25

Linking Research with Extension for Accelerated Agricultural Growth

The Asian region is rich in natural resources, human capital and indigenous knowledge, and much faster progress can be achieved if innovations are outscaled on farmers' fields. This chapter draws attention to issues concerning the need for linking research with extension for faster agricultural growth in Asia. The Asian region is agriculturally vibrant. With 38% of the world's total agricultural land, it houses 80% of smallholder farmers supporting 74% of the world's agricultural population. The region encompasses 39 countries, including 19 commonwealth members with two of the world's most populous countries, China (1.41 billion) and India (1.34 billion). With 3.5 billion people, the region accounts for 58% of the world's population (7.6 billion) (http://www.worldometers.info). Agriculture (crops, livestock, fishery, forestry, and the associated natural resources endowments) is the main source of livelihood for nearly 2 billion people. The region is the largest supplier of the world's food and agricultural products, and has witnessed several innovations in agricultural development. It is evident that the Green Revolution was brought out by a science-led synergistic extension approach capitalizing genetic potential, irrigation, fertilizer, appropriate policies and farmers' hard work. This led to an unprecedented transformation in food security and rural development in the region. Since the mid-1960s, Asian cereal production has almost doubled, reaching nearly 1 billion t, recording an annual growth rate of 3%. Increased agricultural productivity, rapid industrial growth and expansion of the non-formal rural economy resulted in quadrupling per capita GDP, almost halving poverty in the region. However, continuing such gains is becoming a major challenge, especially in the context of declining factor productivity, deteriorating natural resources, impact of global climate change and, above all, fatigue in the existing extension system, which is largely in the public sector. Hence, impact of innovations around natural resource management technologies is not all that evident, as was the case with miracle wheat and rice seeds during the Green Revolution in south Asia in the mid-1960s and 1970s.

The Challenges Ahead

Food demand versus small farm holdings

Food insecurity and poverty, accounting for two thirds of the world's hungry and poor, exacerbated by soaring food and fuel prices, global economic downturn and volatile markets, have surfaced as the major development-related concerns in the region. The problem has intensified further with a sharp rise in the cost of food and energy, depleting water resources, diversion of human capital from agriculture, shrinking farm size, soil degradation, indiscriminate and imbalanced use of chemical inputs and the overarching effects of changing climate. The per capita land availability for agriculture in the region (0.3 ha) is one fifth of that in the rest of the world (1.4 ha). The region's agrarian landscape is predominantly smallholder farmers (~80% of the world's small and marginal farmers). It is estimated that by 2050, foodgrain requirement in the Asia region would be around 70% more than the current demand. A low investment in agricultural research for development complicates the problem further. Future dependence on imported fossil fuels raises concerns regarding price volatility and shocks, and supply disruptions in agriculture production. Therefore, ensuring availability of and economic access to food, in both quantity and quality (nutrition), for the poorest of the poor in the developing countries remains a daunting challenge. To this end, the Global Conference on Agricultural Research for Development (GCARD) road map, developed through the interaction of diverse stakeholders from around the world in Montpellier, France, in 2010, highlights urgent changes required in AR4D globally, especially to address the needs of resource-poor smallholder farmers and consumers. It envisages a major paradigm shift towards farming systems research with greater thrust on 'innovations for greater impacts on small holder farmers', requiring partnerships among stakeholders and their capacity-building. To meet future food demands and to achieve successfully the MDGs, especially in the context of the world leaders' meeting, Rio+20, it has been stressed that improving the efficiency and resilience of agriculture around farming systems in the developing countries would be the only way to move forward (Alarcón and Bodouroglou, 2011).

