Innovative Agricultural Technologies in South Asia

Edited by
Nasreen Sultana
Fatema Nasrin Jahan
S.M. Bokhtiar

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SAARC Agriculture Centre
Dhaka, Bangladesh
Preface

Agricultural research is changing fast. This is particularly so in South Asia: once known for its farmers’ knowledge and publicly funded research, the region is increasingly focusing on research-based technology exchange accumulation. The approach represents a major change in the way that the production of knowledge is viewed, and thus supported. It shifts attention away from research and the supply of science and technology, towards the whole process of innovation. Technology transfer is one of the major elements.

South Asia has a rich agricultural history which spans more than 5,000 years. The Kandian Home Gardens in Sri Lanka, the terraced rice gardens of Nepal, the Apatani system in northeast India, and the fish-rice farming system in Bangladesh are all well-known examples of this unique wealth of knowledge. In a figure, Agriculture in the SAARC Region continues to be the priority sector with 60% of the population engaged in farming for their livelihood. Despite that, South Asia is the fastest growing region in the world, with growth projected to steadily increase from 7% in 2015 to 7.6% by 2017 (World Bank, 2017). While the region has achieved impressive economic growth, it continues to face challenges in food and nutritional security and other development goals. Yet the knowledge and skills of the farming communities who have developed these sustainable, resilient, and productive systems are being increasingly bypassed, overlooked, and undermined by a new era of agricultural research that is taking hold in the region. The rapid growth in agriculture in the region has been largely based on the Green Revolution technologies. Therefore, there are immense possibilities to transfer the innovative technologies throughout the South Asian region.

This publication is an attempt to bring together the Agricultural innovative technology in the region. Formulation of Enabling Policy Recommendations and Project Concept for Popularization of Innovative Agricultural Technologies in South Asia is published to share some of the best innovative technology of SAARC countries. Amongst them, few of the best technologies could be transferred throughout the region based on the country requirements. Besides that, SAARC Agriculture Centre would like to take a long time project to make SAARC Innovation Platform in collaboration with Winrock International. I would like to highly acknowledge Dr. William Sparks, Project Director, Feed the Future Asia Innovative Farmers Activity,
USAID for his constant guidance and supervision. Special thanks to consultant Dr. Punya Prasad Regmi. Also, my special thanks and appreciation goes to Dr. Maksudur, the then Project Director and the current Project Director, Dr. Kabir, Winrock International, Bangladesh for managerial and technical supports. I am thankful to IRRI and Access Agriculture for their financial support. The contribution of Ms. Fatema Nasrin Jahan, Senior Program officer (NRM) for arrangement, technical guidance, and overall coordination is duly acknowledged. Also, I extend my heartfelt thanks to Dr. Nasreen Sultana, Senior Program Specialist (Horticulture) of the SAARC Agriculture Center for editing this manuscript. I would like to highly acknowledge with deep respect to all the focal persons of SAARC countries who made their immense efforts in writing and submitting their respective country papers. I take this opportunity to thank all the participants of the consultation meeting, Institute of Policy Studies of Sri Lanka, Winrock International. I personally hope this publication will provide detail and comprehensive information on innovative technologies of SAARC region. I would welcome receiving feedback, comments, and suggestions from readers for our future endeavors.

Dr. S.M. Bokhtiar
Director
SAARC Agriculture Centre
Foreword

By 2050, food production will need to increase by 70% to feed the projected 9 billion people. With near maximum yield rates on available arable lands in developed countries, most of the required agricultural growth must come from developing countries and require the empowerment of small-scale farmers, particularly in Asia. Technology will be a critical component for this growth.

Agriculture and aquaculture include a wide range of products and consist of many work stages from preparation to production, from post-harvest to processing, and from transportation to marketing. Therefore, there will be no one technology that solves all challenges. Regions that are able to collaborate across borders to source, validate, and scale the appropriate technologies will be best positioned to meet the production needs of small-scale farmers and the food security needs of everyone.

To that goal, Winrock International (www.winrock.org) is proud to collaborate with SAARC and, more specifically, the SAARC Agriculture Centre to identify the best practices and technologies within the eight member countries. This book captures the emerging production needs facing each country and the emerging innovations to address these challenges.

But that is not enough.

To meet the significant growth requirements, SAARC member countries will need to continue increasing collaboration in technology transfer by harmonizing polices and establishing programs by which the most effective technologies can be quickly identified and disseminated. The SAARC Agriculture Centre seeks to establish a SAARC Innovation Platform to accelerate the adoption and scaling of technology.

The SAARC Innovation Platform builds on the work of Winrock International over the last three years during which we have implemented USAID’s Feed the Future Asia Innovative Farmers Activity to source, validate, and market agricultural technology. Over one million individuals have benefited from access to improved technologies and over four million dollars in external investments has been acquired to further expand these efforts.

We continue to share our resources and experiences with SAARC Agriculture Centre to support the launch of the SAARC Innovation Platform. Only by working together can we address the monumental and important challenge of feeding all of our children and our children’s children.

William Sparks
Project Director, Feed the Future Asia Innovative Farmers Activity
USAID (Winrock International)
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<thead>
<tr>
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<td>Access to Information</td>
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<td>ADP</td>
<td>Annual Development Program</td>
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<td>ADS</td>
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<td>Afghanistan Food Security and Nutrition Agenda</td>
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<td>ANPDF</td>
<td>Afghanistan National peace and Development Framework</td>
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<td>ASSRs</td>
<td>Agriculture Sales and Service Representatives</td>
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<td>AWD</td>
<td>Alternate Wetting and Drying</td>
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<td>BAU</td>
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<td>Bangladesh Forest Research Institute</td>
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<td>Bangladesh Livestock Research Institute</td>
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<td>Business Planning and Development Units</td>
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<td>Bangladesh Rural Advancement Committee</td>
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<td>BRICS</td>
<td>Association of five emerging nations: Brazil, Russia, India, China and South Africa</td>
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<td>BSCIC</td>
<td>Bangladesh Small and Cottage Industries Corporation</td>
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<td>Bangladesh Sugar Crop Research Institute</td>
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<td>BSRTI</td>
<td>Bangladesh Sericulture Research and Training Institute</td>
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<td>BTRI</td>
<td>Bangladesh Tea Research Institute</td>
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<td>CARD</td>
<td>Center for Agriculture Research and Development</td>
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<td>CBR</td>
<td>Capacity Building for Results Programs</td>
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<td>CBS</td>
<td>Central Bureau of Statistics</td>
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<td>Climate Change Agriculture and Food Security</td>
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<td>CCDC</td>
<td>Cluster Community Development Council</td>
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<td>CDDB</td>
<td>Cotton Development Board</td>
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<td>CDC</td>
<td>Centre for Disease Control</td>
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<td>CEA</td>
<td>Controlled Environment Agriculture</td>
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<td>CGIAR</td>
<td>Consultative Groups on International Agricultural Research</td>
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<td>CICR</td>
<td>Central Institute for Cotton Research</td>
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<td>CIMMYT</td>
<td>International Maize and Wheat Improvement Center</td>
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<td>CLA</td>
<td>Conjugated Linoleic Acid</td>
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<td>COP21</td>
<td>Conference of Parties (Paris Agreement)</td>
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<td>CRSP</td>
<td>Collaborative Research Support Program</td>
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<td>Climate Smart Agriculture</td>
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<td>CSSRI</td>
<td>Central Soil Salinity Research Institute</td>
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<td>CSV</td>
<td>Climate Smart Village</td>
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<td>DAE</td>
<td>Department of Agricultural Extension</td>
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<td>Directorates of Agriculture, Irrigation and Livestock</td>
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<td>DC</td>
<td>Direct Current</td>
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<td>Department of Food Technology and Quality Control</td>
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<td>Distillers’ grains</td>
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<td>Department of Agriculture</td>
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<td>Department of Agriculture</td>
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<td>Department of Livestock</td>
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<td>DoLS</td>
<td>Department of Livestock Services</td>
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<td>DSR</td>
<td>Dry Seeded Rice</td>
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<td>DSS</td>
<td>Decision Support System</td>
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<td>DSTEP</td>
<td>Decentralized science technology and education program</td>
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<td>Deemed to be universities</td>
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<td>EDP</td>
<td>Economic Development Policy</td>
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<td>Exclusive Economic Zone</td>
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<td>ELISA</td>
<td>Enzyme Linked Immunosorbent Assay</td>
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<td>Effective Microorganisms</td>
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<td>Food and Nutrition Security Program</td>
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<td>Five Year Plan</td>
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<td>Gross Domestic Product</td>
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<td>Gross Domestic Products</td>
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<td>GHGs</td>
<td>Green House Gases</td>
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<td>GI</td>
<td>Galvanised Iron</td>
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<td>GIS</td>
<td>Geographic Information System</td>
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<td>GMP</td>
<td>Good Manufacturing Practices</td>
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<td>GNH</td>
<td>Gross National Happiness</td>
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<td>GoI</td>
<td>Government of India</td>
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<td>Goods and Services Tax</td>
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<td>HAC</td>
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<td>Acronym</td>
<td>Full Form</td>
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<td>HS</td>
<td>Happy Seeder</td>
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<td>HYV</td>
<td>High Yielding Varieties</td>
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<td>Indian Council of Agricultural Research</td>
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<td>ICM</td>
<td>Integrated Crop Management</td>
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<td>ICRISAT</td>
<td>International Crops Research Institute for Semi-arid Tropics</td>
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<td>ICTs</td>
<td>Information and Communication Technology</td>
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<td>Indian Institute of Horticulture</td>
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<td>INAGEP</td>
<td>Innovation and Agriculture Entrepreneurship Program</td>
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<td>Indian Rupee</td>
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<td>International Rice Research Institute</td>
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<td>Indigenous Technology Practices</td>
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<td>International Documentary Union</td>
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<td>J &amp; K</td>
<td>Jammu Kashmir</td>
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<td>KISAN</td>
<td>Knowledge-Based Integrated Sustainable Agriculture in Nepal</td>
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<td>Krishi Vigyan Kendras</td>
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<td>LCAR</td>
<td>Land Cover Assessment Report</td>
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<td>LD</td>
<td>Longissimus dorsi</td>
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<td>LECReD</td>
<td>Low Emission Climate Resilient Development</td>
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<td>LiBIRD</td>
<td>Local Initiatives for Biodiversity, Research and Development</td>
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<td>LRI</td>
<td>Land Resource Inventory</td>
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<tr>
<td>m.a.s.l.</td>
<td>meter above sea level</td>
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<td>Ministry of Agriculture, Irrigation and Livestock (Afghanistan)</td>
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<td>MEW</td>
<td>Ministry of Energy and Water</td>
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<td>MMS</td>
<td>multi-nutrient supplement</td>
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<td>Ministry of Agriculture and Livestock Development</td>
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<td>MRRD</td>
<td>Ministry of Rural Rehabilitation Development</td>
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<td>Mouchas Unnayan Sangstha</td>
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<td>National Agricultural Innovation Project</td>
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<td>Nepal Agricultural Research Council</td>
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<td>National Agricultural Research System</td>
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<td>NBC</td>
<td>National Bio-diversity Center</td>
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<td>NBPGR</td>
<td>National Bureau of Plant Genetic Resources</td>
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<td>NBSS&amp;LUP</td>
<td>National Bureau of Soil Survey and Land Use Planning</td>
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<td>NCF</td>
<td>National Commission on Farmers</td>
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<td>NFT</td>
<td>Nutrient Film Technique</td>
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<td>NGOs</td>
<td>Non-Governmental Organizations</td>
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<td>Abbreviation</td>
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<td>NIP</td>
<td>National Irrigation Program</td>
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<td>NPK</td>
<td>Nitrogen-Phosphorus-Potassium</td>
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<td>NPPC</td>
<td>National Plant Protection Center</td>
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<td>NRM</td>
<td>Natural Resources Management</td>
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<td>NRs</td>
<td>Nepalese Rupees</td>
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<td>National Statistics Bureau</td>
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<td>National Seed Center</td>
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<td>NSSC</td>
<td>National Soil Service Center</td>
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<td>Nu</td>
<td>Ngultrum, Bhutanese Currency</td>
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<td>Provincial Agriculture, Irrigation and Livestock</td>
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<td>Population &amp; Housing Census of Bhutan</td>
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<td>Perennial Horticulture Development Centers</td>
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<td>Prime minister Agriculture Modernization Project</td>
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<td>PPP</td>
<td>Public-Private Partnership</td>
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<td>PROSHIKA</td>
<td>Proshikkhan Shikkha Karmo</td>
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<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
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<td>q/ha</td>
<td>Quintal/ha</td>
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<td>RGoB</td>
<td>Royal Government of Bhutan</td>
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<td>RNR</td>
<td>Renewable Natural Resource</td>
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<td>RSC</td>
<td>Residual Sodium Carbonate</td>
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<td>Rooted Stem Cuttings</td>
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<td>Rice Super Zone</td>
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<td>SAARC</td>
<td>South Asian Regional Cooperation</td>
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<td>Second Crop Diversification project</td>
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<td>Sustainable Development Goal</td>
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<td>Small Farmer’s Group</td>
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<td>Small and Medium Enterprises</td>
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<td>Soil Resource Development Institute</td>
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<td>System of rice intensification</td>
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<td>University of California</td>
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<td>United Nations</td>
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Chapter 1

