indian Council of Agricultural Research
National Academy of Agricultural Sciences
Indian Society of Plant Genetic Resources

Co-Organizers

International Maize and Wheat Improvement Center
The Alliance of the Bioversity International and CIAT
International Crops Research Institute for the Semi-Arid Tropics
International Rice Research Institute

Citation **:** TAAS 2022. *National Symposium on Food, Nutrition and Environmental Security: Towards Achieving SDGs - Proceedings and Recommendations*. Trust for Advancement of Agricultural Sciences (TAAS), Avenue II, Pusa Campus, New Delhi. x+66 p.

Compiled and Edited by **:** Raj Paroda, Bhag Mal and Umesh Srivastava

Published by **:** **Secretary**
Trust for Advancement of Agricultural Sciences (TAAS)
New Delhi

ISBN **:** **978-93-5777-401-7**

For copies and further information, please write to :

Secretary
Trust for Advancement of Agricultural Sciences (TAAS)
Avenue II, Pusa Campus, New Delhi - 110012
Ph.: +91-11-25843243; +91-8130111237
E-mail: taasiari@gmail.com; Website: www.taas.in

Printed **:** December, 2022

Contents

Acronyms and Abbreviations

3Ps	Policy, Program and People
3Cs	Converse, Connect and Collaborate
AA	Amino Acids
ADG	Assistant Director General
AI	Artificial Intelligence, Artificial insemination
a-IDEA	Association for Innovation Development of Entrepreneurship in Agriculture
AIP	Agro-Innovation Piloting, Agri-Business Innovation Platform
AnGR	Animal Genetic Resource
ANP	Analytic Network Process
APMC	Agriculture Produce Marketing Committee
ARI4D	Agricultural Research and Innovation for Development
BI & CIAT	Alliance of the Bioversity International & CIAT
BISA	Borlaug Institute for South Asia
CA	Conservation Agriculture
CAZRI	Central Arid Zone Research Institute
CCFI	Cattleman's Choice Feedyard Inc.
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
CEO	Chief Executive Officer
CGIAR	Consultative Group on International Agricultural Research
CHCs	Custom Hiring Centres
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CoE	Centres of Excellence
COP	Conference of Parties
COVID-19	Corona Virus Disease (COVID-19)

CRA	Climate Resilient Agriculture
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CSA	Climate-Smart Agriculture
CSISA	Cereal Systems Initiative for South Asia
CSR	Corporate Social Responsibility
DARE	Department of Agricultural Research and Education
DBT	Department of Biotechnology
DDG	Deputy Director General
DG	Director General
DH	Doubled Haploid
DMH11	Dhara Mustard Hybrid-11
DUVASU	Uttar Pradesh Pandit Deen Dayal Upadhyay Pashu Chikitsa Vishwavidyalaya Evam Go Anusandhan Sansthan
e-NAM	e-National Agriculture Market
ESP	Enterprise Acceleration Program
EU	European Union
FAO	Food and Agriculture Organization
FO	Farmers' Organization
FPO	Farmer Producer Organization
FPC	Farmer Producer Company
FSII	Federation of Seed Industry of India
GADVASU	Guru Angad Dev Veterinary and Animal Sciences University
GDP	Gross Domestic Product
GEAC	Genetic Engineering Appraisal Committee
GHG	Greenhouse Gas
GHI	Global Health Index
GIS	Geographic Information System
GM	Genetically Modified
GMO	Genetically Modified Organism
GoI	Government of India
GR	Green Revolution

GS	Genomic Selection
GVA	Gross Value Added
HtBt	Herbicide Tolerant Bt (Cotton)
HYVs	High Yielding Varieties
ICAR	Indian Council of Agricultural Research
ICRISAT	International Research Institute for Semi-Arid Tropics
ICT	Information Communication Technology
IFFCO	Indian Farmers' Fertilizer Cooperative Limited
IFPRI	International Food Policy Research Institute
IIHR	Indian Institute of Horticultural Research
IMIC	International Maize Improvement Consortium
IoT	Internet of Things
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
IRRI	International Rice Research Institute
ISARC	International Rice Research Institute South Asia Regional Centre
ISPGR	Indian Society of Plant Genetic Resources
IVF	*In-vitro* Fertilization
IVM	*In-vitro* Maturation
KVKs	*Krishi Vigyan Kendras*
MERS	Middle East Respiratory Syndrome
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MI	Micro-irrigation
MOET	Multiple Ovulation Embryo Transfer
MoS&T	Ministry of Science & Technology
MPMV	*Mera Pani Meri Virasat*
MSSRF	MS Swaminathan Research Foundation
NAAS	National Academy of Agricultural Sciences
NABI	National Agri-Food Biotechnology Institute
NAHEP	National Agriculture Higher Education Project

NAIP	National Agricultural Innovation Project
NARI	Nutri-sensitive Agricultural Research and Innovations
NARS	National Agricultural Research System
NBAGR	National Bureau of Animal Genetic Resources
NFSA	National Food Security Act
NFSM	National Food Security Mission
NGOs	Non-Government Organizations
NIPB	National Institute of Plant Biotechnology
NITI	National Institution for Transforming India
NRM	Natural Resource Management
NMAET	National Mission on Agricultural Extension & Technology
NUS	Neglected and Underutilized Species
NWPZ	North West Plain Zone
OP	Open-pollinated
PAU	Punjab Agricultural University
PDS	Public Distribution System
PJTSAU	Professor Jaishankar Telangana State Agricultural University
PMKSY	*Pradhan Mantri Krishi Sinchayee Yojana*
POC	Point of Care, Proof of Concept
PPP	Public Private Partnership
PPV&FR Act	Protection of Plant Varieties and Farmers' Rights Act
R&D	Research and Development
RA	Regenerative Agriculture
RA-CoP	RA-Community of Practitioners
RoI	Return on Investment
S&T	Science and Technology
SABC	South Asia Biotechnology Centre
SARATHI	System of Agri-Information Resources Auto-transmission and Technology Hub Interface
SARS	Severe Acute Respiratory Syndrome
SAUs	State Agricultural Universities
SDGs	Sustainable Development Goals

SDI	Social Development Index
SDN1	Site Directed Nuclease Technology 1
SHG	Self Help Group
SMAM	Sub-Mission on Agricultural Mechanization
SOET	Super Ovulation and Embryo Transfer
SoPs	Standard Operating Protocols
SRR	Seed Replacement Rate
SS	Sexed Semen
SSR	Science Social Responsibility
S&T	Science and Technology
STI	Science, Technology and Innovation
TAAS	Trust for Advancement in Agricultural Sciences
TAC	Technology Advancement Centres
TCI	TataCornell Institute
TERI	The Energy and Resources Institute
TNAU	Tamil Nadu Agricultural University
US	United States
USD	United States Dollars
UWA	University of Western Australia
VRR	Varietal Replacement Rate
WFPF	Water Financing Partnership Agency
WHO	World Health Organization
WTC	Water Technology Centre
WTO	World Trade Organization

National Symposium on
Food, Nutrition and Environmental Security: Towards Achieving SDGs

BACKGROUND

As the world population continues to grow, much more efforts for research and innovation will be needed to sustainably increase agricultural production, improve the supply-chain, decrease food losses and waste, and ensure that all who are suffering from hunger and malnutrition have access to required nutritious food. Successful experiences since Green Revolution have given confidence in the capability to eradicate hunger with commitment of working together to achieve this goal. The world population is expected to reach 9.8 billion by 2050, which will be about 34 per cent higher than at present. As per estimates globally, we will require 70 per cent more food (FAO 2009) considering the present dietary pattern, income and consumption scenario. India's current population of 1.41 billion (around 17.7% of world population) is likely to reach 1.51 billion by 2030 thus becoming the most populous country in the world. A fundamental question arises as to whether India will continue remaining self-sufficient in food production and achieve sustainable development goals (SDGs) by 2030. The challenge to produce more from decreasing per capita arable land and irrigation water besides increasing abiotic and biotic stresses, is quite alarming. The impact of climate change on agriculture is expected to reduce production of crops like rice, wheat and maize by almost 10-20 per cent. Despite having achieved household food security due to Green, White and Blue revolutions, the problem of poverty, hunger and malnutrition still persists and the real income of the farmer has not increased. Malnutrition is taking a toll across the nations. In India, currently 189.2 million people are undernourished and 34.7 per cent of the children below five years are stunted. By this measure, around 14 per cent of the population is undernourished. Also, 51.4 per cent of women in reproductive age between 15 and 49 years are anaemic and need proper care and nutritious food. In fact, the challenge is not the lack of food; it is rather the poverty which hinders making food available consistently to everyone who needs it. Also, over 90 million children under the age of five are underweight. While stunting is slowly decreasing globally but, more than two billion adults, adolescents and children are now obese or overweight. The consequences are severe for public health, national wealth, and quality of life of

individuals and communities. Achieving the targets of no poverty and zero hunger is not just about calorie adequacy but also for alleviating micronutrient deficiency and availability of food for all. The explicit focus of SDG2 on the importance of ending all forms of malnutrition and the recognition of agriculture as a key player in achieving this goal are specifically relevant for us in India.

We all are alarmed by the fact that the world population continues to grow needing better food, nutrition and environmental security. Hence, beyond doubt, greater efforts for agricultural research, and innovation for development (ARI4D) would be critical to ensure sustainable agricultural production, while improving value-chain, reducing food waste, and having food affordable for those below poverty line, facing hunger and malnutrition. Despite global efforts, the number of hungry and malnourished people has increased by almost 100 million (above 800 million earlier) since COVID-19 pandemic. Thus, an urgent action is needed at the national level to meet the sustainable development goals (SDGs) set to be achieved by 2030, especially no poverty, zero hunger and improved environment. In this context, we need to accelerate our efforts since the maximum concentration of poor, hungry and malnourished people currently are residing in India, and they would urgently need affordable food, good nutrition and environmental security.

TOWARDS ACHIEVING SDGs

The commitment of Government of India to meet SDGs and the Paris Agreement for Climate Change presents a unique opportunity for the entire agriculture sector to get aligned for a better tomorrow. Thus, there is an urgency that policy makers accord high priority to agriculture, which still sustains almost half of the Indian population, to ensure faster agricultural growth to achieve food, nutritional and environmental security for all. This obviously would demand doubling of funds for agricultural research and innovation for development (ARI4D), which still gives the highest returns on investment (RoI more than 10-15 times) compared to other growth-related sectors. Also, the enhanced capital investment in non-Green Revolution areas such as the Eastern and Northeastern regions, especially to improve social development index (SDI), becomes highly justified to ensure an Evergreen Revolution which is sustainable. Besides SDGs, India's commitment for doubling farmers' income is a major policy initiative, which demands specific focus on increased production with low input cost, sustainable agricultural diversification and efficient post-production management including value addition, and new options for linking farmers to market. Obviously, these would demand a paradigm shift in current national agricultural policies to become more pro-farmer, and ensure higher agricultural growth for an overall prosperity. In addition, increase in capital investment in agriculture jointly by the Government and Private Sector,

is warranted in regions that remained uncovered by Green Revolution, especially the Eastern and Northeastern India.

At this juncture, there is an urgency for introspection of existing technology, development and policy related initiatives, and to evolve a new strategy with defined Road Map to accelerate agricultural growth rate, which seemed to have stuck around 3 per cent. Also, accelerating agricultural growth is warranted for achieving SDG2 by 2030. This obviously demands some bold policy decisions, and to scale out new technologies and innovations to ensure increased production linked to input use efficiency, post-production, value-chain, effective partnership with stakeholders, especially the private sector, and the linkages with both national and global markets, and finally their effective implementation. Also, concerted efforts are needed for scaling innovations such as: hybrid technology (maize, pearl millet, sorghum, rice); biotechnology – GM crops (soybean, mustard, maize, brinjal); conservation agriculture - from current 3 to >20 mha; protected cultivation - expand area from current 0.5 to 2.0 mha; micro-irrigation- doubling the area from current 10 mha; bioenergy/biofuel (use of ethanol permitted up to 20%) – potential crops: sugarcane and maize; biofortified crops (quality protein maize, iron and zinc rich rice, iron rich pearl millet, zinc rich wheat) – policy on their pricing; and information communication technology (ICT) for knowledge empowerment – private advisory services, etc. In view of Paris Climate Agreement and the commitments made by the Prime Minister, Government of India in COP 26 held in Glasgow, concerted efforts need to be made to enhance the use of renewable energy, and to reduce one billion tons of projected carbon emission by 2030. In fact, we need to rely now more on agriculture to reduce greenhouse gas (GHG) emission by scaling conservation agriculture (CA) or no-till agriculture, especially in the rainfed areas and by laying greater thrust on agroforestry for enhanced carbon sequestering. Currently, both at the national and international levels, several policy and action platforms are striving to achieve the targets of Paris Agreement but these are either not well aligned or lack much required innovative approach to enhance carbon sequestration capacity. Therefore, there is an urgency to accelerate the efforts to scale conservation agriculture (CA) and agroforestry in a Mission Mode at the national level for meeting our national commitments by 2030.

We all know that the Green Revolution in India is one among the global success stories. The risks of food-insecurity and chronic under-nutrition have been addressed a great deal. However, the problems of hidden hunger from micronutrient and protein deficiency persist. There is a widespread problem of soil micronutrient deficiency of Zn, Fe, Cu, Mn, and B. Different forms of malnutrition - including overweight, obesity and micronutrient deficiencies are also expanding at alarming rates. The crisis triggered by the COVID-19 pandemic serves as a timely reminder

of the fragility of our food system and the importance and urgency of the efforts that we do for food security and nutrition to end hunger. In India, science, technology and innovation (STI)-led Rainbow Revolution transformed the country from 'ship-to-mouth' status to the 'Right-to-Food Bill' situation with formidable foodgrain export and buffer stocking, making it the second largest agrarian economy in the world. Accounting for 18 per cent of the world's population, with only 2.3 per cent of the world's land and less than 4 per cent of global freshwater, the country's STI effort must be geared to produce ***More from Less for More*** without further damaging the agroecological system and accentuating water and carbon footprints.

There are more than 500 million small-scale farms worldwide growing 1/3 of the world food on less than 11 per cent of the world's farmland. The majority of population relies on small-scale farms for their food including almost all of the world's 3.2 billion rural people living in developing countries including India. These small farms harbour greater biodiversity than larger farms, but small-scale farmers are amongst those most likely to suffer from hunger and poverty. About 63 per cent of the world people living in poverty work in agriculture, the majority in small fragmented farms. They are also highly vulnerable to climate change. Yet they receive less than 2 per cent of global climate finance to help them cope and adapt. The country must transform food systems to provide good food to all and decent livelihoods for the people who grow that food, and increase financing to help small-scale producers build climate resilience.

The COVID 19 pandemic has also underlined the fact and cautioned the nations to ensure availability of enough nutritious and diversified food that is produced locally. Also, the number of people who are food and nutrition insecure is expected to further rise in the coming years. Despite global efforts, the number of hungry and malnourished people has reached to about 900 million (additional 100 million) since COVID-19 pandemic. Food safety risks, hazards, pests and emerging diseases including COVID-19 had wide ranging impacts on food security. There is an urgent need for strengthening and consolidating conceptual thinking around food security and nutrition to prioritize the right to food, widen our understanding of food security, and adopt a food systems analytical and policy framework. Policy approaches and actions for food security and nutrition, in the light of the diverse challenges facing food systems, will require critical and multi-dimensional policy shifts and support for enabling conditions that uphold all dimensions of food security. Public sector investment in food and agriculture has declined, raising questions about the appropriate balance between the roles of the public and private sector in supporting food systems. The focus must be on nutrient - dense food through nutrition-sensitive agriculture. Sustaining soil health and re-carbonization of the terrestrial biosphere (e.g., soil, vegetation, wetlands, urban land, mine lands) are critical to putting India on track to achieve SDG 1, 2, 6, 13 and 16 among others.

THE NATIONAL SYMPOSIUM

India is committed to bring a demand-driven and technology-led revolution to meet the challenges of rising demand for food, improved livelihood opportunities for farmers, and to attain sustainable farming for wider agricultural growth. We envision scaling of those innovations in agriculture that would transform existing slowdown into a vibrant and globally competitive enterprise. In doing so, both public and private sector institutions shall have to play important role. Also, there is need to develop mechanisms to monitor effectively the changes occurring towards SDI as well as SDGs. The changes so anticipated shall have to be in a participatory mode. Accelerated growth in crops, horticulture, livestock, dairy, poultry and fishery sectors collectively will enhance nutri-rich crop/ animal/fish production leading to better food, nutrition, health, and environmental security for all by 2030. In view of above, the Trust for Advancement in Agricultural Sciences (TAAS), New Delhi, a neutral 'Think Tank', Indian Council of Agricultural Research (ICAR), National Academy of Agricultural Sciences (NAAS), and the Indian Society of Plant Genetic Resources (ISPGR) in collaboration with Alliance of the Bioversity International & CIAT, International Crop Research Institute for Semi-Arid Tropics (ICRISAT), International Maize and Wheat Improvement Center (CIMMYT) and International Rice Research Institute (IRRI) organized a 'National Symposium on Food, Nutrition, and Environmental Security: Towards Achieving SDGs' on 29-30 August 2022. The National Symposium was well attended by diverse stakeholders (offline and online) from the Central and State Governments, CG Centers, scientific institutions, private sector representatives, policy planners and farmers. The important aspects discussed were: current constraints and options for ensuring food, nutrition and environmental security for all by 2030; strategies for regenerative agriculture (RA) for long-term sustainability; harnessing untapped opportunities by strengthening partnerships; and diversified sustainable production systems on eco-regional basis.

OPENING SESSION

Dr RS Paroda, Chairperson, TAAS and Chair of the National Symposium expressed sincere thanks to Dr Ramesh Chand, Member (Agriculture), NITI Aayog, GoI for sparing his valuable time which reflects his interest and affection for agricultural development in India. He further welcomed participation of representatives from BI and CIAT Alliance, ISPGR, ICRISAT, IRRI, and CIMMYT, and Dr Himanshu Pathak, Secretary DARE & DG ICAR, Dr T. Mohapatra, President, National Academy of Agricultural Sciences (NAAS) and other distinguished experts and participants. He emphasised upon urgency to achieve sustainable development goals (SDGs) by 2030 and mentioned that TAAS had organized 'National Conference on Sustainable Development Goals: India's Preparedness and the Role of Agriculture' in partnership

with ICAR and IFPRI in 2017. At that time, it was concluded that SDGs for India are very important and if we are not able to achieve it by 2030, possibly the whole world will not be able to achieve these goals. Therefore, India emerges in the forefront as far as SDGs are concerned. He further stated that India has made good efforts, yet there are concerns in several Indian states for high poverty. Although we always talk of Green, White and Yellow Revolutions, and despite having achieved so much, our concern is still about achieving household food, nutrition, and environmental security.

Although the nation is producing more food than ever before, yet millions of Indians still lack proper nutrition. It is known that as alternative to rice, wheat and maize, our focus needs to shift now on developing nutrient-dense, gluten free crops. COVID-19 has taught us that we have to diversify our food basket with nutrient – rich local food systems, important not only for the quantity of the food but also for our health and immunity. He cited an example that crop like *kulthi* was earlier eaten in dryland areas, which presently is not consumed anymore. COVID-19 has also brought our focus on conserving our natural resources. We have to not only think of unilateral approach of genetic enhancement but also adopt sustainable agricultural development in crops, horticulture, livestock, fishery, etc. He highlighted that children below five years of age suffer largely for nutrient deficiency including micronutrients. He further stated that China has reduced poverty successfully. Similarly, the state of Punjab has reduced poverty but states like Bihar has to work more on this aspect. Hence, we need to address the concern of poverty on priority. Our capital investment in agriculture was high when we had Green and White Revolutions but it has declined drastically over the years. It was presumed that private sector will come forward, but this has not happened. Hence, it is amply clear that if we do not invest more in agricultural research and innovation for development (ARI4D), possibly we will not achieve SDGs. The annual budget for agricultural research is stagnating, which needs to be doubled urgently. There is a need to keep farmers at the centre stage, make nutrition security a key agenda in agri-food system, integrate science social responsibility (SSR) with corporate social responsibility (CSR), and adopt food system approach and not the food production approach. We need to enhance the potential yield by accelerating genetic gain through combining empirical breeding and genetic selection, high throughput and phenotyping adopting conservation agriculture (CA), effective approach of extension, motivating and attracting youth in agriculture and help farmers as paid extension entrepreneurs. India requires much stronger partnership with all international/national institutes. GoI should enhance funding from existing 0.39 per cent to at least 1.0 per cent (China spends 0.62%, Brazil 1.8% and USA 3%) for agricultural research innovation for development (ARI4D) in this cutting-edge science in IPR era when Hon'ble PM Shri Narendra Modi ji

exhorted from the rampant of Red Fort the new slogan '*Jai Anusandhan'*. ICAR has to strive hard to get required allocation of funds.

