

Regenerative Agriculture for Soil Health, Food and Environmental Security

26 June 2021



Proceedings and Recommendations





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Organizers

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Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADG	Assistant Director General
AICRP	All India Coordinated Research Project
ARI4D	Agriculture Research and Innovation for Development
As	Arsenic
ASF	Alternative Systems of Farming
ASRB	Agricultural Scientists' Recruitment Board
BIRAC	Biotechnology Industry Research Assistance Council
BISA	Borlaug Institute for South Asia
BSS	Brainstorming Session
CA	Conservation Agriculture
CAZRI	Central Arid Zone Research Institute
CC	Climate Change, Carbon Credit
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
CGO	Central Government Organization
CIMMYT	International Maize and Wheat Improvement Center
CSSRI	Central Soil Salinity Research Institute
DARE	Department of Agricultural Research and Education
DDG	Deputy Director General
FAO	Food and Agriculture Organization
Fl	Fluoride
GHG	Greenhouse Gas
GR	Green Revolution
HYV	High Yielding Varieties
IA	Industrial Agriculture
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research

ICAR-CAZRI	ICAR-Central Arid Zone Research Institute
ICAR-IGFRI	ICAR-Indian Grassland & Fodder Research Institute
ICAR-IISS	ICAR- Indian Institute of Soil Science
ICAR-NIASM	ICAR-National Institute of Abiotic Stress Management
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for Semi Arid Tropics
IFDC	International Fertilizer Development Centre
IFS	Integrating Farming System
IIOR	Indian Institute of Oilseeds Research
IISS	Indian Institute of Soil Science
INM	Integrated Nutrient Management
INR	Indian Rupee
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
LISA	Low Input Sustainable Agriculture
LTEs	Long-term Experiments
LTFE	Long-term Fertilizer Experiment
MTNL	Mahanagar Telephone Nigam Limited
NAARM	National Academy of Agricultural Research Management
NAAS	National Academy of Agriculture Sciences
NARS	National Agricultural Research System
NASC	National Agriculture Science Complex
NBPGR	National Bureau of Plant Genetic Resources
NBSS & LUP	National Bureau of Soil Survey and Land Use Planning
NF	Natural Farming
NGOs	Non-Government Organizations
NIAP	National Institute of Agricultural Economics and Policy Research
NIASM	National Institute of Abiotic Stress Management
NR	Natural Resources
NRM	Natural Resource Management
NUE	Nutrient Use Efficiency

OF	Organic Farming
PES	Payment for Ecosystem Services
PJTSAU	Professor Jayashankar Telengana State Agricultural University
PPP	Public Private Partnerships
R&D	Research and Development
RA	Regenerative Agriculture
RLBCAU	Rani Lakshmi Bai Central Agricultural University
SAUs	State Agricultural Universities
SDGs	Sustainable Development Goals
Se	Selenium
SH	Soil Health
SHM	Soil Health Maps
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SRT	Saguna Rice Technique
SSNM	Site-specific Nutrient Management
SVBPUA&T	Sardar Vallabhbhai Patel University of Agriculture & Technology
TAAS	Trust for Advancement of Agricultural Sciences
TECA	Technologies and Practices for Small Agricultural Producers
TFP	Total Factor Productivity
ZBNF	Zero Budget Natural Farming
ZT	Zero Tillage

Brainstorming Session on Regenerative Agriculture for Soil Health, Food and Environmental Security

BACKGROUND

Regenerative Agriculture (RA) is a comprehensive system of farming combining a number of cultivation practices specifically focussing on regenerating top-soil to restore degraded soil biodiversity, rebuild soil organic matter, and improve water retention and nutrient uptake. Relentless depletion of biodiversity, degradation of soil health (SH), and change in climate have necessitated reversing the direction of agriculture from “degeneration to regeneration”. RA also helps in mitigating climate change (CC) by arresting soil organic carbon (SOC), while allowing farmers to maintain productivity growth, and farm income. Fundamentally, RA ‘does no harm’ to the land, rather improves it, using innovations that regenerate and revitalize the soil and environment through adopting practices of conservation agriculture (no-till, soil cover, crop diversification), increased use of compost/ animal manures, recycling waste to ameliorate soil biology and cantering on regulated grazing, mixed cropping/intercropping, etc. leading to healthy soils to produce nutrient rich and high-quality food.

Agriculture is both the victim and cause of ongoing depletion of vital natural resources (NR) -soil, water, air, biodiversity, etc. When in good health, these natural assets nurture productivity growth necessary for food security, minimize the effect of CC and improve biodiversity inspiring sustainable development of agriculture. On the contrary, degradation in health of NRs destabilizes agricultural growth, compromising food, and environmental security. Whether it is degeneration in soil fertility, biodiversity depletion or CC, the epicentre is loss of SH and land quality. Currently, world-wide one billion ha of land area is affected by soil degradation (India’s share ~10 %). In India, the Green Revolution (GR) based agricultural practices have paid good dividends in a short span of time and as a result the country became not only self-sufficient in food but also a net food exporting nation. However, as the time rolled by, these practices- high yielding varieties having narrow genetic base, monoculture, cereal-cereal rotations, repeated tillage, exclusive use of agro-chemicals, excessive irrigation, etc. started weakening agricultural sustainability with declining partial factor

productivity and plateauing output growth rates. Continuing such impassivity has led to degradation of SH because of mining more and replenishing less nutrients. Deterioration in SH in turn became a source of biodiversity loss, build-up of contaminants and pollutants, and rising spectre of CC whose consequences remain uncertain and unpredictable. By now, it is well known that around deteriorating SH nucleates food and nutritional security, farm income, ecological integrity, and global warming/CC. India or for that matter any other country can hardly afford to live with this kind of adverse developments that are at odds with the sustainable growth of agriculture.

Therefore, several alternative systems of farming (ASF) to revive SH have been proposed from time to time. Low input sustainable agriculture (LISA), conservation agriculture (CA), organic farming (OF), natural farming (NF), and zero budget natural farming (ZBNF) are some prominent ASFs recommended to replace or strengthen modern agriculture. While majority of the ASFs protect SH but fail to raise the bar of needed productivity growth. However, among the proposed ASFs, CA has received the maximum attention, being practiced in 102 countries over 205 million ha area covering more than 15 per cent of annual croplands globally and expanding at 10.5 per cent annually. Recently, RA is being projected as a holistic approach for improving soil and environmental health and increased biodiversity leading to productive farms, healthy society, and better economy of farming community.