Poverty and malnourishment

According to the FAO, the number of undernourished people in the world has increased during the last decade, and for the first time the number of hungry people crossed the 1 billion mark. Almost two thirds of the world's hungry (642 million) and 67% of the world's poor have homes in this region. The gains made in the 1980s and early 1990s in reducing chronic hunger have been lost, and the hunger reduction target of 50% by 2015 under the MDGs was not attained. Despite the fall in international food and fuel prices since late 2008, prices in the domestic markets in Asia have invariably remained 15–25% higher in real terms than the trend level, resulting in further distress for the poor. Besides poverty, the region is at present home to 70% of the world's undernourished children and women. The number remains stubbornly high, and lately has shown a rise. In the past year the number of hungry, especially in the south Asia sub-region, has increased by 10.5%, derailing all progress made after the Green Revolution. Currently, lack of economic access, not physical access, is a major challenge before society, especially for policy makers, planners, scientists and those engaged in advisory services in the region.

Natural resource degradation and climate change

The fast-declining and degrading land, water, biodiversity, environment and other natural resources are three to five times more stressed due to population and economic and political pressures in Asia as compared to the rest of the world. The region has already reached limits of land available for agriculture, and there remains no further scope for horizontal expansion. Inefficient use and mismanagement of production resources – especially land, water, energy and agrochemicals – has vastly reduced fertility and damaged soil health. At present, soils are both hungry and thirsty. To a greater extent, lack of political will and appeasement policies to provide free or relatively cheap inputs like seeds, fertilizers, water and energy have exacerbated the problem. Moreover, while maintaining a steady pace of development, the region has to reduce its environmental footprint from agriculture. The reduction in water availability and increased animal and plant diseases will primarily affect poor countries and small island states having limited capacity to respond and adapt to such negative impacts. Regrettably, man-made disasters in some countries, due to lack of political will and overexploitation of natural resources (like the drying of the Aral Sea in Uzbekistan due to overuse of water upstream by central Asian countries), can result in increased misery for the people.

Opportunities to Harness

Genetic resource management

Agricultural biodiversity is a key resource for achieving food and nutritional security. The Asia region has a rich diversity of fauna and flora, including agroforestry species, and is the centre of origin of many important crops, livestock and forest-tree species. This resource can serve as a goldmine for specific/unique traits to be harnessed for germplasm improvement, through breeding and biotechnology applications for developing varieties/breeds possessing high productivity, better nutritional quality, resistance to biotic (diseases and insect pests) and abiotic (drought, frost, flood, salinity) stresses and high adaptation to climatic change. The Green Revolution was mainly due to exploitation of dwarfing and photo-insensitive genes in wheat and rice. Germplasm conservation through use can significantly help in achieving sustainable agricultural growth and development in Asia. It is, therefore, necessary that each country builds an effective NARS by involving all stakeholders, and has a national action plan to conserve scientifically in national gene banks all their valuable genetic resources for posterity. New science such as biotechnology, including GM crops, ICT, nanotechnology etc. offers ample opportunities to benefit the farming community. Fortunately, new innovations in agricultural science, like single-cross maize hybrids, quality protein maize (QPM), hybrid rice, hybrid sorghum, hybrid pearl millet and other crops, Bt cotton, GM technology in corn, rice, canola, soybean, brinjal etc., are available, which need to be outscaled.

Innovations in natural resource management

One of the main reasons for slow growth in agriculture is relatively poor dissemination of emerging technologies relevant to the needs of smallholder farmers. Innovations are needed to meet the major challenge of consistently increasing resource scarcities and to bring in structural transformation in the socioeconomic context to reduce the cost of inputs and for improving the livelihoods of resource-poor smallholder farmers. To liberate nations from hunger and poverty, while sustaining existing natural resources, policy makers have to have a renewed thrust and commitment to additional funding for AR4D. Without this, the task of achieving inclusive growth will remain elusive. Innovations around good agricultural practices such as CA, balanced use of fertilizers, small-farm mechanization for resilience, micro-irrigation, IPM and scientific land use for crop diversification would contribute considerably to arresting natural resource degradation, climate change adaptation and mitigation as well as increased farm productivity and profitability. One such successful example in the region is of CA in the Indo-Gangetic plains, led by the regional NARS (Bangladesh, India, Nepal and Pakistan) and facilitated by the International Maize and Wheat Improvement Center (CIMMYT), which led to a cost–benefit ratio of 1:19 (investments of US$3.5 million led to an output equivalent of US$64 million) through adoption of zero tillage for wheat planting over 2.5 million ha. The area under CA can be easily increased almost four-fold (10 million ha), provided concerted efforts are made in a mission-mode approach to outscale this innovation. Another successful example is of laser land-levelling, adopted recently over 2.5 million ha in north-west India, primarily due to custom-hire service windows. In Haryana alone, it led to saving 1 billion m^3 of water annually. Similarly, direct-seeded rice (DSR) in Basmati varieties has picked up fast in the last two to three years. Replication of such success stories can help farmers in similar ecological situations in other countries without ‘reinventing the wheel’, provided knowledge is shared through effective extension systems.