Innovative Agricultural Technologies in South Asia

Punya Prasad Regmi
Agriculture and Forestry University, Nepal
punyaregmi@gmail.com

Introduction

South Asia is characterized by geographic, social, linguistic, and income diversity. Agriculture is mainly characterized by subsistence farming and limited commercialization with dominance of smallholder farmers. Average landholding remains less than a hectare. Majority farmers are landless and marginal with substantial indigenous people, ethnic minorities, people with disability, and female-headed households (FAO, 2015). Farm households are further characterized by low productivity, low access to technology, limited skill, and labor migration (Bhutani, 2013). Migration has been adversely affecting the availability of agricultural laborers in the rural agricultural communities (Maharjan et al., 2012 and Sharma 2016).

Households often experience farm income risk due to production variation and limited market access, particularly due to price variability and poor, as well as unorganized market infrastructure. The households are ultimately exposed to high risks and uncertainties for their livelihood due to reduced land access, inability to apply inputs, reduced labour availability, and limited access to improved technology (Bhandari & Grant, 2007; FAO, 2015). These households are mostly risk averse and employ both farm and off-farm strategies for their livelihood.

Achieving Sustainable Development Goals (SDGs), including poverty alleviation and ensuring food and nutrition security, have been common agenda for all countries of South Asia. Furthermore, improving household welfare and reducing income inequality of subsistence and smallholder farm households are important concerns for policy makers (FAO, 2015). Household welfare and income inequality largely depend on access to off-farm income opportunities and income level. This is why households derive income by allocating land and labour resources to farm and off-farm activities, mainly to mitigate income risk, reduce poverty, and improve the household wellbeing (Reardon, 1997).
Despite some constraints, South Asia is blessed with tremendous opportunities for transformation of agriculture and overall development of this region. The hardworking millions of youth deserve potentialities for transforming agriculture by harnessing geographic and climatic diversity, and capturing the huge market within it. Technological innovation has a key role in transforming agriculture to increase agricultural production and productivity. A recent (September 20-23, 2018) international conference of YPARD on 'Doubling the Income of Farmers of SAARC Countries: Extension Strategies and Approaches' held in Kathmandu, Nepal reveals commitment of member countries in prioritizing agriculture.

A closer look on use of technology reveals farmers' low access on improved technology complemented by limited coverage and insufficient budget for research on agricultural innovations in this region. South Asian rural farmers use innovative agricultural technologies either developed by research institutions or using indigenous knowledge/skill innovated through local experimentation and adaptation. Indigenous skill might be useful to cope with some problems but may not be instrumental in transforming agriculture sector. Transforming agriculture sector through innovative technologies is a critical need to foster commercialization and modernization. However, attention should be given to how small and medium farmers gain benefits to sustain their livelihoods from the given innovative agricultural technologies. A blend of scientific innovation and indigenous knowledge can be effective in accelerating agricultural development. FAO (2015) also concluded accelerated investment and innovations in agriculture, particularly in R&D, as one of the policy priorities to enhance smallholders' productivity and income in a sustainable way in context of constrained resources, particularly the land, water, and labor resources. It further emphasizes use of technological innovation and communication including e-agriculture to attract future young farmers.

In this context, the sharing knowledge and experiences through SAC provides an opportunity for concerned stakeholders particularly policy makers to exchange appropriate technology across the member countries. Since majority of farmers in this region are smallholders and in transition towards commercialization, the sharing of knowledge and experiences provides an opportunity to import and exchange technology for mutual benefits, overcome the hurdles experienced in innovation management, enable to formulate policy
related to issues that ultimately benefit the small and medium farmers, development stakeholders, and government within SAARC and the beyond.

The ever-increasing population of South Asia accounts for about one-fourth of the world’s population, with the largest proportion of undernourished people in the world. The region alone has more than 1.7 billion population and agriculture engages around 60% of the total workforce.

The big challenge for all the governments of the South Asia and their regional organizations is to achieve sustainable agricultural development through rapid economic development. The current pace of development is very slow, though a considerable progress has been achieved in technological improvements, the rate of growth in farming in developing countries has not attained the expected levels (S.S. Acharya and N.L. Agrawal, 2011). Therefore, the importance of innovative agricultural technologies has been realized at both government level as well farmers’ level. Some of the innovative agricultural technologies are limited to certain local areas within a country whereas some have wider suitability to transfer across borders. This publication has made small efforts in illustrating few but popular innovative agricultural technologies of South Asia.

**Innovative Agricultural Technologies in South Asia**

There are several innovative agricultural technologies being used in South Asia related to agronomy, horticulture, livestock, aquaculture, natural resource management, and agricultural tools and machines. Some promising transferable innovative agricultural technologies of each Member States of SAARC are discussed in detail in the respective country Chapter. Table 1.1 reveals some of the very popular innovative agricultural technologies being adopted in South Asian countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Innovative Agricultural Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>Value chain approach, well designed new orchards, women led kitchen gardens and small scale poultry farming, establishment of horticulture development centers, standardized export-import regulations, established market linkages, establishment of better On-</td>
</tr>
<tr>
<td>Country</td>
<td>Innovative Agricultural Technologies</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Farm water management approaches and Irrigation Association (IA), Public-Private-partnership approach, agriculture mechanization; established learning and experimenting centre on Leaser Land Leveling machine; Application of geographic information systems. Floating bed agriculture, Four crops based cropping patterns, Stress resistance rice varieties, Vegetable production on <em>Gher’s ail</em> (bund) of fisheries in coastal zone, Summer tomato production, E-agriculture and mobile apps, Agriculture information and communication center (AICC), Farm machines, Vermi-compost, Sex-pheromone trap for safe vegetable production, Beekeeping, Integrated rice- fish farming</td>
</tr>
<tr>
<td>Bhutan</td>
<td>Improved Field Crops, Improved Fruits, Improved Vegetables, Farm mechanization, Electric &amp; Solar fencing, Sustainable land management techniques, Organic agriculture and use of EM, Biogas and bio-slurry, Drip irrigation systems, Use of plastic mulches and poly houses, Poly houses, High density multi-tier cropping, and Crop propagation techniques (grafting/top working)</td>
</tr>
<tr>
<td>Maldives</td>
<td>Soil-less farming (hydroponics), Adoption of open-pollinated local varieties as high value crops, Local resource use maximization in nutrient management, Nursery business coming up in islands tied with agro-tourism, Reinventing small-scale poultry operations</td>
</tr>
<tr>
<td>Nepal</td>
<td>Protected cultivation of horticultural crops, Transformation of poultry sector, System of rice intensification (SRI), Farm mechanization, Agribusiness incubation service, Enriching soil quality through biochar, Post-harvest storage and drying of horticultural seeds, Agro-tourism promotion, Organic farming</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>Catch crop cultivation in rice-rice cropping, Alternate wetting and drying irrigation in rice, Leaf colour chart for fertilizer application, Mechanical transplanting for rice, Plot consolidation, G₀ seed tuber production in potato, Straw mushroom cultivation</td>
</tr>
</tbody>
</table>
Cross Border Technologies

Some of the innovative agricultural technologies are cross border in nature. They are originated in a particular country and were adopted by the farmers across the border. The focal persons of each country were requested to mention three very important cross border innovative agricultural technologies which have been used by the farmers of their respective country (Table 1.2). The detailed information on sources of any cross border innovative agricultural technologies is important for the users to use it sustainably.