The RA was proposed by Rodale Institute, USA during 1980s with the aim to rejuvenate SH, sequester carbon, conserve water, improve drainage, and mitigate CC - all for the benefit of productivity-led surge in food security. It focuses on an aggregate of farming methods that harness power of soil biology to build SOC, inspire application of native resources, reduce disturbance to soil, and soil cover; rationalize consumption of fertilizers, use of water, fossil fuel and other synthetic practices. Conceptually, RA philosophy does so by responding compressively for enhancement of soil biology to build SOC. Centrality of SOC in building SH draws strength because tenets of a healthy soil necessary for building food security and mitigate CC are deeply rooted in the concept and content. The positive influence on SH in RA happens as SOC: perks up soil biology favouring carbon sequestration; maintaining soil fertility; regulate water holding and transmission characteristics, provide short-term relief from drought and CC. Thus, RA process in totality targets enhancing and sustainably conserving soil ecosystem for a sustainable production system and mitigate CC. The RA concept, though 40-year in existence, has rarely been discussed and deliberated in India. Hence, to amplify its philosophy, vision, and goal, Trust for Advancement of Agricultural Sciences (TAAS) jointly with Indian Council of Agricultural Research (ICAR), National Academy of Agriculture Sciences (NAAS), International Fertilizer Development Centre (IFDC),

and International Maize and Wheat Improvement Center (CIMMYT) organized a Brainstorming Session (BSS) on “**Regenerative Agriculture for Soil Health, Food and Environmental Security**” on 26 June 2021. Over 75 diverse stakeholders including science leaders, natural resource/social/animal scientists from National Agricultural Research System (NARS) and International Organizations, Functionaries of Development Departments, Non-Government Organizations (NGOs), and farmer representatives participated and deliberated on all aspects of RA. The BSS focused on the following three objectives:

- To discuss potential role of organic farming, zero budget natural farming (ZBNF) and conservation agriculture towards regenerative agriculture so critical for improving soil health, mitigating CC and long-term food security
- To assess the expected returns (social, economic and environmental) over the investments towards Agriculture Research and Innovation for Development (ARI4D) on RA
- To have better understanding for prioritizing R&D efforts on modern and traditional agricultural practices that contribute to RA

INAUGURAL SESSION

The Brainstorming Session (BSS) was chaired by Padma Bhushan **Dr RS Paroda**, Chairman, Trust for Advancement of Agricultural Sciences (TAAS), Former Secretary, Department of Agricultural Research and Education (DARE) and Director General, ICAR. The deliberations comprised opening session, thematic presentations, and a panel discussion by eminent national and international experts followed by concluding session. In the inaugural address, Dr Paroda welcomed Dr T Mohapatra, Secretary DARE and DG, ICAR, Dr Rattan Lal, distinguished invitees, eminent experts and participants, and outlined the importance of the BSS and mentioned about the potential role of organic farming, ZBNF, LISA, CA in building RA for improving SH, food security and climate resilience and also for assessing potential, economic, environmental, and social factors in the context of investment on ARI4D pertaining to RA; and generate better understanding on the role of traditional agricultural practices contributing to RA. He emphasized on conservation of natural resources which have been exploited tremendously. He remembered how 55 years ago, Dr MS Swaminathan and Dr Norman Borlaug initiated GR technologies that increased India's food production by more than three times. He also applauded Indian agriculture sector which excelled even during Covid-19 pandemic. He shared that RA focuses on topsoil regeneration, increase biodiversity, improve nutrient and water cycle, enhance ecosystem services, support bio-sequestration, increase resilience to CC, and strengthen the health and vitality of farm soil. A paradigm shift is needed from cropping to farming systems mode along livestock, agro-forestry, and silvi-pastoral

approach on eco-region basis. There is also a great need to ensure institutional backstopping.

Dr Paroda emphasized on 'One Health' system that breaks down the silos between the health of soil, animal, environment, and humans, so as to track and prevent diseases/outbreaks at source. Further, he stressed on the decline of total factor productivity (TFP), soil degradation, etc. and how we can make-up that difference. Farmers depend on animal mixed farming system, and biofertilizers and biopesticides for integrated pest management (IPM) and hence India requires an aggressive approach. He said that for CA, we have moved very slowly in Asia compared to other regions and stressed on the need to change the mindset of people, support by government policies, strong public private partnerships (PPP) for enhancing RA and greater coordination among different stakeholders to follow diversified farming system, conserve biodiversity and move towards one health concept. A clear way forward on RA, CA, organic farming, and conservation of biodiversity is required to move fast for wider adoption. He emphatically mentioned that we need to enrich our soil and we are bound to replace what we have removed. Soil health (SH) mission need to be re-visited to bring the key technological and policy support to promote RA in general and CA particularly in drylands.

Dr JC Katyal, Former Vice Chancellor, Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar shared that Indian agriculture is at cross-roads in growth performance, we need to re-invent it. He mentioned that RA is an integrated concept which nurtures SH by ecological enhancement and amplify soil biology for sustainable production and focuses on infusing health into soil ecosystem by amplifying role of soil biology. It substantially enhances crop productivity and mitigates CC and build soil fertility. He expressed concern on the over-exploitation of natural resources and exhorted that Indian soils are depleted to the maximum extent, and no further depletion is possible. Also, there had been misuse of water in the past decades, total reliance on high yielding varieties (HYVs), cereal-cereal rotation, imbalanced use of agrochemicals, neglect of organic sources, inefficient use of energy, and industrial path of agriculture focusing mainly on productivity, sidestepping its consequences and environmental costs. Exclusive reliance on HYVs overpowered local types and caused loss to local crop diversity which diminished the potential of plant breeding resulting into emergence of new pests and diseases, mounting use of pesticides, soil microbial diversity falls, and quality of food becomes questionable. The SOC maintains a balance of fertility, physics and biology of soils, builds food security and regulates climate mitigation because it is storehouse of nutrients, regulator of soil structure, nurturer of soil-biota. There is need for alternate system of farming (LISA, ZBNF, OF, NF and CA) to bring back neglected role of soil biology. LISA practices are

highly favourable for sustaining SH but not for food sufficiency/food security. ZBNF yields are largely inferior, helps farmers getting more income due to reduced input cost, but productivity potential is questionable. He further stressed that RA is more comprehensive as it incorporates practices and principles of CA, OF, mixed cropping, integrated farming and modern agriculture technologies. In fact, CA works as a bridge to sustainable agriculture (SA), and RA is destination to SA. Finally, he highlighted that adopting all practices related to RA as stated above is not necessary and there is need to focus on zero tillage (ZT), longer rotations centering on mixed cropping, use of organics, and mixed farming; superimposing practice of self-fertilizing by endosymbionts, composting and raised-bed planting will hold significant value in certain agro-ecologies. There is need to translate RA in fulfilling goal and vision of an agricultural production system for food, nutrition, climate mitigation, and livelihood security. He stressed on integrating functioning of useful soil biology by maximizing return of larger proportion of organic resources; harnessing role of microbiota/bio-stimulants in accelerating *in situ* composting of recalcitrant native materials would be necessary to enhance value of organics. He exhorted to mainstream RA practice and principles and to create a market for trade of ecosystem services; instituting a policy that supports rewarding and incentivizing farmers who adopt SH regenerative practices-infusing resiliency into farming, would be of fundamental necessity. He also advised the researchers to have new knowledge and skills on RA and validate RA on sustainable basis to successfully transform modern agriculture to RA. There is need for launching of production system based, multi-location, cross-institute, pan-disciplinary term studies in action research mode.