Dr Steven Weiss, in his special remarks, spoke about supporting Indian partners in achieving the SDGs. He expressed that the Alliance has faced unprecedented challenges in the last couple of years that made the path to the SDGs steeper due to COVID-19 pandemic, and more recently the increase in the food prices. Already existing pressures linked to climate change are now compounded with public health risks and market imbalances which highlight weaknesses in the food systems with adverse effect on diets, nutrition and environment. Climate change situation threatens to reduce production of rice, wheat and maize among others which are all very important for India also. Land use changes resulted in decreased availability of agricultural land and increased degradation of lands. Despite all the advances, there is persistent poverty, hunger and malnutrition, which need to be addressed. The Alliance has decided to shift its perspective on food from 'consumption to nourishment' to provide access to healthy food choices. Current global environmental changes also compel to rethink about our agricultural practices, and influence in policy decisions, and addressing the challenges by working across sectors. He further highlighted the importance of safeguarding and using our agrobiodiversity. The Alliance is contributing to food and nutrition security at various levels. In March 2022, it launched 'Future Seeds'- a global innovation hub for the conservation and use of crop diversity. This 'state-of-the-art' gene bank in Asia houses more than 65,000 distinct samples of beans, cassava and tropical forages, and is working to improve commodity systems through the enhancement of key staples and ensuring their integration across production and market systems. Additionally, safeguarding food and commodity systems against climate change opens various opportunities to harness local agriculture biodiversity as a means to achieve nutrition security.

In India, the Alliance is already contributing towards the use of local agrobiodiversity and their value-chains and access to fruits and neglected and underutilized species in rural and ethnic communities to ensure food nutrition and environmental security. A need was felt for further collection, conservation of genetic resources specifically from India to develop resilient crop varieties, animal breeds, also to identify new crops which can withstand climate change and help in mitigating its impact on the environment, and make a healthy diet. Synergies are required from government institutions and policies to ensure 'farm to fork', uptake of the improved crop varieties and breeds, increase in public and private investments in research and innovation. He informed that the Alliance is optimistic about working in partnerships to realize a food and nutrition secure future. There is a need to have unique opportunity to leverage the potential of agrobiodiversity as part of a systemic solution for land restoration, biodiversity conservation, improved nutrition and climate action for which multi-sectoral

approaches are needed to transform the food systems. He affirmed that the Alliance and the CGIAR remain committed in supporting the agriculture, nutrition and environmental sectors.

Dr Jacqueline Hughes, DG, ICRISAT emphasized that our food systems are vulnerable to natural shocks, climate change, insect-pests and diseases whether directly affecting humans such as COVID-19 or fungal and bacterial epidemics and insects such as fall armyworm, which move across continents or parasitic weeds like 'striga' in West Africa; and civil unrest affecting local food systems; and the Ukraine war which has affected global food systems. Wildfires in North America reduced corn yields by 50-63 per cent. These natural calamities disrupt our food chains, increase food prices and cause distress to many communities. For the drylands, we need to develop better adapted varieties of crops which could thrive well and continue to yield sufficient quantities of nutritious food. Now, there is a need to speed-up the breeding process, for example, in chickpea, rapid generation advancement technologies enable us to reach ready to market stage in 3-5 years compared to 12 years through conventional breeding. The new technologies like gene-editing need to be used to develop varieties particularly to overcome some of the critical issues like rancidity and aflatoxin. Marker-assisted breeding is routinely used to eliminate or at least partially eliminate the need for field screening. There is a need to use specialized sensors for phenotyping both in glasshouses and in the field where internet of things (IoTs)/drones are used to capture the huge amount of data/information necessary to achieve smart agriculture.

Traditional crops of dryland such as, sorghum and millets are quite important but have largely been ignored. These highly nutritious crops are adapted to the harsh production environments where heat and soil moisture are limiting. Smallholder farmers produce half the world's food, and generate about half the rural income and yet we often do not encourage them in a holistic way. In the International Year of Millets 2023, enabling policies should be in place to facilitate uptake and production, seed availability etc. Necessary aspects of the value-chains are to be addressed for such neglected but nutritious crops. Also, as we are aware one-third of the food produced is lost during production, processing, transportation and in *mandis*, and also on the dining tables. Need of the hour is for transformative game-changing technologies preferably with the consumer pull; and to support the dryland farmers with these tried and tested technologies. If we can bring the best minds together, both private and public sectors to work together, and remain transparent, then there is a fair chance to have the opportunity to reach the SDGs successfully. She further suggested to think out-of-the-box, and take substantial steps to direct research programs to develop diverse resilient, nutritious and sustainable food systems that can meet the food and nutrition needs of our growing global population.

Dr Bram Govaerts, DG, CIMMYT, asserted that along climate change problems, high food prices, global supply-chain disruptions associated with ongoing COVID- 19 pandemic, and conflict in a breadbasket of the world, there is a need to address these challenges and implement initiatives and actions that contribute to achieving no poverty, zero hunger, and environmental sustainability. There is need to come up with the solutions that Indian farmers and consumers need for transforming the existing food systems. The CIMMYT has a long history of collaboration with India which began with Nobel Peace Prize winner Dr Norman Borlaug in 1963 when the challenge was to pave the way for the Green Revolution that saved billions of lives in this subcontinent. It is high time to bring the same momentum to have a transformational effort to the challenges of building long-term prosperity and peace based on an Evergreen Revolution.

Collectively, we can build resilience for a hotter, drier and more densely-populated world where conflict for scarce resources including water will become more frequent. CIMMYT and BISA would be pushing forward this food system transformation relentlessly in line with the CGIAR's 2030 research and innovation strategy. The researchers at CIMMYT will try to do this by implementing pioneering crop systems research that leads to yield, nutrition, environmental and economic gains for Indian farmers and their households. He stated that India is actually moving in the right direction. CIMMYT is also working for India's tropical maize systems with a unique public-private partnership model called the International Maize Improvement Consortium (IMIC). The capacity to deliver new high yielding and climate resilient maize varieties to the Indian farmers has been greatly enhanced by establishing a new Maize Double Haploid Facility at Agricultural Research Station, Kunigal (Karnataka) in December 2021, inaugurated by Dr Raj Paroda. At the same time, the Cereal Systems Initiative for South Asia (CSISA) standardized extension program across India by setting up convergence platforms that bring together the public, civil society and private sector. As a result, the Indian Extension System has now adopted this integrated tool and approach to extension and local capacity building by convening convergence platforms in Bihar, Odisha, and eastern Uttar Pradesh. This is just a sample of the many exciting and ongoing R&D efforts and activities that CIMMYT, BISA and esteemed partners have in India, which will have great beneficial spill-over effects across the whole South Asia/Asian region. CIMMYT is also engaged in a very ambitious and far-reaching R&D agenda that decisively will contribute to climate resilience sustainability and exclusive agricultural development for a nutrition secure world. He hoped that this symposium will yield concrete action plans for consolidating enabling partnerships that will lead to enduring transformation of South Asian food systems.

Dr Jean Balié, DG, IRRI in his remarks, expressed that India is facing several challenges to ensure food nutrition and environmental security. Globally also, there are growing concerns on feeding the exponentially growing population

with fewer resources available along with rising inequalities in economic social and environmental terms. India, however, has come a long way since the 1970s with the level of absolute poverty in the beginning of the 21st century, and now emerged incredibly with high economic growth. World Bank estimates that between 2011 and 2015, India has managed to uplift 90 million people out of extreme poverty–a huge achievement for the country when it experienced an uncontrollable circumstance such as COVID-19, which certainly shook not only the health systems but also the entire economy. The pandemic has exacerbated existing inequality but Government of India has responded with well-crafted fiscal and monetary policy support. India is still expected to grow by over 7.4 per cent in 2022 making it one of the fastest growing economies in the world. Hence, there is an opportunity to make further progress on achieving the SDGs in India. It has made good progress on SDG 1 (ending poverty), and SDG 3 (good health and well-being) and SDG 12 (responsible consumption and production). There is also scope to do more on SDG 11 (zero hunger), SDG 14 (sustainable cities and communities), and SDG 15 (life below water). It is important that India may adopt a long-term perspective and take a holistic view of the challenges and opportunities in particular their interconnectivity. There is a need to focus on creating an enabling environment for all sectors to work together in an integrated manner towards a common goal. The agriculture and food sectors have a key role to play in achieving SDGs in the country. The CGIAR and its centers in Delhi have been working to develop innovation and novel approaches that help improve not only agricultural productivity but also food system efficiency as well as economic, social and environmental sustainability. IRRI India is a top priority partner and has a long association with the country. Some of the work that IRRI is doing in India on collaboration with Indian partners includes developing new rice varieties (tolerant to biotic and abiotic stresses such as floods and drought) and also on developing new crop management practices that can help improve productivity and reduce the environmental footprint of rice cultivation such as the impact of rice stubble burning, which is a big challenge for India. In addition, IRRI is working in India at its Varanasi centre i.e., International Rice Research Institute South Asia Regional Centre (ISARC), on developing value-added products such as low glycaemic index and biofortified rice. These products have the potential to improve nutrition and health and provide additional income to farmers. Of course, these products need to be distributed in a timely and efficient matter.

The IRRI is also working with Indian partners to promote the use of various innovations in agriculture which include mobile applications, policy and markets, initiatives to empower women and youth, e.g., development of women-led farm and cooperative businesses in Odisha. There is a need to map the landscapes and accordingly identify the most suitable mixed-cropping and livestock systems to effectively address these long-term challenges in the wake of climate change.

Agriculture and food sectors are both a cause of greenhouse gas (GHG) emissions accounting for nearly 30 per cent of total GHG emissions globally. There is an urgent need to understand it and measure the real carbon footprint of each food system, and do it together down to the landscape and farm levels. It is to be ensured that food policies are supportive of sustainable agricultural practices, low carbon agricultural value-chains, and are context-specific taking into account the diverse needs of different stakeholders. Fortunately, strong network of institutions and a wealth of knowledge and experience are in place, and together have to build on this legacy to create even more diverse and resilient food systems. He concluded that investment in support of international regulatory R&D has been declining since the 1980s, though drastically needed to address the new challenges of food, land and water systems. IRRI, CIMMYT, ICRISAT and other centres should come together to promote agricultural research for food system transformation in India. He felt confident that together we can develop the technologies, and our institutional innovation will strengthen capacity and adopt better policies to enable rural communities and IRRI is ready to work with India as a long-term partner.

Dr Himanshu Pathak, Secretary DARE and Director General, ICAR mentioned about development debates both in India and globally and that India has made good progress in food production. He highlighted that between 1951 and 2000 (50 years), our per capita food production increased by 50 per cent from 850 g per person per day in 1951 and 1.2 kg per person per day in 2000-2001. In the next 20 years (2001-2021), the country achieved 50 per cent growth, means whatever country achieved in the first 50 years after independence, could achieve in another 20 years, which amply showed the accelerated growth in food production in India. Until now, the country was producing mainly rice and wheat but now is moving in favour of biofortified varieties, more nutritious food, horticulture (fruits and vegetables), livestock and fisheries. India has world's half of the underweight children, half of the stunted children, hunger index is really very bad, hence there is need to re-look and ascertain why we are not able to translate our achievements on the ground. He further mentioned about the plight of pregnant and lactating women who are in the poor state of health and require remedial measures on priority. ICAR has developed several biofortified varieties, but more concerted efforts are needed to bring a paradigm shift towards quality and nutrition. In fact, India is not food shortage country, farmers are poor and not able to purchase Mere increase in production will not help in achieving food and nutrition security, instead nutrient-rich food is essentially required. Climate change will increase temperature affecting food production adversely, which needs to be addressed.

Dr Ramesh Chand, Member, NITI Aayog at the outset, mentioned that agriculture is the riskiest and the oldest profession of humankind. He emphasised that science

is going to be the quest of all the solutions and that is also the new approach of India, which has to be science-centric/ technology-centric but of course taking the traditional aspects also into consideration. The latest announcements and policy directives indicated how the country is going to capture modern science with the traditional knowledge to make Indian agriculture sustainable and resilient and has to increase productivity and profitability. R&D is going to play a very crucial role as without new technology; country cannot solve the problems of land degradation, water depletion and ultimately productivity, production, profitability and so on. Hence, it is very clear that NITI Aayog is going to identify some implementable and improved solutions. India released rice varieties containing very high protein (almost double) but these have not been upscaled to the required extent. He mentioned that science and the scientists have delivered good technologies but it has not reached the masses (the unreached). Majority of farmers still lack better technologies and improved varieties and this needs to be looked into seriously. Our students and our new researchers also have to understand as to how it can be implemented. He further mentioned that many of our colleagues can really frame and guide, helping a great deal in the process. There is a need to have solution-oriented projects with a shift from output to outcome-oriented approach. Secondly, NITI Aayog is trying to shift from 'crop system-based research to holistic system-based research' taking the whole chain together. We have been working for 'farm to fork' but time has come to work as per farmers' needs i.e., from 'fork to farm'. Finally, he suggested to go for crop diversification, nature-friendly farming, establishing market mechanism, working in close collaboration with national/international institutions particularly CG partners, private organizations, revitalizing the whole technical research development, innovation outcome-oriented research projects.

Dr T Mohapatra, President, NAAS and Former Secretary DARE and DG, ICAR expressed his gratitude to Dr RS Paroda, and emphasised that it is not just we are discussing on various aspects of food system, but more importantly, we are celebrating the life time achievements of a visionary who has transformed agriculture in this country and also very significantly contributed to agricultural development globally. He further expressed his sense of gratitude to him for contributing very passionately even today with the same zeal at the age of 80 years for the development of agriculture both at the national as well as global level. He mentioned that we know about our problems and deficiencies and also about what needs to be done. Speakers from CG system and Dr Himanshu Pathak have made relevant points concerning meeting SDGs by 2030 and talked about clear direction for future course of action ensuring nutrition and environmental security. There is a need to remove bottlenecks so that program implementation improves and efficiency is increased. The National Academy of Agricultural Sciences (NAAS) has published 105 policy papers. The TAAS publications are so fantastically

synthesised and brought out that those who go through them will be immensely benefitted. In these publications, certainly there will be many take-home messages for all of us including as to how we improve on our nutritional outcomes and meet the target of SDGs by 2030.

Dr Bhag Mal, Secretary, TAAS expressed gratefulness to Prof Ramesh Chand, Member (Agriculture), NITI Aayog for gracing the occasion as Chief Guest and his illuminating address highlighting the Way Forward. He profusely thanked Dr T Mohapatra for his special address and for being closely involved in developing the program of this symposium right from the beginning, and to Dr Himanshu Pathak, Secretary DARE and DG, ICAR delivering his address giving clear direction for future course of action ensuring nutrition and environmental security. He profusely thanked Drs Bram Govaerts, DG, CIMMYT, Dr Jacqueline Hughes, DG, ICRISAT, Dr Jean Balié, DG, IRRI, Dr Steven Weiss of the Alliance of Bioversity International and CIAT for giving their special remarks focusing on way forward for achieving SDGs based on their international experiences. He felt extremely grateful to Dr RS Paroda, Chairman TAAS and Former Secretary, DARE and DG ICAR for his welcome remarks and setting the context of the national symposium. In fact, he was the brain behind conceptualizing and developing the program so meticulously and also in catalysing the national and international organizations to become co-organizers and sponsors of this important event and provide the platform for intense discussions to address the concerns and issues and find possible solutions. He further expressed sincere thanks to all the dignitaries, distinguished guests, special invitees and participants for their presence and all the colleagues engaged in making organizational arrangements.

THEMATIC PRESENTATIONS

Technical Session I : Reorienting Crop Research for Food and Nutritional Security

This session was co-chaired by Dr PL Gautam, Former Chairperson, PPV&FRA, and Dr Trilochan Mohapatra, President, NAAS. Dr Umesh Srivastava, Former ADG (Horticulture), ICAR was convenor of the session. The session started with a plenary lecture by Prof RB Singh followed by presentations by Drs OP Yadav, AK Shasany and HP Singh.

Prof RB Singh, Former President, NAAS, while delivering the plenary lecture on *Science-led Growth in Agriculture for Alleviating Hunger and Poverty,* stated that globally, science, technology and innovation (STI) continuum has been the main driver of agricultural growth, development, and transformation of national socioeconomic and agro-ecological milieus, and evolving dynamically to meet the fast-changing development goals–leaving no one behind. In India, science-led

innovation and development of high-yielding, better quality, photo-insensitive, biotic and abiotic stress resistant/tolerant, and input responsive crop varieties, miracle seeds, especially of wheat and rice, and their country-wide adoption ushered in the Green Revolution in the mid-1960s. India is the largest producer of milk (210 mt with growth rate of 6.3%), spices (11 mt), cotton (640.42 mt, 2% lower than last year) and pulses (23.03 mt); second largest producer of wheat (106.84 mt), rice (130.29 mt), horticulture production (341 mt) which includes fruits (107.1 mt), vegetables (200 mt), and third largest producer of egg (122 billion). Between 1965 and 2020, foodgrain production had quadrupled. The Green Revolution was followed by similar revolutions in production of fruits and vegetables (Golden Revolution), milk (White Revolution), and fisheries (Blue Revolution), production increasing by 7-12 times. Collectively referred to as 'Rainbow Revolution' transformed the country from the 'ship-to-mouth' status and chronic energy deficit to the 'Right-to-Food Bill' situation, with foodgrain export (US $ 18 billion in 2021) and buffer stocking, making it second largest agrarian economy in the world. In cotton, 92 per cent area is under Bt hybrids by 7 million farmers mostly smallholders. Net income of Bt cotton farmers doubled. There is a need to promote biotechnology to eradicate poverty and hunger, but policy paralysis continues. Despite Rainbow Revolution and rapid economic growth of 7-8 per cent, India has nearly one-fourth of the world's hungry (nearly 200 million people), one-third of the world's stunted children, about 40 per cent of world malnourished children and half of the world's wasted children. Agriculture is 2-3 times more effective than other sectors in elevating agrarian crisis, yet investment in agriculture is very low. The country experiences increasing pressure on natural resources, climate change, fragmenting land holdings and fast urbanisation. The historical slogan *'Jai Jawan Jai Kisan'* voiced by then PM Lal Bahadur Shastri in 1965 was augmented with *'Jai Vigyan'* by the late former PM, Atal Bihari Bajpai in 1998 and further augmented by *'Jai Anusandhan'* by Prime Minister Narendra Modi in 2019 and pronounced by him from the Red Fort on the *Amrut Mahotsav* Independence Day 15 August 2020 to underpin the nation's political will to transform *'Harit Kranti'* into *'Satat Harit Kranti'* (Evergreen Revolution).