Table 1.2 Cross Border Innovative Agricultural Technologies in South Asia

<table>
<thead>
<tr>
<th>Country</th>
<th>Technologies</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>Agricultural Machines (leveling, sowing and harvesting), Improved crop varieties (grain, fruits, and vegetables)</td>
<td>China</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Hybrid rice, Amrapali (A mango fruit variety), and Dragon fruit</td>
<td>Private Nursery and Vietnam</td>
</tr>
<tr>
<td>Bhutan</td>
<td>Crop germplasms, Improved crop varieties, Farm, spray and postharvest machines, Drip irrigation, Poly houses and plastic mulches, and Plant protection chemical and fertilizer</td>
<td>India, Bangladesh, Nepal, Thailand and Japan</td>
</tr>
<tr>
<td>Maldives</td>
<td>Hybrid seeds, Drip irrigation systems, Imported manure and compost</td>
<td>India, Thailand and China</td>
</tr>
<tr>
<td>Nepal</td>
<td>Hybrid seeds and breeds, High-tech structures, and Machines</td>
<td>India and China</td>
</tr>
</tbody>
</table>

Research and Development for Innovative Agricultural Technologies

The research, training, and extension are the three major areas of development of any innovative agriculture technologies. However, there are some dedicated research institutions, like Nepal Agriculture Research Council, to carry out agriculture research on innovative technologies in Nepal. There are four Agriculture Research and
Development Centers spread throughout the country in Bhutan with the mandate to perform various research and development works. Under the National Agricultural Research System there are several research institutes in Bangladesh including Bangladesh Rice Research Institute, Bangladesh Jute Research Institute, Bangladesh Sugar Crop Research Institute, Bangladesh Livestock Research Institute, Bangladesh Fisheries Research Institute, Bangladesh Forest Research Institute, Bangladesh Tea Research Institute, Bangladesh Sericulture Research and Training Institute, Soil Resource Development Institute, Bangladesh Institute of Nuclear Agriculture, and Bangladesh Agricultural Research Institute and Cotton Development Board. In Afghanistan, the Ministry of Agriculture, Irrigation and Livestock has a very important role in coordinating other institutions to support farmers. Maldives has established Hanimaadhoo Agriculture Center with a narrow mandate focusing on varietal testing, and few other research programs are in place for fertilizer and pesticide testing of commercial crop varieties. There are various government organizations, semi-governmental organizations, non-governmental organizations, and universities doing agricultural research and development works in Sri Lanka. The apex body in Sri Lanka for government research funding is National Research Council. Different institutes are responsible for conducting research on innovative agricultural technologies in Sri Lanka including Rice Research and Development Institute, Tea Research Institute, Rubber Research Institute, Coconut Research Institute, Agrarian Research and Training Institute, and Sugarcane Research Institute. In India agricultural research and education is coordinated by Indian Council of Agricultural Research (ICAR). As of 2017, there are 64 ICAR Institues and 15 National research Centers are devoted to conduct agricultural research along with universitis and othe specialized bodies. Based on research demand in agricultural sector, there are 10 research institutes working throughout Pakistan. Agricultural research in Afghanistan is impleting through 17 research stations in differentagro-ecological zone of the country under the Agricultural Research Institute of Afghanistan (ARIA).

**Popularization and Commercialization of Innovative Technologies**

The popularization and commercialization of innovative agricultural technologies help in the development and application of a new
product, process, and service in order to earn more profit. Once the innovation is popular its commercialization increases to a greater extent. Examples include new innovations such as Vermi Compost and Sweet Gourd Production Using Pitcher Irrigation in Saline Area in Bangladesh, SRI technologies in Nepal and Sri Lanka, Hydroponic in Maldives, Poly houses in Bhutan, and Leveling machines in Afghanistan. Each of these are very popular technologies with commercial importance.

The agriculture and livestock ministries and departments in all South Asian countries play vital roles for the popularization and commercialization of innovative agricultural technologies. The Ministry of Agriculture, Irrigation and Livestock of Afghanistan; The Ministry of Agriculture and Forests of Bhutan; The Ministry of Agriculture of Bangladesh; The Ministry of Fisheries and Agriculture of Maldives; The Ministry of Agriculture and Livestock of Nepal; and The Ministry of Agriculture of Sri Lanka have been playing lead roles to popularize and commercialize innovative agricultural technologies in their respective countries.

Institutional and Policy Arrangement

Each country in South Asia has institutional and policy arrangement to enhance agricultural production, productivity, and farm as well as household income. The Government of Bangladesh has several policies such as The National Agricultural Policy 2018, The National Seed Policy 2018, Integrated Minor Irrigation Policy 2017, The National Organic Agriculture Policy 2016 and the The National Agricultural Extension Policy 2015. These policies have been implemented with the support of numerous plans, programs, and development projects under Annual Development Program.


The Ministry of Agriculture and Livestock Development of Nepal formulates policies and programs, coordinates agriculture
development programs, and implements agriculture development plans, programs and projects through its departments, provincial departments, Agriculture Knowledge Centers, Veterinary Hospital and Livestock Experts Centers, as well as through extension agents placed in the Agriculture/Livestock Section of the Municipalities. Farmers groups, farmers cooperatives, private sectors such as community-based organizations, non-governmental organizations, commercial and commodity alliances are also engaged in imparting innovations for agricultural development. The Government of Nepal has formulated many policies, acts, regulations, orders, plans and programs for the development and transformation of Nepalese agriculture sector. For example, The constitutions of Nepal 2015, National Agricultural Policy 2004, Agriculture Development Strategy (2015-2035), Agribusiness Promotion Policy 2006, Agricultural Biodiversity Policy 2014, National Land Use Policy 2012, and Agriculture Mechanization Promotion Policy 2014.

Presently, there are no specific policies in the Maldives for generating and improving innovative agricultural technologies. Also, there is no overarching legislation on agricultural activities. However, vision and mandate of all agricultural related activities flow from the Agriculture Development Master Plan 2010-2020. Other relevant legislation that influence agricultural development include 7th National Development Plan and Maldives Land Act of 1996. Maldives Agricultural Policy and Midlives Forest Policy are still in development.

**Recommendations for Promoting Innovative Agriculture Technologies**

The regional and national institutions, mainly government institutions, have immense roles in developing and disseminating innovative agricultural technologies in South Asia and SAARC countries. Governments need to strengthen national agricultural research systems and investments by establishing linkages between components, institutions and policies to create enabling environments for innovation. The following recommendations are suggested to promote innovative agricultural technologies to be considered by SAARC and its member countries:

- Review agricultural knowledge systems and follow more interactive, demand-driven Agricultural Innovation Systems,
- Establish agribusiness incubation facilities and improve farmer to farmer communication,
• Design policies to enable small and medium farmers to adopt innovative agricultural technologies,
• Generate incentives (such as recognition of innovators) for agricultural techniques and technologies,
• Modify policies and regulatory framework to recognize and incentivize innovations,
• Develop critical monitoring, supervision and evaluation of programs,
• Strengthen the capacity of national resource centers, research institutes, laboratories and human resources,
• Increase adaptability testing of fertilizer, seeds and machineries to ensure quality and efficiency,
• Develop and upgrade capacities of institutions directly engaged with cross border technologies,
• Promote custom hiring centers for mechanization, and
• Expand and effectively execute insurance policies to protect farmers from income risk.

Potential Roles to be Played by SAARC Agriculture Center

Majority of the people of South Asia earn livelihoods mainly from agriculture which is subsistence in nature. The SAARC Agriculture Center (SAC) has pivotal role to change the current situation in terms of poverty, hunger, and malnutrition and transform into a vibrant and prosperous region. As a central agency of the SAARC countries, SAC has vital role in coordinating, consolidating, and integrating all the available technologies of the region and making those available to the farmers in a manner that reaches farmers in mainly small and medium categories. There is immense potential to create a conducive environment for cross-border governance of agricultural science, technology, and innovation. Being a Regional Institution, SAC must concentrate on promoting innovative agricultural technologies through knowledge sharing, regional networking, and capacity building. The recommendations related to both the SARC as a whole and specific to each country are mentioned in each country paper. Some of the envisioned key roles that the SAC could play in the promotion of innovative agricultural technologies are listed hereunder:

• Strengthening agricultural research and extension focusing on innovative agricultural technologies,
• Providing inputs for developing regional policies, strategies, projects, primarily through developing networks in crop, livestock, and fisheries sectors; and for efficient management of soil, water, and other natural resources,

• Supporting new and innovative techniques and systems in agriculture, including production, post-harvest, and food processing,

• Assisting collaborative studies, inter alia, on agricultural marketing and distribution systems, harmonization of agricultural related standards, promotion of agricultural trade, food security, risks, and disaster management in agriculture,

• Helping and undertaking collaborative capacity building programmes in agriculture and allied sectors with focus on skill development and research on frontier areas,

• Assembling and propagating information for agricultural advancement in the region,

• Facilitating the easing of quarantine regulations in force to fast track the transfer of technologies among the SARRC countries, including sharing of germplasm as the existing procedures are tiring and red tapped,

• Creating a web-based central digitalized technology information where technologies are made accessible to the grass root implementers anytime from anywhere,

• Evaluating and adapting climate smart interventions in agriculture sector. The interventions required for smaller holder farmers for adaptation to climate change are not adequate. There is a need for a more productive and more resilient agriculture practices and technologies,

• Facilitating strong advocacy and an enabling policy support to promote organic agriculture in the SRARC countries by re-orienting the current conventional research system into organic agriculture,

• Facilitating the crop diversification for mountain agriculture, which requires seed multiplication and germplasm management,

• Providing assistance in sharing co-skills necessary for innovation among member countries and arranging exposure to farmers between member countries in order to generate ideas for innovation,
• Facilitating funding possibilities to enhance institutional capacity and research on innovation,

• Developing SAARC agriculture technology forum and organizing technical working group meeting regularly,

• Organizing SAARC level agricultural conference annually with greater participation of researchers, development organizations, government people, farmers, NGOs, private sectors, and Universities, and

• Developing a protocol to ease for the transborder flow of innovative agricultural technology.