Recently, the International Food Policy Research Institute (IFPRI) has brought out an interesting publication entitled *Millions Fed*, covering around 20 success stories from around the world, half of which are from Asia alone. Similarly, the Asia-Pacific Association of Agricultural Research Institutions (APAARI) has published around 45 success stories from the Asia-Pacific region, indicating how developing countries have made faster progress through outscaling new innovations. Learning from them, many NARS have gained equally well, like adoption of hybrid rice in India, the Philippines and Vietnam, based on spectacular results in China. Similarly, the story of baby corn in Thailand could be repeated in India. Success of IPM in rice in Indonesia has also been repeated in many countries. GM cotton technology has also been adopted fast in China, India and Pakistan.

Other potential sectors

Horticulture

This region also has huge potential to promote horticulture. Most of the countries in the region have not paid due attention to this sector. At present, the need is to diversify the food basket by producing more vegetables and fruits. The post-harvest losses happen to be high, ranging from 10% to 30%. This situation needs to be changed through the application of processing technology, value addition, cold storage and rapid transportation.

Livestock

Besides crop productivity enhancements, strategies are needed to usher in 'White' and 'Blue' Revolutions in this region. This would need new production models to enhance contribution from the livestock and fishery sectors. Mechanization and automation of dairy farms, measures to provide good-quality feed and fodder, provision of improved seed varieties for fodder crops, and value addition of milk and meat products are some of the measures for enhancing the livestock industry.

Fishery

Fishery is another potential sector that can help achieve food and nutritional security. The inland fish farms, with adoption of modern technologies, managed by skilled human resource, can make all the difference. The success story of tilapia fish farming in the Philippines, sea bass in Israel and king prawn in Thailand and India are some examples worth emulating. In fact, willingness to adopt new ideas has transformed typical fish farmers and even young professionals in the Philippines, Thailand, India and elsewhere into thriving entrepreneurs.

Strengthening Collaboration and Partnerships

The Green Revolution was the outcome of partnership between NARS, international centres like CIMMYT, the International Rice Research Institute (IRRI) and the extension system, including progressive farmers. Regional and global networks and partnerships for knowledge-sharing and enhanced capacity development of different stakeholders are a must for outscaling innovations in similar ecologies. It has been increasingly realized that under the changing scenario of production to consumption, a linear approach in technology development and deployment would not serve the purpose of meeting MDGs. For inclusive growth in agriculture through large-scale uptake of new technologies, a major paradigm shift in approach is needed from R&D to AR4D, involving greater participation of all stakeholders. Past experiences from regional organizations/programmes like the Asia-Pacific Association of Agricultural Research Institutions (APAARI), the South Asian Association for Regional Cooperation (SAARC), the Association of Southeast Asian Nations (ASEAN), the Rice-Wheat Consortium (RWC) and the Cereal Systems Initiative for South Asia (CSISA) have revealed that regional partnerships are important to catalyse faster adoption of new technologies, mainly through sharing success stories around good agricultural practices (SAARC, 2016).

APAARI has been instrumental, since its inception in 1990, in promoting regional cooperation for agricultural research, and has organized a series of expert consultations on emerging issues concerning AR4D. Some of these were on: food crisis and biofuel; productivity enhancement; biotechnology and biosafety; post-harvest management; CA; climate change; and women and youth. From Sri Lanka, the Council for Agricultural Research Policy (CARP) has been an active member of APAARI from the very beginning in most of these initiatives. A similar partnership with the Department of Agriculture (DOA) in Thailand would prove beneficial.

