Strategy Paper

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Progress Through Science

Urgency for Scaling Agricultural Innovations to Meet Sustainable Development Goals (SDGs)

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Progress Through Science

Trust for Advancement of Agricultural Sciences (TAAS)

GOAL

Ensuring an accelerated movement for harnessing agricultural sciences for the welfare of people.

MISSION

Promoting growth and advancement of agriculture through scientific interactions and partnerships.

OBJECTIVES

- To act as a Think Tank to deliberate on key issues relating to agricultural research and innovation for development (ARI4D) and influence policy decisions
- To organize workshops, conferences, brainstorming sessions, policy dialogues, seminars and special lectures on emerging issues and new developments in agricultural sciences
- To disseminate knowledge among stakeholders through publication of proceedings, strategy papers and policy briefs
- To recognize and award the scientists of Indian and foreign origin for their outstanding contributions towards Indian agriculture
- To facilitate scientific interactions and partnership building of non-resident Indian agricultural scientists with Indian scientists

Urgency for Scaling Agricultural Innovations to Meet Sustainable Development Goals (SDGs)

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Preamble

Accelerating agricultural growth is an important goal for most of the nations for achieving Sustainable Development Goals (SDGs), especially to remove poverty, have zero hunger and ensure environmental security. Those developing nations that have reoriented their agricultural research for development agenda towards scaling of innovations have made much faster progress. Greater the emphasis on agricultural research for innovation, higher had been the growth for agricultural gross domestic product (GDP) (Shenggen Fan, 2013).

In fact, Green Revolution was in itself an innovation led initiative around the use of high yielding dwarf wheat and rice varieties that responded favourably to higher inputs leading to quantum jump in productivity. The factors of success had been: i) political support, ii) good institutions and human resource, iii) availability of critical inputs (seeds, water, fertilizer, etc.), iv) enlightened extension workers and hard working farmers, and above all, v) strong partnership among the stakeholders.

Considering emerging second generation challenges of Green Revolution like factor productivity decline, depleting natural resources, increasing cost of inputs, higher incidence of diseases and pests, higher cost of inputs, rising concern of

nutritional quality and safety of food, reduced profit to farmers and above all the adverse impact of climate change. Obviously, increasing income, especially of 80 per cent farmers who are small and marginal, having holdings less than 2 ha, would require technologies and innovations by which they can save cost on inputs and have more income by higher productivity, quality and also by linking to value chain and markets. Thus, scaling of innovations like hybrid technology, conservation agriculture, microirrigation, integrated nutrient management (INM), integrated pest management (IPM), adoption of genetically modified (GM) food crops, protected cultivation, etc., becomes high priority. For this to happen, enabling policies, strong public-private partnership and innovative extension systems to transfer right knowledge especially around secondary and specialty agriculture would be needed. Moreover, innovation without incentives and rewards and congenial policy environment, including intellectual property rights (IPR) regime, would not be possible for which we shall need innovative institutional as well as policy related reforms to make a difference - as was experienced during the Green Revolution era.

For any innovation to be scaled-out, it is critical to first assess their economic feasibility and potential for large scale adoption as well as impact. Moreover, many innovations are farmer led, which need to be assessed, validated, refined and outscaled in order to harness the expected benefits by farming community at large (TAAS, 2013). For this, farmer participatory approach need to be adopted with active involvement of scientists and provision of incentives, especially in the form of bankable projects with availability of credit at low interest rates of <4.0 per cent (Saxena, 2017).

Urgency to Meet SDGs: Some Initiatives

Indian Council of Agricultural Research (ICAR), having the mandate for research, extension and education, had

been engaged in providing national public goods that help accelerate agricultural growth by disseminating appropriate technologies to the farmers. In the process, *Krishi Vigyan Kendras* (KVKs), now numbering around 680, have been instrumental in providing front line extension for scaling new technologies that had helped farmers increasing production as well as income.

Besides front line demonstrations (FLDs), a large number of farmers in each district have been provided access to new seeds, planting materials, good agronomic practices (GAP) and training of farmers for skill development. These institutional systems have helped considerably in making faster growth in different sectors of agriculture.

Provision of revolving fund for enhancing availability of seeds of improved varieties/hybrids, faster multiplication of planting material, fabrication of tools and implements, etc. all helped in accelerating the growth of Indian agriculture. Even to ensure effective involvement of private seed sector, the ICAR provided freely the breeder seeds of parental lines of hybrids of crop varieties for faster multiplication and distribution of seeds to farmers. This obviously led to faster growth of seed sector in India. Various mechanisms of incentives and rewards were also put in place in late 1990s based on Johl Committee Report (1995). Somehow, these incentives have not reached the real performers for their extra efforts due to bureaucratic hurdles and resistance to change. To encourage private sector involvement in research and development (R&D), even provisions of intellectual property rights (IPRs) and Protection of Plant Variety & Farmers Right Act (PPV&FRA) were enacted in the beginning of new millennium.