Considerations in Establishing SAARC Innovation Platform

All the participants of the three day workshop on Formulation of Enabling Policy Recommendations and Project Concept for Popularization of Innovative Agricultural Technologies in South Asia held in Colombo, Sri Lanka during 29 to 31st October 2018 sufficiently realized on various issues to be considered while writing proposal to establish SAARC Innovation Platform (SIP). Two days of the three were fully devoted to four major issues to be covered by SIP which included sources, process, validation, and scaling up.

There are several benefits of SIP for the generation and use of innovative agricultural technologies, enabling quick and efficient solutions for recurring problems, and platform could act as a central environment to discuss and share ideas that lead to collective improvement of innovation capacity in the region. This will help to foster interaction among a group of relevant stakeholders around shared interest and be useful in diagnosing problems, exploring joint opportunities, and investigating solutions. The SIP will be instrumental in both strategic and operational levels. The following considerations have to be properly addressed in the proposed SIP:

• Vision, mission, goal and objectives,

• Policy commitment among the government,

• National agricultural innovation platform among multi-stakeholders,

• Common interest area,

• Respective division such as planning and policy division, technical division, administrative and human resource division, and monitoring and evaluation division,
- Defined terms of references,
- Proper and effective communication system,
- Monitoring and Evaluation

Considering all the features aforementioned, there is no doubt on the dire need of having SIP for the region to bring tangible changes through innovative agricultural technologies. This platform in the process will bring the following impacts in meeting the diverse requirements of agriculture in SAARC countries:

- Maximize free exchange of new regional ideas and cross border technologies among the research fraternity including the private entrepreneurs and NGOs- a faster means of disseminating and transferring the technologies,
- Facilitate expertise exchange visits within the region,
- Full utilization of knowledge and skills of the researchers and scientists,
- Create an opportunity to institutionalize and initiate best innovative technology award to both the research scientists and farmers,
- Capacity building of the young researchers,
- Government commitment and the political willpower,
- The technology requirement of the particular country, and
- A policy to harness the potentiality of specific location.

**Concluding Remarks**

The South Asian countries are under the economic category of low to middle income group in the global economic map, and these countries are fighting against poverty, hunger, and food and nutrition insecurity from the time immemorial. Still, agricultural is the mainstay of this region, however subsistence in nature. Small and medium farmers are unable to access the innovative agricultural technologies. This situation demands for a strong role of SAARC Agriculture Center bringing together the government agencies/organizations, scientists, private entrepreneurs, and INGO/NGOs in a common platform to unfold the reality of stagnated agriculture development process. Beyond the strong and flourishing regional cooperation that we already have in place, a further
horizontal step is required to harness the challenges and threats to opportunities through vertical thinking process.

There are several innovative agricultural technologies both local and cross border in nature germane to agronomy, horticulture, livestock, fisheries, plant protection, and agri-engineering. Such technologies are mostly designed to suit the specific farm and farmer’s needs. South Asia has predominantly small and medium farmers, and therefore while designing technologies their specific requirements must be considered. At the same time, conducive policy environments must be established and implemented. The regional cooperation helps in strengthening policy environments and applications of cross border technologies. SAARC has enormous scope in bringing together the member states and response on such matters for sharing innovative agricultural knowledge, technology, and technical know-how. All the member states can benefit by harnessing potentials and earning foreign exchange. Conservation of natural resources, food and nutrition security, poverty alleviation, easy access to innovative technologies, regional trade, and commerce may be the priority areas of SAARC countries. The SAARC and the national governments have made several declarations and commitments which must be executed and modified as per requirements. The SAARC Agriculture Center has compiled conservation agriculture technologies of South Asian Countries and many of them are cross border technologies. For instance, SRI system is very popular in Bangladesh and gaining popularities in Nepal too. Similarly, zero tillage or minimum tillage, drip/ sprinkle/surface irrigation, intercropping in fruits, land leveling, green manuring, rice and maize based cropping system, mulching, agroforestry, composting, inter-cropping, and so many other technologies are common in SAARC countries and beyond. There are several innovative and proven technologies related to crop varieties, animal breeds, tools, and implements which have cross border applications in SAARC countries. The current need is to establish a SAARC Innovation Platform to analyze constraints and potentials in terms of both policy and implantation perspectives and finding common ground to the proper use of innovative agriculture technologies. SAARC Agriculture Center should be able to assist member countries in designing and implementing Cross Border Agriculture Transfer Model.
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Chapter 2
Innovative Agricultural Technologies in Afghanistan

Sabawoon Chakhansuri
Department of Agriculture Statistics & Management Information Systems
Ministry of Agriculture, Irrigation and Livestock (MAIL), Afghanistan
sabawoonh@gmail.com

Introduction
Agriculture is the driving force and the backbone of the Afghan economy. Opportunities in agriculture are driving demands by women and men farmers that planners and agricultural experts have not anticipated. These opportunities need nurturing and support from government to propel agriculture to a new level. They must be capitalized upon as they represent a unique possibility for the Ministry of Agriculture, Irrigation and Livestock (MAIL) to address structural and capacity demands; enable farmers to generate increased income; provide greater food and nutritional security and self-sufficiency for families and the country. MAIL’s response to these challenges is the strategic framework document, of which this will summarize and will provide a glimpse as to its planned efforts for the next five years.

Achievements
Production in virtually all areas of agriculture across the country has increased. For example, since 2007, wheat yield has risen 4.5% per year, although in a fluctuating trend every year, and has generated up to 1.3 million Full Time Employment (FTE) opportunities in both on and off-farm. Similarly, horticultural activities have produced significant returns to farmers and traders. Over two million people are involved in horticulture sector generating revenues exceeding $700 million, contributing to 6.7% of overall GDP and 34% of agricultural GDP. Livestock production contributes 3.8% of National GDP and 15% of agricultural GDP valued at $684 million. It employs 1.1 million men and women, particularly amongst the most economically impoverished. Exports from this sector continue to be modest, amounting to $116 million per annum. Total amount of land brought under irrigation is currently 2.4 million hectares, resulting in an additional 350 thousand ha of fertile land, allowing production to rise across the country, producing two crops per year and generating returns of $350-400 per hectare.
Efforts are under way for MAIL to move from an institutional focus to a ‘farmer centric’ focus; where the views and needs of farmers are carefully considered to ensure that appropriate investments are planned and that MAIL acts as an enabler for farmers to realize greater value for their products. The Ministry has already acted on recruiting 34 new directors for its provincial offices who have been hired through strict competency-based CBR process. The Institutional reform proposes to change both function and form of how MAIL operates. For many years agricultural interventions have had an uneven approach towards assistance to subsistence and institutional farmers. It has engaged both categories of farmers through the same planning and investment prism, resulting in uneven support to those deserving the most help while also missing the opportunity of promoting institutional (semi-commercial and commercial) farmers to make greater use of the private sector. Similarly, MAIL would play an important role as a facilitator on behalf of farmers with other institutions of government and the private sector. In addition, relevant Sustainable Development Goals (SDGs) are being incorporated in all priorities. Recognizing that poverty is a major challenge in Afghanistan, the focus is on Goal 1 of the SDGs and specifically on targets 5, 6 and 7 on building resilience for the poor; mobilize resources to address poverty in all its forms and develop pro-poor policies that target gender and increased investment in providing opportunities to eradicate poverty.

**Agricultural Mechanization**

Extension of China-donated new technology (machines) is more significant in terms of leveling land and sowing and harvesting agriculture crops to prevent agriculture waste.

*Laser land leveling machine:* Laser-assisted land leveling machines offer a great potential for saving irrigation water, nutrients and agro-chemicals. MAIL has been undertaking Laser land Leveling machine for developing agriculture sector by improving uneven fields, unnecessary bunds, and ditches, which are responsible for significant water losses and yield reduction. These technologies are helpful, for
example, to make a flat land on growing crops, a laser land leveling machine can be used to prevent water wastage and substantial to reaping and decreasing wastage of agricultural crops.

Agricultural Mechanization Directorate, as policy maker, is responsible to organize and manage all national agricultural mechanism plans, mandates and procedures, rules and regulations which can play worthwhile role in regard to these efforts.

**Learning Centers** are established for learning and experimenting with all agriculture machines and tractors of Mold Company. In the initial stage, the setup of learning centers will be on agri-zones (Central, Eastern, Southern, Western, South-Western, North-Eastern and North) level. In aforesaid stations, farmers, cooperatives members and other participants can learn methods and uses of these technologies theoretically as well as practically.

Moreover, the monitoring and evaluation department is responsible to evaluate the importing and producing of these technologies through the private sector to ensure the standardization of imported machines to the country. Furthermore, this directorate can also play a significant role in providing technical services and advice to all importing companies across the country.

The directorate is determined to distribute 180 tractors and paddy growing machines to farmers in many provinces in 2019 with an installment payment period of 4-5 years.

**Strategic Priorities**

For the next five years, MAIL proposes to address the following seven priorities:

(i) **Irrigation:** Investment in irrigation and in agriculture provides a unique opportunity in Afghanistan to facilitate economic growth, increase rural employment and enhance food security, especially in rural areas. On Farm Water Management Project jointly implementing by Ministry of Energy and Water (MEW) and MALI targeted rehabilitation of more than 1000 irrigation schemes to increase water availability from the current 2.4 million ha to 2.7 million ha in the next five year. The MEW manages primary irrigation infrastructure and MAIL is responsible for developing and managing irrigation systems and networks – these include better management of on-farm water by rehabilitation of irrigation canals, institutional strengthening,
and technical demonstration activities, and rangeland water resources construction of watersheds. Over the next five years, MAIL is committed to an accelerated rehabilitation and construction program of physical works. This will be driven by the National Irrigation Program (NIP) targeting increase production and productivity through irrigation and improved water management practices with a long-term focus to achieve the pre-war irrigated land level of 3.1 million ha in the next ten years. It encompasses rehabilitation and new construction, as well as capacity building and strengthening institutions and develops standards and procedures for establishing Irrigation Associations (IA).