Knowledge-sharing and Capacity-building

APAARI is supporting a major programme known as the Asia-Pacific Agricultural Research Information System (APARIS), under which more than 45 success stories from the region, beside proceedings and recommendations of several expert consultations and workshops, have been published and widely disseminated. Details of these success stories can be accessed from the APAARI website (www.apaari.org). APAARI has also proclaimed some important regional declarations relating to AR4D such as the Tsukuba Declaration on Climate Change, the Suwon Framework on Agrobiodiversity, the Bangkok Declaration on Strengthening Agriculture Research for Development etc. All these have received considerable attention of policy makers and planners in many countries towards reshaping/reorientating their research and extension agenda for the benefit of resource-poor farmers who are in dire need of technical backstopping knowledge.

Strategy for Linking Research with Extension

Research should be sensitive to local needs and meet the aspirations of farmers and consumers, and there should be closer working relations between research and extension organizations. The scientists involved in basic, strategic, applied and adaptive research, together with subject matter specialists, extension workers and farmers, should be seen as an integral component of the knowledge dissemination and agricultural advisory system. The interface between research and technology transfer is indeed very critical for converting outputs into outcomes. In fact, we need to link 'land to lab' and 'village to institution'. This would require a paradigm shift from a top-down to bottom-up approach for technology generation, refinement and adoption. In the present context, the agriculture sector has to be more scientifically oriented and technology-driven. As stated earlier, almost all problems of contemporary Asia require interdisciplinary, inter-institutional and regional, rather than national, solutions. Furthermore, the research agenda of the institutions could be better organized for technology development and dissemination. In all institutions, technology transfer programmes need to be an integral part of technology development to empower farmers with proper knowledge. Farmers' participatory research has to receive major attention (FAO, 2013).

The Indian Extension System – an Example

Research and extension to work hand in hand has been a challenge over the past 50 years. From time to time, several experiments were conducted to make the extension system vibrant, effective and meaningful. Agriculture in India is a state subject. Accordingly, states follow the central government schemes launched from time to time. Built on the foundations of the Community Development Programme (CDP), started in 1952, public sector extension followed an evolutionary pathway. The Intensive Agriculture District Programme (IADP) (1961–1962), the Intensive Agriculture Area Programme (IAAP) (1964–1965), the High Yielding Varieties Programme (HYVP) (1966–1967) and the Farmers' Training and Education Programme (FTEP) (1966–1967) are some of the significant developments leading to the growth of agricultural extension in India. Undoubtedly, these programmes created awareness and paved the way for acceptance and application of genetic resource technologies. These, however, were ineffective in serving the needs and aspirations of small and marginal farmers. This weakness, inherent in the early technology transfer system during the Green Revolution period, is believed to have widened the gulf between the resource-rich and resource-poor farmers (Paroda, 2014).

In India, agricultural institutions (ICAR institutes and SAUs), in collaboration with the Department of Agriculture, generate technologies and transfer them to stakeholders. In the 1960s, the agricultural production situation was so critical that intensification of agriculture with the use of HYVs became unavoidable. The programmes, such as the Integrated Agriculture Development Programme (IADP), the Intensive Agriculture Area Programme (IAAP), the National Demonstration (ND) and the High Yielding Variety Programme

(HYVP), gained momentum. The sole purpose of these programmes was for increasing crop yields by using modern means of production. This approach, though paying good dividends, generally failed to help poor farm households. The emphasis was broadened from agricultural development to rural development, and programmes like the Small Farmers Development Agency (SFDA), the Marginal Farmers and Agricultural Labor Development Agency (MFALDA), the Drought Prone Area Programme (DPAP) and the Integrated Rural Development Programme (IRDP) were launched in the 1970s (Paroda, 2014).