For the benefit of both R&D investors and end-user farmers/consumers, the concerned intellectual property (IP) related statutory bodies and the Ministries of Commerce & Industries

and Agriculture and Farmers Welfare, in consultation with public and private sector organizations/stakeholders, must proactively visit the existing rules, laws and acts on the subject of innovation in agriculture. Where necessary, required amendments be brought about to create an enabling environment to encourage new innovations and their adoption, while ensuring proper access and benefit sharing.

Incentives and rewards were also an integral component of the prestigious World Bank Project named National Agricultural Technology Project (NATP), negotiated in 1998, followed by greater thrust of public-private partnership for scaling innovations under the second phase of WB project named as National Agriculture Innovation Project (NAIP). It eventually helped in outscaling many useful innovations for the benefit of end users - the farmers, producers and the consumers (ICAR, 2006; 2014).

Some of the recent initiatives for scaling innovations by the Ministry of Agriculture and Farmers' Welfare are: Attracting Rural Youth in Agriculture (ARYA), *Mera Gaon Mera Gaurav*, National Skill Qualification Framework, skill development training, Value Addition and Technology Incubation Centres in Agriculture (VATICA)', knowledge systems and homestead agricultural management in tribal areas, nutri-sensitive agricultural resources and innovations (NARI), climate smart villages, web and mobile advisory services. The farmer producer organizations (FPOs) can play potential role in innovation upscaling and hence providing needed support to them is also important.

The Department of Biotechnology (DBT) has also taken up several initiatives for scaling innovations through Biotechnology Industry Research Assistance Council (BIRAC), a platform to nurture industry-academia connectivity. Other initiatives include biotechnology parks and bioincubators, science clusters, etc. Even though there are different schemes

for agricultural biotechnology such as Biotech-KISAN scheme, the performance is not on par with other sectors like health. There are also schemes to encourage scientist/faculty to move to entrepreneurship. The key challenges for the entrepreneurs are lack of financing and market access. DBT had started several initiatives such as Students Innovations for Advancement of Research Explorations (SITARE), eYUVA (creating entrepreneurial culture in universities), BioNEST (nurturing entrepreneurship by establishing bioincubation centres) for supporting entrepreneurs. Also, there is a need for accelerating entrepreneurship fund and possibility of social immersion programs for incubators to assess the market needs (Renu Swarup, 2017).

Similarly, various initiatives by the National Innovation Foundation (NIF) for promoting grassroot entrepreneurship included Micro Venture Innovation Fund, Grassroot Technological Innovation Acquisition Fund and establishment of NIF Incubation and Entrepreneurship Council. Innovations are also encouraged by organizing exhibitions and through awards and scholarships. Participatory research and decentralized fabrication and services are essential for improving technologies for outscaling in India (Usha Zehr, 2017).

Innovations need to be considered in totality; Invention, Innovations-Policy-Institutions being so essential to develop a strategy for their scaling-out. ICAR needs to strengthen the existing policies, institutions and incentives for upscaling and outscaling innovations. The existing policies and mechanisms need thorough review in the present context. There is an obvious need to have competent human resource with marketing expertise so as to commercialize the technologies and taking them to small farmers, BIRAC model of DBT is a platform for innovations. Similar model needs to be developed in ICAR. Farm Producer Organization (FPO) could be a good option for promoting agricultural innovations and commercialization of technologies. While

planning for upscaling and outscaling, adequate care needs to be taken to avoid planning fallacy (underestimation of the time and resources). Now we need to think "can innovation be really engineered?" and applied to address the present day requirements of smallholder farmers (Gulati *et al.*, 2006; Renu Swarup, 2017; Suresh Pal *et al.*, 2017).

As stated earlier, agriculture being an important sector for elimination of poverty and hunger, and addressing the concern of climate change, key Sustainable Development Goals (SDGs), importance of relevant innovations can't be overemphasized for inclusive agricultural and economic growth (Shenggen Fan, 2013). In order to create needed environment for innovation, emphasis on capacity development is essential for India to progress and compete, especially in the present era of globalization. Hence, generating new innovations to meet emerging challenges, involving both public and private sectors is the need of the hour. The impact of innovations would be possible only through the implementation of commensurate policies and required IPR regime. In this context, National Intellectual Property Rights (IPR) Policy and implementation of Protection of Plant Variety and Farmers' Right Act (PPV&FRA), by the Government of India would certainly accelerate the pace of innovations (Saxena, 2017), provided both are harmonized and implemented to ensure access and benefit sharing (ABS) by those associated around innovation chain, while keeping the interest of farmers into consideration.