(ii) **Wheat:** Sustainable development of the wheat sector in order to achieve self-sufficiency, improve food security and better response in cases of emergency and crises across the country are the objectives of the National Wheat Program. This will involve improving productivity and will require taking a more proactive approach in partnering with the private sector at one end and facilitating farmers to achieve economies of scale through well-tailored agricultural packages at the other. Both of these tasks face numerous challenges in acquiring high quality agricultural inputs, incentivizing private sector investment to strengthen market elements of the value chain and ensuring aging seed is constantly replenished by new high-yield location-specific varieties. The next five years will see MAIL address a number of systemic and technical challenges in a more coherent manner in order to meet its original intention of reaching the production target of 5.9 million MT. In the next five years, MAIL anticipates an expansion of additional 110 thousand hectares of irrigated and rain-fed under wheat cultivation, increase current yield for irrigated land from 2.45 to 3.1 MT per ha and rain-fed land from 1.03 to a minimum of 1.3 MT per ha. Strategies for dry-land farming will also be expanded in order to effectively utilize the land where irrigation shortages continue to occur. Other cereal crops such as Rice, to be increased to 1 million MT in five years, while production of maize and barley will be intensified for feed and crop rotation purposes.

(iii) **Horticulture Value-chain:** Horticultural crops cover approximately 360,000 ha, accounting for 14% of the total irrigated land area, employing more than two million people, in
the various steps of the value chain of which some 90,000 are in the non-farm economy. Among the perennial horticultural crops of strategic importance are grapes, pomegranates, almonds, pistachios and vegetables—most of which are exported. The horticulture sub-sector contributes US$1.4 billion to the national GDP, equivalent to 34% of agricultural GDP and 6.7% of national GDP. The horticulture sub-sector has grown at the rate of 5.5% per year over the past decade, and as the potential of expanding further, raising farm incomes, generating productive jobs and improving food security in the rural and urban communities if timely investment is made in agro-processing. Critical intervention priorities in this sector are a) expansion of horticulture land-base by at least 12,400 ha per year, b) increase productivity per year, c) develop promising value-chains, d) Infrastructure and Market Development, e) Standardization, f) Support Private Sector, g) Develop Nursery Industry, h) and expand the land under protected agriculture.

(iv) **Livestock development:** The livestock sector contributes significantly towards Afghan economic growth and employment as well as import substitution for livestock products. Based on current prices, the contribution of livestock to National GDP in 2012–2013 was 3.1%, though it was 0.7% lower than the previous year (3.8% in 2011–2012). The sector provides 15% (US$680 million) of the agricultural GDP annually and creates about 1.1 million full-time equivalent jobs, 15% of which are off-farm. It also provides an exclusive livelihood for Afghanistan’s nomads, who follow traditional grazing routes across the country. Livestock, as a commodity also has the potential to yield rapid income and employment generation under the right circumstances. However, for the domestic livestock industry to flourish to a point at which it can offset imports, MAIL will update its regulations covering the import and export standards for livestock products, a more coherent and domestically-driven health component and greater outreach of extension support. Considerable potential exists for the
expansion and semi-commercialization of the livestock industry. While the scope for subsistence farming to contribute to growth is limited, a substantial number of farmers could, through limited inputs (technology, credit, contract farming, etc.), enter market-based agriculture by moving towards semi-intensive/semi-specialized farming practices. There is already an indication that progressive farmers are beginning to diversify in order to capture new opportunities for generating income from livestock production, especially in peri-urban areas where there is better access to a rapidly growing demand for animal products. This is especially true in the case of semi-commercial dairy and poultry production, but also increasingly, seasonal fattening of sheep and goats as and when market prices of feeds and meat allow a profit to be made.

(v) Climate-sensitive Natural Resources Management: Despite frequent natural disasters and the impact of climate change, Afghanistan remains a country rich in natural resources such as 1.7 million hectares of forest (2.63% of the total surface of the country), 30.1 million hectares of rangelands (46.84% of the total surface of the country). These resources have a significant economic, social and cultural value. Although Afghanistan has made advances in cataloguing its natural assets, passing laws and developing policies, further progress will be made by conservation of over 100 thousand hectares of natural vegetation, reforestation and agro-forestry of more than 60 thousand hectare of lands to enhance climate change adaptation, improve urban and rural ecosystem, provided habitat for wild life. MAIL is currently comparing its approaches to neighboring countries in tandem with the recent COP21 framework. MAIL will review its abilities to adapt sustainable ways to address adverse effects of climate change through raising awareness about the climate change phenomenon and its effects on agriculture and livelihoods. While this will be done in conjunction with the Emergency
Preparedness and Disaster Risk Reduction activities, MAIL recognizes the crucial need to protect and build upon its existing NRM base to ensure a curative and causative approach. Through structured programs on agricultural adaptation, farmers, herders, and particularly women will be better positioned to plan and implement low-cost interventions.

(vi) **Food and Nutrition Security**: Afghanistan is a country with high-levels of food insecurity and severe malnutrition with 33% population of the country facing high levels of food insecurity. While other components jointly address the availability and access to food, MAIL acknowledges need of greater efforts focusing on improving the utilization of nutritious food through dietary diversity (e.g. kitchen, commercial and school gardening) and food safety. Building upon evidence-based strategies from previous similar endeavors, MAIL will collaborate closely with other Afghanistan Food Security and Nutrition Agenda (AFSANA) members to coordinate efforts through its Extension Workers and Home Economists to improve feeding and food preparation practices in a systematic and sustainable manner. It bridges the existing gender gaps in addressing the needs of women engaged in the agricultural sector, centered around: providing technical support to meet women’s needs in nutrition-sensitive agriculture, launching urban and peri-urban agriculture, small-scale agro-based enterprises, enhancing women’s skills development training programs at community level, and women micro-entrepreneurship in view of women’s restricted mobility.

(vii) **Intuitional Reform and Capacity Building**: In response to the priorities above, MAIL has undertaken a reform process to increase its capacity and presence at the district and community level and improve management capacity at the central level. This will be done without additional number of staff. Central to the reform effort will be the resetting of how planning is conducted. Planning will be bottom up approach using newly acquired Geographic Information Systems (GIS) for identifying areas of cultivation including amount of land, water, type of agriculture. Baseline data will be communicated upwards from the DAILs to the Provincial Agriculture, Irrigation and Livestock (PAILs) offices where analysts will compile and organize data for onward use both by the PAILs as well as the
Planning Directorate (PD) in Kabul. The PD in turn will meet with relevant directorates to discuss priorities and investment strategies. Once agreement is reached, a consolidated plan including a budget will be prepared and presented to senior management, including the Minister.

Drivers and Enablers
Seventeen Research Centers spread in the seven agro-ecological zones have been established and are keys to improved extension work across the country. In addition, Perennial Horticulture Development Centers (PHDCs) are established in six locations in all major agro-ecological zones of Afghanistan, and conduct adaptive research on fruit trees, provide a repository of the national collection, training and demonstration facilities for farmers, improved saplings and root stock for the nursery industry. Both extension and research closely hold a great promise in terms of driving improvement both in plant and animal research to ensure that the quality of native breeds and species are preserved and protected. Improvement of new strains of animals and plants are vital to a strong horticulture, cereal and animal production industry. By building Farmer Resource Centers (FRCs) around research centers and in provincial centers, a unique opportunity has been created/opened to refocus provincial office activities on technical matters, including important support provider and source of information to district level Integrated Agricultural Service Centers. This will be additionally supported by trained Agriculture graduates and extension officers of the newly established National Agriculture Extension Institute of MAIL in Kabul. Research centers can play a vital role in ensuring that standards are developed to protect farmers from input delivery systems that are of dubious and questionable quality. About 60% of subsistence farmers rely on inputs from MAIL. Turning such inputs to the private sector has posed some special problems. However, it’s clear that a well-functioning private sector monitored and controlled through research centers can provide the needed assurance that farmers require to grow quality products.

A way out for many subsistence farmers from marginal existence is to be organized into various types of Farmers Organizations (FOs). Already many framers are forming water user association and growers’ cooperatives. The groups of marginal farmers are the most expedient way to allow them a greater voice in terms of their ability to
negotiate better with private service providers, traders and providers of credit. The provision of credit can be better utilized when FOs are well organized. Organizing subsistence farmers holds great promise for many out of poverty and living on the edge. Extension services will play a key role in introducing ideas and incentives to persuade and encourage farmers among others to adopt new ways of farming, including awareness of market prices and availability of services.

Subsistence farmers are not the only marginal and disenfranchised group. Women farmers constitute an important group whose contribution while great often are neglected in planning and investment strategies. It is estimated that women constitute up to 40% of the farm work force. MAIL intends to create targeted investment strategies for women in all productive sectors. Given the conservative and traditional strictures in Afghan society, it is imperative that pro-women policies and designs be considered, whether in irrigation, cereal production, horticulture, or livestock. Increasingly, women can be found in contributing and producing commercial level vegetables in many parts of the country. Postproduction harvest and processing in horticulture and livestock are becoming important activities where women are transforming their role in agriculture, and its ancillary impact both socially and economically on their families. In addition, there has been a marked increase in year-round expansion and production of vegetables over the last few years. Women producers are producing high quality vegetables by using their own technologies such as covered farming. Using covered farming technology for year-round fruits and vegetable production through woman involvement can be a profitable market engagement for farmers. This technology could be extended to a commercial scale across the country leading to increased employment on and off the farm. Again, the emphasis on the demand side will involve active engagement of the private sector, focusing on market development and value addition activities. As a crosscutting function, MAIL will adopt a strategy of rationalizing public and private sector roles, further establish regulatory frameworks and
provide training and capacity building for a variety of local institutions and private sector agents.

Underpinning most of MAIL’s activities is predicated on the role and capacity of how the Private Public Partnership unfolds. The government, in partnership with the private sector, will establish the necessary regulatory framework and enabling environment for the export markets to flourish. In addition, significant emphasis will be placed upon branding Afghan products through an innovative PPP approach attracting already active export companies to support domestic products. Promoting an enabling environment for promotion of investment in small and medium enterprises and agro-processing will include the joint formulation of critical strategies in agro-processing, SME development with the Ministry of Commerce and Industry. These will be underpinned with a detailed sub-sector study to determine the potential for value addition of crops with the lowest risk crops by the government and its partner agencies or through PPP arrangements. In the longer term, specific rules and regulations, standards, quality control and other measures will be established and updated for production, processing as well as marketing, import and exports with the aim of developing export-orientated, high quality agricultural system.