The most significant development took place under the World Bank project and the Training and Visit (T&V) extension programme, started in the mid-1970s. The emphasis was on efficient technology transfer using promising research results. The system, however, proved to be of little help to small farmers, especially those in rainfed areas. To bridge this gap and increase the reach of extension services, the ICAR launched its front-line demonstration programmes such as the Operational Research Project (ORP), Lab-to-Land and National Demonstration. The ICAR established Krishi Vigyan Kendras (KVKs), which are also known as district science centres. This is an institutional mechanism for a front-line extension approach, and so far about 700 KVKs have been established all over India. The need was also felt for technology appraisal, refinement and transfer, and the Institution Village Linkage Programme (IVLP), based on participatory methodology, was launched in selected locations in 1998 under the World Bank's National Agricultural Technology Project (NATP) (Paroda, 2014).

The approach has been reversed from 'top down' to 'bottom up'. New institutional arrangements for technology dissemination through establishment of the Agricultural Technology Management Agency (ATMA) at district level have enabled better coordination and convergence of all rural advisory programmes. Under the project, a State-level Agricultural Management and Extension Training Institute (SAMETI) has been created to provide training to state-extension functionaries. Later, other projects, like the National Agricultural Innovation Project (NAIP), were implemented to give agricultural research/technology generation systems an explicit development- and business-oriented perspective through innovative partnership models.

Application of ICT has also been promoted in agriculture. The Indian Tobacco Company (ITC) has spearheaded an Integrated Rural Development Programme (IRDP) to empower farmers and raise rural incomes. The strategy for this is broadly centred around information and knowledge dissemination, access to quality inputs and markets, generation of supplementary incomes and natural resource augmentation. Farmers are given critical information and relevant knowledge on farm productivity, prices and markets through ITC's e-Choupal. This platform enables access to quality inputs for better productivity besides expanding reach to markets. Dedicated radio and TV channels are also in the offing. The private sector has also come up to support farmers by empowering them with better technology and providing them with quality inputs. Also, use of smart phones has become popular to access knowledge (Paroda, 2014).

Outscaling Farmer-led Innovations

In the pursuit to enhance both agricultural production and income, farmers do consistently try to make agriculture efficient and cost-effective. In the process, they have come out with numerous innovations around improved farming practices and livelihoods. These innovations have supported food security. Farmers identified a number of new/indigenous traditional crops and developed varieties with enhanced productivity and better quality through selection. They also identified livestock breeds and developed technologies for low-cost animal and fish rearing and processing, efficient horticultural practices, value addition and better marketability of farm products. In addition, a number of farm implements and tools have been designed and manufactured by farmers to increase operational efficiency and productivity. Commendable work has been done by women farmers, especially in germplasm conservation, post-harvest management and value addition, which helped to enhance farm income. In fact, farmers are silently innovating, adopting new practices and continuously improving them. Unfortunately, these farmer-led innovations, over generations, have not been recognized and documented. Also, the IPR on the innovations made by farmers and their documentation often lacked in the past. Value of traditional knowledge and its documentation has also remained unnoticed by scientists. As a result, the advantages of many technologies developed by innovative farmers have not been reaped by other farmers. Efforts are needed to record farmer-led innovations in agricultural practices and blend them with modern science through refinement and validation in a participatory mode. The innovative farmers need encouragement and financial support for their creativity. Accordingly, an Agriculture Innovation Fund/Board needs to be created at the national level to supplement the efforts of such farmers by awards/rewards and by providing them with some financial assistance (APAARI, 2011; Dar, 2014).

Linking Farmers to Market

Agriculture is the only enterprise where cost is determined by others, rather than by the producers. To ensure competitive price of produce, the role of middlemen has to be minimized and market forecasting systems have to be strengthened so that farmers can take the right decisions on crop planning, production and sale of produce. Recent studies by the US Agency for International Development (USAID) have indicated that 50–70% of smallholders are in transition from subsistence to commercial farming in many countries of Africa and Asia. In most of the south-Asian countries, urbanization and industrialization are not creating sufficient numbers of off-farm jobs to accelerate agricultural commercialization. Overcoming the commercialization barrier requires an upgrading process around investment in local infrastructure, strengthening of business services and improvement in farmer's skills through efficient extension systems, which are not visible. Also, in view of the considerable decline in public extension services over the last two to three decades, farmers were not able to access vital technologies and services. Studies show convincingly that income growth generated by agriculture would be up to four times more effective in reducing poverty than growth in other sectors (Growth Commission, 2008). Therefore, income growth in agriculture needs to be stimulated further by linking farmers to markets. There is a need to develop a sustainable model for marketing that should allow farmers to sell directly to consumers. Hence, value-chain development involving farmers, direct sales by farmers, contract farming, organized retailing by farmers and the establishment of farmers' associations, self-help groups and/or companies would go a long way in achieving these goals (APAARI, 2011).