Experiences Abroad

Since industrialization, agricultural innovations in the developing countries had predominantly been brought in by the public sector. But with commercialization of agriculture, private sector including multi-national companies (MNCs) having base in developed countries have been major providers of technology. In the United States, public sector

universities became R&D labs for the private companies after the enactment of Bayh-Dole Act of 1980 (Bayh-Dole Act, 1980), which allowed universities and other non-profit institutions to have ownership rights on their discoveries that resulted from federally-funded research. This facilitated transfer of technologies to the private sector through establishment of Science Parks and Incubators. Europe also followed similar institutional framework to facilitate new innovations and their faster dissemination. Lately, greater emphasis on innovation in China, mainly public funded, has transformed its economy through greater participation of private sector and foreign companies for out scaling innovations.

In the pre-World Trade Organization (WTO) era, as stated above, the public sector institutions in the developing countries had played major role for generation of national public goods through agricultural research. On the contrary, in the past-WTO era, with economic liberalization, the private sector investments in agricultural innovations helped in faster delivery and adoption. Some of the developing countries moved faster in promoting the culture of corporatization in research and development (R&D). MLSCF and MARDI (Malaysia), Fundacion (Chile), CENTEV and EMBRAPA (Brazil), Technoserve (Mozambique), Timbali (South Africa) and IAA-IPB (Indonesia) are such public sector funded research institutional incubators that have worked in partnership with private sector for upscaling and outscaling innovations. Also, some multi-stakeholder platforms did get developed for scaling innovations (e.g. MasAgro, Mexico) (Shenggen Fan. 2013).

Current Challenges

Earlier, agri-innovations had relatively simple process/cycle of their development and dissemination through public extension system for the benefit of end users, mainly the

farmers. However, with the emerging complexities of modern time, new and rather more efficient players have entered in the process. The emphasis on commercialization of technologies and resource generation has also necessitated involvement of new actors, mainly private sector companies in commercialization of research products. These new initiatives are mainly being guided by profit motive and finding favour because of efficient and faster delivery mechanisms, though sometime more costly for smallholder farmers. On the other hand, some rural innovations by enterprising farmers are also recognized as potential options for solving the location specific problems, but they need validation, further refinement and outscaling for the benefit of larger farming communities,. Mainstreaming of such innovations is, therefore, a challenge which needs to be recognized and resolved by appropriate incentive and reward mechanisms and institutional/public-private partnerships. Thus, innovations have moved away from the conventional innovation systems (linear transfer of technology) to those of agricultural innovation systems (multi-stakeholder platforms) and also to farmers' innovation systems - grass root innovations (Saxena, 2017).

There is a need for figuring out complementarity between the public and private research organizations for scaling-up and scaling-out agricultural innovations for small holder farmers and major barriers in such collaborations. Unlike the public sector, private sector concentrates on fewer technologies and invests heavily to evolve those technologies. The key constraint with the public sector is longer duration (7-10 years for any varietal development) and need for higher investment. The major preconditions for scaling-out innovations are: threshold be need based, relevant, should have the proof of concept, must comply with regulations, cost of compliance, proper incentives and a sense of urgency (Bhooshan, 2017).

Somehow, under our conditions, the innovations have invariably not been subjected to evaluation for socioeconomic impact, as being done in most developed countries. Taking clue from the technologically advanced economies, India also realized that adequate efforts have not been made to encourage and emphasize on promoting innovations which is a key factor to generate agribusiness opportunities and to increase farmers' income. Also, guidelines for incentives and rewards for outscaling innovations and resource generation though evolved but were not implemented effectively. Somehow, the pace of promoting innovations and permitting the right incentives to researchers have also remained quite slow (Saxena, 2017), thus becoming an impediment.

Problems such as nutritional security, climatic change and declining profitability are some of the major issues and challenges which need to be urgently redressed. In-depth analysis of commercialization mechanisms at the system and organization levels has also not been paid due attention which needs to be done on priority for upscaling and outscaling agricultural innovations. Also, the lack of enabling policies, slow dissemination of knowledge concerning new technologies, intellectual property right issues, inadequate infrastructure and environment for capacity development, and lack of financial resources do pose serious challenges for faster scaling of innovations. Hence, these need to be effectively addressed being now a national priority.

Opportunities

There are several technologies which need to be outscaled. In the dairy sector, such technologies include animal identification, precision animal feeding, advanced reproductive technologies, disease diagnosis innovations, technologies for detection of adulterants in milk and milk products, small-scale farm machineries (such as mobile machine milker). There are now four generations of technology for improving

reproductive health and these must be scaled out. Artificial insemination and semen sexing can make a major impact on milk productivity. Kerala and Kolar Model of community milking, and technology for value added dairy foods are now standardized and need immediate interventions for its outscaling. In order to better understand technology and their spread, people's mind-set of "managing livestock under zero or low input" should be changed to "commercial enterprise" (Indra Mani, 2017).