He emphasized that ever-intensifying water crisis, deteriorating soil health, fast eroding agro-biodiversity, increasing GHG emission and ever-aggravating climate change, persisting high socioeconomic inequities, trade and market distortions, high wastage along the value-chain, and the asymmetry of low and poorly planned investment in agricultural research, education, and technology generation and transfer must be addressed on priority. Accounting for 18 per cent of the world's population, with only 2.3 per cent of the world's land and less than 4 per cent of global freshwater, the country's STI effort must be geared to produce ***More from Less for More*** without further damaging the agro-ecological system and accentuating water and carbon footprints. To meet SDGs by 2030, production has

to go up by 70 per cent, rural poverty has to go down by 100 per cent, hunger by 100 per cent and GHG emission by 35 per cent. Demand-driven STI include climate change, sustainable diversification and intensification and consumer awareness and these are to be addressed. For that, breeders have to go for cutting-edge technologies which will require in place pangenome libraries, high throughput genotyping, rapid generation advancement (speed breeding), double haploid (DH) haplotype apomictic F1; precision phenomics, genomic selection (GS), epigenomics, big data analysis, artificial intelligence (AI), and digital platforms. Scientists have to go for gene-edited products (SDN1 and SDN2 categories) as it is non-GMO to liberate science to serve the society. The USA, France, Canada, Australia, Japan and Argentina treat such products as non-GMO. He emphasized the need to synergise Green Revolution with Gene Revolution coupled with IPR protection for attaining Evergreen Revolution; revolutionise oilseed production attaining self-sufficiency before 2030; adopt innovative technologies, viz., digital solutions, IoT, Blockchain technologies, analytics, precision agriculture to produce more to feed the most populous nation in a sustainable manner; also promote carbon farming, and reduce GHG emission. The time has come to use drones in precision agriculture. Its application saves 30 per cent input, 95 per cent water and time and ensure timely application of inputs. The Sub-Mission on Agricultural Mechanization (SMAM) scheme provides subsidy on drones to government institutes (100%), FPOs (75%) and for individual farmer (40-50%). He further emphasized that a well-coordinated action and strategy between Centre and the States is needed to ensure that agriculture is not left behind. Hon'ble PM Narendra Modi has emphasised *Atmanirbhar Bharat, Swasthya Suraksha* and Inclusive *Bharat Sabka Saath Sabka Vikas, Sabka Vishwas*. The following paradigm shifts are needed for enabling science to alleviate poverty and hunger : i) keep smallholder farmers at the centre stage of national development, especially their linkage with markets towards doubling farmers' income; ii) make nutrition security a key goal of agriculture-food system; iii) shift from grey to green growth for green economy through enhancing soil, water and biodiversity health and conservation based on multidisciplinary research; iv) move from subsistence to commercial agriculture, promote robust entrepreneurship, start-up initiatives, Make-in-India, and export; v) shift from mere price policy to income policy to ensure inclusive livelihood security; vi) pursue advanced modern technologies and liberate science to serve society by creating science-based regulatory regimes; vii) ensure effective implementation pathways with differentiated responsibility and accountability of all stakeholders to achieve desired impact at the ground level; and viii) integrate Science Social Responsibility (SSR) with Corporate Social Responsibility (CSR) and foster synergy among Science of Discovery, Science of Delivery and Science of Communication towards effective transfer of proven technologies and judicious feedback.

Dr OP Yadav, Director, ICAR-CAZRI, speaking on *Reorienting Crops Research for Food and Nutritional Security*, emphasised that Indian agriculture is facing serious challenges in terms of climate change, state of natural resources, and severe malnutrition. The potential yield of crops has to be increased to produce more from the given land resources by exploring all possibilities. There is need for accelerating rate of genetic gain by combining empirical breeding with new interventions like genomic selection; high throughput and accurate phenotyping; and data digitalization. Reducing breeding-cycle time by adopting rapid generation advance, doubled haploid (DH) and tissue culture will be very critical in addition to having access to good off-season breeding nurseries. Genome-editing technology, approved recently by Government of India, opens new opportunities and needs to be exploited.

He emphasized that for enhancing potential yield and accelerating genetic gain, we need to go for precision breeding through new technologies, viz., molecular marker-assisted breeding, genomic selection; genotyping, higher throughput phenotyping, and gene-editing; speed breeding by reducing breeding cycle time by using double haploid in maize, anther culture in rice, 3-4 generations in a year (rapid generation advance), and access to good off-season nurseries; and data-driven hybridization, inbreeding, selection and evaluation. There is need to use more productive inbred lines, and develop climate resilient crops to tolerate drought, flooding, heat especially at maturity. Multiple tolerance and resistance need to be induced through gene pyramiding. Strengthening of pre-breeding through strategic use of germplasm for discovering new traits; development of trait specific pools/populations and mini-cores; using wild relatives as new sources of tolerance/resistance would result in the development of climate-resilient crops with better capacity to tolerate drought and supra-optimal temperatures. So far, a large number of biofortified varieties of selected crops have been developed. There is a need for innovations in hybrid breeding in several crops. He further emphasised to have IoT (biosensor-based) diseases and pests' detection, real-time surveillance and better forecasting using remote-sensing, and development of next generation smart bioformulations and growth regulators. For consolidating crop science impact, strengthen product delivery system and share genetic resources with due recognition of access and benefit sharing. There is a need to connect policy makers, civil societies on genetic modification, science-based decisions, vouching for enhanced funding etc. Human resource in plant breeding and cutting-edge areas of biotechnology and gene discovery should be made available with long-term sustained funding. For the development of biofortified varieties there is need to mainstream biofortification as a regular breeding objective, define the maximum threshold of nutritional traits, and promote millets to address challenge of malnutrition. There is also need to maximise heterosis through the use of

inbred parental lines that are more productive, good combiners and diverse to reduce homogeneity.

Dr AK Shasany, Director, ICAR-NIPB, spoke on *Genetic Enhancement for Nutrition and Environmental Security,* and compared the progress in various agricultural fields, the status in 1950 and 2021 for example net sown area 131/142 mha; foodgrain production 51/316 mt; fruits and vegetables 25/341 mt; oilseeds 5/38 mt; pulses 8.4/23.3 mt; milk 17/210 mt; spices 0.02/11 mt; cotton 3/32 m bales;and sugarcane 57/431 mt. Further, he informed that 8.9 per cent of the world population lives in hunger and to meet food security need by 2050, food products must be increased by 70 per cent; soybean (51%), sugarcane (87%), wheat (60%), and maize (71%). Maize and wheat yields have taken a hit in some of the world's most important breadbaskets. For example, in China, maize production has decreased by 7 per cent and wheat yields in Russia have plummeted by 14 per cent. He asserted that ensuring food and nutritional security of the growing world population in an environment friendly manner is the biggest challenge to agricultural scientists and policy makers. During Green Revolution, HYVs developed through conventional breeding and the use of agrochemicals have significantly increased crop productivity that played a significant role in achieving food security. Unfortunately, a significant proportion of world population is still undernourished due to non-availability of sufficient calories and nutritional deficiencies. However, recent advances in genomics and gene-editing technologies provide hope for genetic enhancement of crops with improved resilience to climate change, higher productivity and nutritional quality with efficient conservation of natural resources. Recently, massive gene pool of agricultural as well as orphan crops has been characterized at genome level that can be exploited to develop high-yielding, nutritionally-superior and climate resilient crops. Several crops developed by introducing genes for improved agronomic characters, insect pest resistance, and enhanced nutrition are commercialized in many countries. In addition, scientists have developed a large number of genetically improved crops for various traits, which are pending for commercial release by regulatory authorities due to biosafety and ethical issues. It is a welcome step by GoI that it has recently given approval for environmental release of DMH-11 Mustard by GEAC. The door is now opened to go for GM crop now. Further, exemption from stringent GM rules to crops developed using CRISPR/Cas9-based genome editing technology falling under SDN1 and SDN2, inspire us to strengthen our efforts to develop genetically enhanced crops with desirable traits, which may be released for commercial cultivation for the benefit of farmers as well as consumers.

According to the Fifth Assessment Report of Intergovernmental Panel on Climate Change (IPCC), climate change is affecting food and farming, diminishing availability of protein, iron, and zinc. The desired traits, in general, are high

content and quality of protein, and oil, high vitamin content, low toxic substance and biofortification. Vitamin A rich crops can provide up to 50-100 per cent of daily vitamin A needs for women and children when taken regularly. In future, there is need to focus on bacterial, viral and fungal resistance, grain weight, grain size, grain number, panicle number and plant architecture, cold drought and salt tolerance, thermo-sensitive genetic male-sterility or hybrid breeding, biotic stress tolerance (cold, drought and salt), herbicide tolerance, improved crop quality, improved crop field and disease resistance using gene-editing technology. Gene-editing is a powerful tool for improving the biotic and abiotic stress tolerance, nutrition, and flavour allergenicity and agronomic traits of food crops. GM technology will play critical role in empowering farmers in feeding global population and protecting environment. There is a need for indigenous IPR protected target repository for genome-editing. Also, there is a need for long-term climate resilient research.

Dr HP Singh, Former DDG (Hort), ICAR while speaking on *Horticulture for Enhanced Nutritional Security,* apprised that the growth of horticultural crops is economically rewarding. This sector is expected to grow and contribute significantly to food and nutritional security, provided the sector is nurtured with focused infrastructure development and conducive policy environment. Fruits and vegetables are important sources of nutrients, dietary fibre, and phytochemicals. A diet rich in vegetables and fruits can lower blood pressure, reduce risk of heart disease and stroke, prevent some types of cancer, lower the risk of eye and digestive problems, and have a positive effect upon blood sugar, which can help keep good appetite. Horticultural interventions to enhance food safety at farm level combined with extensive nutrition and food safety education can offer a long-term food-based strategy to control and eliminate micronutrient malnutrition in the resource poor people. Currently, the agriculture sector is confronted with pressures of increasing population, dietary changes, depleting and degrading natural resources (agrobiodiversity, soil and water), climate change, and shortage of skilled human resources and continued fragmentation of land leading to agrarian distress. The challenges of the future are much greater than before. Hence, addressing food, nutritional and environmental security is a great concern. To achieve enhanced farm income and address malnutrition, effective planning for diversification to horticulture is needed.

The demand of horticultural produce is increasing at a very fast rate due to increasing export, demographic change, the change in food habits from predominantly cereals to a richer mix of vegetables and fruits resulting in increased consumption due to realization of nutritional and health properties. Diversification to horticulture has been a fruitful proposition to enhance the income of small and marginal farmers. The requirement of horticultural crops particularly fruits and vegetables by 2030 would reach to 550 mt, while significant development has

taken place in food availability, a lot needs to be done to achieve high production levels. A shift to Hi-tech horticulture, has become extremely important. Besides, future efforts of R&D need to focus on : i) exploitation of genetic diversity, ii) achieving self-sufficiency in seed and quality planting materials, iii) improving productivity and availability of horticultural produce, and iv) reducing cost of production. The emerging challenges of fast-growing population, shrinking land and other natural resources, the fast-eroding gene pool, some production constraints, especially of seed and planting materials, rootstocks, abiotic and biotic stresses, lack of skilled human resource and huge post-harvest losses due to absence of dedicated cold chain need to be addressed on priority.

Technical Session II : Role of Livestock and Fishery for Food & Nutrition Security

This session was co-chaired by Dr AK Srivastava, Vice Chancellor, DUVASU, Mathura and Dr JK Jena, DDG (Fishery Sciences) ICAR. Dr Amrish Kumar Tyagi, ADG (ANP), ICAR was convenor of the session. The session started with plenary lecture by Dr AK Srivastava followed by presentations by Drs JK Jena, Inderjeet Singh and BP Mishra.

Dr AK Srivastava, VC, DUVASU, Mathura in his plenary lecture on *Strategic Role of Livestock Sector for Nutritional and Environmental Security*, apprised that livestock is the most important for nutrition security. In India, around 100 out of 147 million households depend on animal husbandry as primary source of food and nutrition. Over 70 million are totally dependent on livestock for their livelihood. Out of these, 75 per cent are landless, marginal and small with average herd size of 2-8 animals. This sector is predominantly unorganized and the strength of livestock-based nutrition security depends on – constant and sustainable growth despite limited investment from public and private sector; availability of mega biodiversity and the largest population; highest milk production (210 mt) with high growth rate (6.3%); world's largest buffalo germplasm; 28-33 per cent contribution in agricultural GDP; and more equitable distribution of milch animal holding than land resources. People in drought prone regions depend more on livestock-based nutrition. In early 1970's, India's milk production was 1/3rd of US and 1/8th of European countries. Today, it is twice the US and 25 per cent more than EU. As per estimates, country's milk production would be 276 mt and 330 mt by 2028 and 2033-34, respectively (NITI Aayog). This sector supports livelihood, food and nutrition security to 80 million farmers. More than 20 million are in organized sector/cooperative. There are 0.2 million dairy cooperatives and societies. Milk provides 18 of 22 essential nutrients for humans, contains all 9 essential amino acids (AA) in high proportion; 'Milk Matrix' is the best example to understand, how so many nutrients and bioactive molecules interact to produce the overall

good effect on health, consuming milk corrects the amino acids (AA) deficiency in cereal based Indian diet; and milk whey proteins rapidly build, maintain and repair damaged muscle.

India has glorious journey of meat production with 8.14 mt in 2019-20. India is second in the world in goat meat production (12-13%), though per animal meat productivity of sheep and goat is low. Meat is the most nutrient-dense food available for human and hence meat production must increase by 6-folds. Egg production has increased from 39.1 billion in 2001 to 114.4 billion in 2020. It contains high quality proteins with all essential amino acids; and classified as 'Super food' or 'Perfect food'. Major challenges include 75 per cent emerging animal diseases are also affecting human population over last two decades, and about 80 per cent rural population is always under threat of acquiring zoonotic diseases. Out of 5 new human diseases appear every year, 3 are of animal origin; 80 per cent of microbial agents with potential bioterrorist use, are zoonotic pathogens. Of millions of enzootic viruses in animals, about 50 per cent have the potential to invade humans (SARS, MERS, Influenza, Corona). In India, livestock emit about 50 per cent of GHG emission from agriculture sector. It is also losing energy worth 2.8 crore/day due to GHGs. Livestock dung is also a source of energy, improves soil health, bioremediate environmental pollutants, source of microbial enzyme. Animal health is most important for human health, environment health and security, and also to assure food safety from farm-to-fork. As such in today's scenario, implementation of "One Health Concept" on the ground is the need of the hour.

He emphasized that greater emphasis should be given to increase the productivity of indigenous cow and buffalo by selective breeding or provide semen of selected bull to the farmers. The livestock farming is beneficial for farmers to increase their income and also help government policy i.e., double the farmers income. He informed that all breeds of cattle and buffalo in India are good source of A2 protein as compared to exotic breed of Europe and other countries. A2 protein enhances the immunity in human. Livestock is major contributor in agriculture and total GDP of country and in future also it will be continuing in national food and nutritional securities and can be explored further for modern technologies for producing indigenous products for more export and increase the income of farmers.

Dr JK Jena, DDG (Fishery Science), ICAR, stated that Fisheries and aquaculture in India during the last 70 years have made great strides in enhancing fish production, improving the livelihood security of millions of fishers/fish farmers, providing diverse avenues for entrepreneurship, and steering the sector towards vibrant and high-income avenues. During the past seven decades, fish production has registered a remarkable increase, from 0.75 mt in 1950 to 14.73 mt in 2020-21.

India is now the second largest global fish producer. The export earnings of the fishery product have reached Rs 61,445 crore (USD 7.74 billion) in 2022. The country has an ambitious target of producing 22 mt of fish by 2025. Sustainable intensification and expansion of resource base need to be the key focus for fish production increase for future food and nutrition security. The current focus on off-shore fisheries requires improved technology and investments. The contemporary farming methods such as cage culture in reservoirs and open-sea, biofloc and recirculatory systems, etc., will need higher attention. Species and system diversification with greater water and energy use efficiency; stock improvement through selective breeding, genomics and genome editing and cryo-preservation; effective disease diagnosis and control measures are some of the important R&D thrusts for enhancing production and productivity, thereby meeting the goal of nutrition security by 2030 as envisaged in SDGs. Although there have been extensive efforts over the years, the vastness of the country and increasing expectations warrants greater efforts. There is a greater focus on dissemination through aggressive training and demonstration and large-scale upscaling of the proven technologies through resource mobilization and convergence of different Departments and Ministries of Central and State Governments for achieving livelihood, food and nutrition security. Most salient points needing attention are: i) large-scale upscaling of the proven-technologies for intensification of the food fish production, ii) targeting post-harvest loss to near 0 per cent by 2030 through recycling and responsible production and consumption, and iii) networking hatcheries, entrepreneurs, markets and marketing channels through PPP mode for dreaming to move to the top position in fish production by 2035.

Dr Inderjeet Singh, Vice Chancellor, GADVASU, Ludhiana, talked on *Strategic Reorientation for Buffalo Research and Development*. He said that buffalo has been an integral part of livestock agriculture in Asia for over 5,000 years providing draught power, milk, and meat. India is the highest producer of buffalo milk amounting to 104 mt, which is about 50 per cent of the total milk produced in the country. The average milk production potential of buffaloes in India is approximately 1,400 kg as compared to 900 kg in cattle including crossbreds. India holds eighth rank by producing 4.7 mt of meat per annum. It was probably due to the enormous export potential of this commodity to the Middle East countries. There is a lot of scope for buffalo meat production in comparison to cow meat, due to its tender and low cholesterol quality. Moreover, social taboos are not attached to the buffalo slaughter unlike cow and swine. India, mainly being a dairy country, has a tremendous export potential with buffalo meat. The national breeding policy for buffalo is selective breeding of the major buffalo breeds with *Murrah* for milk, grading up of the non-descript and low producing breeds of buffaloes. Most of the states have well defined breeding policy, with the main features being in consonance with the central policy.

Buffalo has high biodiversity and is considered to have higher disease resistance, better tolerance to high hot and humidity conditions prevalent in different agro-climatic zones. These animals are also more efficient in feed conversion efficiency of crop residues and naturally available low-quality roughages. A large network of central and state government farms exists with the objectives of young bull production, their evaluation and distribution in the field for breeding with the ultimate aim of breed improvement and conservation. Some of these farms are now engaged in semen production and distribution in the state as per breeding policy. Incentives/awards initiated by some of the state Governments for cash incentives to the owners of high-quality animals are certain steps towards conservation and improvement. e.g., incentives for *Murrah* by the state government varying from ₹5,000 to ₹15,000 per lactation based on the milk yield. ICAR established ICAR-National Bureau of Animal Genetic Resources (NBAGR) at Karnal, a nodal agency to undertake activities on identification, evaluation, characterization, conservation and utilization of livestock genetic resources. The main reproductive biotechnologies – cryopreservation of semen and artificial insemination, MOET/SOET, IVM/IVF, embryo sexing, somatic cloning, embryonic and adult stem cells and transgenics- have helped in boosting milk production, improving reproduction, faster growth of elite animals and controlling diseases. The way forward requires consolidation of scattered small-holder systems into larger family farms or commercially operated farms, with mechanisation along with application of modern technologies like AI and precision farming systems for realising efficient economical production.

Dr BP Mishra, Director, ICAR-NBAGR spoke on *Capitalizing on our Animal Genetic Resources*, and covered the AnGR biodiversity, documentation and registration of animal breeds, conservation and trait characterization, etc. India possess a large animal genetic resource (AnGR) diversity, with a range of farm animal species like zebu cattle, riverine buffalo, swamp buffalo, sheep, goat, pig, horse, donkey, camel, yak, mithun, chicken, duck and geese, distributed over the vast geographical and ecological regions. There are 177 registered and Indian Gazette notified indigenous breeds of livestock and 22 of poultry, which are diverse and distinct with high genetic variability and known for their climate resilience, disease resistance and optimized production in their production system. Role of agrobiodiversity has been recognised under 12 SDGs, and SDG2: advocates to promote sustainable agriculture for achieving global food security, with Indicator 2.5.1 and 2.5.2 directly concerned to preserving AnGR diversity. New technologies of animal breeding, genomic selection and gene editing may boost the genetic potential of many breeds, along with utilizing their adaptability traits. Many native populations as well as species, well harmonized with local production system like goat, sheep, camel and yak for milk; native pig, mithun, swamp buffalo, duck, geese for meat can also be potential contributors for food security and achieving SDGs. As the way forward, use of farm animal diversity

is important for the sustainable production through actions such as: i) preserve the AnGR diversity and improve and value add for sustainably increasing its contribution in food security and healthy nutrition, ii) undertake documentation of native AnGR in the country in mission mode, iii) provide legal protection to native AnGR diversity and its uniqueness for global competitiveness and future capitalization, iv) conserve germplasm of all native breeds in next 5- 8 years for utilization in future, and v) intensify research on trait characterization for identifying unique genomic regions and biomolecules for sustainable food supply and quality nutrition to the masses and in achieving zero hunger goal.