Micro-financing

Providing effective and efficient financial services in the agriculture sector continues to be a challenge. The FAO argues that poorly functioning financial markets make farmers reluctant to adopt new practices and technologies and also reduces their risk-taking abilities. Therefore, objectives of micro-financing cannot be overlooked. Some flagship institutions in Asia such as Bank for Agriculture and Agricultural Cooperatives (BAAC) in Thailand; village banks (Unit Desas) of Bank Rakyat in Indonesia (BRI-UD); and Grameen Bank (GB) in Bangladesh have demonstrated how to successfully supply loans and other financial services in rural areas. Such institutions need to be created on a large scale. There is a need to establish a closer relationship between finance and production, income distribution, empowerment and welfare. The happy situation is that several innovations are being examined to make financial support available to farmers. In India, Kisan (farmer) Credit Cards (KCC) are being issued to all farmers to avail themselves of credit at low interest rates (APAARI, 2011).

Policy support

The appropriate policies on provisions of subsidies on key inputs; promotion of efficient technologies such as CA; innovations and improved varieties; and creation of institutions such as farmers' cooperatives, self-help groups, farmers' clubs and farmers' companies need to be inculcated in agriculture development plans. In the coming years, south-Asian countries would need to foster long-term productivity policies by investing heavily in agricultural R&D, while introducing institutional reforms to create an environment facilitating adoption of new technologies. Emphasis needs to be given to look again at domestic agricultural policy to make it more effective for infrastructure development, risk management and easy credit availability.

Empowering Women for Inclusive Growth

Globally, about 43% of women are engaged in agriculture. In India, 60% of farming operations are performed by women. Therefore, agriculture can be a primary driver for empowering women. Innovations would improve their work efficiency and would also ensure overall household development and nutrition security. However, women are invariably deprived of access to agricultural knowledge, credit, technology to overcome their drudgery and market-related services. Often they are deprived of their rights to land and resources. All these adversely impact their performance. *The State of Food and Agriculture Report of 2010–11* by the FAO indicated that reducing the gender gap between male and female farmers would raise yields on farms by 20–30%. As a consequence, this would lead to reduction of undernourished people, globally, by 12–17%. This, in turn, would translate into 100–150 million fewer hungry people. Hence, technology generation relevant to women farmers and its adoption should become an important agenda for future agricultural growth (ICAR, 2012).

Retaining Youth in Agriculture

Asia can reap demographic dividends if attention is paid to creating more and better jobs, improving the technical skills and education of youth and providing efficient matching of labour supply and demand through regulations and mobility. The ageing population of farmers and declining interest among rural youth in taking up agriculture as a profession are challenges for agricultural sustainability in India and also in other countries of the region. A large section of youth invariably prefers to migrate to cities to seek employment, especially government jobs. Hence, a major challenge today is how to retain youth in agriculture. This certainly cannot be left unaddressed. The declining interest of rural youth is directly related to existing poor physical amenities, socioeconomic conditions and lack of an enabling environment. Economic factors such as low-paid employment, inadequate credit facilities, low profit margins and lack of insurance against crop failure are also discouraging other factors. Social factors include public perception about farming, especially parental desire that their children should opt out of agriculture. Environmental issues include poor soil health, non-availability of water for irrigation and climate change. Proper incentives for their involvement in agricultural education, research and extension and linking them to expanding markets would have positive effects in attracting youth in agriculture (YPARD, 2012; MSSRF, 2014).