Scaling-out innovations in case of agro-processing and value addition also needs to be given due attention. Exploitation of value added products from agrobiomass like lignin and algae, food products of bioprocessing and chemical processing and composite fruit coating can generate immense benefits for farmers and rural entrepreneurs. Most of these processes are either restricted to labs or not taken up for required scaling at scale (Bhooshan, 2017).

There is also an urgent need for upscaling and outscaling small farm mechanization for improved efficiency. Greater involvement of industries for commercialization is needed. Contract research on Urea Ammonium Nitrate Application System funded by the Dept. of Fertilizers and National Fertilizer Ltd. is a good example of success. Unique facilities such as 'Design Innovation Centre', a collaborative initiative by Indian Institute of Technology (IIT), Kanpur and Indian Agricultural Research Institute (IARI) is a promising model for incubation, design improvements and start-up facilitation. There is need for increased public funding for research in agricultural mechanization, establishment of national centres in different zones for mechanization, scaling-up innovations through public-private partnership (PPP), linking of grass root level innovations through institutional innovations and establishment of design innovation centres as well as testing (Jat, 2017).

Innovations in protected cultivation for producing high quality, high value agricultural produce are quite important These include plastic mulching coupled with fertigation, walk- in poly- tunnels for vegetables, insect proof net house, shade net structures, vegetable farming under rain-shelters, naturally ventilated polyhouse, climate controlled hi-tech green houses for disease free nursery raising, hi-tech soil less production, etc. Protected vegetable cultivation had been very successful in Ladakh and several other places. However, there are a few key constraints which include high initial cost, poor quality material, high cost of inputs, lack of guidance, knowledge and marketing, nematode problem, lack of refrigerated vehicles, etc. In order to outscale these technologies, there is need to accelerate research efforts towards developing crop varieties/hybrids suitable for protected cultivation, skilled human resource, establishment of Bureau of Indian Standards (BIS), standards for polyhouse materials, and their testing as well as a cluster approach. Low cost polyhouse, mulching, and fertigation have proved to be more popular because of their low cost (Singh, 2017).

There are various options for outscaling innovations in the field of natural resource management. Innovation is an amalgamation of technology, local adaptation, social inclusivity, and access to the end users. It is important to understand the big challenges associated with "half innovations" and the successful cases of converting them into "full innovations" based on local needs. Major requisitions for outscaling natural resource management (NRM) innovations includes long-term investment, system approach, portfolio of policies and practices, patience, capacity, innovation led business models and robust ex ante analysis on return on investment. The scientific social responsibility/ science-corporate social responsibility needs to be given due importance. Since these NRM based innovations generate lot of social and environmental goods, there is an urgent

need for greater public investment in their promotion and use (Jat, 2017).

The various technologies outscaled by public institutions, such as Indian Agricultural Research Institute (IARI) and strategies adopted for outscaling innovations include technology commercialization through public-private partnership (PPP), assuring access to knowledge and information through PUSA KRISHI-app, partnerships for enhancing service provision and linking farmers with market through FPO (Beej India Ltd.). The issues, concerns and challenges include disconnect between production and marketing, licensing issues with industries, lack of exclusive funding support to agro start-ups, insufficient delegation of powers to cutting edge level institutions, lack of strong actions against IP violation, lack of trained professionals and technology readiness. The way forward could be demand driven R&D, with more industry/research/ academia interaction, technology transfer and integration with incubation for start-up, virtual marketing place and use of mobile/internet technologies.

Greater emphasis is required for providing incentives to the researchers ICAR has taken steps to grant incentives for patenting, innovations and partnership and to establish IP management structure involving institute and zonal technology management units and national platform - Agrinnovate India Ltd - for interface with private sector, including international technology transfer. Emphasis had also been laid on the role of vision, skill, incentives, resources and action plan for innovation. There is a need for establishing central cell/platform to screen the innovations at ICAR level. There is also a need for creating innovation fund to promote and commercialize new technologies. The research initiatives also must now be taken-up in a systems' approach rather than the present trend of single approach based on disciplines /commodities.