Animal husbandry sector's contribution to national GDP and that from agriculture and allied fields has increased to 5.2 and 30 per cent, respectively, without commensurate budgetary allocations for research and development in the sector. In this sector, contribution of buffalo is quite impressive, though this has not yet attracted anticipated attention of policy makers. Buffalo's superior germplasm home-tract, resistance to prevalent and emerging diseases and superior quality of milk and meat are hallmarks of the species in dairy and animal husbandry sector. Buffalo farming practically helps in eliminating poverty and hunger, ensuring good health of masses, besides providing employment to women thus enforcing gender equality. The focus of further research has to be on developing sustainable technologies for faster and reliable genetic enhancement with reliable data generation, genomics, modern reproductive technologies, tackling seasonality, improving reproductive efficiency through research on uterine health, application of artificial intelligence for heat detection and precise timing of insemination and strategic supplementations for increased conception rates. In addition, there is need to develop efficient machinery, semen freezing protocols, pen-side tests for pregnancy diagnosis, economic feeding modules with precision feeding, methane mitigation and evolving climate resilient husbandry practices. Preventive healthcare, neonatal mortality and ethno-veterinary practices require development of vaccines, low-cost rearing protocols and validation. Efficient technologies for waste management are relegated though utmost important for environmental sustainability. The drastically declining budgetary allocation to animal science research in the country will thwart progress made so far and compromise development of overall animal husbandry sector and hence needs to be addressed.

Technical Session III : Harnessing Innovation to Address SDGs

This session was co-chaired by Dr Renu Swarup, Former Secretary, DBT, New Delhi and Dr JK Jena, DDG (Fishery Sciences), ICAR. Dr Sunil Archak, National Fellow, ICAR-NBPGR New Delhi was convenor of the session. The session started with plenary lecture by Dr Rajeev Varshney followed by presentations by Drs Ram Kaundinya, ML Jat and AK Singh.

Dr Rajeev Varshney, Director, CCFI & SABC, Murdoch University, Australia talked on *Harnessing Genome Editing and Gene Pyramiding*. Crop improvement offers sustainable solutions for food production in the form of high-yielding, nutritious crops that can withstand various biotic and abiotic stresses. It has now become possible to decode genomes and assemble gene repertoire almost for every crop species. Innovative trait mapping approaches have identified genes of interest for agronomic traits of interest in many crop species. Genomics-assisted breeding approaches including marker-assisted selection and gene pyramiding were used to develop better varieties in several crops. In parallel, genetic engineering approaches were also successful in developing crops that have resistance to insect damage, tolerance to herbicides and resistance to plant viruses.

Novel genomics-assisted breeding approaches such as haplotype-based breeding and genomic selection will be useful to introgress superior haplotypes for agronomic and nutritional traits. Similarly with advances in genomics and molecular biology, it is possible now to identify the causal genes and also bases in genes affecting the trait. With conducive policy environments for gene-editing in several countries including in India, gene-editing approaches are expected to deliver the next generation crops with higher yield, better nutrition, and resistance/ tolerance to insect damage, herbicides as well as fungal/bacterial/viral diseases. Delivery of such improved crops will also minimize use of pesticides, and herbicides. Use of herbicide-tolerant crops will facilitate no-till planting to maintain soil health and lower fuel and labour use. The biotechnology approaches will thus contribute to ensure food, nutrition, economic and environmental security.

Lastly, he recommended that there is need to provide dedicated funds in plant science especially for genomics and systems biology to identify causal genes and superior haplotypes; to move towards designer soil microbiome for harvesting optimum yield and nutrition. Further, there is need to be pro-active in germplasm sequencing and analysis for accelerating haplotype-based breeding and genomic prediction approaches. For gene-editing, there is need to focus on some key issues, e.g., genetically enhanced somatic embryo development and plant regeneration, increase gene delivery titer and efficiency, develop transgene landing-site technology, improve homologous recombination efficiency, targeted mutagenesis or allele replacement with no trace of transgene, thus harnessing full potential of gene-editing to build scale neutral technology- the seed that can facilitate climate resilience, enhanced nutrition and save environment. Since technology is proven, GoI's guidelines/SoPs is required to be in place. Also, there is need to prioritize crops/traits and approach combination, and ensure that the product reaches the farmers.Rapid delivery system needs to be established/strengthened for ensuring delivery of improved varieties, better agronomic practices, and mechanization required for harvesting higher produce. There is dire need to farmers' access to

better markets, value-addition, and food processing for more income to farmers and deliver better products to consumers. International partnership needs to be strengthened to learn from each other and get priority access on useful technologies.

Dr Ram Kaundinya, DG, FSII, spoke on *Protecting Innovations in Improving Food and Nutrition Security*. He asserted that research and innovation is critical for achieving food, nutrition security and SDGs. Protecting innovations through legal and administrative means is important to encourage investments into research and innovation – in both public and private sectors – unless it is created as a public good with free access. New crop protection products, plant nutrition products, biological products, seed varieties, biotech traits, planting materials, digital services, custom services, and satellite data-based services need protection. Innovation in products, processes, services, business models, algorithms, and data generated could be possible because of investments, manpower and intellectual efforts over many years – farmers derive the maximum benefit from these innovations in agri-inputs – leads to creation of value for the society and for the economy. Research investments in India are below 1 per cent of Agricultural GVA. Further, he said that SDGs 2, 3 and 12 represent the target which the world has taken up to ensure zero hunger, healthand well-being for all and responsible consumption and production. All three of them add up to ensuring food security and good nutritious food for the entire population, influencing dietary habits to consume healthy food thereby aligning agriculture towards sustainable production systems. Increasing yields and producing nutrition rich biofortified crops are critical elements of this target. These sub-targets cannot be achieved unless we bring research and innovation in a big way in agriculture as envisaged in SDG 9 that refers to industry, innovation and infrastructure. Agricultural research is to be strengthened across the globe in a big way to meet SDGs.

Significant investments will enhance developing new technologies and products that can transform our food systems in a sustainable way. The research investments, public or private, must produce return on investment (RoI). But, commercial models that do not reward research and innovation do not encourage investments in this critical area. Protecting innovations from unauthorised copying, misuse and abuse is essential not only to ensure proper returns to the investor but also to make the innovation add value to the customer over a long period of time. Patents and Plant Variety Protection are legal methods of protecting technologies, products and seeds for a certain period of time. All innovations in plant biotechnology and plant breeding have to be delivered through seed. Hence, protecting seed from piracy is a very important element in attracting investments into innovation in this area. Multiple methods to improve protection of innovations in agriculture are possible. Firstly, there is a need to improve awareness among all stakeholders including farmers, common consumers, law enforcement agencies and others about

intellectual property in seeds, biotechnology and other agricultural inputs, their long-term benefits to both farmers and consumers, how to identify original innovation, the applicable laws and how to enforce them. Secondly, swift disposal of cases at lower courts is to be ensured. Thirdly, public education on the need for protecting innovation in agriculture is important because of the misconception that protection of innovation is anti-farmer. High impact innovations cause creative change in existing systems. Government policy must support such disruptive innovations. Innovations delivering benefit to farmers, consumers and environment create added economic value in the system which eventually leads to growth and prosperity for the country. Innovations are generally lost in agri-input industries due to: i) rampant stealing of products (breeding material from research programs, parent seeds from production fields, and bulk seed from production fields); ii) difficult to protect OP varieties, planting materials, traits – easy to copy or steal (e.g. HtBt); iii) copying of crop protection and crop nutrition products and also biological products; iv) fake and spurious products (product and trade mark) violations; and v) hacking of digital systems and algorithms. These need to be protected through enforcement of IP laws.

Innovation is the lifeline of S&T which needs to be nurtured and protected for delivering the best benefits to society. There is need to: i) create awareness about details of innovations and IP in agriculture and legal provisions for protection among stakeholders including general public; ii) capacity building programs among government and police officers to identify infringements and to take appropriate action under the law; iii) special IP benches at district level courts to quickly dispose of cases of infringement; iv) award of IP registrations should be a time bound process - efficient and trust building; v) ambiguity between PPV&FR Act and Indian Patent Act regarding protection of traits in plants to be removed urgently; vi) promote market driven research and innovation in both public and private sectors; vii) recognize and reward high impact innovations including grass root level innovation; viii) incorporate courses at undergraduate level covering innovation, IP laws and protection of IP and ethics in doing business; and ix) political will is needed at Centre and States levels to protect innovation and IP in agriculture

Dr ML Jat, Global Research Program Director, Resilient Farms and Food Systems Program, ICRISAT, while presenting the on *Scaling Regenerative Agriculture for Food and Nutrition Security*, informed that growing climate crisis, rapidly degenerating soils, eroding agrobiodiversity and highly volatile markets have raised concerns for achieving the SDGs. The climate change has already slowed down the agricultural productivity growth by 21 per cent in the past 50 years. The climate risks in the recent past led to significant yield losses, e.g. heat wave 2022. This has posed a serious threat to food and nutrition security and livelihoods of billions. Therefore,

agri-food systems require systemic solutions packaging climate-smart, regenerative and profitable innovations.

Sustainable intensification, regenerating soils, building resilience through low-emission, and nutrition-sensitive innovations and strategies in smallholder agriculture are critical for ensuring food and nutrition security and improved livelihoods. However, this would require holistic approaches combining genetic innovations, soil, climate and resource informed designing of cropping/farming systems, integrated and efficient use of production input considering soil-crop microbiome interactions, and adaptive measures to climate shocks, market inclusivity and ecosystem services. There is a need to focus on trans-disciplinary multi-stakeholder innovations combined with knowledge intensification to build climate safety nets for improved well-being of smallholder farmers and rural poor communities. Regenerative agriculture (RA), in recent past has increasingly been advocated by the civil society, agribusiness, farmers, NGOs, researchers and policy planners. Therefore, we need to evolve science evidence based robust strategy for scaling RA towards sustainable food and nutritional security and other key SDGs. Most agricultural R&D has been component-focused, which often limits scaling and the potential for impact at scale. Scaling RA for impact at scale would need multi-pronged approaches and strategies as: i) a tailored approach for implementation of RA practices keeping in view the large diversity of farms, farming systems, farmer circumstances and take-off points across the diversity, ii) mapping of crop types and cropping systems for defining input-value chains, market linkages and knowledge hubs for scaling RA, iii) targeted bundled system solutions for investment priorities and adoption of RA, iv) integrate well tested practices of RA to build the confidence of stakeholders specially farmers based on success stories/learnings, constraints and opportunities on RA, v) imitate strategic research on ecological plant protection, rhizosphere microbiome effects of nutrient cycling, capture and release, plant uptake and produce quality, vi) approaches, tools, protocols, verification and enabling policies needed for mainstreaming RA in the R&D plans for accelerated adoption, vii) use digital tools and techniques in bridging the knowledge gaps, viii) develop a new cadre of RA-Community of Practitioners (RA-CoP) through inclusion of RA in course curriculum, development of inclusive training modules, hands-on training and certification courses on RA, and ix) define business models and market opportunities to identify potential niche for scaling and accelerated adoption of RA.

Dr AK Singh, DDG (Extension), ICAR, while speaking on *Innovations in Agricultural Extension for Production Sustainability,* mentioned that the country experienced less production of wheat in *rabi* 2021-22 (due to terminal heat), area under paddy reduced in current *kharif* in eastern and central India (deficit rainfall), stunted paddy in Punjab, Haryana and Uttarakhand (due to Southern Rice Dwarf Streak

Disease), FAW incidence in *kharif* maize, demand of diversification, nature positive agriculture, precision agriculture; mustard area increased in *rabi* 2021; enhanced production and productivity of pulses and oilseeds; and continued production gains in foodgrains and horticultural crops. He further expressed that India currently attained self-sufficiency in pulses, as area (mha), production (mt) and yield (kg/ha) increased by 19.7, 55.8, and 30.2 per cent, respectively, as compared to 2015-16. There is a need for increasing production of oilseeds by 50 per cent from 359.5 lakh tons in 2020-21 to 541.0 lakh tons in 2025-26. There is a need to focus on cultivation of mustard, soybean, and groundnut. To increase edible oil production from 10.53 mt to 18.00 mt by 2025-26 from all sources including oilseeds and oil palm can reduce imports from 60 to 40 per cent by 2025-26. Under Nutri-sensitive Agricultural Research and Innovations (NARI) Scheme of ICAR for integrated gender and nutrition, greater thrust needs to be given on: i) promotion of biofortified varieties (over 70); ii) mapping of indigenous regional foods available and prescribing local food-based recipes (*Nutri Thali*), *Nutri Garden*- growing nutri-foods at the backyard, and iii) capacity development of *Anganwadi* workers. The scheme was piloted in Madhya Pradesh and Chhattisgarh in 76 KVKs and 450 model farms, and the target was kept at 100 nutri- smart villages by 2022.

He further apprised that paddy-wheat cropping system replaced almost all other crops in NWPZ; annual groundwater withdrawal in Haryana by 137 per cent of its extractable groundwater resources- resulted in 6-7 times increase in paddy cultivation in Haryana post green revolution. *Mera Pani Meri Virasat* (MPMV) Scheme was launched in 2020 to incentivize for diversification from paddy to alternative less water intensive crops (maize, cotton, pearl millet, pulses, fruits and vegetables). About 1.16 lakh acre during *kharif* 2020 and 2021 diversified from paddy to alternate crops, provided incentives to 74,133 farmers. Market-driven crop diversifications schemes (Madhya Pradesh) are being implemented (organic vegetables, medicinal plants) in 1.86 lakh acre. Mustard area doubled in three years (12.33 lakh ha). Concern of production system is climate change affecting the area and yields of various crops. There is also a growing demand to diversity for edible oils, pulses, cotton and other products. The unique set-up of *Krishi Vigyan Kendras* (KVKs) started in 1974 has proved one of its kind and the only gateway of frontline technologies in the district. So far, the ICAR has established 732 KVKs across the country and these KVKs are engaged in much complex deliverables related to climate change, nutri-sensitive agriculture, resource conservation, special drives for disadvantaged and aspirational districts in India and other focused area programs.

The ICAR initiative on climate resilient agriculture (CRA) was scaled up from 121 villages in 2018 to 446 villages in 2021. Total climate resilient practices tailored to context and location specific situation under four modules were demonstrated by 121 KVKs. Custom hiring centres (CHCs), seed and fodder banks, district level contingency plans were also some of the prominent models, which

were successfully developed and implemented. agro-met advisories and alerts were also made part of the regular advisories. A new model was established in collaboration with CSISA-CIMMYT to create a database through concurrent feedback. Farmer producer organization (FPO) is another model for collective farming and collective marketing to ensure the much-needed bargaining edge to farmers with input dealers for remunerative price of their produce. Nutrition based expansion needs to be created through awareness and capacity development of various stakeholders, development of value chain, literacy campaign, etc. Digital application in agriculture needs to be promoted. ICAR launched the System of Agri-Information Resources Auto-transmission and Technology Hub Interface (SARATHI). The *Kisan SARATHI* is an interactive digital platform to facilitate farmers to get right information at right time in their desired language to help farmers and empower them for personalized advisory, live interaction in local language with domain expert; avail facility to register through toll free and Mobile App (*Kisan* 2.0) which provides direct interface to farmers. The structural framework of the extension system needs to be strengthened to fulfil its ever-enlarging scope. Policy support in the context of enhancing resource use efficiency, food and nutrition security, diversification, precision farming and application of drone and other modern technology in agriculture are also essential with a strong extension intervention. Extension needs to focus on national priorities including precision farming (using sensor based and drone technology), bridging yield gaps (technology and extension), ensuring sustainability in production system and minimizing natural resource degradation (soil, water, agrobiodiversity, etc.) promotion of cooperative/group farming and marketing through FPOs, promotion and handholding of youth led agri-startups, climate change adaptation and mitigation, nutrition and biofortification for ensuring production sustainability.

He recommended for proper need assessment; ascertaining yield gaps; working of multi- department and - multi-institution simultaneously; research and scaling-up; need for farmers' participatory approach for agricultural development through technology centric extension; food system and ecosystem approach to be remunerative and sustainable agriculture; need for climate resilient agriculture, digitization and long-term forecasting; and energy-efficient agricultural technologies for empowering small farmers. There is need for convergence between departments and organisations for effective implementation of schemes and programs; large scale public awareness; and faster technology dissemination.

PANEL DISCUSSION

Agricultural Research and Innovation for Development (ARI4D)

The session was co-chaired by Dr RS Paroda, Chairman, TAAS and Dr RB Singh, Former President, NAAS New Delhi. Dr Anuradha Agrawal, National Coordinator,

NAHEP, ICAR New Delhi, was convenor of the session. There were 13 panelists who presented their views on agricultural research and innovation for development (ARI4D).

Dr Renu Swarup, Former Secretary, Department of Biotechnology (DBT), expressed that from zero hunger to combating climate change to conserving water, land and natural resources, it is important that there is a special focus on new technology deployment for bringing in a transformational change. The next agricultural revolution must be with science and technology at its core. Agriculture development must look at both the demand as well as the value chain/supply sides of the food-scarcity equation, using technology to improve and address the real needs of consumers and reengineer the value chain to meet the desired goals. It is now important to identify the new technologies, processes and products, which are either ready or in late-stage development and can make a huge impact not just on the agriculture development but also on the overall nutritional and livelihood status of human kind. A complete holistic view needs to be taken for addressing the priorities of plants, animals, and aquaculture. It is imperative that we identify innovative technologies and processes and work on innovative models of program implementation, governance and effective delivery. Some recent advances in technology development which have still not been deployed as per their full potential are: transgenics, marker assisted selection, gene-editing, and metabolomics. In fact, there is a need for urgent attention on the whole omics area of proteomics, genomics etc., speed breeding, nano-technology and precision farming, which includes the use of information technology, drones, AI, IoT, sensors and others. Enhanced nutritional security is to be achieved through various new technology development initiatives. The focus has to be on the minimum input and the maximum output. A pool of new technologies is now available, and what we need is a clear action plan for the way forward not just for deployment of these technologies for maximizing the returns, but also for developing innovative, novel need-based implementation and execution models involving all stakeholders.

The principle of the 3 Ps (policy, program and people) needs immediate attention for adoption. There is an urgent need for focusing on the right policies, which provide an enabling ecosystem for innovation to thrive and scale, and the right policies can be effective with the right set of programs. Learnings from the recent response to COVID-19 would be very helpful since agriculture also needs a special focused attention if we have to achieve our targets and meet domestic and global demands. The regulatory framework requires special attention to ensure that a clear regulatory pathway is outlined for all new technologies. Policy guidelines need to be clearly framed for – enabling technology licensing, both technology acquisition and technology transfer, which will allow smooth technology licensing between academia, industry, start-ups both at national and

global level; and also, for academia, industry partnership and allowing academic researchers to set- up spin outs. The existing approved guidelines for the Ministry of Science & Technology (MoS&T) need to be taken-up for other departments / organizations for promoting the entrepreneurial ecosystem. The efforts to bring about modifications in the Biodiversity Act, need to be expedited keeping in view the recent developments in policy allowing industry and start- up engagement with academia to develop new technology and translate innovate research to affordable products. For achieving success and accomplishing the goals we need strong teams of well-trained human resource. The focus has to be on building skilled quality teams and the right leadership in the programs on graduate, postgraduate, doctoral and post-doctoral trainings for better impact delivery. Special training initiatives need to be launched to make our researchers industry employable, and the knowledge on new and disruptive technology and required tools and platforms to be imparted. Specialized centres of excellence (CoE) and technology advancement centres (TAC) need to be established involving Central Institutes, State Agricultural Universities (SAUs), research labs in both public and private sectors and also with international partnership through bilateral and multilateral initiatives. These centres should focus on capacity building and adoption of new and emerging technologies to ensure that the country has the best talent and this can take up the latest technological advances for addressing our priorities. A clear road map with a well-articulated action plan and implementation strategy is the Way Forward to have a technologically-empowered nation and meet the challenges to achieve the targets of SDGs.