Dr Rattan Lal, Director, Carbon Management and Sequestration Centre, The Ohio State University, Columbus, Ohio USA through a recorded message emphasized on reducing environmental footprint of India's agrarian sector by adopting sustainable soil management principles. He shared that GR was seed centric and based on growing improved varieties of foodgrains (especially wheat and rice) with liberal use of chemicals, intensive tillage and groundwater irrigation. But, the current production systems demand: i) soil based -with focus on SH and its resilience, ii) ecosystem based - with reliance on eco-efficiency of inputs, and iii) knowledge based- dependent on proven technology for sustainable management of natural resources (e.g., landscape, water, air, biodiversity). He mentioned that if we remove soil nutrients and organic matter from soil, we must return it too. He urged not to burn the crop residue as burning of rice straw is not good for the soil, environment, or the human health. Rather, the entire crop residue should be returned to the soil. We use fertilisers and pesticides indiscriminately and thus the soil dies which should never happen. Our *Shastra* say *Dharti is Mata* and it must be worshipped. Also, he advocated for not practicing flood irrigation and

rather adopting drip irrigation, as it saves water, and plants grow better as their roots don't get drowned. The farmers who follow good agricultural practices, and maintain crop cover should be rewarded by giving an incentive of INR 5,000/ha .

Health of the soil, plants, animals, environment and the humans are interconnected. If the health of soil deteriorates, our health also deteriorates. Soils are carbon sinks-if we increase the organic matter by photosynthesising carbon dioxide (CO₂) from the atmosphere and build-up the organic matter in India to 2 -3 per cent in the next 20-30 years, many problems related to CC will be alleviated. A healthy soil will protect from flooding in the monsoon and drought in the summer. Soil is one of five big carbon sinks on earth, and it traditionally held a great deal of carbon that has now entered the atmosphere. He further emphasised that life in the soil (activity and species diversity of soil biota) must thrive and flourish so that it can generate ecosystem services essential for human wellbeing and nature conservation which can only be done by restoring soil organic matter (SOM) content to above the critical level by creating a positive soil/ecosystem carbon budget. Dr Lal not only emphasised the concept of soil physical health and resilience as an effective strategy for meeting the farming challenges of a changing climate, but also reiterated that soil contains 1,550 giga tons of organic carbon in SOM, as well as 750 giga tons of inorganic carbon, which adds up to three times the amount of atmospheric carbon. He further emphasised that there is need to reduce carbon emission from farm operations. The most economic, natural, low-hanging fruit is restoring soil. Growing crops on healthy soils produces more food from less land area, less use of agrochemicals, less tillage, less water and less energy. He felt urgency for improving SH in GR belt, and desired that possible options may be given to farmers to improve SH. He also emphasised on the need for bringing out Soil Health Maps (SHM) every five years.

Dr T Mohapatra, Secretary, DARE and DG, ICAR applauded Dr RS Paroda who is always in the forefront to give new direction to agriculture. India has large population which is increasing incessantly and there is need to have enough food for them and thus country needs to evolve new technologies for increasing productivity. About RA, he emphasized that the concept is not new, but complex. In the past several years, soil fertility is considerably deteriorated which needs to be improved through balanced use of fertilizers. Also, there is need to change the mindset of farmers too. He further emphasised that rice-wheat cropping system economics is higher and simultaneously also important to devise ways to diversify this system. Productivity in organic agriculture is low; probably science is not contributing enough in this area. He cited example of Bhutan-an organic state where production is so low that they need to import food from other countries. He emphasised as to how RA along with reduced chemical use can help in shifting

from modern agriculture. He opined that we should work only in limited area as far as RA is concerned. He opined that unless science-based evidences are in place, we can't go exclusively for RA. There is need to intensify research for validation through long-term experiments. Also, required public awareness is needed to promote RA. He further stated that the most promising solution is to start with healthy soil which has the ability to pull carbon out of the atmosphere and store it underground, where it can restore nutrients and feed an array of plant species and micro-organisms. This is important because up to one-third of greenhouse gas (GHG) emissions come from the food system, an estimated 80 per cent of which comes from agriculture. Hence, we can make a meaningful difference by practicing RA through a holistic, principles-based approach to farming that seeks to strengthen ecosystems and community resilience. For RA, there are five questions that must be addressed: i) what is the problem to which RA will provide a solution? ii) what is to be regenerated? iii) what agronomic mechanism will enable or facilitate regeneration? iv) can this mechanism be integrated into an agronomic practice that is likely to be economically and socially viable in the specific context? and v) what political, social and/or economic forces will drive use of the new agronomic practice?

TECHNICAL SESSION: THEMATIC PRESENTATIONS

The Technical Session on "Thematic Presentations" was chaired by Dr SK Chaudhari, Deputy Director General (NRM), ICAR. Four thematic presentations were made during this Technical Session: i) technology landscape for enhancing SH in RA, ii) evidence based scalable CA practices addressing RA, iii) learnings from long-term experiments towards RA, and iv) role of integrated farming for RA in drylands.

Dr AK Patra, Director, ICAR- Indian Institute of Soil Science, Bhopal discussed on the technological landscape for enhancing SH in RA. He shared that as per UN estimates on soil degradation, the topsoil will be lost within next 60 years leading to a situation of no farming conditions. The major causes of soil degradation include increased use of chemicals, deforestation, and CC aberrations. Sleepwalking agriculture is getting into a crisis under the current production technologies. The soil nutrients are going into the air than soil, causing - high GHG emission, reduced nutrient use efficiency (NUE), decline in SOC (≤ 0.5), decline in soil biodiversity, imbalanced fertilizer use and nutrient mining of almost 10 million tons every year. He emphasized on the RA principles as the way forward to revert land degradation (soil protection); to maximize crop productivity per unit area; to enhance carbon storage- soil biodiversity, SH; and to increase ecosystem services. There is need for microbial composting which can be accomplished in 30-35 days using vegetable and fruit wastes. He advocated for the enabling

policies along with incentives and rewards for RA and creation of ecosystem services. He emphasized on the following important points:

- An objective and evidence-based approach to RA is needed to fully understand the discrepancies between the scientific literature and the experiences of farmers.
- There is need to modify current practices of cultivation to minimize the mechanical, chemical and physical mistreatment to the soil.
- Trials are required to tailor CA practices suitable to local conditions for widespread adoption.
- Soils need to be managed by mimicking in nature's way to protect and enhance soil biodiversity, health and sustainability and protect them from conversion and degradation.
- Diversified agriculture encompassing components of integrating farming system (IFS), integrated nutrient management (INM)/ site-specific nutrient management (SSNM), biochar and integrated pest management (IPM) should be promoted for minimizing use of chemicals in agriculture and include these as a promising tool for RA.
- Enabling policies including incentives and rewards for RA and creation of ecosystem services are needed urgently.