There are some major innovations that currently need to be out scaled as a matter of priority keeping in view their expected impact and the benefits as national public goods. These are: i) hybrid rice - the current area coverage in last two decades is hardly 2.0 m ha, whereas scope exists for at least 10.0 m ha in the next decade; ii) single cross maize hybrids - the area covered under these hybrids presently is less than 60 per cent, whereas scope exists for almost 90 per cent of maize area; iii) conservation agriculture - under rice-wheat cropping system, current area is about 3.5 m ha, whereas scope exists for almost 8.0 m ha in the Indo-Gengetic Plains alone. The CA innovation also has vast scope under rainfed farming covering around 55 per cent of the total 144.0 m ha cultivable area in the country; iv) protected cultivation - the current area under protected cultivation is around 50,000 ha, compared to 2.0 m ha in China; v) microirrigation - out of total irrigated area of 64.7 m ha, the area so far covered under microirrigation is only 7.7 m ha, which can certainly be doubled in the next decade. Hence, it is evident that to harness the benefits of these innovations, concerted efforts are urgently needed in a Mission Mode. There are many more useful innovations that need to be outscaled immediately and hence require a critical introspection as to how these can be scaled much faster for the impact on livelihood of small holder farmers (Jat, 2017; Singh, 2017).

Policies for Innovations

For successful scaling of innovations, there is an obvious need to put in place enabling policies: i) institutional policies such as facilitation of farmers cooperatives like FPOs with proper legal framework, establishment of a cadre of trained agri-business professionals at the village level, credit at low interest to the farmers across value chain, machine rental services, etc., ii) research policies aiming at promotion of

agro-ecological based research, research for trade policy, agro-processing, value chain development, sustainable livelihood, new funding models for encouraging translational research, iii) price policies around fixing of minimum support price (MSP), inclusion of efficiency, compensation for risk and ecosystem services, and iv) right policies for more investment in resilient agriculture rather than subsidies, and promoting capital investments by the private sector. There is also an urgent need to attract private sector in development of whole sale markets, warehouses and cold storage, agro-processing infrastructure, canal lining for irrigation and private agricultural extension. The National Agricultural Research System (NARS) seemed to have undergone various policy reforms in research, intellectual property rights (IPRs) and technology transfer mechanisms (Saxena, 2017; Suresh Pal *et al.*, 2017), yet more aggressive approach is needed to reap the benefits of new innovations around sustainable intensification of agriculture.

Also, there is an urgent need for human capital for development of innovation and invent-innovate-invest continuum and concepts of skill, speed and scale in innovation system. The country needs to place greater emphasis on human capital development, particularly for building entrepreneurship for which availability of adequate funds is essential. There are concerns over the abysmal state of credit and information access by the farmers in India, through it has potential for huge impact on the income of farmers. Such concerns relate to livestock sector insurance (presently granted in limited cases that too for high yielding animals) and issues around taxation of dairy, fishery, poultry and value chain related enterprises. There is thus an urgent need to promote value chain approach both through research and through policy reforms.

Even though technological innovations are abundant, institutional constraints lead to their low adoption. The

problem of lack of appropriate policies, institutions and technologies were also present at the cusp of the Green Revolution during 1960s. Whereas, the Government has an important role to play even now, the innovation system has become multi-sectoral involving other actors of the society. Therefore, there is an urgent need for institutional and policy reforms which are more appropriate in today's context. Hence, the institution and policy related failures need to be revisited for needed reforms. Also, the lack of internal capacity for negotiating complex trade and other international treaties need to be addressed, on a priority basis. The United States of America has a much stronger private sector activity in venture capital, whereas European countries have a number of public sector business models for scaling-up and scaling out innovations in agriculture. Who bears the risk in innovations which are fostered and how risks and rewards are shared between the public and the private sector are the issues which need clear agri-business models? Government should also innovate shifting from being mainly directive to a more facilitative role in promoting of innovations. This would require a cost-effective regulation system for investment and commercialization of economic, efficient and productive innovations (Gulati *et al.*, 2006; Shenggen Fan, 2013).

The major policies for scaling-up innovations should center around incentive (non-subsidy) and reward system, enabling policy environment for faster adoption of innovations, increased resource allocation for agricultural research for development (at least 1% of agricultural GDP), scaling innovations through public-private partnership, and policy and institutional reforms for large scale adoption of efficient resource saving technologies such as conservation agriculture (CA).

Different states led institutional and policy reforms for outscaling innovations in microirrigation and water

management are worth critical assessment for this impact. The states of Rajasthan, Andhra Pradesh, Maharashtra and Gujarat cover about 45 per cent area under microirrigation, whereas potential for this technology is estimated to be 8.6 m ha in the country. Andhra Pradesh model of Micro-Irrigation Project, Karnataka PPP model and Rajasthan model of allowing only microirrigation and ban on flood irrigation in Narbada canal command area are some of the successful examples worth replicating in other states.