Earlier, seed, pesticide, fertilizer and farm machinery were the only potential sectors to employ agricultural graduates/rural youth. Lately, new opportunities are emerging in IT-linked agri-extension, seed technology, biotechnology, food processing, cold storage, packaging, supply-chain management, insurance and farm credit. The private sector and NGOs are also engaging rural youth. In this context, we now need greater thrust on vocational training of youth (including females) for relevant skill acquisition and greater confidence-building to serve as 'technology agents' as well as efficient knowledge/service providers on a custom-hire basis. It is high time that all-out efforts are made at all levels to engage youth in multifarious activities around 'plough-to-plate', so as to make farming an attractive as well as lucrative profession. Knowledge-based agriculture around secondary and speciality agriculture can enhance opportunities for additional income for youth (YPARD, 2012).

The Future Road Map: The Need for a Paradigm Shift

The success of the Green Revolution was mainly due to a holy alliance between researchers, extension specialists and farmers. The technology dissemination approach adopted was top-down and centred around individual farmers. Faster adoption of technology was also on account of miracle seeds of wheat and rice, promoted largely by the public extension system, which, over the years, has become relatively weak. On the contrary, new innovations around natural resource management require a bottom-up approach, involving farmers' participation, while ensuring confidence-building among farming communities to take risks and make agriculture more scientific and resilient. In the process, sharing of knowledge on good agricultural practices, without dissemination loss, and incentives for critical inputs become highly crucial to be successful. Also, partnership among key stakeholders becomes essential to promote growth in agriculture. In the process, care is also needed to overcome complacency that has crept into the public extension/advisory services. A paradigm shift is needed from the present NARI system to NARES. This would require active involvement of stakeholders such as farmers, NGOs, the private sector, scientists and policy makers. Another shift has to be in the extension approach towards translational research to ensure outscaling of innovations for greater impact on productivity and income.

In this context, an extension approach has now to be around farming communities rather than individual farmers. Also, NRM-related innovations would require more lead time to assess impact on farmers' fields, unlike the impact of HYVs on crop productivity. This throws a new institutional challenge for needed reforms in existing extension systems, which mostly depend on public organizations. The role of the private sector, especially through involvement of youth and gender in agriculture, becomes most relevant in the present situation. Hence, empowering youth (both men and women) through vocational training and building a cadre of technology agents to provide technical backstopping as well as custom-hire services to smallholder farmers would go a long way in linking research with extension for accelerating agricultural growth. We need to link 'land with lab', 'village with institute' and 'scientists with society' to ensure faster adoption of resource-saving technologies that would benefit producers and consumers. In the process, the agriculture technology agents would become job creators and not job seekers and provide, on farmers' doorsteps, the best technologies as well as quality inputs. Another strategy could be to create 'agri-clinics' where technology agents could join hands to ensure a single-window system of advisory services to farmers so that they need not run from 'pillar to post'. In fact, a good farmer is knowledge-hungry and does not want to depend only on government subsidy.

The Way Forward

Agriculture in Asia must liberate the region from the twin scourges of hunger and poverty and of malnutrition in children and women. The region must continue to feed the world with adequate food. Accelerated science and innovation-led agricultural growth must be inclusive and should address the needs and aspirations of resource-poor smallholder farmers in the Asia-Pacific region. Under the growing challenges of resource degradation, escalating input crisis and costs, and with the overarching effects of global climate change, the major gains in foodgrain production will largely depend on a paradigm shift from integrated germplasm improvement to integrated NRM. The future AR4D efforts by NARS must now be reoriented towards a farming systems approach involving farmers' participatory approach. We need to employ innovative ways for effective dissemination of knowledge and lay greater emphasis on outscaling innovations for needed impact on the livelihood of smallholder farmers. Henceforth, 'farmer first' should be the goal of all NARES to bridge the income divide between farmers and non-farmers, and it should benefit equally producers and consumers. To ensure this, developing countries in the Asia-Pacific region must enhance their investments (almost triple) in AR4D to address effectively the emerging challenges, thus ensuring food, nutrition and environment security for all.

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