Dr ML Jat, Principal Scientist and Sustainable Intensification Strategy Leader, CIMMYT India, New Delhi talked about the evidence based scalable CA practices addressing the RA. He mentioned that in the UN Food Systems Summit 2021, transformation of agri-food system was highlighted as a key agenda to achieve Sustainable Development Goals (SDGs). It was underlined that agri-food systems need to ensure- healthy food for all, heal and protect the environment, and animals, should be safe and equitable to promote vibrant economies without intensifying the crisis of global CC. The RA has the potential to contribute to the UN food system objectives. He highlighted that the anthropogenic CC has reduced the global agricultural total factor productivity by about 21 per cent in the past six decades. The slowdown actions are equivalent to losing seven years of productivity growth globally including Asia and India. Therefore, restoration of SH and reversal of biodiversity loss is the key entry point as well as integration of CA with RA. He shared that CA is practiced globally on 205 million ha area in over 102 countries and expanding @ 10.5 million ha every year. The multi-criteria analysis of CA in South Asia revealed system productivity increase by 5-12 per cent, WUE by 10-30 per cent, energy saving 46-62 per cent, labour saving 26-44 per cent, profitability enhancement by 20-27 per cent and GHG reduction by 12-33 per cent. He emphasized that CA transformation to RA require a system approach, multi-criteria-based domain targeting, skill and knowledge enhancement, emphasis

on social and behavioural science communication and common neutral platform for learnings, collective wisdom and action. The principles of CA contribute to the RA, and India would require a national level planning and enabling policies. He concluded highlighting the following salient points/ suggestions:

- Elements of CA significantly contribute towards RA by improving SH, reversal of biodiversity loss while minimizing the negative environmental impacts through ecosystem services and other societal benefits.
- Transformation from CA to RA would require IFS and soil conservation approaches as the entry point to regenerate and contribute to multiple provisioning, regulating and supporting ecosystem services and enhance not only the environmental, but also social and economic dimensions of sustainable food production
- The CA systems dramatically improve biodiversity, increase the SOM, and bring positive environmental externalities, and minimize abiotic stresses.
- India has a large potential (at least 50 mha) for adoption of CA/RA across diversity of cropping systems and agroecologies (irrigated, rainfed, arid) through appropriate targeting, investments, knowledge and capacity enhancement and enabling policies.
- There is a need for creating a pull factor for transforming CA to RA by incentivizing farmers for carbon credits/eco-system services through repurposing the subsidies and developing carbon markets for private sectors.

Dr BS Dwivedi, Director, ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur discussed in his presentation the learnings towards RA from the long-term experiments (LTEs). He shared that there are more than 600 active LTEs globally and 50 per cent in Europe alone. The LTEs data contribute towards RA knowledge on biodiversity, soil enrichment and enhancing ecosystem. Most of the LTEs are dynamic in nature including the oldest Rothamsted LTE which reveal that “4 per 1, 000” carbon goal has limitations as farmers do not have necessary resources. Overall, the European LTE reveal that SOC can be increased significantly following the RA principles of minimum tillage and organic fertilizer, which lead to high productivity and microbial activity. The Indian LTEs reveal that INM through inorganic + organic fertilizer helps in keeping high SOC stocks, improve soil physical and biological properties. The Indian LTEs can accommodate the tenets of RA but need to be modified to retain their relevance. Evidence based benefits should be considered for RA. The SH maps are needed every 5 years. He further highlighted that:

- More realistically, promote practices that increase SOC like FYM and INMin RA, which improve soil quality translating in higher yields.

- Less relevant treatments of LTEs may be replaced with RA practices and even the need-based bifurcations of plots can be made to test different tenants of CA/RA.
- An “Expert Group” should be formed before making such changes and also design the minimum common data sets protocols linked to online portals to keep symmetry.
- Mechanized composting units need to be promoted at village level, incentivize best fertilizer management practices, link RA with national schemes and conduct large scale demonstration for skill development and knowledge sharing.

Dr OP Yadav, Director, ICAR-Central Arid Zone Research Institute Jodhpur highlighted in his presentation the role of IFS for RA in drylands and irrigated agriculture. He highlighted that IFS and RA are interlinked as both share the crop and livestock component that targets to improve soil organic matter, soil biodiversity, carbon sequestration to reverse CC, enhance productivity, diversification, resilience, income, risk aversion and livelihood. He presented IFS models from several agroecologies of drylands in India and concluded that increase in SOC is consistent among all the IFS models. IFS without fertilizer use are not sustainable in the dryland systems. He also emphasized that farming can't be done without mineral fertilizer use in India. The IFS models provide efficient utilization of nutrient, water, and energy flows as output of one component acts as input of another component. The silvi-pastoral based IFS models help in improving the microbial diversity significantly including fungal population, bacterial count, actinomycetes and earthworm. The INM system in IFS enhances the carbon management index significantly. Agroforestry is an integral component of the IFS system that helps in recycling the tree biomass and storage of carbon in soil. This overall helps in making the system as carbon sink and neutralizing the higher GHG emission from the livestock. The role of agroforestry is much higher in dryland conditions due to limited crop biomass in drylands. In dryland IFS models, compost contributes significantly in increasing soil carbon stock than the tillage practices, whereas microbial biomass and soil enzymes are higher in zero tillage (ZT) systems. In India, more than 50 IFS models have been developed and adopted by farmers, which can be linked for RA based scientific studies. To harness the full potential of RA through IFS, there is a need for diversification and innovations in the IFS models. This would require enabling policies and their proper implementation. He made the following important suggestions:

- IFS has a key role to play in RA and IFS dynamism needs to be maintained through tweaking existing models.
- Due to increased pressure of livestock in drylands, the grasslands and rangelands are highly degraded. These need to be rejuvenated involving community and RA practices.

- Farmers 'field-based IFS models can complement and strength RA integration through appropriate targeting to diversity of farm typologies.
- Multi-criteria approaches including profitability tradeoffs and critical factors such as water, soil carbon, GHG emission, etc. should be used for designing the sustainable RA based IFS.
- Mainstreaming of ecosystem services is a must with proper incentivization and reward/award system along with enabling policies with appropriate implementation mechanism.

PANEL DISCUSSION

The Panel Discussion on 'Strategy for Regenerative Agriculture" was moderated by Dr SK Chaudhari, Deputy Director General (NRM), ICAR, New Delhi. Eight panellists, namely, Drs AK Srivastava, Anil Kumar Singh, V Praveen Rao, HS Gupta, Usha Barwale, Chandrashekhar Bhadsavle, Himanshu Pathak and Upendra Singh made interventions and have provided useful suggestions for the way forward.

Dr AK Srivastava, Member, Agricultural Scientists' Recruitment Board (ASRB), New Delhi opined that RA is a practice of integrating crop and livestock to enhance carbon sequestration and SH. Among all the five principles of RA, the integration of livestock with crop is the most important. By doing so, increase in soil water retention, carbon sequestration and SH, and biodiversity are achieved. He suggested rejuvenating Indian pastures and grasslands through RA for enhancing animal production. He emphasized that extensive livestock farming which is being carried out on meadows, pastures and mountains and nomadic livestock farming which moves from one place to another will help in conservation of SH and environment. Globally, grasslands occupy about 24 per cent of total geographical area when animals stay on these lands for grazing, they provide urine and dung to soil and enhance soil fertility, their hooves trample the soil, thus increasing the sunlight, nutrient and water infiltration in soil. The crushed leaves and stem from not eatable and non-desirable plants provides natural mulch that helps in retaining the soil moisture and water run-off during rainy season. The pawing and bellowing of animals also help in breaking the hard soil and improve physical SH. If animal dung is used judiciously, it is a boon for soil, crop and environment, if not, it is a catastrophe to environment, as globally 55-65 per cent of total methane gas is being generated from animals, and dung is also playing major role in methane gas production. He also shared that use of animal dung and urine increases the mineral status of soil, stimulate plant growth, increases resistance of plant against pests and diseases. It also increases sulfoxidation and phosphorus solubilization. Toxic level of macro/ micro/ trace metals and minerals in soil and water affects the quality and SH, water, food grains and ultimately the human and animal health.