Intensifying Agri-Innovations

The evolution of Indian National Agricultural Research and Extension System (NARES) had primarily been based on social commitment and with a motive to provide national public goods and to serve the majority of resource poor and small farmers. Thus, innovations had been an integral part of Indian agricultural research for development (AR4D) system right from the beginning. In view of the need for evaluation of innovations for much needed socio-economical impact, India also felt the need for promoting innovations to generate agribusiness opportunities and to increase farmers' income. It is in this context, ICAR timely responded and prepared guidelines for Agri-IPRs Management and Commercialization in 2006 (Johl Committee Report, 1995; ICAR, 2006) and also initiated a National Agriculture Innovation Project (NAIP) with funding from the World Bank. Also, guidelines for incentives and rewards for outscaling innovations and resource generation were put in place. Somehow, the pace of promoting innovations and allowing the right incentives to researchers has remained slow (Saxena, 2017) due to lack of organization and management (O&M) reforms, which must now be accelerated.

A countrywide network of Institute Technology Management Units (ITMUs) have been created for management of agri-innovations and agri-intellectual properties in all

ICAR institutes duly supported by the Zonal Technology Management & Business Planning and Development (ZTM & BPD) units at selected ICAR institutes. This new initiative did help in kick-start innovation awareness and importance of their commercialization. ICAR Rules and Guidelines for Professional Service Functions were accordingly published for smooth implementation of Indian Agri-IPR Network in the year 2014 (ICAR. 2014). Eventually, many agri-technologies and services from Indian NARES have successfully been commercialized. The Business Planning and Development Unit (BPD), under National Agricultural Innovation Project (NAIP) project, and Agri-Business Incubators (ABIs) established under the National Agriculture Innovation Fund (NAIF), was an experiment aiming at commercialization of new innovations. Accordingly, the entire process of innovation generation and commercialization, involving public-private partnership, led to an intangible treasure of experience, which needs to be promoted and further intensified for better management of agri-innovations in future (Bhooshan, 2017).

The strength of an innovation is generally considered in terms of its commercial and societal value. As such, a large number of agricultural innovations identified and commercialized during the previous decade need to be outscaled. Also, India needs to innovate further in order to address the emerging challenges in agriculture. Role of private sector, though well realized and appreciated for input development and delivery, is still to be appreciated and expanded to non-conventional areas and the role and the very importance of public- private partnership has to be appreciated and promoted further. In addition, there should be adequate provision of dissemination of innovations around the management of natural resources and sustainable farm practices, which though significant but possibly have not invited needed attention of the private sector (Gulati *et al.*, 2006; Usha Zehr, 2017).

In a short span of agri-innovations and IPRs regime, India has successfully commercialized some new technologies. In addition, ICAR has built the needed capability of handling innovation and IPR related issues. However, there are many innovations and technologies which have remained underutilized. Important among these are animal health, protected cultivation, microirrigation, watershed development, hybrid technology, GM seeds, bioagents like biofertilisers and biopesticides, farm machinery, post-harvest technology around value chain, etc. Hence, there is an urgent need to revisit technology dissemination and commercialization mechanisms and associated policies in the context of scaling current and future innovation in agriculture. There is also a need for looking at the commercial aspects as well as the incentive and reward systems for promoting innovators, so that a clear Road Map is available for faster implementation.

The Way Forward

The following are some important action points for scaling innovations for impact on smallholder farmers:

- Innovations have played and will continue to play a significant role in agricultural transformation. However, the innovation process involves both multiple stakeholders and the enabling policy environment which need to be paid due attention to ensure impact in the broader national agricultural perspective. Agricultural research must move from commodity centric to systems' approach, and all stakeholders (farmers, private sector, NGOs, etc.) be part of the research for innovation continuum. Hence, institutional/innovation platforms are essentially needed to encourage much needed scientist-farmer, and public-private partnerships.
- In order to achieve an innovation driven agrarian economy, innovation capacity of research and

development systems, civil society organizations (CSOs), and especially the farmers need to be developed. For this purpose, intensity of public investment will have to be enhanced considerably. Also, greater attention would be needed towards capacity development of people responsible for scaling innovations for successful commercialization.

- There is an urgent need to strengthen existing technology transfer system within NARS (frontline extension, Agri-Business Incubator, Agrinnovate India Ltd.) and establish technology parks as well as transfer systems for commercialization both in ICAR and SAUs. Also, it requires placement of adequate manpower, financial resources and freedom to operate. Convergence of technology and diversification of extension and other service systems are also critical for outscaling innovations.

- The available innovations, including those that are farmer-led, must be assessed for needed validation, refinement and prioritization based on their commercial potential. This should also entail identification of right partners for successful ventures. Financing, risk management and incentives for outscaling innovation are necessary to encourage potential entrepreneurs.