Dr Kadambot Siddique, Director, Institute of Agriculture, University of Western Australia (UWA) expressed that agricultural productivity in India is below its potential. Some of the constraints include limited use of modern farming methods, volatility of weather, weaker agricultural support services, lack of market-oriented production systems and fragmented and small farm size. Feeding a growing Indian population and ensuring food and nutritional security in future thus becomes a daunting challenge, especially with climate change. Indian agriculture sector needs to advance from traditional system (labour-intensive) to modern agribusiness systems (capital and technology intensive). Adoption and scaling of new technologies and innovations through an enabling policy environment, with inclusiveness of all stakeholders, can accelerate agricultural growth in India. New and exciting opportunities exist for harnessing science for new gains with precision agriculture, biotechnology, sensor technology, bioinformatics, climate-smart agriculture (CSA), robotics, drones, big data management, AI and soil health and biology. Climate change and growing population are challenging the agri-food sectors to meet society's food demand while sustaining the environment and natural resources. Social, economic, and environmental sustainability are closely intertwined and the necessary component for truly sustainable food systems. We need to work

together towards more sustainable, solution-oriented and innovative technologies (including capacity building) and policies. The networks need to be turned into communities of practices that share, multiply, expand and scale knowledge. We also need to look at selected case studies in India to develop a model that can assist in decision-making about intervention design and investments in agricultural innovation. Different processes, which together determine the capacity to innovate, need to be considered, both to realise impact at scale during the lifespan of an agricultural development intervention and to improve the capacity to innovate. Investment and market forces are accelerating our journey towards a sustainable future. The greatest dividend from sustainable practices will always be the creation of resilient farming and agribusiness. However, there is increasing opportunity for additional reward if evidence of sustainability outcomes can be provided to stakeholders. Farmers need to be aware of the requirements for sustainability reporting and develop the capability and capacity to do so if that additional opportunity is to be captured.

Some areas needing focused attention are: i) improving food and nutrition security and protecting natural resources; ii) increasing environmental sustainability and promoting sustainable intensification technologies and practices; iii) bringing circularity in the agriculture value-chain; iv) tools and technologies for emission reduction and climate change adaptation strategies; v) tools and technologies to guide farm decision; vi) gender and generation balance in the agri-food sector; and vii) innovations in capacity building in the agricultural higher education and vocational training sectors.

Dr SK Vasal, Former Distinguished Scientist, CIMMYT, expressed that in the wake of continuing population growth, livestock revolution and numerous challenges facing agriculture especially climate change, there is an increasing recognition regarding the importance of food and nutrition security in a sustainable manner without adversely affecting the resource soil base. We have huge challenges in designing appropriate breeding strategies together with new modern biological tools to address the new emerging problems. Equally important is to design instant strategies to solve these problems. For this, it is important to diversify crops which contribute to global food basket. In the second half of 20th century, scientists have exerted in an unprecedented manner to bring about a succession of landmark achievements beginning with hybrid corn in the US, wheat and rice bringing Green Revolution in Asia, the livestock revolution, and currently the biotechnology revolution, which is an exciting and most dramatic revolution of our times.

To surmount 21st century challenges, it is imperative that our breeding programs must use broad-based highly diverse germplasm. Additionally, for every crop an appropriate germplasm management system needs to be developed

for better germplasm flow and to maximize use and introgression of genebank accessions. For hybrid crops, we should have the knowledge of heterotic groups and patterns. Also, as part of inbred-hybrid technology, new and better heterotic groups be developed both for normal and nutritionally enhanced materials. We must strategize to do more with less through statistical designs, evaluating more lines for making hybrids and simplifying field operations that are cost-effective, less laborious and completely error proof. There is need to develop multiplier effect strategies to foster and strengthen public–private partnership by way of developing and distributing semi-finished products applicable to both self-fertilized and cross-pollinated crops. Time jumping strategies need to be introduced to reduce the breeding cycle by DH technology and through conscious efforts to identify tester lines from different patterns, which will be involved as a parent of hybrid. Hybrid technology provides opportunity to develop special trait populations for agronomic traits as well as for biotic and abiotic stresses. Indirect strategies should also be deployed to find solutions to most complex problems such as stay green trait, tolerance for foliar diseases and good standing ability for various types of stalk rots. Power of testing and evaluation should be fully utilized to find stable genotypes and for reaction to biotic and environmental stresses. Quest for unstoppable genetic gains through either incremental or quantum jump methodologies be continued through teamwork in an interdisciplinary mode by adopting strategies that are solution-oriented and multi-purpose. Modern biological technologies need to be blended with conventional technologies as and when feasible.

Dr Vibha Dhawan, Director General, TERI, highlighted that India's population is increasing and is expected to reach 1.51 billion by 2030, making food and nutrition security the country's most pressing challenge. Simultaneously, climate change and its negative impact on crop productivity is now a reality, thus posing new challenges for sustainable agriculture. As a result, India has the highest number of severely malnourished children under the age of five, while 14 per cent of the population is undernourished. Besides, 51.4 per cent of women of reproductive age between 15 and 49 years are anaemic and need proper care and nutritious food. Given these facts, it is critical to develop climate-resilient crop varieties that are high-yielding and have multiple disease resistance. Furthermore, instead of monoculture, farmers should diversify their farming by cultivating local landraces and underutilised crops, which are not only tolerant to different stresses but also lead to future food and nutrition security. Crop biodiversity, an important component of biological diversity, has a crucial role in sustaining and strengthening the food and nutrition security. In the course of genetic improvement, yield levels of most staple crops have reached a plateau due to the narrow genetic base in these crops. To widen the genetic base for further improvement, there is a need to collect, characterize and conserve crop

biodiversity particularly local landraces and wild species. Sustainability goals such as zero poverty and zero hunger are interconnected because agriculture employs over half of the Indian working population and contributes 17-18 per cent of the country's GDP. As a result, the adoption of fortified crops, smart agriculture inputs such as nano-fertilizers and nano-pesticides, as well as biofertilizers could increase agriculture productivity and farmer's income, resulting in elimination of micronutrient deficiencies and the availability of food for all. This would obviously necessitate infusing more funds for agricultural research, innovation and development. Additionally, deliberate efforts are required to leverage disruptive innovations such as precision farming, hybrid technology, genome-editing for crop improvement, speed breeding, conservation agriculture, protected cultivation, bioenergy/ biofuel crops, biofortified crops, pricing policy, and increased use of information technologies for the promotion and sales of agricultural produce.

There is an urgent need to promote demand-driven technology to meet the challenges of increasing demand for food, and improved livelihood opportunities to accomplish sustainable farming for wider agricultural growth. Accelerated growth in staple crops, horticulture, livestock, dairy, poultry and fishery sectors leading to nutritionally rich food for health, and environmental security for all by 2030 is need of the hour. At TERI, our innovative technologies are aligned with the Government of India mission to support farmers and agriculture productivity through our multipronged efforts towards improving soil and plant health, agriculture, and environment sustainability.

Dr Keegan Kautzky, Senior Director, Global Youth Program and Partnership, WFPF mentioned that over the past 30 years, the proportion of the world's people who are hungry has dropped from 34 per cent to 12 per cent. In India, total foodgrain production increased from 198 to 316.0 mt over the last 20 years, and the undernourished population declined from 21.6 per cent to 16.3 per cent, with 23.5 million fewer undernourished people and 16.2 million fewer stunted children. These extraordinary achievements are rooted in key agricultural advances and critical investments to advance healthy, sustainable, equitable, resilient food systems. The World Food Prize – the premier global award for food and agriculture recognizes the breakthrough innovations and innovators in agriculture, nutrition, health, development and humanitarian assistance that have enabled large numbers of people to escape hunger. Fifty-one laureates have been recognized with the World Food Prize since its inception in 1986 and notably, 8 of these laureates are from India. Tragically, COVID-19, climate change and conflict have begun to turn back the clock on this progress - with over 800 million now hungry or malnourished globally, and 224 million in India alone - undermining our ability to alleviate hunger and achieve the SDGs by 2030. COVID-19 has led directly to 6.5 million reported deaths, and millions more have died from the increased hunger, malnutrition and poverty caused by COVID-19 related economic disruptions. Even

before the pandemic began, climate change was disrupting the business of growing food (and income) for the world's increasing population. Conflict in Asia, Africa, Latin America and now in Europe is exacerbating these negative trends, driving up the price of food and energy, blocking trade in farming inputs and outputs, isolating vulnerable populations, and generating huge increases in refugee flows. Underlying inequities in development and food systems exacerbate the impacts of all three factors for the world's poor. Recent projections by International Food Policy Research Institute (IFPRI) warn that declines in agricultural production and disruptions to the food supply-chain in India could decrease food production by 16 per cent, resulting in a 23 per cent increase in hunger, and over 70 million at risk of food insecurity nationwide by 2030. We are not on track to achieve the SDGs and the 2030 Agenda. In response, the World Food Prize Laureates called on global leaders earlier this year to leverage investments and food systems innovations to tackle global hunger, and collectively and comprehensively address the triple threat of COVID-19, climate change, and conflict.

In India, this requires decisive, bold action and investments in key agricultural innovations critical to achieving healthy, sustainable, equitable, resilient food systems by 2030, including: i) scaling-up sustainable agriculture systems and conservation agriculture practices that enable higher crop yields and household incomes, while requiring less agrochemicals, land, water and energy, ii) critical investments in carbon sequestration and soil-centric solutions, iii) climate-resilient crops able to withstand our increasingly erratic weather conditions, and new and evolving diseases and pests' threats, iv) improving the nutritional value of our food and advancing breakthroughs in biofortification to address the macro and micronutrient deficiencies, v) better seed technologies, increased biodiversity, promising new innovations in microbial seed coating and soil enhancement, and improvements in the local and global seed trade, vi) advances in aquatic foods, aquaculture and fish farming for improved nutrition and health, gender-empowerment, more resilient ecosystems, greater agricultural biodiversity and dietary diversification, and improved livelihoods, vii) improved access and management of water resources with farmer-focused solutions, viii) innovation in information and communication technologies driving a digital revolution in real-time access to information, and dynamic new ways to empower farmers, ix) improved access to agricultural financing and credit, and advancement of innovative models of microfinance, training, and social support systems, x) strong community-based agricultural research and development, building the capacity of local farmers and families, and prioritizing the most vulnerable populations, and xi) empowering the next generation of agricultural and food leaders, improving the talent pipeline, and preparing the innovators and entrepreneurs for the work force of the future.

The proven success of each of each of these innovations provides a clear pathway to progress. Most importantly, we must remain focused on the farmer. Dr Varghese Kurian, the Father of the White Revolution, transformed India's dairy industry, making India the largest milk producing country in the world, by giving power to the food producers and processors. Dr Norman Borlaug reminded us of this truth with his final words "Take it to the farmer". It is one of the great lessons of the Green Revolution and the agricultural advances in India of the 20th Century. Smallholder farmers and food producers are the first and most important stakeholder in solving food insecurity and achieving the sustainable development goals.

Dr Prabhu Pingali, Founder Director, TCI emphasised about the challenges for agricultural development and food security improvement. We have been largely successful in addressing calorie hunger through increased supplies and access to food grains, particularly rice, wheat, and maize. However, we made limited progress in addressing hidden hunger caused by inadequate access to protein and micronutrient-rich foods. Transforming food systems to enhance the supply of diversity and nutrient quality is the dominant challenge for India's food systems today.

A priority food systems-policy-agenda for better nutrition outcomes include the need for promoting food system diversity. Creating a level policy playing field would help improve the incentives for diversification of production into non-staple foods. A crop-neutral policy allows farmers to make crop production choices. Investments in road and transport infrastructure and cold storage systems are required for developing markets for perishable products and investments in market information systems especially through cell phones, could significantly cut transactions costs for market participation. Closing the gender gap in technology access directly contributes to increasing productivity and enhancing women's empowerment. Policies promoting food safety should be a priority for upgrading traditional markets and ensuring that human health is safeguarded. Specialized training for farmers in meeting quality and safety standards would help integrate smallholders into market value chains. Also, formalized contracts and access to finance are essential for diversifying production systems. R&D is essential for enhancing food and nutrition security*:* Continued high levels of investments are needed to enhance the productivity of the major staple grains (rice, wheat, and maize) to meet their rising demand due to population and income growth. Additionally, productivity gains in traditional staples, such as millets, sorghum, and pulses need to be focused to improve the diversity of diets and essential micronutrient availability. Such investments could provide new opportunities for growth in the marginal production environments and enhance the supply and accessibility of micronutrient-rich food to the rural poor. These crops can also help make the food system climate-resilient. Biofortification of staple and non-staple

food can be a sustainable means to reduce immediate concerns of micronutrient deficiency. Essential micronutrients, such as iron, zinc, and vitamin A, can be accessed through biofortified foods cost-effectively. Policies for enhancing agricultural productivity, nutrition, health, and environmental sustainability are often made by different ministries with little scope for maximizing synergies across them. Policy convergence across ministries is essential for ensuring food and nutrition security and for achieving the SDGs. Convergence is also needed between central and state level policies that impact agriculture, food and nutrition.

Dr HS Gupta, Chairman, Assam Agriculture Commission, Government of Assam, highlighted that the challenge to feed the burgeoning world population of 8.6 billion and India's 1.51 billion in the year 2030 amidst declining per capita availability of arable land, fast eroding natural resources, looming threat of climate change and diminishing investment in agricultural research, innovation and development (especially in India) appear to be insurmountable, but the success of Green Revolution of 1960s lends support in assuring of our success if a concerted effort is made globally in general and India in particular.

He flagged some of the issues that are likely to ensure desired increase in production and productivity of nutritious food while maintaining natural resources base in a sustainable manner. These include: i) improved technology needs to be made available to end users. Success of GM crops all over world in increasing production and productivity of many crops is well-known, yet India did not approve any other GM crops after Bt cotton although no adverse impact has been reported so far. Fortunately, Government of India has permitted the use of gene-edited crops and recently the environmental release of GM mustard hybrid and we must exploit the potential of GM technology for the benefit of our farmers; ii) The policymakers have decided to promote Natural Farming without any scientific validation and with financial allocation of hundreds of crores though there is dearth of funds for agricultural research. Of late, the proposal is to bring 15 per cent of the country's cultivate land under natural farming by 2030 and extend it to 30 per cent 2050. There is urgent need for scientific community to convince the government about the right step forward for ensuring food security; iii) India's investment in agricultural R&D and extension is very low (0.5% of GDP) which needs to be enhanced to at least 1.0 per cent of agricultural GDP urgently. We should strive to make amendments in Green Revolution technology by coupling it with conservation and regenerative agriculture, etc., to reduce the erosion of natural resource base and allow farmers to choose the technology like use of genetically engineered crops to increase production and productivity of nutritious crops, and help in combating biotic and abiotic stresses.

Dr Mruthyunjaya, Former National Director, NAIP expressed that by 2030, India will be free of poverty, hunger and malnutrition, and become an environmentally

safe country and craft a way forward. The SDG 17 emphasizes the importance of building strong partnerships for future successes. Global agri-food system is massively disrupted owing to challenges of climate change, recurring environmental disasters, human sufferings due to COVID-19 pandemic, increasing global trade restrictions, fast depleting and degrading natural resources, several global commitments, persisting poverty, hunger and malnutrition, frequent geo-political tensions, continuing structural barriers, etc. It is also true that India has a potential to unlock economic value of $50-65 billion through digital agriculture by 2025. These challenges and unlimited opportunities have put enormous pressure on agriculture-focused countries like India to explore more sustainable options leveraging technology mediated inter-institutional and multi-organizational partnership at local, national, regional and global level.

The Indian Green Revolution was an outstanding example of partnership between ICAR institutions and CGIAR Centres like CIMMYT and IRRI. More recently, partnership in the form of consortium of ICAR institutions with State Agricultural Universities (SAUs), Private Sector, NGOs, Central Institutes, State Institutes, and International Institutes, has paid rich dividend under National Agricultural Innovation Project (NAIP). Concerted efforts have been made to promote partnership but with mixed results largely on account of lack of trust, not ready to forgo super profit, needed incentives, inflexible rules and procedures, inordinate delay in decision making by the Government which is unacceptable. Since partnership is very vital for achieving sustainable agricultural development, our foremost overarching recommendation is urgently overcoming the above bottlenecks at the earliest. We further recommend harnessing an ideal public-private partnership (ecosystem) model with partners. Harnessing public-private partnership ecosystem consists of Government, agri-start-ups, FOs/FPOs/FPCs/SHGs/NGOs, academia and research institutions and the private sector. In this ecosystem, the different sectors will contribute as follows: data sets, field resources, policy and governance, and financial support; agri-start-ups, emerging technical innovations, digital and high-tech services and agility and business model innovations; FPOs/NGOs, contribute to farmers (including women and youth) awareness, cooperative structure, capacity building and implementation support; academia and research institutions, domain expertise, collaborative research, validation and quantification of digital services; and private sector, investment, technology/IPs, distribution system, research and design.

Dr Arvind Kumar, DDG (Research), ICRISAT emphasised that ICRISAT's mission is to reduce poverty, malnutrition and environmental degradation in the drylands of Asia and sub-Saharan Africa. These mission goals are well aligned to the SDGs, wherein time is running out with just eight years left to achieve these. With the COVID-19 disruption in dryland agriculture slowly becoming manageable; climate change is posing a bigger threat to the food and national security and environmental

sustainability. Right now, the world is on a trajectory for catastrophe with the way the increase in temperature has started affecting agriculture adversely. The World Health Organization (WHO) estimates that climate change will adversely affect our health. The poorest are being hit the hardest over the last decade with floods, droughts, and storms affecting 15 times the number of people in low-income coastal countries as compared to wealthier coastal countries. In a 3-degree warmer world, those living in Africa, South Asia, and elsewhere will be affected more with hunger. Yields of essential crops like millets, pulses and oilseeds will be reduced as growing seasons shift, temperatures rise, and floods and droughts becoming more frequent. In addition, livestock and fisheries will have adverse effect due to heat stress, shifting, and declining stocks, and extinction. To meet these challenges, ICRISAT has repositioned its programs, reconceptualised the partnerships, revitalized its voice, and rethought how it will support the farmers and other stakeholders in the value-chain. ICRISAT and its partners advanced the innovative work with new resources, tools, and products, to achieve inclusive, sustainable growth across Asia and sub-Saharan Africa.

Some of the interventions ICRISAT has co-designed with partners' support to meet the challenges that serve as a road map for achieving the SDGs are: i) assessing the current and future needs of markets and designing product and technology interventions to meet the market needs; ii) modernizing the NARS breeding programs on cereals, millets, pulses, and oilseeds to develop high-yielding, climate-resilient, and nutritious varieties; iii) supporting deployment of novel phenomics and genomics tools, data-driven decisions in product development for achieving higher genetic gain; iv) develop context- seed systems to improve seed replacement rate (SRR) and varietal replacement rate (VRR); deploy digital seed corridors for seed quality and traceability, v) assessing soil health and providing sustainable nutrient management solutions towards regenerative agriculture, vi) providing water budget-based cropping systems and digital extension services, vii) efficiently utilizing the potential of rice fallows with innovative crop, NRM and climate-smart farming options, viii) innovative cropping systems development to suit specific agro-ecologies and markets, ix) community-led (FPO/FPC) decentralized processing units for value addition and creating market linkages, and x) build capacities of scientists, extension workers, and farmers for maximizing efficiencies.