Agriculture is a critical link in a broader chain of factors impacting livelihoods and social structures, and it can be directly linked to state building at the national level. With over 70% of the population involved in agriculture it is important to recognize the new dynamics that are unfolding at the rural areas. As more young people attend and acquire education, their values and aspirations are changing. Many opt to leave farming and find work in urban areas. Employment close to the farm where young high school graduates can benefit from ancillary agricultural product processing is a key step in that direction. Similarly, the establishment of private tractor, threshing, and milling services can add significant number of jobs in farming communities. It is axiomatic that a thriving community will attract other public and private services such as schooling, training centers and police services. Increased employment generated off the farm can add greater vibrancy to community growth.

The expansion in production and productivity of the Afghan farmer is moving at a faster pace than anticipated. Accesses to improved inputs and technology have resulted in surplus in a number of areas in agriculture. This increase in production requires greater emphasis on
the development of markets and transitioning from current subsistence farming practices to rationalized market oriented production systems. The potential for expansion of the agri-business sector is enormous and requires a number of enabling instruments to transition into a new era of production and marketing. Such a transition requires that constraints and challenges are closely examined and the establishment of essential platforms to realize this important potential. Given the increasing number of agriculture value added products (18 products), it is essential that initiatives relating to agribusinesses are directly linked with emerging value chains.

The inclusion of the Citizens Charter and its provision of a menu consisting of five basic services through the CCDC and the CDCs will recast how agricultural services will be planned and delivered. Further rationalization of this new process will also impact on provincial budgeting process. Working closely with CDCs and the CCDC in areas such as extension and irrigation close coordination and cooperation with the MRRD will ensure addressing the community needs in line with MAIL’s farmer-centric approach. MAIL is working in close association with the Ministry of Energy and Water (MEW) for identifying water basins and river intakes areas of mutual interest and technical convergence to expedite the building of irrigation canals and intakes where appropriate. Similarly, in the area of Counter Narcotics, MAIL will closely consult with the Ministry of Counter Narcotics to identify strategies that will ensure that MAIL’s efforts in crop production and irrigation are well coordinated. Working closely with Ministry of Commerce and Industries, MAIL will expand efforts to coordinate and work seamlessly in the development of Public and Private Partnerships.

**Implementation Plan**

MAIL will shift toward a programmatic approach in which all on budget and off budget projects will be subject to planning and investment analysis, ensuring that a coherent approach is adopted, and in doing so to put an end to the idiosyncratic project base approach currently in practice. Planning will be bottom up, as described earlier, and will constitute the driver for all investment decisions in different areas of the country. Provincial Centers will become the premier centers for planning, designing, executing and monitoring/evaluation. While the NPP implementation has started during FY 2016 with piloting the reforms using the internal resources, the budget is projected for the years 2017 to 2021 in line with ANPDF timeline.
Chapter 3

Innovative Agricultural Technologies in Bangladesh

Md. Abdul Jalil
Department of Agricultural Extension, Khamarbari, Dhaka
jalilplaning@gmail.com

Introduction

Bangladesh has the highest population density in the world and is located in the tropics of South Asia. It has a total area of 147,570 sq. km bordering with India on the West and North, Myanmar on the East, and Bay of Bengal on the South. The major part of Bangladesh is on deltaic alluvial plain and only one tenth of land area consists of hills with vegetation.

Rice is the staple food. Local varieties of rice with an average yield potentiality of less than 1.00 metric ton per hectare were the only resource to feed the population of 75 million during late sixties. Farmers used traditional technology where there were no uses of chemical fertilizers. Rain fed Aus and Aman were only the crops where a vast area covered with single cropping. At that time a high yielding rice varieties from IRRI (IR-8) had been introduced in Bangladesh that could be treated as the first innovation to combat the challenges of food production. Farmer’s cooperatives at Cumilla area adopted the innovation first. Department of Agricultural Extension, Ministry of Agriculture, Bangladesh started to motivate the farmers to cultivate the variety and trained them in technical knowledge. Line transplanting, use of chemical fertilizers at definite rate and time, irrigation, and weeding were also innovations provided to the farmers.

Still, agriculture is the largest producing sector of economy since it comprises about 17% of the country’s GDP and employs around 45% of the total labor force (BBS, 2017). The average cropping intensity was estimated at 192% and 194%, respectively in 2015 and 2016 (BBS, 2017). That indicates the agricultural operation is gradually increasing. However, the main problems of this sector are loss of arable land, mono cropping, climate change and natural disaster, imbalanced use of fertilizer and pesticide, inefficient water use, attack of pests and diseases, land degradation, and lack of quality inputs. Every year 80,000 hectare of agricultural land is lost due to building
infrastructures and river erosion. Thus, the major crops of rice, wheat, maize, jute, potato, pulse, oil seed, and sugarcane are cultivating every year in the same land, and this mono crop cultivation restricts the crop diversification and reduces soil fertility (Hoque, 2001). Moreover, most of the farmers are marginal, having per capita cultivable land is only 12.5 decimal (Quasem, 2011).

Technology is the basis for sustainable agricultural growth. Enhanced agricultural productivity and growth depend to a large extent upon the widespread adoption of appropriate technologies by farmers. Seed, fertilizer, and irrigation technologies known as “Green Revolution Technologies” have long played major roles in the growth of agriculture production in Bangladesh. The country has made commendable progress in domestic rice production through farmers’ adoption of these technologies. In the early 1970s, Bangladesh was a seriously food-deficient country with a population of about 75 million. Today, the population is more than 160 million, and Bangladesh is self-sufficient in rice production, which has tripled over the past three decades. Innovation in agricultural is the key to sustain the productivity growth needed to meet the growing and more diverse demand for food, feed, fuel and fibre at global level, while preserving environmental resources and adapting to and mitigating climate change.

Both horizontal and vertical expansion of crops, rapid introduction followed by dissemination of innovations, would help combat the food security challenges and lead to poverty alleviation in Bangladesh. National Agricultural Research System (NARS), with a strong linkage with public and private extension system, has been trying hard to develop the appropriate technologies or innovations to satisfy the crying needs of the population. New variety development, appropriate agronomic practices, mechanization, ICT/GIS based services, area or soil based crop modeling, etc are some of the fields of innovations where emphasis are being given.

**Innovative Agricultural Technologies**

Several innovative agricultural technologies are being used in Bangladesh related to agronomy, horticulture, livestock, aquaculture, natural resource management, and agricultural tools and machines. The most important 10 technologies have been considered for this paper. Out of ten five are related to small and medium farmers.
(i) **Floating Bed Agriculture:** A vast area of Southern part of Bangladesh is situated more than two meters below mean sea level and vulnerable to high tides. Flooding and water logging are common problems in this area. Land less, marginal, and small farmers of the southern part of Bangladesh have been using submerged lands for producing vegetables and raising seeding for rice and other crops on floating beds for a long time.

With the use of available water hyacinth (*Eichhornia crassipes*) and other aquatic weeds, local communities have developed a technique to construct reasonably-sized floating platforms or rafts on which vegetables and other crops can be cultivated. The production system is the major livelihood option for about 60-90% of the locals. Biodiverse vegetables and spice crops are grown sustainably over the years on floating beds. The land with the water is used for production of fish in the open water and crops on the floating beds. This traditional cultivation technique is, therefore, an environmental-friendly means to utilize the natural resources of wetlands and providing employment, income, food and nutrition for the farming families and local communities.

The floating bed agriculture has been declared as one of the Globally Important Agricultural Heritage Systems sites by FAO-UN in 2015. Bangladesh Agricultural Research Institute (BARI) has recently initiated research on floating agricultural production systems. Department of Agricultural Extension (DAE) is also implementing a project to transfer the production system in a similar ecosystem.

(ii) **Four Crops Based Cropping Patterns:** At present total cultivable land is 8.5 million hectare which is decreasing at the rate of about 1% per year. There is very little scope for increasing cultivated land, though there is an ample scope for increasing cropping intensity from the present 194% to 400%, by intercropping short duration crops, like mustard, potato,
mungbean and Aus rice in the rice based cropping pattern (Hossain et al., 2014). In case of production agronomy, targeting high yield through high cropping intensity and productivity is the most logical way to raise the total production. However, to produce more food within a limited area, the most important option is to increase the cropping intensity by producing three or more crops over the same piece of land in a year. As a result four cropping system (T. Aman – Mustard – Mungbean - T. Aus, Potao – Wheat – Mungbean - T. Aman, Mustard – Boro rice – Jute - T. Aman, Lentil – Mungbean – T. Aus - T. Aman, Onion – Mungbean – Jute – T. Aman) has been adapted for increasing crop productivity, generating employment to bring additional income for the rural poor by utilizing fallow and under-used land of the country.

Rice equivalent yield, cost and return of the above mentioning four cropping patterns are 1.70, 1.63, 2.24 and 1.50. Due to growing of four crops in a year in the same piece of land, cropping intensity and productivity is increasing, more employment opportunities for male and female laborers are created, and consequently food and nutritional security is being ascertained for the farmers and the nation as a whole.

(iii) Stress Resistance Rice Varieties: Bangladesh is one of the countries worst affected by climate change, and cultivating stress-tolerant rice varieties have the potential to become very important in the near future. Every year drought affects about 100,000 hectares (250,000 acres) of land in the Northern part of Bangladesh during the July to September period. Bangladesh has drought-tolerant rice variety, which should play a key role in helping drought-affected farmers in northern Bangladesh deal with increasingly variable summer weather. Bangladesh Rice Research Institute (BRRI) developed drought resistant rice varieties BRRI dhan56, BRRI dhan57 BRRI dhan 66 and BRRI dhan71 are being suggested to cultivate in drought affected area.

About 1.0 million hectares of cultivable land of the coastal areas of Bangladesh are affected by different levels of salinity. Production of rice in salinity-prone coastal areas of Bangladesh is significantly lower to these adverse effects of climate change. A group of photosensitive and tall rice varieties has adapted in
those areas. Development of BRRI dhan47, BRRI dhan53, BRRI dhan73 and BINA dhan8 for dry season is a major breakthrough for breeding salt tolerant rice in Bangladesh. The potential yield of the varieties ranged from 5.4 to 8.3 t ha⁻¹ in different saline prone areas.