Among all minerals, the excess and toxic levels of selenium (Se), arsenic (As) and fluoride (Fl) in soil, water and foodgrains are most important. Similarly, the problem of fluoride excess in soil and water is also very serious in several parts of India. As per Government of India data, the problem of excess/toxic level of Fl soil and water are found in 19 states and 230 districts, where 11.7 million populations are affected. Fluoride is accumulated in all food crops such as wheat, rice, maize, tomato, potato, coriander, onion, beans, brinjal, leafy vegetables and pulses. He highlighted the following major points/suggestions:

- Integrating livestock with crops and grasslands is the key towards RA
- There is significant production of livestock manure and urine which if used judiciously coupled with other sources of nutrients, will not only reduce the GHG emissions but also complement to INM in RA systems.
- Large chunk of land is affected with problems of selenium (Punjab), arsenic (Bengal delta plains), Fluoride (Rajasthan), etc. wherein crop-livestock systems with judicious use of livestock excreta (dung and urine) could provide opportunity as a part of solution to these problems and help moving towards increased use of RA.

Dr Anil K Singh, Former DDG (NRM), ICAR, New Delhi stated that Indian agriculture is diversified and solutions to problems are highly location-specific. Hence, diversified agroecologies and location-specific solutions should be integral parts of RA in the context of Indian agriculture. The market scenario also influences the farmers' decision and, therefore, both profitability and adaptability will be the key factors for RA adoption. For RA to succeed, crop-livestock farming covering 75 mha in rainfed region is a key niche area not only to enhance income and livelihoods but also to bring climate resilience. Inclusion of mineral fertilizers is a must in RA-based production system to enhance food and other commodities production to feed the population which is expected to touch 1.64 billion in 2050. Secondly, organic fertilizers cannot bridge the gap or become a substitute for chemical fertilizers. The RA practices should consider building resilience to CC as a priority. The carbon sequestration, an important component of SH should be the priority in RA. Payment for ecosystem services (PES) is now recognized world over and in India, there is need to have a proper valuation of the ecosystem services provided by RA and an institutional mechanism put in place to provide incentive to RA farmers. Incentives given to farmers go into the "Green Box" unlike subsidies which are generally discouraged. Key highlights of his interventions are as follows:

- Scaling NRM technologies is always a challenge. Hence, it is better to avoid rigid principles of any concept and to provide flexibility for location specific adoption.

- Ecosystem services are critical and must be implemented but after proper quantification, verification, and with protocols across diversity of farming systems and agroecologies (irrigated and rained).
- Tradeoff analysis for food production against natural resources should be done to develop a sustainable strategy for targeting RA.
- There are around 100 districts of India having less than 50 kg nutrient use which provides opportunities for dissemination of RA.
- There is a strong need for social inclusivity and strong socio-economic research for scaling of NRM technologies in general and RA in particular.

Dr V Praveen Rao, Vice Chancellor, Professor Jayashankar Telengana State Agricultural University (PJTSAU), Hyderabad initiated his intervention highlighting on current policies as key barriers to the widespread adoption and scaling of RA and IFS. He shared that enabling Government policies are critical for widespread transition towards RA. The current policies encourage monocultures, chemical-dependent agriculture, which is a challenge for transition to RA. Lack of awareness, knowledge gaps, trusted technical assistance, willingness to change, and clear accessible entry points for transitioning to RA are other impediments. A disconnect between scientific validation, broad principles and top-down expert-led dissemination of RA from actual farmer-led experience and practice are other challenges. Lack of an operationalizable method to design RA systems across a wide range of contexts and to scale- up the process of scientific learning and validation may hinder the progress of adoption of RA. There is a need to address the disconnect between the wider social and ecological values of RA which are well attested with the likelihood of immediate and short-term decreases in yields and directly impacting already marginalised farmers. There is need to move from on-farm approaches to landscape and ecosystem approaches. Major points/suggestions made by him include:

- There is strong need for 'Food System' thinking toward 'Agri-Food Nexus' and 'One Health' mission in relation to RA.
- There is a need to have strong science-based clarity on context, concept, processes, standards for moving towards RA in different production systems and ecologies.
- The revolution in RA cannot occur without re-imagining agricultural science, validation of RA systems, removing barriers to innovative farmers, and willingness to change their operations.
- Carbon markets are a major area of opportunity for transitioning to RA which requires enabling policies. However, developing standardized measurable indicators to monitor, report, and verify successful regenerative food production systems are lacking and need to be addressed.

- One of the challenges to realizing a full transition to RA is lack of clarity in “regenerative practices” and still significant work needs to be done to ensure that responsible members of the food production and consumption chain understand the impacts of RA and align their production and purchasing decisions accordingly.

Dr HS Gupta, Former Director General, Borlaug Institute for South Asia (BISA), New Delhi emphasized that industrial agriculture (IA) has enabled to produce enough food for the growing population of the world but simultaneously deteriorated SH, degraded water quality and more importantly contributed to CC through emission of GHG resulting in global warming. Therefore, it is high time to look for an alternative technology that not only enriches the SH through large scale carbon fixation but also helps in meeting the demand for food as well as climate-smart agriculture. RA is indeed capable of improving SH by restoring SOC and mitigating CC by reducing GHG emission but it can't be outscaled uniformly globally or in India. For large scale adoption of RA, validation of its crop productivity is important as expected to feed 9.7 billion people by 2050, which requires: i) 60 per cent more food by 2050; ii) 50 per cent more foodgrains will be needed (305 mt at present to 457 mt in 2050) to feed India's burgeoning population. Additionally, we shall require 438, 183, 58, 45, 483 and 18 mt of vegetables, fruits, sugar, edible oil, milk and meat, respectively. This would require a four-fold increase in land productivity. The major points/suggestions emerged from his intervention are given below:

- Some of the concepts such as ZBNF considered as RA needs to be given a serious thought as to how these can feed the population in our country.
- RA should be evaluated in default OF areas and degraded lands, and perfected in Indian context. The current RA practices would perhaps not be able to meet the nutrient requirements of crops in high productivity zones.
- LTEs of AICRP indicate not only sustainability but improvement in SH with compost use @10 tons/ha/year along with recommended doses of NPK fertilizers.
- While we evaluate RA scientifically, India should continue to improve time-tested intensive agriculture, harmonizing with other emerging technologies like CA, which has so far paid rich dividends and helped in making India not only self-sufficient but a net exporter of several agricultural commodities.