Dr V Praveen Rao, Former Vice Chancellor, Professor Jaishankar Telangana State Agricultural University (PJTSAU), stated that technology is changing the way various stakeholders, namely, scientists, policy makers, consultants, farmers, etc. access, disseminate and use information in agri-food value-chain. There is a need to consider innovations like remote sensing, sensors and drones helping them track weather, soil moisture, crop growth and development and overall health

by monitoring stresses imposed by water shortage; nutrient deficiency; insect-pests, pathogens and weeds infestation; salinity and water logging. The industrial revolution technologies such biotech, seed tech, smart fertilizers, nanotechnology, AI, robotics, cloud computing, biologicals for crop protection and regulations, smart farming or digital agriculture (sensing and monitoring, big data analytics to precision farming) and novel farming systems such as vertical farming, hydroponics, aeroponics, etc., are also transforming agricultural practices. Secondly, consumers and retailers are demanding more transparency in agri-food value-chain, about where their food comes from, how it is produced, what agri-inputs are used, how nutritious and healthy it is, and how its production impacts the ecosystem. Farmers and food manufacturers must work to meet these transparency demands, SDGs and global net zero emission commitments etc.

According to World Economic Forum Reports, there are more than 1,000 agri-tech and agri-start ups offering solutions in the agri-food value-chain ranging from crop planning to seed to market connect to supply of healthy food. Gap between technology skills and domain agriculture expertise and associated skills has been a major impediment for 'agri-start ups' which needs to be addressed. The farmers need to be protected from any undue implication of the technology. There are more than 100 incubators in India which have been focusing on domains other than agriculture, with a very few (10-15%) operating exclusively in agriculture. Majority of the newly emerging agri-incubators are housed in National/International level institutions (AIP at ICRISAT; a-IDEA at NAARM; *PusaKrishi* at ICAR-IARI; and SINED at ICAR-NDRI; Best Hort. at ICAR-IIHR, etc). In case of SAUs, the number of incubators is much lower. Except for pioneers like ABD at TNAU, Coimbatore or MABIF at Madurai, ABI at CCSHAU at Hisar and Agri-Hub at PJTSAU, Hyderabad, the overall number across 71 SAUs in the country is very low. The country still lacks a national level standard template and process of validation and certification for agri-tech technologies and services. Field trials, technology refinements, standard operating protocols (SoPs), validation and certification for agri-tech solutions and services is critical to assess and stabilise the technology and generate farmer and industry's trust and needs to be developed. Another gap is the lack of strong industry-academia connects between SAUs and ICAR research and education system. Larger agro-industries play a critical role in shaping the vision of the future considering the existing market scenarios, challenges and demands. Industry should be part of the incubation process at agri-hub innovation centres in academic institutions. The scientific inputs should go hand in hand with market feedback/ inputs. Incubation process also requires strong connect with agri-tech investors The national and state governments through a consultation process should create an integrated national platform for testing, validation and certification through the network of Centres of Excellence, AICRIP schemes, WTC, KVKs, DATTAC, etc. This platform will test and validate digital and hi-tech farming solutions across

agri-food value chain as a qualifier for these solutions. This process would be a periodic activity through agri-cohats as is being implemented at Agri-Hub Innovation Centre at PJTSAU rather than a one-time selection process. The SAUs and ICAR institutions can offer validation and certification of agri-tech solutions through following four channels: i) Incubation Program - Product development support, customized scientific/ business mentoring, advisory on regulatory issues, go to market assistance, fund raising assistance for POC or early-stage start-ups; ii) Agro-Innovation Piloting (AIP) – Early growth stage agri-tech start-ups to pilot/ validate the start-up technology through a soft- landing platform at real farm situation, iii) Co-Innovation Program– For early growth stage start-ups to collaborate and co-create and co-develop technology offering (products/ services) jointly between a start-up team and the agricultural scientists in the respective domain, and iv) Enterprise Acceleration Program (ESP) - Acceleration support to growth stage start-ups.

Dr Ashwani Pareek, Executive Director, NABI, Mohali opined that an integrated and cohesive partnership among all the stakeholders is imperative for enabling innovations and developments in agriculture. R&D has to be done not only in crop plants but also in animals, fisheries, mechanics and policy making, which clearly needs strong collaboration among all sectors directly or indirectly linked with agriculture. During the past 75 years of independence, India has shown a clear commitment and leadership to demonstrate how a resource-poor nation can get transformed into a resource-sufficient nation owing to partnership. It is a pride to share that despite the hard time of COVID-19 pandemic, the agriculture sector has continued to progress all these years and contributed to the economy of the country. The Hon'ble Prime Minister released 17 biofortified crops on the occasion of World Food Day in the year 2020. However, we are now facing unprecedented challenges in sustaining the food security situation. In 2021-22, wheat crop in the country witnessed a sharp decline in productivity due to occurrence of terminal heat waves, wherein Punjab we observed as high as 40 per cent decline in yield. Currently, the western world is witnessing unprecedented high temperature, implications of which will be evident in future. To tackle these challenging issues, agriculture R&D needs enabling environment. The recent policy of GoI towards regulation of gene-edited crops and recent environmental release of DMH-11 Mustard by GEAC is a welcome step, and we need to welcome new tools and technologies of crop improvement. The salient points emerged from the intervention are: i) strengthen research and development through setting up advanced research and training centres for undertaking cutting-edge research and suitable training programs; ii) enhanced investment in ARI4D and strengthening partnership as per the call *Jai Anusandhan* given by the Hon'ble Prime Minister; iii) establish more start-ups in agriculture to boost the farm level innovations and generate employment for youth, iv) exploiting gene editing technology for faster

crop improvement and growth of agriculture especially when the Government policies are also supporting this initiative; v) new crop varieties requiring less water for cultivation need to be developed and also new extension activities promoting the use of diverse crops and crop management practices need to be strengthened; and vi) soil health also cannot be ignored, hence natural means and ways of soil restoration needs to be adopted in regions affected by these stresses.

Dr GN Hariharan, Executive Director, MS Swaminathan Research Foundation (MSSRF), Chennai highlighted the efforts made for enhancing household availability, access and consumption of diverse and nutritious food by increasing food production, agricultural productivity and rural income, and promoting sustainable management in agriculture and ecosystems. The strategy adopted includes research and development, capacity development, promoting grassroot institutions and policy advocacy. Participatory research and action also need to be focused on farming systems and nutri-dense crops and species' policy analysis on sustainable food and nutrition security; and planning, monitoring and evaluation of food systems. The work in Koraput district in Odisha, which is largely a rural, agrarian economy with declining land-holdings, poor incomes, nutrition insecurity, and threats of climate change, dealt these by pooling together land-based enterprises like fishery, poultry, duckery, apiary, field and horticultural crops, etc. Farmer-led extension strategy adopted in Kolli Hills, Namakkal proved to be highly successful in enhancing farmers' income through millets-based farming system. There is a need to promote multi-story mixed farming with nutri-dense crops to enhance nutrition and the income of tribal families in the region.

Dr JC Rana, Country Representative, Alliance of Bioversity International and CIAT, New Delhi expressed that the sustainable development encourages us to conserve and enhance our resources by gradually changing the manners in which we develop and use technologies. Natural resource depletion and adverse impacts of environmental degradation including loss of biodiversity undermine the ability of countries to achieve sustainable development. Therefore, countries must ensure sustainable food production systems, and implement resilient agricultural practices that increase productivity and production, maintain ecosystems, strengthen capacity for adaptation to climate change related extreme weather events and other disasters. Greater emphasis needs to be given to maintain the genetic diversity of plants, animals and fish on farms while ensuring sustainable food, nutrition, environment, and livelihoods security. Recently, natural/ regenerative agriculture is attracting more attention. However, there is need to standardize suitable agro-technologies including varieties and breeds that perform well under regenerative form of agriculture. Indigenous crops, varieties and breeds have been projected as the most suitable candidates to response to natural environment; nevertheless, these crops and species including many neglected and underutilized

species (NUS) need to be mainstreamed. Traditional agriculture and food systems including associated knowledge need to be blended with modern technologies while finding solutions to achieve SDGs. In depth nutrition profiling of local plant species including identifications of bioactive compounds and linking these with study on efficacy of therapeutic properties of nutrients as well as clinical trials for bioavailability and functional properties. This will help in developing value chains and attracting industry to take such products from farm to fork and to markets.

There is a strong need of enhanced awareness and knowledge on the importance of agrobiodiversity and its role in mitigation of the adverse impacts of climate change and malnutrition at all levels from schools to policy level. Policy enabled environment promotes access to besides fair and equitable sharing of benefits arising from the utilization of agrobiodiversity and associated traditional knowledge is to be created. Investments need to be increased for making payments especially on areas such as carbon credits, and other ecosystem services. However, we must develop robust evaluation and assessment tools and methodologies. Also, there is a need for increased networking and establishing common platform of diverse stakeholders such as policy planners, research, academia, industry, private, professional and civil societies etc. The collective efforts will enable us to create sustainable development environment that safeguards needs of the people living today while ensuring future generations the opportunities to meet future needs.

SPECIAL SESSION

Announcement of Borlaug Field Award

Dr Himanshu Pathak, Secretary, DARE & DG, ICAR was the chair of the Special Session in which Borlaug Field Award was announced and a special lecture on *Sustaining Soil Health for Posterity* was delivered.

Dr Keegan Kautzky, Senior Director, Global Youth Program and Partnership, World Food Award Foundation gave the background of the award and announced the name of awardee. He thanked the organizers to include the World Food Prize Foundation in the National Symposium discussions and have given special opportunity to announce the name of ***Dr Mahalingam Govindaraj as the 2022 Borlaug Field Award recipient*** at the event ! It provided a powerful platform to celebrate his success in developing biofortified pearl millet varieties and to elevate these critical advances in nutrition-sensitive food systems in India and Africa. The response has been very strong and positive, and he appreciated Dr Govindaraj for his grand success. He further complemented for the strong partnership, and the opportunity to continue collaborating closely with TAAS to advance the SDGs and achieve zero hunger!

Special Lecture on Sustaining Soil Health for Posterity

Prof Rattan Lal, Distinguished Professor, Ohio State University, delivered a special lecture on *Sustaining Soil Health for Posterity*. He highlighted that Green Revolution in India is a global success story. Though the risks of food-insecurity and chronic under-nutrition have been addressed but the problems of hidden hunger from micronutrient and protein deficiency still persist. There is a widespread problem of soil micronutrient deficiency of Zn, Fe, Cu, Mn, and B. The problem is compounded and exacerbated with rapid urbanization and creation of megacities. Thus, India has fallen short of accomplishing SDGs. He stressed that the focus of Indian agriculture has to shift to transformation of food systems which must meet the nutritional needs under increasingly difficult environmental challenges such as degrading of soil health, global warming, decreasing and polluting water availability, and dwindling biodiversity. He emphasized that India has the required natural resources to advance nutrition security, improve human health, and enhance environmental sustainability. Adoption of best management practices can reduce the area under cropland, decrease water demand, and reduce resource inputs of chemicals by enhancing use efficiency of reducing losses. The food system transformation in India, similar to elsewhere in the world, must produce more from less, optimize the use efficiency of inputs, and minimize leakage of agri-chemicals in the environment (soil, water, air).The focus must be on nutrient dense food through nutrition-sensitive agriculture. Modern urban systems must plan to produce a specific amount of food within the city limits by soil-less production systems. On diversification, he reiterated that nutrition security should be ensured. Further, science, technology and innovation (STI) targeted to solve both generic and location-specific challenges are the key drivers for transforming agri-food systems. These can transform the sustenance and low return livelihood to a profitable and respectable occupation for smallholder farmers, while motivating, attracting and empowering youth and women in agriculture.

He emphasized that a paradigm shift is needed to: i) increase productivity, profitability, inclusiveness and efficiency of human engagement, ii) achieve complete nutrition security, iii) address the challenges of climate change, iv) adopt environment-friendly sustainable practices, and v) establish efficient farmer-market linkages. He highlighted that one has to keep in mind 3Cs (converse, connect and collaborate) to see that smallholder farmers do not go to bed hungry. Strategic intervention is needed and only nutrient use efficiency-based input should be used while keeping in mind the input-output management. There is a need to concentrate on policy, basic and translational science should be differentiated and one should value both. Indian agriculture has so much of output but the outcome is not visible. The question arises as to why we are not achieving outcome when

we have so much of output. Also, farmer-market linkage must be promoted strongly. Agriculture must be a part of the solution to restore and improve the environment. Sustaining soil health and re-carbonization of the terrestrial biosphere (soil, vegetation, wetlands, urban land, mine lands) are critical to putting India on track to achieve SDGs including SDG 1, 2, 6, 13 and 15 among others.

Dr Himanshu Pathak, while delivering his concluding remarks, appreciated the announcement made for Borlaug Field Award especially due the fact that the recipient of the award was an Indian scientist. He thanked the World Food Award Foundation for choosing this platform for announcing the award. He also appreciated the excellent presentation made by Prof Rattan Lal on sustaining soil health for sustainability. He emphasized that sustaining soil health is extremely important for posterity. Thus, focus of Indian agriculture must shift to transformation of food systems to meet the nutritional needs under degrading soil health, warming climate, reduced water availability, and dwindling biodiversity. He further mentioned that India having critical natural resources must take urgent steps to ensure nutrition security, improve human health, and protect the environment.

CONCLUDING SESSION

Prof RB Singh, in his concluding remarks**,** underlined that science, technology and innovation (STI) continuum has been the main driver of agricultural growth, development, and transformation of national socioeconomic and agro-ecological milieus, and evolving dynamically to meet the fast-changing development goals, leaving no one behind. In India, science-led introduction and development of high-yielding, better quality, photo-insensitive, biotic and abiotic stress resistant/ tolerant, and input responsive crop varieties, miracle seeds, especially of wheat and rice, and their country-wide adoption ushered in the Green Revolution in the mid-1960s. He emphasised to introduce a food-cum-fortification approach for eliminating iron, iodine, zinc and vitamin A deficiency and accord priority to overcoming chronic and hidden hunger in pregnant women, and in children in the 0-2 years age group. Dietary diversification supported through food basket and public distribution system (PDS) diversification might be useful particularly for micronutrients enrichment. For instance, as compared to rice, finger millet (*ragi)* is 34 times richer in calcium, five times in iron and two times each in phosphorus and minerals. There is need to promote organization of Community Grain and Water Banks by local communities with the *Gram Sabhas* providing social oversight, and promote the concept–store foodgrains and drinking water in every village, and pay particular attention to safe drinking water, primary health care and education on nutrition.

He further reiterated that inadequate purchasing power is the main cause of hunger at household and individual levels. Considering that 60 per cent of the

region's work force is still dependent on agriculture and contribution of agriculture to GDP has generally decelerated or stagnated in the recent decade, productivity of agriculture sector as well as non-farm employment and rural development must be accelerated particularly for improving household and individual level food security. India should aim to achieve comfortable levels of food self-sufficiency. In addition, India faces constraints and challenges of sustaining and accelerating growth in agricultural productivity; reducing the gap between marginal and favoured areas and bridging huge yield gaps, and high vulnerability causing fluctuations in production, and serious implication of climate change and sea level rise. Greater attention needs to be given to enhancing productivity, profitability and income of small, marginal, sub-marginal and landless farmers through developing, transferring and providing appropriate technologies, inputs and services, and improving input use efficiency; linking farmers with markets, strengthening post-harvest management, agro-processing, value-addition, enhancing food availability for the poor through market, trade and distribution reforms, safety nets and integrated on-farm and non-farm employment and income; and formulating and implementing appropriate policies, strategies, institutions and services for sustained food security. To achieve the desired goals, effective pathways need to be developed for scaling innovations by combining ITK, conventional methods, and adopting NextGen cutting-edge technologies evolved nationally or internationally, enduring STI through an excellent education system, and leveraging strong public-private partnership. He also recommended for increased investments in R&D, the urgent need for enabling policy environment for scaling innovations, and suggested clear transformative action points.

Dr RS Paroda, Chairman, TAAS, while concluding the deliberations of the National Symposium envisioned that technology development plays a significant role in achieving SDG targets by improving the efficiency and effectiveness of new and more sustainable methods of development. The creation of new technologies that foster research and stimulate innovation is thus required. These can be boosted by strengthened knowledge-sharing and collaboration amongst stakeholders both at the national and international level. Rapid shifts in digital technologies are changing the context for pursuing the sustainable development goals (SDGs). Innovation and investments are required to make supply-chains more efficient by developing sustainable and durable markets. To support these markets, we must also improve rural infrastructure, particularly roads, storage, and electrification, ensuring farmers' ability to reach a wider consumer base. Further, he emphasized on the need to address a wide range of issues related to food and nutrition security, efficient and sustainable use of natural resources, adoption of hybrids and biofortified seeds, expansion of irrigation and market networks, development of the livestock sector, and agri-business management. Attention is also needed to focus on raising farm profitability, reducing cost of

production, and strengthening producer-market linkages. He further advocated for higher investment in research for development, strong public-private partnerships, and search for pro-poor innovations and their effective implementation. This needs out-of-the-box thinking and a clear strategy. To achieve the SDG of zero hunger, India will have to meet the food demand of its projected 1.51 billion by 2030, and this indeed is a big challenge. With the launch of several social safety net programs like the National Food Security Act, strengthened public distribution system of foodgrains at subsidized rates, and ready-to-eat food offering ventures, the country will move faster in achieving the SDG on hunger. He expressed the need to promote precision agriculture, protected cultivation to improve input-use efficiency, conservation agriculture (CA) for carbon sequestration in a mission mode, and farm mechanization including custom hiring services to make agriculture farmer-friendly.

To meet SDGs by 2030, he asserted that the first challenge is to increase food production, while minimizing the environmental impact and increasing natural resource efficiency, which will require increasing agricultural productivity in the country where the agricultural sector contributes an important share of gross domestic product (GDP) and large productivity gaps still exist. The second major challenge would be to improve the access to food and markets, as hunger often occurs where there is enough food produced but access to food is poor. The third challenge is to orient food consumption towards sustainable diets that are less resource-intensive and more nutritious, which will be crucial for the sustainability of the food system. Currently, as per FAO estimates 32 per cent of the total food produced globally is wasted and changes have to occur at different points along the food-chain: production, storage, transportation and consumption. He advocated for use of hybrid technology, gene revolution, gene-editing, genomics, IPR protection; and a liberated science to serve the society. This could be done by creating science-based regulatory regimes; precision agriculture; and adopting digital solutions and artificial intelligence (AI). There is need for scaling innovations and disruptive technologies evolved nationally or internationally; and ensuring effective implementation pathways with differentiated responsibility and accountability of all stakeholders to achieve desired impact at the ground level. India's preparedness to accomplish the SDG 13 on climate action was established by launching of different programs, institutions, policies, and adoption of measures, like 33-35 per cent reduction in emission intensity by 2030; launch of National Missions on Climate Change; preparation of action plans on climate change; and development of drought-tolerant, submergence-tolerant, salinity-tolerant varieties of different crops. Also, there is a need for implementation of Soil Health Card Scheme for better management of fertilizers; dissemination of better water management technologies; dissemination of zero tillage; awareness generation on crop residue burning impact; initiation of climate smart village concept; and development of integrated farming systems.