- An Innovation Platform would help accelerate scaling-out innovations and, therefore, an 'Agri-Innovation Board' be established urgently in the Ministry of Agriculture and Farmers Welfare. The Board should be headed by an eminent agricultural scientist and membership be drawn from different Ministries, including Finance, Commerce and Industry.

- To begin with, the Board must start financing activities to scale-out agricultural innovations. This could be under the funding support for innovation (Start-up India, Atal Innovation Scheme), or through a separate funding

mechanism such as National Innovation Fund (NIF) initiated by the Council of Scientific and Industrial Research (CSIR).

- Concerned ICAR institutes and SAUs must ensure providing skill based certificate training for entrepreneurship, and in addition to provide much needed backstopping services so critical for successful scaling of innovations. The manpower, so trained, can work as para-innovators or technical service providers. Also to link with the industry, NARS should build effective partnership with organizations such as Federation of Indian Chambers of Commerce and Industry (FICCI), the Associated Chambers of Commerce and Industry of India (ASSOCHAM), Confederation of Indian Industry (CII), etc.

- Farmer Producer Organizations (FPOs), self-help groups, cooperatives, producer companies, etc., could effectively be involved for outscaling innovations. These organizations should have easy access to technology, financial services, including credit, and hand-holding from public organizations for promoting demand-driven innovations in the broader national interest.

- Participation of private sector in R&D and upscaling and outscaling of innovations would need an enabling policy environment and access to public technology and funding resources. Role of private sector need to be expanded to non-conventional areas and the public-private partnership needs to be strengthened further. In order to facilitate this, the Government should move from "directive" to a "facilitation" role. This may require revisiting existing regulations in order to provide a "predictable and enabling" regulatory framework. Also, incentives and rewards to innovators need to be put in place to sustain their interest in outscaling as well as much needed technical backstopping.

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Recent TAAS Publications

- Global Conference on Women in Agriculture - Proceedings and Recommendations, March 13-15, 2015.
- Brainstorming Workshop on Upscaling Quality Protein Maize for Nutritional Security - Recommendations, May 21-22, 2015.
- The Ninth Foundation Day Lecture on "21st Century Challenges and Research Opportunity for Sustainable Maize and Wheat Production" by Dr. Thomas A. Lumpkin, Former DG, CIMMYT, September 28, 2015.
- National Dialogue on Efficient Management for Improving Soil Health - New Delhi Soil Health Declaration - 2015, September 28-29, 2015.
- Regional Consultation on Agroforestry: The Way Forward - New Delhi Action Plan on Agroforestry 2015, October 8-10, 2015.
- National Dialogue on Innovative Extension Systems for Farmers' Empowerment and Welfare - Road Map for an Innovative Agricultural Extension System, December 17-19, 2015.
- Round Table Discussion on Promoting Biotech Innovations in Agriculture and Related Issues - Proceedings & Recommendations, August 4, 2016.
- Awareness cum Brainstorming Meeting on Access and Benefit Sharing – Striking the Right Balance – Proceedings, October 22, 2016.
- Delhi Declaration on Agrobiodiversity Management – Outcome of International Agrobiodiversity Congress 2016, November 6-9, 2016.
- National Conference on Sustainable Development Goals: India's Preparedness and Role of Agriculture, May 11-12, 2017.
- Policy Brief on Efficient Potassium Management in Indian Agriculture, August 28-29, 2017.
- Regional Policy Dialogue on Scaling Conservation Agriculture for Sustainable Intensification, Dhaka, Bangladesh, September 8-9, 2017.
- Policy Brief on Scaling Conservation Agriculture in South Asia.
- Retrospect and Prospect of Doubling Maize Production and Farmers' Income – Strategy Paper by Dr. N.N Singh, September 10, 2017.
- Indian Agriculture for Achieving Sustainable Development Goals - Strategy Paper by Dr. R.S. Paroda, October, 2017.
- Strategy for Doubling Farmers' Income - Strategy Paper by Dr. R.S. Paroda, February, 2018.
- Livestock Development in India - Strategy Paper by Dr. A.K. Srivastava, Member, ASRB & Trustee, TAAS, February, 2018.
- Policy Brief on Agricultural Policies and Investment Priorities for Managing Natural Resources, Climate Change and Air Pollution - April, 2018.
- Women Empowerment for Agricultural Development - Strategy Paper by Dr. R.S. Paroda, May, 2018.
- Brainstorming Meeting on Harnessing Intellectual Property to Stimulate Agricultural Growth – Proceedings and Recommendations, July 27, 2018
- Road MAP on Motivating and Attracting Youth in Agriculture (MAYA)
- Regional Conference on Motivating and Attracting Youth in Agriculture (MAYA) - Proceedings and Recommendations, August 30-31, 2018
- Motivating and Attracting Youth in Agriculture - Strategy paper by Dr. R.S. Paroda, November, 2018