Dr Usha Barwale, Director, Grow Indigo, Jalna opined that agriculture should not be just viewed as a problem in CC due to high GHG emissions, rather it should be considered as a solution to GHG mitigation while increasing profitability of smallholder farmers. Smallholder farmers need to be supported for carbon

sequestration and RA. She particularly highlighted the following important points:

- RA is a concept leading to sustainability but needs to focus on processes required to make it sustainable and scalable.
- RA practices provide an opportunity for generating additional income for farmers through carbon trading or its incentivizing for carbon credits/ecosystem services.
- Mere soil carbon sequestration was a major bottleneck in carbon trading due to amount of carbon sequestered and its verification in smallholder farms was not possible. However, recent developments on approvals of new and flexible protocols for carbon credits such as Verified Carbon Standard (VERRA) protocols accepted globally provides flexibility to capture total carbon footprints in terms of CO₂e, now provides excellent opportunity to incentivize farmers for carbon credits for RA practices.
- Incentivizing farmers for carbon credits will not only help in creating a pull factor for adoption of RA, but also will generate additional income to the farmers through trading carbon and investments by private sector, corporate and Government as part of their commitments to carbon neutrality by 2030.

Mr Chandrashekhar Bhadsavle, Innovative Farmer, Saguna Rice Farm, Saguna Baug, Neral, Dist. Raigad, Maharashtra shared his empirical observations about RA method of farming- Saguna Rice Technique (SRT). The SRT is a super low-cost technology and gives a guarantee of higher productivity even under extreme weather conditions. The technology has been accepted by the farmers in all agro-climatic zones of Maharashtra and is being used successfully for 25 different crops. He defines SRT as CA/RA, essentially a regenerative method of farming that does not cause atrocity of tillage, completely stops soil erosion, promotes the natural production of earthworms (birthplace of biodiversity), increases SOC, considerably increases the productivity of the land and provides happiness and confidence to the farmer. It also uses less irrigation water and less labour especially in paddy crop. Successful SRT farmers attract dignity in society and attract youth also in getting engaged in the farming. It is an easy-to-understand technology and now accepted by Food and Agriculture Organization (FAO) for their Technologies and Practices for Small Agricultural Producers (TECA) Program. SRT addresses six SDGs, namely, no poverty, zero hunger, good health and wellbeing, clean water and sanitation, decent work and economic growth, and climate action. He further opined that SRT would fit into “Negative Carbon Emission Farming” as mentioned by Dr Rattan Lal. His NGO has started a carbon incentive program with 20 farmers by paying INR 1,200 per ha to those who demonstrate an increase of 0.5 per cent organic carbon of their soil by adopting SRT. Finally, he made the following important points:

- SRT is contributing to several SDGs, included in TECA of FAO and recommended for 25 crops.
- SRT adopted principles of CA and RA, which not only help in getting increased yields and income but also enhance social capital through respect from fellow farmers. It is very important for scaling and adoption of new technologies.
- Currently, nearly 4,000 farmers are adopting the SRT.
- Aggressive dissemination of the scientific facts of RA in relation to the use of chemicals must be made through all SAUs by organizing demonstrations. Farmers are misguided to use organic farming rather than educating them about the facts of per cent organic carbon present in their soil.

Dr Himanshu Pathak, Director, ICAR-National Institute of Abiotic Stress Management, Baramati, Pune enumerated three objectives: i) potential role of OF, ZBNF and CA towards RA, ii) expected returns (social, economic and environmental) over the investments towards AR4D on RA; and iii) developing a road map for efficient and integrated RA. He emphasized that sustainable SH management should be the core of RA and should follow the basic law of restitution or replenishment. Indian soils with about 0.5 per cent SOC content can supply only 35-40 kg N per ha per season, which is sufficient to produce only 2 tons per ha rice and 1.5 tons per ha wheat, but we need to produce 5 tons per ha or more. Therefore, soil nutrients should be replenished from external sources of fertilizer and manure. The RA, thus, should ensure that harvested nutrient is replenished back to the soil by maximization of organic sources. However, chemical fertilizer has to be the key component of RA which should be driven by modern science with the latest tools and techniques including biotechnology, nanotechnology and space technology to make it profitable and sustainable. He exhorted RA as a potential technology but warned that: i) soil has a limit of carbon storage, the complex nature of soil carbon and increasing global temperature make it unlikely to increase SOC further; ii) long-term studies on soil carbon storage in tropics are not so promising; iii) sequestering biogenic carbon in soil, though good for SH, does not add much to long-term climate benefit because of its short-term nature and continuous cycling with atmospheric CO₂. Therefore, research is needed to validate the claims and refine the technologies to maximize the returns expected from RA. He further pointed out that there is need to develop a framework of RA, which is broad-based and flexible. The following steps need to be taken: i) identification of the areas where RA interventions will be suitable; ii) using balanced and INM practices including organic and inorganic sources; and iii) implement IFS approaches in larger areas including high-yielding, biofortified crop varieties; improved water, nutrient and crop management technologies; and livestock management. He made the following important observations/suggestions:

- There is a need for taking stock of good elements of crop management practices and integrating these with RA considering sustainable SH management and complemented by location-specific external application of inputs.
- Chemical fertilizers will continue to play a critical function for food and nutrition security. In India, for cereal production, 65 per cent of the nutrients come from chemical fertilizers higher than global average of 48 per cent.
- Judicious and balanced use especially the nitrogen is important as N_2O is the highest (19%) contributor followed by rice production (17%) to GHG emission from agriculture and hence nitrogen management will have to play key role in RA.
- Practices recommended under RA should be strongly science driven deploying the latest tools and techniques.

Dr Upendra Singh, Vice President, International Fertilizer Development Centre, Muscle Shoals, Alabama USA stated that RA is highly niche and site-specific, requiring a holistic understanding of interactions between soils, climate, management, and socio-cultural factors. Hence, recommendations need to be customized. The RA is a continuous process requiring a long-term commitment and investment. The soil organic matter (SOM) decline occurs within two to five years, rejuvenation and soil organic matter build-up takes up to 10 times longer and requires more efforts. The key issues to be addressed to improve SH are how to generate more and better-quality organic amendments and how do we recycle wastes and nutrients more efficiently and profitably? Integrated soil fertility management (ISFM) is the first step towards RA. It emphasizes the integrated use of balanced mineral fertilizers and organic amendments in combination with best agricultural practices, such as CA practices. Organic amendments in ISFM improve the efficiency of the applied fertilizers and improve soil water availability, which together increases microbial biomass and diversity. The NextGen fertilizers that are climate-smart and utilize soil ecosystem services are needed to contribute towards food and nutritional security, as well as biotic and abiotic resilience, while improving SH and biodiversity should be part of the RA concept to enhance sustainability. Nutrients flow from farmlands to urban centers (with produce), therefore recycling practices that are fast, less labour-intensive, and with lower transportation cost per unit of nutrient or carbon are needed to bring nutrients and organic amendments back to farmlands. New technologies of converting waste to wealth like “black soldier fly (*Hermetia illucens*) larvae to convert manure or wastes to a larvae manure product”, and vacuum pyrolysis “converting kitchen and municipal wastes, crop residues, sugarcane mill wastes, sawdust, etc., into biochar and biofertilizers (humic and fulvic acid)” should be the integral parts of RA. With a rapid turnaround time and high capacity (0.1-10 mt per hr), the

vacuum pyrolysis process can eliminate rice straw burning, reduce environmental pollution, and eradicate human health hazards while recycling biochar and nutrients into farmland. The following major points emerged from his intervention:

- There is need to develop and define customized recommendations for soil and nutrient management in different cropping systems in RA under varied agro-ecologies.
- There is a need to critically analyze and quantify amount of quality organic nutrient sources and how to generate additional quality organic amendments to complement the chemical nutrients towards RA
- There is need to develop and use next generation fertilizer that contain C, N, S, P, K plus other nutrients, use the ecosystem approaches, and improve NUE.
- There is a limited mechanism for effective and profitable nutrient cycling (bringing nutrients back to farm) and hence processes need to be devised and implemented for value chain nutrient cycling with minimal environmental hazards.