RECOMMENDATIONS

The sustainable development goals (SDGs) do provide a unique opportunity for agricultural sector to get aligned to achieve a better tomorrow for the world. India reportedly has the largest number of undernourished and poor people in the world. Hence, India must accelerate the pace to achieve SDG, to reduce poverty, eliminate hunger and achieve food security globally. In fact, agriculture be seen as an important sector to achieve the goals of eliminating both poverty and hunger, while ensuring nutrition and environmental security. The following important recommendations emerged from the in-depth discussions during the National Symposium, which need to be implemented on priority:

I. Harnessing Crop Science for Food and Nutrition Security

1. A paradigm shift is needed now to use science to help alleviate poverty (SDG1) and hunger (SDG2) through: (i) greater focus on smallholder farmers and linking them to markets; (ii) moving from food to nutrition security; (iii) from irrigated to dryland agriculture by making grey areas green; (iv) from subsistence to commercial agriculture by promoting entrepreneurship, start-up initiatives, make-in-India drive and enhancing export potential; (v) liberate science to serve society through enabling policy and regulatory regimes; and (vi) moving from Green to Evergreen Revolution.
2. In order to produce more from declining natural resources, the yield potential of crops must be increased by harnessing new science such as: molecular marker-assisted breeding, genome editing, phenotyping; speed breeding through double haploids in maize, another culture in rice and use of off-season nurseries; data-driven hybridization using productive inbred lines; developing climate resilient crops resistant to drought, flood, heat especially at maturity; multiple tolerance through gene pyramiding; and strengthening pre-breeding programs with focus on more use of crop wild relatives.
3. Mission mode efforts are needed now to scale specially the disruptive innovations like hybrid technology, especially in maize, pearl millet, sorghum, rice, etc. Major thrust is needed to develop high quality hybrid rice for the upland rainfed ecology and breeding for high yielding, early maturing *Basmati* rice for direct seeding, and better quality hybrid rice suited to north-western region. In maize, the major focus be on genetic diversification through introgression of temperate germplasm in the tropical background to develop single cross maize hybrids with yield potential higher than 6 - 8 t/ha in the *kharif* season and 10-12 t/ha in the *rabi* season. In sorghum, hybrids tolerant to shoot fly, grain mould, stem borer, drought and salinity; high juice recovery, with better green fodder digestibility, and also more biomass for paper and pulp industry be bred and promoted. In addition, productive hybrids with drought

tolerance and excellent grain quality for *rabi* season in Maharashtra must be developed. In pigeonpea, early maturing (110 days) hybrids are urgently needed to expand the area in the north-western states of Punjab, Haryana, Rajasthan and Gujarat.

4. GM technology is most relevant for both enhancing food production and protecting the environment. The future lies in GM and biofortified crops. There is a need to deploy GM crops that have proven potential around the world. Globally, 18 million farmers in 30 countries have planted 200 mha with GM crops, whereas India planted only 11.6 mha under cotton. With exception of cotton, the Indian GM crops policy is now being reviewed favourably. Besides GM Mustard, there is need to seriously consider release and adoption of GM technology in soybean and maize. Biofortification is a cost-effective and sustainable approach to address malnutrition among children. The first biofortified high-iron variety of pearl millet, *Dhanashakti*, was released in 2012. Another high iron pearl millet variety, ICMH 1201, having 75 mg/kg Fe and 40 mg/kg Zn along with 30 per cent higher grain yield than *Dhanshakti*, was also developed. Other biofortified crops that are ready for use include: (1) orange flesh sweet potato (ß-carotene), (2) wheat (Fe and Zn), (3) lentil (Fe), (4) rice (Zn), (5) maize (ß-carotene), and (6) cauliflower (ß-carotene).
5. For dryland crops having low environmental footprint, there is need to increase their water use efficiency/water productivity by breaking the nexus between earliness and low productivity, besides adaptation to low nutrient availability in the soils. Special thrust is also needed to promote conservation agriculture (CA) for sustainable intensification; expanding area under protected cultivation doubling micro-irrigation area from current 10 mha; and enhancing use of biofuel from potential sugarcane and maize crops.
6. In view of the limited scope for income growth through area expansion, which stagnates at around 140 mha, the focus be now on raising cropping intensity, reducing inefficiency in production, diversifying the production portfolio towards high-value agriculture and enhancing water-use efficiency.
7. The horticultural crops (fruits and vegetables) would need greater attention to increase both production and productivity. Though the conventional horticulture will continue to increase the income of small and marginal farmers, shift to 'Hi-tech Horticulture' is now extremely important. Future R&D efforts are needed for: (i) exploitation of genetic diversity, (ii) production of seed and quality planting materials and rootstocks having resistance to abiotic and biotic stresses, (iii) skilled human resource in emerging technologies, (iv) reducing post-harvest losses, and (v) reducing the cost of production of horticultural crops through better crop management.

8. There is an urgent need to develop technologies that support production of more food and nutrition with less inputs; support technologies that promote diversification of food production; advance frontiers for nutrition-driven technologies; strengthen rural-urban linkages that will help propel economic development, food security, and nutrition status; and promote sustainable intensification technologies.

II. Promoting Livestock and Fishery Sector

9. There is a distinct need to develop the livestock sector that remains constrained by effective breeding, healthcare, and extension services. Major thrust is required for better production and supply of feeds and fodders, and higher allocation of resources. The insurance cover is also negligible in the animal sector. Therefore, efforts to develop the livestock sector aggressively will help increase farmers' income and household nutrition security.
10. Livestock farming being quite beneficial to the farmers doubling their income needs to be promoted vigorously. Greater attention be given to improve the local breeds of cattle which are considered good source of A2 protein milk. There is need to use modern technologies for value added products, especially for enhancing the export potential and increase the income of farmers. Greater attention is needed on use of improved technologies such as cryopreservation of semen, artificial insemination, MOET/SOET, IVM/IVF, embryo sexing, somatic cloning, embryonic and adult stem cells and transgenics for boosting milk production and faster growth of elite *desi* animals.
11. Buffalo R&D requires consolidation of scattered small-holder systems into larger family farms or commercially operated farms, with mechanisation along with application of modern technologies like AI and appropriate heat detection methods, health management and precision farming systems for realising efficient economical production; low-cost nutrition / alternate protein sources, production of vaccines and diagnostics and production, and climate resilient buffalo farming.
12. Concerted efforts are required now to reduce GHG through efficient management of animals; increase production through better herd health, ration to feed animals based on their nutrient needs; and integrated dairy farming (mixed crop-livestock).
13. National Livestock Mission needs to lay greater focus on quality feed and fodder; risk coverage through animal insurance; conservation and characterisation of indigenous breeds; quality fodder seed and feed availability; efficient AI system, quality semen and increased awareness for better quality animal products.

14. Also, there is need to improve the processing, value-addition, diversification and fortification of milk and other livestock products especially buffalo, goat and sheep meet. Also, awareness for nutritional and therapeutic potential of non-ruminants' milk like goat, camel, mithun and yak has to be expected for local use and export.
15. In fishery sector, large-scale adoption of new technologies is needed for fish production and to reduce post-harvest losses to the minimum. Also, there is urgent need of networking of hatcheries, entrepreneurs, and marketing systems through PPP mode for attaining higher position in fish production. There is need for creation of domestic market for shrimp; international market for freshwater fishes; developing market infrastructure: enhancing investments (public and private); creating hygienic markets within the reach of consumers, assured live-fish supply; creating demand for processed and value-added fish products; facilitating online marketing, and population of fish as healthy food.

III. Enabling Policies and Program Implementation

16. Widening the policy space with much needed faith in agricultural science and new technologies without fear and with human face, is very much needed for accelerating growth. Therefore, an aggressive approach on policy advocacy and reforms is urgently warranted for scaling innovations especially to achieve SDGs urgently by 2030.
17. Ensuring meaningful engagement of all stakeholders in the formulation of national strategies, implementation plans and monitoring of the progress towards achieving SDGs, using baseline data for defined goals, be our national priority and be reviewed periodically.
18. Knowledge updation of farmers on new technologies, practices and recent advancements is a must. Building multi-lateral and multi-sectoral technology transfer mechanisms, including private sector extension through involvement of youth (including women), for linking science to society is the current need. Also, farmers must think of embracing diversification, secondary and specialty agriculture for higher income and sustainability. Greater use of ICT for dissemination of related knowledge to the farmers will be highly beneficial.
19. Indian farmers now need urgently the market linkages through e-NAM, revision of APMC; provision of pledged storage for urgent credit needs. Farmers and consumers stand to gain if facilitated for the online retailing of agricultural commodities. Also, we must take full advantage of globalization of agriculture and have advanced preparedness for emerging new WTO regime. This would also require a long-term export policy conducive to our small holder farmers.

20. There is an urgency to reshape agriculture through policy changes. India must increase substantially its capital investments for much needed infra-structure development, health and education, by involving both public and private sectors, especially in the eastern and north-eastern regions so as to capitalise on rich natural resources that have great potential for faster agricultural growth and for achieving evergreen revolution.
21. In order to achieve the SDG on hunger and malnutrition, India will have to make urgent efforts towards, women empowerment, healthcare, sanitation, drinking water, nutrition awareness, and incentives for promoting biofortified crops, QPM maize and diversified local foods. There is an urgent need to: (i) improve economic and physical access to diverse, nutrient-rich foods through biofortification and nutrition-sensitive food processing, (ii) leverage of existing platforms, for example MGNREGS NFSA, NFSM,, PMKSY, PMFBY, NMAET, NMAET, etc and (iii) empower women in agriculture by ensuring land and property rights and formation of women's cooperatives/self-help groups for improving convergence of health, nutrition, agriculture, and other social sector initiatives.
22. The rapid growth in demand for high-value food commodities, including animal products, is an opportunity for farmers to diversify their production portfolio and capture the benefits of value addition in agriculture. The policy should provide for higher allocation of resources to these high-value and high-growth sectors by developing inclusive markets and value chains. Also, there is need for appropriate policies on strengthening livestock and fisheries sectors, promotion of poultry and bee-keeping, and development of non-farm sector for enhancing the income of farmers.

IV. Coordination and Implementation

23. SDGs have several interconnected goals and, thus, require an effective coordination and convergence mechanism at all levels through an inter-disciplinary and inter-institutional/ departmental approach to draw collective strength for desired impact. Such coordination mechanism has to be top down for effective monitoring and evaluation.
24. Despite witnessing Green, White and Blue Revolutions, having attained impressive production of food, milk, and both inland and marine fish, India ranks 100 among 113 countries in global health index (GHI) and prevalence of poverty is around 16 per cent. Besides physical access, our major aim should now be to provide economic access to available food through effective implementation of national food security act and other safety net initiatives, especially in the regions/states where maximum poverty and hunger exist.

25. The National Agricultural Research System (NARS), consisting of ICAR Institutes and the State Agricultural Universities (SAUs), should also involve other stakeholders such as NGOs, FPOs, private sector institutions, farmers and agribusiness entrepreneurs. Joint efforts by all will be critical to an accelerated progress towards SDGs. At the same time, it is imperative that policy makers accord high priority to agricultural research for development (AR4D) and ensure enhanced allocations (a minimum of 1 per cent of agricultural GDP) to NARS and strengthen the food systems for physical and economic access to resource poor people residing in rural and urban areas.
26. Continuous prioritization as well as re-prioritization are needed for finalization of research portfolio so as to ensure that it is in tune with the fast-changing global, regional and national needs. The 'top-down' approach adopted in the past will have to be changed to make it a 'bottom-up' approach. Shift from project to program mode and also from commodity/crop to farming system's mode are urgently warranted. In this context, focus on crop diversification, hybrid seeds/high value crops, biotechnology, ICT, GIS, AI and good agronomic practices (GAP) would help in doubling farmers' income and attain resilience in agriculture with efficient input (water, fertilizers, chemicals for pesticides) use.
27. Adopting eco-friendly and climate resilient technologies, with emphasis on efficient farming systems in different eco-regions and strengthening of activities for improving soil health through organic matter recycling, conservation agriculture, efficient and need based use of nutrients, using decision support systems and soil test results, improved water use efficiency using micro-irrigation techniques etc. would help achieving resilience in agriculture.

Annexure I

Technical Program

DAY 1 : MONDAY, 29 AUGUST 2022

09.00-09.30	**REGISTRATION**	
09.30-11.00	**INAUGURAL SESSION**	
10.00-10.10	**Welcome**	**AK Singh**, DDG (Agril. Extn.), ICAR
09-30-09.40	**Welcome & Setting the Context**	**RS Paroda**, Chairperson, TAAS
09.40-09.50	**Special Remarks**	**Stephan Weise**, MD Asia, Alliance of BI & CIAT
09.50-10.00	**Special Remarks**	**Jacqueline Hughes**, DG, ICRISAT
10.00-10.10	**Special Remarks**	**Bram Govaerts**, DG, CIMMYT
10.10-10.20	**Special Remarks**	**Jean Balié**, DG, IRRI
10.20-10.30	**Address by Special Invitee**	**Himanshu Pathak**, Secretary, DARE & DG, ICAR
10.30-10.40	**Address by Special Invitee**	**T Mohapatra**, President, NAAS
10.40-11.00	**Inaugural Address**	**Ramesh Chand**, Member, NITI Aayog
11.00-11.05	**Vote of Thanks**	**Bhag Mal**, Secretary, TAAS
11.05-11.30	***Tea Break***	
11.30-13.30	**TECHNICAL SESSION I : Reorienting Crop Research for Food and Nutrition Security**	
Co-Chairs	**: PL Gautam**, Former Chairperson, PPV&FRA **: T Mohapatra**, President, NAAS	
Convenor	**: Umesh Srivastava**, Former ADG (Hort.), ICAR	
11.30-12.00	**Plenary Lecture** Science-led Growth in Agriculture for Alleviating Hunger and Poverty	**RB Singh**, Former President, NAAS

12.00-12.20	Reorienting Crops Research for Food and Nutrition Security	**OP Yadav**, Director, CAZRI
12.20-12.40	Genetic Enhancement for Nutrition and Environmental Security	**AK Shasany**, Director, NIPB
12.40-13.00	Horticulture for Enhanced Nutritional Security	**HP Singh**, Former DDG (Hort), ICAR
13.00-13.30	**Discussion**	
13.30-14.30	***Lunch Break***	
14.30-16.00	**TECHNICAL SESSION II : Role of Livestock and Fishery Sector for Food & Nutrition Security**	
Co-Chairs	**: AK Srivastava**, VC, DUVASU	
	: JK Jena, DDG (Fisheries), ICAR	
Convenor	**: Amrish Kumar Tyagi**, ADG (ANP), ICAR	
14.30-15.00	**Plenary Lecture** Strategic Role of Livestock Sector for Nutrition and Environmental Security	**AK Srivastava**, VC, DUVASU
15.00-15.20	Research in Fishery Sector for Food and Nutrition Security	**JK Jena**, DDG (Fishery), ICAR
15.20-15.40	Strategic Reorientation for Buffalo Research and Development	**Inderjeet Singh**, VC, GADVASU
15.40-16.00	Capitalizing on Our Animal Genetic Resources	**BP Mishra**, Director, ICAR-NBAGR
16.00-16.30	**Discussion**	
16.30-17.00	***Tea/Coffee***	
18.00-20.00	**Felicitation Function: 80th Birthday of Dr RS Paroda**	
20.00-21.00	***Dinner***	

DAY 2 : TUESDAY, 30 AUGUST 2022

09.00-10.40 TECHNICAL SESSION III : Harnessing Innovation to address SDGs

Co-Chairs : Renu Swarup, Former Secretary, DBT
: BS Dhillon, Former Vice Chancellor, PAU
Convenor : JL Karihaloo, Former Coordinator, APCoAB

09.00-09.30	**Plenary Lecture** Harnessing Genome Editing and Gene Pyramiding	**Rajeev Varshney**, Director, CCFI & SABC, Murdoch University
09.30-09.50	Protecting Innovations in Improving Food and Nutrition Security	**Ram Kaundinya**, DG, FSII
09.50-10.10	Scaling Regenerative Agriculture for Food and Nutrition Security	**ML Jat**, Global Research Program Director, Resilient Farms and Food Systems Program, ICRISAT
10.10-10.30	Innovations in Agricultural Extension for Production Sustainability	**AK Singh**, DDG (Extn), ICAR
10.30-10.40	**Discussion**	

10.40-11.00 ***Tea/ Coffee Break***

11.00-14.00 PANEL DISCUSSION : Agricultural Research and Innovation for Development (ARI4D)

Co-Chairs : RS Paroda, Chairman TAAS
: RB Singh, Former President, NAAS
Convenor : Anuradha Agrawal, NC NAHEP

Panelists

Renu Swarup, Former Secretary, DBT

Kadambot Siddique, Director, Institute of Agriculture, UWA

SK Vasal, Former Distinguished Scientist, CIMMYT

Vibha Dhawan, Director General, TERI

Keegan Kautzky, Senior Director, Global Youth Program and Partnership, WFPF

Ajay Vir Jakhar, Chairman, Bharat Krishak Samaj

V Praveen Rao, VC, PJTSAU

Prabhu Pingali, Founder Director, TCI

	HS Gupta, Chairman, Assam Agriculture Commission **Mruthyunjaya**, Former National Director, NAIP **Arvind Kumar**, DDG (R), ICRISAT **Badrinarayan Chaudhary**, General Secretary, Bharatiya Kisan Sangh **Ashwani Pareek**, Executive Director, NABI **GN Hariharan**, Executive Director, MSSRF **JC Rana**, Country Representative, Alliance of BI and CIAT	
14.00-15.00	***Lunch Break***	
15.00-16.30	**SPECIAL SESSION**	
Chair : Himanshu Pathak, Secretary, DARE & DG, ICAR		
15.00-15.30	Announcement of Borlaug Field Award	**Keegan Kautzky**, Senior Director, Global Youth Program and Partnership, World Food Award Foundation
15.30-16.10	**Special Lecture** Sustaining Soil Health for Posterity	**Rattan Lal**, Distinguished Professor, Ohio State University
16.10-16.30	**Chairman's Remarks**	**Himanshu Pathak**
16.30-17.00	**CONCLUDING SESSION**	
Concluding Remarks : **RB Singh** : **RS Paroda**		
16.50-17.00	**Vote of Thanks**	**Bhag Mal**, Secretary, TAAS
17.00	***Tea/Coffee***	

List of Participants

1. **Mr Sanjay Agarwal**
   ADG, ICRISAT, New Delhi
   Email: s.agarwal@cgiar.org

2. **Dr Anuradha Agrawal**
   National Coordinator,
   ICAR-NAHEP, KAB, Pusa Campus,
   New Delhi - 110012
   Email: anuagrawal1@yahoo.co.in

3. **Dr SP Ahlawat**
   Division of Plant Exploration and Germplasm Collection, ICAR-NBPGR, New Delhi - 110012
   Email: nbpgr.exploration@icar.gov.in

4. **Dr Nawab Ali**
   Former DDG (Agril. Engg.), ICAR,
   New Delhi - 110012
   Email: alinawab11@gmail.com

5. **Dr Sunil Archak**
   Agriculture Knowledge Management Unit, ICAR-NBPGR,
   New Delhi - 110012
   Email: akmu.nbpgr@icar.gov.in

6. **Dr Jean Balie**
   DG, International Rice Research Institute, Philippines
   Email: j.balie@irri.org

7. **Dr Chandrish Ballal**
   Former Director, ICAR-NBAIR,
   Bengaluru
   Email: ballalchandish@gmail.com

8. **Mr Raju Barwale**
   Chairman, MAHYCO,
   Jalna, Maharashtra
   Email: raju.barwale@mahyco.com

9. **Dr Anil Bawa**
   Former Pr. Scientist, ICAR,
   New Delhi - 110001
   Email: anil_bawa@yahoo.com

10. **Dr Rakesh Bhardwaj**
    ICAR-NBPGR, Pusa Campus,
    New Delhi - 110012
    Email: rb_biochem@yahoo.com

11. **Dr KC Bhatt**
    Pr Scientist, ICAR-NBPGR,
    New Delhi - 110012
    Email: kcbhattps@yahoo.com

12. **Dr Raghavendra Bhatta**
    ICAR-National Institute of Animal Nutrition and Physiology, Bengaluru
    Email: directornianp@gmail.com

13. **Dr Pratibha Brahmi**
    Principal Scientist,
    ICAR-NBPGR, New Delhi - 110012
    Email: Pratibha.Brahmi@icar.gov.in

14. **Dr VP Chahal**
    ADG (Agril Extn), ICAR,
    New Delhi - 110012
    Email: chahalvp@gmail.com

15. **Dr Ramesh Chand**
Member, NITI Aayog,
New Delhi - 110007
Email: rc.niti@gov.in

16. **Dr Amaresh Chandra**
ICAR-Indian Grassland and Fodder Research Institute,
Jhansi (Uttar Pradesh)
Email: director.igfri@icar.gov.in

17. **Dr Malavika Dadlani**
Former Jt Director (Res),
ICAR-IARI, New Delhi - 110012
Email: malavikadadlani.md@gmail.com

18. **Dr Narendra Dadlani**
Former Executive Director,
NSAI, New Delhi
Email: nkdadlani@gmail.com