About the Author

Dr R.S. Paroda has made valuable contributions in the field of agriculture both as a researcher and an able administrator. He has made significant research contributions in the field of plant breeding and genetic resource management. During the period 1994-2001, Dr. Paroda spearheaded and modernized the national agricultural research system (NARS) as Director General, ICAR and Secretary, DARE, Government of India. During his leadership of ICAR, more than 20 new institutions were created in crops, horticulture, livestock, natural resource management, fishery, agricultural engineering and social science sectors. Dr. Paroda is well known for initiating and strengthening many visionary programs at the national level. The prestigious National Agriculture Technology Project (NATP) of the World Bank was designed by him to reorient agricultural research, education and extension system to meet new challenges faced by the agricultural research system. Dr. Paroda is the main architect of one of the world's largest and most modern National Gene Banks housing more than 200,000 crops germplasm accessions. The impressive National Agricultural Science Centre (NASC) Complex, located at Pusa Campus, was built mainly at his initiative and direction. International Crop Research Institute for Semi Arid Tropics (ICRISAT), Patancheru and Agriculture Research Institute of Kazakhstan have named their Gene Banks after Dr Paroda in recognition of his notable contributions in the field of genetic resource management. Dr Paroda has received several national/international awards and recognitions, including the most prestigious PADMA BHUSHAN in 1998. Other awards conferred on him are: Rafi Ahmed Kidwai Memorial Prize (1982-83), ICAR Team Research Award (1983-84), FICCI Award (1988), Om Prakash Bhasin Award (1992), Asia-Pacific Seed Association Special Award (1995), CGIAR Award for Outstanding Partnership (2000), Life Time Award by Association of Agricultural Scientists in America (2001), Dr Harbhajan Singh Memorial Award (2001), Dr B.P. Pal Memorial Award (2003), Borlaug Award (2006), ISCA Gold Medal for Excellence in Science (2006), Gold Medals from Ministry of Agriculture of Armenia (2006) and Vietnam (2012), Life Time Achievement Award of 'Agriculture Today' (2008), Dr A.B. Joshi Memorial Award (2012), Prof. Kanniyan Memorial Award (2012), and Krishi Shiromani Samman by Mahindra and Mahindra Ltd. (2013). He has been conferred Fellowship of several National Science Academies like, INSA, NAAS, NASI and was elected as General President of the prestigious Indian Science Congress in 2000-2001. Among international recognitions, he was elected as Fellow of Agricultural Academies of Russia, Georgia, Armenia, Tajikistan and the Third World Academy of Sciences (TWAS). He had also been the President of more than a dozen Agricultural Scientific Societies. Both American Society of Agronomy and the Crop Science Society of America had awarded their prestigious Honorary Membership on Dr Paroda in 2001. Dr Paroda has been conferred honorary D.Sc. by 15 academic institutions including Ohio State University, Indian Agricultural Research Institute, Scientific Council of Agricultural Academy, Republic of Azerbaijan and State Agricultural Universities at Pantnagar, Kanpur, Jorhat, Coimbatore, Hyderabad, Udaipur, Varanasi, Srinagar, Meerut, Bhubneshwar, Ludhiana and Dharwad. Dr Paroda served as founder President of Global Forum on Agricultural Research (GFAR) from 1988-2001. He also served for more than two decades as Executive Secretary of Asia-Pacific Association of Agricultural Research Institutions (APAARI), a well known regional organization fostered by him to strengthen regional research collaboration. He had served as Chairman as well as Vice-Chairman of ICRISAT Board, member of Board of Trustees of IRRI, member of WMO High Level Task Force on Climate Services, member of Advisory Council of Australian Center for International Agricultural Research (ACIAR), member of Finance Committee of CGIAR and a member of the Governing Board of the Commonwealth Agriculture Bureau International (CABI). Dr. Paroda has spearheaded the organization of several international conferences and discussion sessions including, International Crop Science Congress (1996), Indian Science Congress (2001), Global Conference on Women in Agriculture (2012), Agricultural Science Congress (1997, 1999), Global Conference for Agricultural Research and Development (2012) and 1st International Agrobiodiversity Congress (2016), Till recently, Dr Paroda worked for the overall benefit of farmers as Chairman, Farmers Commission of Haryana, Chairman of Working Group on Agriculture and member of Rajasthan Planning Board, when State Agriculture Policies both in Haryana and Rajasthan were released. Currently, He is Member of Strategic Impact, Monitoring and Evaluation Committee (SIMEC) of CGIAR. As Chairmen of the Trust for Advancement of Agricultural Sciences (TAAS), his goal is to link science to the society.