PARTICIPANTS' VIEWPOINTS

Besides the panellists, a few other participants were invited to put forth their viewpoints about the strategies for RA and these are summarized below:

Dr JS Samra, Former Chief Executive Officer, National Rainfed Area Authority, Government of India has expressed concern on circulatory stubble management and RA. He emphasised that RA should focus on right tracking of C, N and water cycles. In addition to soil, water and biodiversity, RA should focus on air quality and rising air temperature. He shared that many surveys carried out by social organizations have revealed that farmers are aware of ill effects of residue burning on soil and human health, but it is their economic compulsion. He recommended *in situ* recycling, mulching, composting in pits, heaps, windrow and recycling. He shared that, we have been ignoring emissions of the recycling processes of *in situ* decomposition, curing of dung and straw in the pits, heaps and windrows. All over the world, technologies have been developed for efficient harnessing of emissions as renewable energy by keeping intact recycling of carbon sequestration and all other nutrients It is simply scaling-up of the harnessing of *Gobar Gas* and manure at household level since 1962 in India. It produces renewable energy worth INR 30,000 per ha of paddy plus employment in the commercial plants. These plants offer INR 1,500 per ton of straw at the factory gate or farmers may like to exchange it with manure (digestate or residue) generated @ 50 per cent of the straw input. Recovery rate of manure in composting in pits or windrows is also

about 50 per cent. The real cost (including subsidy being paid by government) of *in situ* management is about INR 5,000 per ha which will be saved

Dr Bhag Mal, Secretary, Trust for Advancement of Agricultural Sciences and former Director, ICAR-Indian Grassland & Fodder Research Institute, Jhansi highlighted that RA offer tremendous potential towards better livelihoods and healthy environments. Therefore, a scalable method of integrated farming involving regenerative practices such as diverse crops and cropping systems including agroforestry, CA, crop rotations, livestock, fisheries, light tillage tools, etc. for co-producing RA, led by farmers themselves, is essential if a new productive, resilient and healthy farming future is to be realised. Finally, the success or failure of the proposed RA practices will depend on whether Indian farm policies are transformed from supporting chemical-based agriculture to making it economically possible for thoughtful, caring farmers to create and sustain regenerative integrated farming systems.

Dr Umesh Srivastava, former ADG (Horticulture), ICAR suggested a possible transition road map from conventional to RA required across stakeholders include: i) creating financial mechanisms and market structures that support RA outcomes, ii) empowering farmers to build coalitions at the grassroots level, iii) policy in place to build a resilient agricultural economy, iv) build and demonstrate the business case for RA, v) engage with consumers to increase demand for regenerative products, vi) prioritize nutritional benefits to enable healthy diets, and vii) mobilize stakeholders to enable regenerative practices to mainstream. The challenge is too great for any one organisation to tackle alone and hence there is need to work together to address systemic barriers.

RECOMMENDATIONS

The following main recommendations had emerged from the Brainstorming Session:

I. Promoting Regenerative Agriculture (RA)

1. Conceptually, RA is not a single technology but it is an innovative process about which farmers and other stakeholders need to be educated that this process involves regenerating of the top soil and increasing biodiversity and input-use efficiency. It centres around ecosystem services that mitigate climate change, sustain agri-food systems and produce healthy foods using innovations around conservation agriculture, integrated farming systems, agroforestry, organic farming, etc. along with good agricultural practices. The recently concluded UN Food Systems Summit 2021 has also highlighted the importance of RA for sustainable farming, which has highlighted the

urgency to scale RA in an ecosystem-oriented approach focusing mainly around conservation agriculture for sustainable intensification (CASI) in a big way. Hence, its infusion and out-scaling should be considered as a public good at the national and regional levels to reap multidimensional benefits including “source of GHGs to sink to mitigate climate change”.

2. For majority (80%) of small and marginal farmers of India, the redesigned concept of RA must induct practices that require minimum external input yet give maximum profit. In pursuance of these objectives, the alternative farming systems like: i) conservation agriculture for sustainable intensification (CASI); ii) Saguna rice technology (SRT); iii) livestock integration with crop production; iv) use of SOC building products: biochar, compost, manures, etc.; v) carbon-sequestering systems like: agroforestry, silvipasture, etc.; vi) building SH by advocating integrated soil fertility management practices (inorganic fertilizers+ organic manures), vii) fostering drainage by professional water percolation technology (bed planting and zero tillage); viii) ensuring a net biodiversity gain by introducing bio-inoculant and minimizing entry of agro-chemical pollutants from agriculture need to be adopted and practiced.
3. A paradigm shift is needed from cropping to faming system mode along with livestock, agro-forestry, and silvi-pastoral approach on eco-region basis. In fact, integrating livestock with cropping systems and grasslands is the key action for spreading concept of RA. In pursuance, it needs to be closely linked with the existing Soil Health (SH) Mission and integrated farming systems. Major focus of this alliance should target mainly the dryland regions where crop-livestock systems dominate and help in taking maximum benefit of livestock excreta (dung and urine). This is an effective existing SH problems. The targeted agro-ecologies may include: i) low fertilizer (less than 50 kg) consuming 100 districts in India; ii) selenium affected land in Punjab and Haryana; iii) arsenic affected areas of West Bengal delta plains; iv) fluoride affected tracts of Rajasthan and Telangana, and v) default organic farming areas that are degraded.
4. A National Mission on RA be initiated to deal comprehensively at the micro-level for the process of validation and diffusion of all its elements holistically. The main goal and vision of this Mission should be to promote regenerative farming concept to benefit farmers, raise their income and sustainability of their naive farming enterprise. The sample pilot studies on RA with farmers’ management, researchers mentoring, and active participation of development departments/aid agencies need to be launched.
5. In order to enhance ownership of and willing acceptance of the findings of field pilots, a feedback mechanism should be an integral part of this study.

Giving due weightage to farmers' views about their needs and perspective on RA would be a key action point before promoting RA on large areas.

6. Change of people's mindset at this juncture is very critical for which concerted efforts through media for public awareness be made. Also, there is an urgent need to ensure institutional backstopping for promoting the concept of RA.