19. **Dr Randhir Dalal**
Professor, International Institute of Veterinary Education and Research, Rohtak (Haryana)
Email: rsdalal1@gmail.com

20. **Dr Pratap Deshmukh**
B-71 (IInd Floor), Naraina Vihar,
New Delhi - 110028
Email: write2psd@gmail.com

21. **Mr Sanjay Deshpande**
MAHYCO, Jhandewalan,
New Delhi - 110005
Email: sanjay.deshpande@mahyco.com

22. **Dr Vibha Dhawan**
Director General,
The Energy and Resources Institute,
New Delhi - 110003
Email: vibhad@teri.res.in

23. **Dr BS Dhillon**
Former Vice-Chancellor,
PAU, Ludhiana - 141004 (Punjab)
Email: dhillonbaldevsingh@gmail.com

24. **Ms Sonal D'Souza**
Bioversity International, NASC,
Pusa Campus, New Delhi - 110012
Email: s.dsouza@cgiar.org

25. **Dr PL Gautam**
Former Chairperson,
PPVFRA, NASC Complex,
New Delhi - 110012
Email: plgautam47@gmail.com

26. **Dr Bram Govaerts**
Director General,
International Maize and Wheat Improvement Center, Mexico
Email: b.govaerts@cgiar.org

27. **Dr HS Gupta**
Chairman,
Assam Agriculture Commission,
Guwahati (Assam)
Email: hsgupta.53@gmail.com

28. **Dr Sandhya Gupta**
Division of Tissue Culture and Cryopreservation Unit,
ICAR-NBPGR, New Delhi - 110012
Email: nbpgr.tccu@icar.gov.in

29. **Dr Veena Gupta**
Division of Germplasm Conservation,
ICAR-NBPGR, New Delhi - 110012
Email: nbpgr.conservation@icar.gov.in

30. **Dr GN Hariharan**
Executive Director,
MSSRF, Chennai
Email: gnhariharan@mssrf.res.in

31. **Dr Jacqueline Hughes**
Director General,
International Crops Research Institute for the Semi-Arid Tropics, Hyderabad
Email: J.Hughes@cgiar.org

32. **Dr I Sivaraman**
Scientist, ICAR-Central Institute of Freshwater Aquaculture, Bhubneshwar - 751002
Email: fishiva26@gmail.com

33. **Dr SK Jain**
Former Professor (SST),
ICAR-IARI New Delhi - 110012
Email: skjainsst@gmail.com

34. **Dr ML Jat**
Global Research Program Director, Resilient Farms and Food Systems Program, ICRISAT, Patancheru
Email: M.jat@cgiar.org

35. **Dr HS Jat**
Principal Scientist,
ICAR-Central Soil Salinity Research Institute (CSSRI), Karnal - 132001
Email: hsjat_agron@yahoo.com

36. **Dr JK Jena**
DDG (Fisheries),
ICAR, KAB II, Pusa Campus,
New Delhi - 110012
Email: ddgfs.icar@gov.in; jkjena2@gmail.com

37. **Dr JL Karihaloo**
Former Coordinator,
APCoAB, Bangkok,
New Delhi - 110012
Email: jlkarihaloo@gmail.com

38. **Dr Ram Kaundinya**
Director General,
Federation of Seed Industry of India (FSII), New Delhi - 110001
Email: ram@kaundinya.in

39. **Dr Ravinder kaur**
Former Project Director,
ICAR-WTC, IARI, New Delhi - 110012
Email: rk132.iari@gmail.com

40. **Dr Keegan Kautzky**
Senior Director,
Global Youth Program and Partnership, WFPF
Email: kkautzky@worldfoodprize.org

41. **Dr KD Kokate**
Former DDG (Extn),
ICAR, New Delhi - 110012
Email: kdkokate@gmail.com

42. **Dr Arvind Kumar**
DDG (R), ICRISAT,
Hyderabad (Telangana)
Email: arvind.kumar@cgiar.org

43. **Dr Anil Kumar**
ICAR-Central Institue for Women in Agriculture, Bhubaneswar (Odisha)
Email: director.ciwa@icar.gov.in

44. **Dr Ashok Kumar**
ICAR-National Bureau of Plant Genetics Resources,
New Delhi - 110012
Email: director.nbpgr@icar.gov.in

45. **Dr Krishna Kumar**
Dr Rajendra Prasad Central Agricultural University Pusa,
Samastipur - 848125 (Bihar)
Email: vc@rpcau.ac.in

46. Dr Vinod Kumar
ICAR-NBPGR,
Pusa Campus, New Delhi - 110012
Email: vinod.kumar15@icar.gov.in

47. Dr Jyoti Kumari
Principal Scientist (Plant Breeding,
ICAR-NBPGR, New Delhi - 110012
Email: jj.gene@gmail.com

48. Dr Rattan Lal
Distinguished Professor,
Ohio State University, Ohio (USA)
Email: lal.1@osu.edu

49. Dr Bhag Mal
Secretary, TAAS, Avenue II,
Pusa Campus, New Delhi - 110012
Email: bhagml@gmail.com

50. Dr SK Malik
Principal Scientist, ICAR-NBPGR,
New Delhi - 110012
Email: skm1909@gmail.com

51. Dr S Mauria
Former ADG (IT&TM, IT, Seeds,
P&PP), ICAR, New Delhi - 110001
Email: smauria@gmail.com

52. Mr Nipun Mehrotra
Agricollaboratory
Email: nipun@agricollaboratory.com

53. Dr BP Mishra
Director,
ICAR-NBAGR, Karnal - 132001
Email: director.nbagr@icar.gov.in

54. Dr T Mohapatra
President, NAAS,
NASC Complex, New Delhi - 110012
Email: tmnrcpb@gmail.com

55. Dr Mruthyunjaya
Former National Director,
NAIP, KAB-II, New Delhi - 110012
Email: mruthyunjaya1947@gmail.com

56. Dr M Nagesh
ICAR-National Bureau of Agricultural
Insect Resources, Bengaluru
Email: director.nbair@icar.gov.in

57. Dr Suresh Pal
Former Director, ICAR-NIAP,
New Delhi - 110012
Email: spl.econ@gmail.com

58. Dr Yash Pal
ICAR-National Research Centre on
Equines, Hisar - 125011
Email: nrcequine@nic.in

59. Dr Ravi Pamarthi
ICAR-NBPGR, Pusa Campus,
New Delhi - 110012
Email: ravi.pamarthi@icar.gov.in

60. Dr SN Pandey
Former ADG (Horticulture),
ICAR, KAB II, New Delhi - 110012
Email: drshyamnaginapandey18@
gmail.com

61. Dr N Parasuraman
Principal Archivist & Knowledge
Manager, MS Swaminathan
Research Foundation, Chennai
(Tamil Nadu)
Email: raman@mssrf.res.in

62. Dr Ashwani Pareek
Executive Director,
National Agri-Food Biotechnology
Institute, Mohali - 140306
Email: ashwani.p@nabi.res.in;
ashwanipareek@gmail.com

63. Dr RS Paroda
Chairman, TAAS, Avenue II,
Pusa Campus, New Delhi - 110012
Email: raj.paroda@gmail.com

64. Dr Himanshu Pathak
Secretary, DARE & DG, ICAR,
Krishi Bhawan, New Delhi – 110001
Email: dg.icar@nic.in

65. Ms Nikki Pilania
Founder- Mango Dairies,
Pilibhit (Uttar Pradesh)
Email: chaudharyfarms@gmail.com

66. Dr B Neeraja Prabhakar
Sri Konda Laxman Telangana
State Horticultural University,
Administrative Office, Rajendra
Nagar, Hyderabad 500030
Email: vc@skltshu.ac.in

67. Dr S Rajendra Prasad
University of Agricultural Sciences,
GKVK Campus, Bengaluru - 560065
(Karnataka)
Email: vc@uasbangalore.edu.in;
vcuasb1964@gmail.com

68. Dr S Rajkumar
ICAR-NBPGR,
Pusa Campus, New Delhi - 110012
Email: s.rajkumar@icar.gov.in

69. Dr Rampal
ICAR-National Research Centre on
Orchids, Pakyong, Sikkim - 737106
Email: director.nrco@icar.gov.in

70. JC Rana
Country Representative,
Alliance of Bioversity International
and CIAT, NASC, New Delhi - 110012
Email: j.rana@cgiar.org

71. Dr Gurinderjit Randhawa
Division of Genomic Resources,
ICAR-NBPGR, New Delhi - 110012
Email: nbpgr.genomic@icar.gov.in

72. Dr Rajvir Rathi
Head-Agricultural Policy &
Stakeholder Affairs, Crop Science
Dn., Bayer Crop Science Limited,
Aerocity, New Delhi - 110037
Email: rajvir.rathi@bayer.com

73. Dr RS Rathi
Principal Scientist, ICAR-NBPGR,
New Delhi - 110012
Email: ranbir.rathi@icar.gov.in

74. Dr TN Raviprasad
ICAR-Directorate of Cashew Research,
Puttur - 574202 (Karnataka)
Email: director.dcr@icar.gov.in;
dircajures@gmail.com

75. Dr D Damodar Reddy
ICAR-Central Tobacco Research
Institute, Rajahmundry - 533106
(Andhra Pradesh)
Email: directorctri@gmail.com;
ctri-ap@nic.in

76. Dr Juan Lucas Restrepo
Director General, Bioversity
International, Rome, Italy
Email: J.L.Restrepo@cgiar.org

77. Dr VV Sadamate
Agril. Extn Specialist & Former
Adviser (Agriculture), Planning
Commission (now NITI Aayog),
GoI, New Delhi - 110001
Email: sadamatevv@gmail.com

78. **Dr Asitava Sen**
CEO CropLife India, New Delhi
Email: asitavas@gmail.com

79. **Dr SK Sharma**
Former Vice-Chancellor, CSK HPKV, Palampur - 176061 (Himachal Pradesh)
Email: skspbg@yahoo.co.in

80. **Dr AK Shasany**
ICAR-National Institute for Plant Biotechnology, New Delhi - 110012
Email: director.nipb@gmail.com

81. **Dr Kadambot Siddique**
Director, Institute of Agriculture, UWA, Perth, Australia
Email: kadambot.siddique@uwa.edu.au

82. **Dr RB Singh**
Former President, NAAS,
NASC Complex, New Delhi - 110012
Email: rbsingh40@gmail.com

83. **Dr HP Singh**
Former DDG (Hort.),
ICAR, New Delhi - 110012
Email: hpsingh50@gmail.com; hpsingh2008@gmail.com

84. **Dr Inderjeet Singh**
Vice-Chancellor, GADVASU,
Ludhiana - 141004 (Punjab)
Email: inderjeet.dr@gmail.com

85. **Dr AK Singh**
DDG (Agril. Extn.),
ICAR, KAB-I, Pusa Campus,
New Delhi - 110012
Email: aksicar@gmail.com

86. **Dr BM Singh**
Former Pr Scientist,
ICAR-NBPGR, New Delhi - 110012
Email: bmsingh1@hotmail.com

87. **Dr DP Singh**
ADG (Vegetable Crops),
ICAR Hqrs, New Delhi - 110012
Email: dpsingh45@yahoo.com

88. **Dr Kirti Singh**
38G, Maruti Nagar, TD College Main Gate, Husainabad, Jaunpur - 222002 (Uttar Pradesh)
Email: kirtisinghwnrf2013@gmail.com

89. **Dr Rakesh Singh**
ICAR-NBPGR,
Pusa Campus, New Delhi - 110012
Email: rakesh.singh2@icar.gov.in

90. **Dr Rameshwar Singh**
Vice-Chancellor,
Bihar Animal Sciences University,
Bihar Veterinary College Campus,
Patna - 800014 (Bihar)
Email: vc-basu-bih@gov.in

91. **Dr RP Singh**
Former Head (Agronomy),
ICAR-IARI, New Delhi - 110012
Email: drsinghrp@rediffmail.com

92. **Dr Sanjeev Kumar Singh**
Treasurer ISPGR, ICAR-NBPGR Campus, New Delhi - 110012
Email: sanjeev.singh1@icar.gov.in; sanjeevs99@rediffmail.com

93. **Mr Harvir Singh**
Rural Voice, New Delhi
Email: harvirsingh@ruralvoice.in

94. Mr Sultan Singh
Sultan Fish Seed Farm,
Karnal (Haryana)
Email: sfsfinfo@gmail.com;
sfsfarm@yahoo.com

95. Dr Bansa Singh
ICAR-Indian Institute of Pulses
Research, Kanpur - 208019
Email: diriipr.icar@gmail.com;
director.iipr@icar.gov.in

96. Dr Anil K Singh
Vice-President, NAAS,
NASC Campus, New Delhi - 110012
Email: aksingh.icar@gmail.com

97. Dr Ramendra Singh
Senior R&D Adviser,
IFFCO, Gurugram
Email: ramendra.singh@gmail.com

98. Dr PS Sirohi
EA - 172, Arya Samaj Mandir Road,
Inderpuri, New Delhi - 110012
Email: pssirohi2005@yahoo.com

99. Dr AK Srivastava
Vice-Chancellor, DUVASU,
Mathura - 281001 (Uttar Pradesh)
Email: duvasuvc@gmail.com;
aksrivastava.asrb@gmail.com

100. Dr Umesh Srivastava
Consultant, TAAS & Former ADG
(Hort), ICAR, New Delhi - 110012
Email: srivastavaumesh@gmail.com

101. Dr RM Sundaram
ICAR-Indian Institute of Rice
Research, Hyderabad - 500030
Email: director.iirr@icar.gov.in;
director.iirr@icar.gov.in

102. Dr Renu Swarup
Former Secretary,
DBT, New Delhi - 110003
Email: renuswarup01@gmail.com

103. Dr Kuldeep Tripathi
Councillor-North Zone ISPGR,
ICAR-Campus, New Delhi - 110012
Email: kuldeep.tripathi@icar.gov.
in; kdtripathi89@gmail.com

104. Dr Amrish Kumar Tyagi
ADG (ANP),
ICAR, New Delhi - 110001
Email: amrishtyagi1963@yahoo.com

105. Dr Vandana Tyagi
Division of Germplasm Exchange &
Policy Unit, ICAR-NBPGR,
New Delhi - 110012
Email: nbpgr.exchange@icar.gov.in

106. Mr Narayanan Unny
Navara Eco Farm, Kerala
Email: unnysfarm@gmail.com

107. Dr Ashutosh Upadhyaya
ICAR-ICAR Research Complex for
Eastern Region, Patna 800014
Email: directoricarrcer@gmail.
com; director.icar-rcer@icar.gov.in

108. Dr Rajeev Varshney
Director, CCFI & SABC, Murdoch
University, Australia
Email: rajeev.varshney@murdoch.
edu.au

109. Dr SK Vasal
Former Distinguished Scientist,
CIMMYT, Mexico
Email: skvasal@gmail.com;
svasal12@yahoo.com

110. Dr Manjusha Verma
Joint Secretary
ISPGR, ICAR-NBPGR Campus,
New Delhi - 110012
Email: manjusha_v@yahoo.com;
Manjusha.Verma@icar.gov.in

111. Dr Shashi Verma
Ex Editor, ICAR,
KAB-I, New Delhi - 110012
Email: shashidivinechinmaya@
yahoo.co.in

112. Dr Stephan Weise
MD Asia,
Alliance of BI & CIAT, Rome, Italy
Email: s.weise@cgiar.org

113. Dr Rashmi Yadav
Email: rashmigbp@gmail.com

114. Dr OP Yadav
Director, ICAR-Central Arid Zone Research Institute, Jodhpur - 342003
Email: opyadav21@yahoo.com;
director.cazri@icar.gov.in

115. Dr Bitore Zhumakhanov
Project Executor, Kazak Research Institute of Soil and Agrochemistry, Almaty (Kazakhstan)
Email: dbitore@mail.ru

Recent TAAS Publications

1. National Dialogue on Innovations in Agricultural Extension: A Way Forward, 8-9 April, 2022 (September 2022).
2. Towards Secure and Sustainable Agriculture - Strategy Paper by Dr. R.S. Paroda, August, 2022.
3. Expert Consultation on Promoting Efficient Irrigation Technologies for Water Saving Across Scales and Sectors, 25 February, 2022 (May 2022).
4. Expert Consultation on Accelerating Export of Seed Spices: Challenges and Opportunities - Proceedings and Recommendations, 22 November 2021 (January 2022).
5. National Workshop on Bridging the Yield Gaps to Enhance Foodgrain Production: A Way Forward - Proceedings and Recommendations, 26 August, 2021 (December 2021).
6. Report on Policies and Action Plan for a Secure and Sustainable Agriculture in Hindi, October, 2021.
7. Youth as Advisory Agents, Input Providers and Entrepreneurs – Article by Dr. R.S. Paroda, September, 2021.
8. Brainstorming Session on Regenerative Agriculture for Soil Health, Food and Environmental Security - Proceedings and Recommendations, 26 August, 2021.
9. Stakeholders Dialogue on Enabling Policies for Harnessing the Potential of Genome Editing in Crop Improvement - Proceedings and Recommendations, 17 March, 2021 (June, 2021).
10. Harnessing Genome Editing for Crop Improvement – An Urgency : Policy Brief, May, 2021.
11. Accelerating Science-Led Growth in Agriculture: Two Decades of TAAS, May, 2021.
12. A Road Map on Stakeholders Dialogue on Strategies for Safe and Sustainable Weed Management, January, 2021.
13. Fish Farming in North India-A Success Story by Dr Sultan Singh, December, 2020.
14. Dr MS Swaminathan Award for Leadership in Agriculture - A Compendium, October, 2020.

15. A Road Map on Stakeholders Dialogue on Current Challenges and Way Forward for Pesticide Management, September, 2020.
16. A Road Map on Stakeholders Dialogue on Way Forward for the Indian Seed Sector, June, 2020.
17. Biofertilizers and Biopesticides for Enhancing Agricultural Production – A Success Story by Dr Basavaraj Girennavar, June, 2020.
18. A Road Map on Policy Framework for Increasing Private Sector Investments in Agriculture and Enhancing the Global Competitiveness of Indian Farmers, December, 2019.
19. Crop Biotechnology for Ensuring Food and Nutritional Security – Strategy Paper by Dr J.L. Karihaloo and Dr R.S. Paroda, December, 2019.
20. A Road Map on Efficient Land Use and Integrated Livestock Development, November, 2019.
21. National Dialogue on Land Use for Integrated Livestock Development - Proceedings & Recommendations, 1-2 November, 2019.
22. Horticulture for Food & Nutritional Security - Strategy Paper by Drs. K.L. Chadha & V.B. Patel, October, 2019.
23. Urgency for Scaling Agricultural Innovations to Meet Sustainable Development Goals (SDGs) – Strategy Paper by Dr. R.S. Paroda, April, 2019.
24. Tenth Foundation Day lecture on "Can India Achieve SDG 2 – Eliminate Hunger and Malnutrition by 2030" by Dr Prabhu Pingali, Professor in the Charles H. Dyson School of Applied Economics and Management at Cornell University, January 24, 2019.
25. Motivating and Attracting Youth in Agriculture - Strategy paper by Dr R.S. Paroda, November, 2018.
26. Women Empowerment for Agricultural Development - Strategy Paper by Dr R.S. Paroda, May, 2018.
27. Policy Brief on Agricultural Policies and Investment Priorities for Managing Natural Resources, Climate Change and Air Pollution - April, 2018.
28. Strategy for Doubling Farmers' Income - Strategy Paper by Dr R.S. Paroda, February, 2018.
29. Livestock Development in India - Strategy Paper by Dr A.K. Srivastava, Member, ASRB & Trustee, TAAS, February, 2018.
30. Indian Agriculture for Achieving Sustainable Development Goals -Strategy Paper by Dr R.S. Paroda, October, 2017.

Trust for Advancement of Agricultural Sciences (TAAS)
Avenue II, ICAR-Indian Agricultural Research Institute (IARI)
Campus, New Delhi - 110012, India
Ph.: +91-11-25843243; +91-8130111237
E-mail: taasiari@gmail.com; Website: www.taas.in