In fact, boro is the traditional crop of the Northeastern (Netrokona-Kishoreganj-Sylhet) haor area. The haor areas are naturally hazardous compared to those of the other irrigated areas of the country. With increased global warming, the haors are getting more hostile to offer a safe harvest. A boro crop in the haor area generally encounters difficulties like a failure of timely crop establishment, cold injury in the reproductive stage of an early crop, and flash flood damage at the premature to mature stage of a crop. Cold-tolerant and short-duration rice varieties BRRI dhan 56 and BRRI dhan 57 have been developed for the farmers in haor regions in the country so that they can harvest the crop before the onset of flash floods reducing the risk of becoming water logged.

(iv) Vegetable Production on Gher’s ail (bund) of Fisheries in Coastal Zone: The Bangladesh coastal zone is a significant maritime habitat of ecologically rich and economically important natural resources. The coastal region, especially the southwestern portion (Satkhira, Khulna and Bagerhat), is one of the most promising areas for shrimp cultivation. Most of the shrimp culture being practiced is by the extensive and improved methods, known as gher culture. Gher means an enclosed area characterized by an encirclement of land along the banks of tidal rivers. There, farming is a challenge due to an acute shortage of cultivable lands.

Two-thirds of the land in this area is used exclusively for harvesting shrimp, primarily because of an ongoing intrusion of saline water across the river delta and floodplains, destroying natural vegetation. The only areas of land that remain dry are the raised dikes, known locally as gher, which are built to serve as embankments surrounding fish ponds. Many vegetable farmers in the southern zone have begun growing crops on these earthen dikes (Gher’s ail).

They raised and broadened their ail (bund), which was used mainly for area demarcation, soil and water conservation, and
easy movement to the field, and began to cultivate vegetables. Farmers not only used the top portion of the bund, but also utilized the two sides of it. On average 5-10% of the field was converted into uplands.

The main crops grown on the bund include Ladies’ finger, hybrid tomato, chili, Amaranthus, cucurbits (bottle gourd, ridge gourd, snake gourd and pumpkin), and Dolichos bean. Often, farmers grow two plants of different heights simultaneously to maximize the light, moisture, and nutrients. The cost benefit ratio of turnip cabbage (Kohl Robi), tomato, cabbage, binjal, okra, chili, Indian spinach, bottle gourd, bitter gourd and cucumber were 1.63, 2.49, 2.22, 2.82, 2.45, 2.83, 2.51, 2.62, 2.38, 2.37 respectively.

Gher farming is now the primary livelihood strategy of more than 100,000 rural households in the south-west of Bangladesh. Gher farming has brought about dramatic changes in the society as well as to the institutions that govern the local and the regional economy.

(v) **Summer Tomato Production:** Tomato is one of the most important vegetables in terms of acreage, production, yield, commercial use, and consumption. It is a good source of vitamin C, vitamin A, calcium, iron, etc (Matin et al., 1996). Demand of tomato for both domestic and foreign markets has increased manifold due to its excellent nutritional and processing qualities. Considering the growing demand and importance of tomato, Bangladesh Agricultural Research Institute (BARI) has taken initiative to develop off-season summer and rainy season tomatoes.

So far BARI has developed and released two hybrid tomato varieties i.e. BARI hybrid tomato-3 and BARI hybrid tomato-4 which can be grown during summer and rainy season under poly-tunnel.

Fortunately, the farmers of Bagherpara Upazila of Jashore district started to adopt this technology as pioneer farmers since 2005. The average yield of
BARI hybrid tomato was found 32.78 t/ha. The average return per hectare over variable cost is observed to be Tk 11,44,387 on full cost basis and Tk 12,07,481 on cash cost basis. On average, benefit cost ratio was found to be 4.19 on full cost basis and 5.09 on cash cost basis. The cost per kilogram of hybrid tomato cultivation was Tk 10.94 and return from one kilogram of tomato production is Tk 45.83. The overall socio-economic status of the sample farmers have improved by 20.33%.

(vi) *E-agriculture and Mobile Apps*: Bangladeshis created a large number of mobile applications, web sites, and web pages to help agricultural technologies to reach the farmers easily and solve various problems related to agriculture. As a result of these initiatives, advanced agricultural technology is being expanded rapidly among farmers, saving time, cost, and commute of farmers and agricultural extension service providers to get agricultural services. In order to implement these initiatives, the Access to Information Program (a2i) of the Prime Minister’s Office has provided technical support and the DAE has taken initiative to expand the country’s most effective initiatives.

Farmer’s Window is a picture-based database of crop diseases, pests, insects, and fertilizers. By looking at the picture, the farmer or any user can identify any problem of the crop, and by clicking on the problem in the database can get solutions for that problem. It can easily be used on laptops, desktops, and smart phones. After collecting identities of more than a thousand problems of one hundred and twenty crops from all over the country, the data store has been standardized by the expert committee adding solutions. Through this, the farmer can get the solution of any crop problem from Union Digital Center (UDC), Farmers Information and Advice Center (FIAC) and Agriculture Information and Communication Center (AICC) beside his home. An advanced farmer can also get solution to the problem of crop using mobile phone window. Each month the site averages 3000-3500 visitors. Farmer’s Window received the champion award of World Summit on Information Society (WSIS prize 2016), given by United Nations International Documentary Union (ITU).

Significant other innovation is the ‘digital address of the peasant’, a database of crop information and production technology. This
database has been formulated with the information on crop varieties, production methods, fertilizer and irrigation management, etc. Every month the site receives approximately 4000-4500 visitors.

Pesticide Prescriber has been invented as an ICT-based agricultural service to avoid the overuse of pesticides. This service has also become an essential requirement for agricultural extension workers as they can learn suitable drugs for specific crop species and their application methods. The invention of the pesticide prescriber has been implemented by Upazila Agriculture Office, Srimangal, and Maulvibazar. It can also be found on the website of the Department of Agricultural Extension. This prescriber has been playing an important role in creating public awareness of the harmful effects of pesticides. Approximately 40 people visit this site daily.

(vii) Agriculture Information and Communication Center (AICC): Use of Information and Communication Technologies (ICT) in information dissemination in agriculture sector is increasing in popularity, especially in technology transfer to the farmers as various forms of ICT devices and centers abound in Bangladesh today. The recent innovation of agricultural information delivery has been started by the government with 20 Agricultural Information and Communication Center (AICC) and it has planned to increase the numbers to cover most of the Agro-Ecological Regions of the country. Agricultural Information Service (AIS) has selected 499 clubs based on some criteria among the existing Integrated Pest Management (IPM)/Integrated Crop Management (ICM) clubs and termed the club as AICC. It is equipped with ICT devices like Computer, Printer, Scanner, Webcam, Internet, etc. From this center people are getting direct benefit by getting information through ICT, such as web browsing, Skype consultation, printing documents, etc. Some local entrepreneurship is developing through AICC. As a whole AICC is not only using an information delivery point rather it is being used as the complimentary force of extension services and capacity development of the rural people.

(viii) Farm Machineries: Farmers of Bangladesh have to continually adapt to challenges including climate change effects, such as, rising temperatures and increasing fuel prices to sustain productivity. As a result, many farmers are using innovative agricultural machinery to improve the precision and speed of
planning and harvesting operations while reducing fuel, irrigation water, and labor requirements. With the introduction of cheap, easy-to-operate and easy-to-maintain 2WTs (Two wheel tractors), agriculture in Bangladesh has become highly mechanized during the last decade. Nearly 80% of farmers use 2WTs because they are versatile and can be fitted to a variety of innovative auxiliary equipment for planting, threshing and irrigation.

In recent years the pace of mechanization has accelerated in Bangladesh. Table 3.1 depicts the current status of agricultural mechanization in the country. Bangladesh Rice Research Institute (BRRI) and Bangladesh Agricultural Research Institute (BARI) have developed mechanical devices to cope with the problems of labor force, fuel, and irrigation water. Rice transplanter, combined harvester, weeder, thresher, winnower, drum seeder, potato harvester, corn sheller, and urea granules/urea super granules applicator are some innovations that have been gradually popularized by the farmers.

Government of Bangladesh has been providing financial assistance for purchasing agricultural machineries which is 70% for ‘Haor and the Southern coastal areas and 50% for rest part of the country. So far 26.3 million taka has been provided to expand agricultural mechanization.

Table 3.1 Present Status of Agricultural Mechanization in Bangladesh

<table>
<thead>
<tr>
<th>Name of Machinery</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractor</td>
<td>35000</td>
</tr>
<tr>
<td>Power Tiller</td>
<td>700000</td>
</tr>
<tr>
<td>Pump (DWT)</td>
<td>35322</td>
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<tr>
<td>Pump (STW)</td>
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<tr>
<td>Pump (LLP)</td>
<td>170569</td>
</tr>
<tr>
<td>Rice Transplanter</td>
<td>400</td>
</tr>
<tr>
<td>Name of Machinery</td>
<td>Number</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Reaper</td>
<td>500</td>
</tr>
<tr>
<td>Mini Combine Harvester</td>
<td>200</td>
</tr>
<tr>
<td>Closed Drum Transfer</td>
<td>220000</td>
</tr>
<tr>
<td>Open Drum Transfer</td>
<td>150000</td>
</tr>
<tr>
<td>Corn Sheller</td>
<td>150000</td>
</tr>
<tr>
<td>Sugarcane Crusher</td>
<td>50000</td>
</tr>
<tr>
<td>Winnower</td>
<td>2000</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Mechanization Activity</th>
<th>% Mechanized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivator</td>
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</tr>
<tr>
<td>Irrigation</td>
<td>63.0</td>
</tr>
<tr>
<td>Transplanting</td>
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<tr>
<td>Fertilizer Application</td>
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<tr>
<td>Weeding</td>
<td>65.0</td>
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<tr>
<td>Insecticide Application</td>
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</tr>
<tr>
<td>Harvesting</td>
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<tr>
<td>Threasing</td>
<td>70.0</td>
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<tr>
<td>Winnowing</td>
<td>6.0</td>
</tr>
<tr>
<td>Drying</td>
<td>2.0</td>
</tr>
<tr>
<td>Storing</td>
<td>4.0</td>
</tr>
</tbody>
</table>

(ix) **Vermi-compost:** Soil is a critical element of successful agriculture and is the source of the nutrients to grow crops. Agriculturally dependent Bangladesh needs around 3375 thousand metric tons of fertilizer each year to keep up the backbone of the economy. The average organic matter content of the soil is 1% or below. Initiatives have been taken by the government for preserving soil fertility. Vermi-compost is one of the major initiatives taken by the government. Vermi-compost is an excellent, environment friendly, nutrient-rich organic fertilizer and soil conditioner.
Our goal and objective is to reduce environment pollution (due to chemical fertilizers & waste materials) and at the same time introduce vermin-compost as a supporting tool for land management, while protecting and increasing the fertility of soil, as well as agricultural production to the multiple extents. Its nutritional characteristic is 7-10 times higher than any other compost and it can maintain usual soil temperature. The demand and use of vermi-compost are increasing daily. The number of vermin-compost heap was 35095 in 2015-2016 fiscal year from where total 40008mt vermin-compost was produced.