II. Research and Development

7. There is need to create an Indian narrative of RA on building SOC as 1 per cent change would help replace about 30 kg fertilizer N, enhance soil's capacity to store more water and create a trust of useful soil biology. Since these low carbon foot print farming systems are economically and environmentally sustainable, those of the farming communities who adopt these farming systems as routine farming methods need to be appropriately incentivized/rewarded. Hence, there is an urgent need to establish an award/ reward system of payment of INR 5,000/ha/year to the farmers to encourage them for scaling RA related practices.
8. There is an urgent need for reorientation of research agenda by including RA for future research. Given the multifarious facets of RA in addressing the 'Agriculture-Food-Health Nexus', greater focus needs to be given on generating multi-location long-term scientific data using new knowledge, skills and capacity through translational research. This would require an inter-disciplinary approach as a transformational action for ongoing national NRM research agenda. Infact the defined benchmark sites should be regularly monitored and the data, thus collected, be used to help in modelling ongoing changes in productivity in relation to normal and abnormal nuances of climatic patterns. Thus, integrating it with modern tools and technologies - spatial science, digital science, application of big data analytics and machines, would be necessary for bridging knowledge gaps, better technology targeting and agroecology-based scaling to smallholder farmers.
9. The proposal on bench-mark sites need not necessarily be a de-novo activity to be funded by ICAR. While there will be need for setting up new sites in the heartlands representing uninvestigated food production systems, and agroecologies, the existing ICAR-AICRP on Long-term Fertilizer Experiment (LTFE) sites may be strengthened/ modified. In either case, the purpose would be to generate comprehensive and regular scientific data covering all aspects of RA. Establishing an expert group to regularly monitor and advise for this would be highly desirable. ICAR may consider constituting an expert group to suggest scale, tools and new data normals for establishing bench-mark sites or for making suggestions on modifications in the existing LTFEs without any significant deviation from the objective of ongoing research.

10. There is need to bring out Soil Health maps every 5 years. Health of the soil, plants, animals, environment, and humans are interconnected; therefore, the whole process of top-soil regeneration would require rejuvenating life in the soil (activity, number, and species diversity of soil biota). The focus of RA research must be on utilizing the services of useful endophytes that help in carbon sequestration and mobilizing the availability of soil immobilized nutrients (P). Besides, N fixing Rhizobia, role of soil fungi also need to be harnessed to the maximum extent, especially in hastening the process in situ decomposition of crop residues. The long-term studies on integrated use of biofertilizers and inorganic fertilizers be an important aspect for accelerating the process of regenerative agriculture.
11. Quantification and verification mechanisms and protocols for awarding credits for ecosystem service need to be devised. Accordingly, for reducing carbon footprint through adoption of RA practices by the farmers, needed incentives shall have to be put in place. Granting monetary rewards and carbon credits is seen to help creating a pull factor for adoption of RA as well as generate additional income to the farmers through carbon trading. Adequate funds for such investments need to be mobilized from the private sector as part of their corporate social responsibility. Besides, funding support by the Government in the form of incentives for scaling conservation agriculture for sustainable intensification would help in faster adoption of RA.
12. There is need to also develop and use the next generation fertilizer molecules that contain C, N, S, P, K plus other nutrients. Integrating their use with ecosystem approaches that enhance nutrient use efficiency will further promote their adoption on large scale and hence be given priority attention.
13. While evaluating RA practice scientifically; India should continue to improve the role of time-tested modern agriculture by harmonizing it with other resource conservation technologies, especially like CA, which has so far paid rich dividends in making India not only self-sufficient in foodgrains but a net exporter of many agricultural commodities fetching currently around US\$ 40 billion.

II. Enabling Policies

14. For holistic development/revival of the agricultural economy, the government needs to consider investing in soil health so as to ensure faster adoption of innovations like conservation agriculture, micro-irrigation, biofertilizers, natural resource conservation programs, etc. Greater policy support through increased investment for R&D on RA, and compensation/incentives for those who adopt ecosystem/ environmental services for sustainable intensification.

15. Concerted efforts are needed to critically analyze and quantify how RA contributes to existing national policies developed to reduce the negative impact of agriculture on soil health, biodiversity, the environment, and consequently the health of our people.
16. Carbon markets which constitute a major area of opportunity for transitioning to RA practices, requires an appropriate policy push. There is an urgent need to develop standard indicators to monitor, and verify successful soil regenerative food production systems in order to benefit farmers willing to do so that they receive desired monetary adopt good agronomic practices (GAP) benefits through carbon trading by involving corporate sector.
17. Soil health (SH) mission needs to be re-visited to provide the key technological and policy support for promoting RA in general and CA in the particular in drylands region. There is need to mainstream RA practices also through needed government policy support for rewarding farmers who adopt soil health regenerative practices that are critical for resilience in existing farming practices.

Program

26 JUNE 2021 (15.00-19.00 HRS)

Co-Chairs : RS Paroda, Chairman, TAAS
: T. Mohapatra, Secretary, DARE & DG, ICAR and President, NAAS

INAUGURAL SESSION

15.00-15.10	Welcome and Setting the Context	RS Paroda, Chairman TAAS
15.10-15.30	Regenerative Agriculture: Prospect and Potential for Sustaining Soil Health and Food Security	JC Katyal, Former VC, CCSHAU
15.30-15.40	Soil Health and Regenerative Agriculture	Rattan Lal, Director, CMASC, OSU
15.40-16.00	Special Address	T. Mohapatra, Secretary DARE & DG, ICAR and President, NAAS

THEMATIC PRESENTATIONS

Chair: SK Chaudhari, DDG (NRM), ICAR

15.05-16.05 Technical Session: Research, Development and IP Management

Chair: RS Paroda, Chairman, TAAS

16.00-16.15	Technology Landscape for Enhancing Soil Health in Regenerative Agriculture	AK Patra, Director, IISS
16.15-16.30	Evidence Based Scalable CA Practices Addressing Regenerative Agriculture	ML Jat, Principal Scientist, CIMMYT
16.30-16.45	Learnings from Long-term Experiments: Towards Regenerative Agriculture	BS Dwivedi, Director, NBSSS & LUP
16.45-17.00	Role of Integrated Farming for Regenerative Agriculture in Drylands.	OP Yadav, Director, CAZRI

PANEL DISCUSSION: Strategy for Regenerative Agriculture

Moderator: SK Chaudhari, DDG (NRM), ICAR

17.00-18.00 Panelists

AK Srivastava, Member, ASRB

AK Singh, Vice-President, NAAS

V Praveen Rao, Vice Chancellor, PJTSAU

HS Gupta, Former Director General, BISA

Usha Barwale, Grow Indigo

Chandrashekhhar Bhadsavle, Saguna Rural Foundation

Himanshu Pathak, NIASM

Upendra Singh, IFDC

18.00-18.30 General Discussion

CONCLUDING SESSION

18.30-18.40	Outcome - A Way Forward	JC Katyal , Former VC, CCSHAU
18.40-18.55	Concluding Remarks	SK Chaudhari , DDG (NRM), ICAR RS Paroda , Chairman, TAAS
18.55-19.00	Vote of Thanks	Bhag Mal , Secretary, TAAS

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