In a cycle of 35-45 days 320-384 kg of vermi-compost can be produced from each heap. It is reported from the field that farmers around the demonstrations are quickly adopting the vermi-compost production technology.

(x) **Sex Pheromone Trap for Safe Vegetable Production:** Sex-Pheromone Trap is an environmentally friendly and cost-effective method of pest control which uses insects’ own hormones to prevent their spread. Chemical insecticides have more negative effects on human health and environment. Pheromone trap is an alternative method to control insects in the crop field and at the same time protects human health and the environment. This method has created a silent revolution in pest control management in the country. In a sex pheromone trap, a capsule containing the female sex hormones of insects is hung in a plastic bottle which is half-filled with soapy water and has two holes cut in the side to allow the insects to enter. Once the insect enters they cannot escape.

The pheromone traps are proven to be an effective pest control solution for vegetables like pumpkin, okra, cauliflower, cabbage, bottle gourd, ribbed gourd, teal gourd, sponge gourd, snake gourd and beans. In 2015-2016, total 2925 demonstration and 4300 Farmers’ Field school were established under Safe Food production project. In 2016-17, total 1313 demonstrations were
established under National Agricultural Technology Project (NATP) phase II. All the demonstrations performed well, and field observation shows that farmers around the demonstrations are very much interested to adopt the technology.

**(xi) Beekeeping in Bangladesh:** Honey is produced by two ways; one is naturally (i.e. not by culture), and other one is cultured, termed as apiculture. In apiculture, honey bee species, *Apis cerana* and *Apis mellifera* are cultured in a certain type of wooden box. Honey production acts as a source of increasing farmers’ income particularly for the small and medium farmers. Bangladesh government and many NGOs like, Bangladesh Institute of Apiculture (BIA), Bangladesh Small and Cottage Industries Corporation (BSCIC), Proshikhan Shiksha Karmo (PROSHIKA), Mouchas Unnayan Sangstha (MUS) have taken various schemes to provide technological support, such as training, marketing facilities, and supply of necessary equipment for beekeeping to increase the production of honey in the country.

PROSHIKA has innovated and introduced a number of new technologies to modernize apiculture practice in Bangladesh. Apiculture requires investing low capital and little time and promises a high return (Annual progress report PROSHIKA, 2000). Managed beekeeping then spread all over the country with the help of BSCIC, Proshika and Bangladesh Institute of Apiculture (BIA). Currently, about seven beekeeping organizations are involved in practicing apiculture in the country (Table 3.2). In fiscal year (2015-2016) 1, 02,979 honey bee boxes were established and the production was around 1,022 MT.
Table 3.2 Beekeeping Organization present in Bangladesh

<table>
<thead>
<tr>
<th>Name of Organization</th>
<th>Location</th>
<th>Number of members</th>
<th>No. of bee Boxes</th>
<th>Govt. affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh Beekeepers Association</td>
<td>Dhaka</td>
<td>More than 517</td>
<td>More than 50000</td>
<td>Registered</td>
</tr>
<tr>
<td>Beekeepers Welfare Society</td>
<td>Gazipur</td>
<td>517</td>
<td>42911</td>
<td>Registered</td>
</tr>
<tr>
<td>Chattagram Mouchashi Somitee</td>
<td>Mirashwaria, Chattagram</td>
<td>27</td>
<td>2241</td>
<td>Not Registered</td>
</tr>
<tr>
<td>Gazipur Mouchashi Somitee</td>
<td>Gazipur Sadar, Gazipur</td>
<td>48</td>
<td>3984</td>
<td>Not Registered</td>
</tr>
<tr>
<td>Uttorbongo Mouchashi Somitee</td>
<td>Hatikumbar, Sirajong</td>
<td>202</td>
<td>16766</td>
<td>Not Registered</td>
</tr>
<tr>
<td>Sundarban Mouchashi Somitee</td>
<td>Horinagar, Shatkhira</td>
<td>125</td>
<td>10375</td>
<td>Not Registered</td>
</tr>
<tr>
<td>Narail Mouchashi Somitee</td>
<td>Raghunathpur, Narail</td>
<td>115</td>
<td>9545</td>
<td>Not Registered</td>
</tr>
</tbody>
</table>

The benefit cost ratio of beekeeping is around 1.59, which showed that this business is profitable. There is a great potential of this technology to create employment in rural areas to reduce poverty.

(xii) **Integrated Rice-Fish Farming:** Bangladesh people are popularly referred to as "Macche-Bhate Bangali" or "fish and rice makes a Bengali." The demand for rice and fish is constantly rising, with the population increasing by more than three million people each year. However, the land available for rice and fish farming is not expanding. Nevertheless, fish farming in rice fields offers a solution to this problem, contributing to food production and income generation.

The total area of rice fields in Bangladesh is about 10.14 million ha and there are a further 2.83 million ha of seasonal rice fields where water remains for four to six months of the year. These inundated rice fields can play an important role in increasing fish production through integration of aquaculture. Integrated rice-fish production can optimize resources used through the complementary utilization of land and water.
There are two types of rice-fish farming systems depending on the source of fish: culture and capture. In the capture system, wild fish enter the rice fields from adjacent floodplains during the monsoon and reproduce in inundated rice fields. On the other hand, rice fields are deliberately stocked with fish in the culture system. Fish farming in rice fields can be broadly classified as concurrent (integrated) and rotational (alternate). In the concurrent system, rice and fish are grown together, while in the rotational system they are grown alternately. According to the survey, 54% of farmers practiced concurrent rice-fish farming and the rest (46%) cultured rotationally.

In general, the concurrent rice-fish culture system is practiced in plain-lands and medium lowlands, while the rotational system is performed in deeply flooded lowlands. The average farm size is found to be 0.33 ha and 0.29 ha in the concurrent and rotational system, respectively. Many fish species prefer to reproduce in rice fields. Such natural aggregations of fish in rice fields inspire rice-fish farming for increased productivity. Rice-fish interaction can indeed increase the rice yield. It has been reported that the cultivation of fish in rice fields increases rice yields by 8 to 15%.

A wide range of fish species are cultured in rice fields. The selection of species depends on farming systems. Concurrent farmers mainly stock common carp, silver barb, Nile tilapia and silver carp. In rotational culture, the most common fish species are catla, rohu, mrigal, silver carp, grass carp and bighead carp. It is therefore assumed that integrated rice-fish farming can ensure food security for the people of Bangladesh.
Cross Boarder Innovative Agricultural Technologies

Beyond the geographical boarder, some innovations have been introduced in Bangladesh and popularly adopted by the farmers at subsistence and commercial level of farming. For example, Bangladesh and India have a common border. Sometimes Bangladeshi people collect seeds of Indian rice varieties without any formal procedure and vice versa. In this situation, the Indian rice variety is an innovation for Bangladesh agriculture because it did not exist before. Among the cross border innovative technologies, following three can be considered as successful:

(i) **Hybrid rice:** Hybrid rice was developed in China during the year 1964 by Professor Longping Yuan, who is often called “the father of hybrid rice”.

Hybrid rice was introduced in Bangladesh in 1998 by the Ministry of Agriculture. In 1999, four hybrid varieties were cultivated in the country: three of which came from India and one from China. Initially, due to high yield performance, it became very popular. One hundred and eighteen Hybrid rice varieties have been released in Bangladesh by National Seed Board (NSB) from 1997 to October 2014. Out of these 118 varieties, 110 varieties are imported. Only 8 Hybrid rice varieties are developed in Bangladesh, of which four varieties were developed by Bangladesh Rice Research Institute (BRRI), and the other four were developed by Bangladesh Rural Advancement Committee (BRAC). Out of the imported 110 varieties, the source of 93, 16 and 1 rice varieties are China, India and Philippines, respectively. Different companies, Non-Governmental Organizations (NGOs), Farms, Seed industries, and public sector like Bangladesh Agricultural Development Corporation (BADC) are importing the Hybrid rice seeds from abroad commercially.

Initially area under hybrid rice cultivation significantly increased, but later decreased. Currently, only 7.48% of total rice area is under hybrid cultivation in Bangladesh; while in China, by contrast, hybrid rice covers around 57% of the total cultivated rice area. It should be popularized in the country.

(ii) **Amrapali (A mango fruit variety):** Amrapali mango, a hybrid variety of Dasher and Neelum, was introduced in 1971. The variety was developed in India by Dr. PijushKanti Majumdar at the Indian Agriculture Research Institute in Delhi.
In 1998, Bangladesh Rural Advancement Committee (BRAC) started to import *Amrapali* seedlings from India. Since then *Amrapali* seedlings are imported from India and distributed to make this plant available across the country. Recently BRAC has started to produce seedlings from mother plants in its own area offices. At present, BRAC has been producing *Amrapali* hybrid seedlings from the scion of the mother plants grown by BRAC in its own garden.

*Amrapali* have no alternate bearing, accommodate a greater number of plants in a small area, adaptability rate is high, yield and quality is high, size is moderate to small, and % age of sweetness is high. Department of Agricultural Extension (DAE) is playing vital role to disseminate this innovation technology at the farmers’ level. Cultivation of high yielding *Amrapali* is gaining popularity in Bangladesh due to higher economic prospect of the fruit.

(iii) **Dragon fruit:** The origin of *Hylocereusspp.* is the tropical and sub-tropical forest regions of Mexico and Central and South America. From the centre of its origin, dragon fruit spread to tropical and sub-tropical America, Asia, Australia and the Middle East.

In Bangladesh, dragon fruits were introduced by some private entrepreneurs from different countries and some elite farmers started to grow it commercially in different places, like, Ashulia, Dhaka and Halda Valley Tea State, Fatikchari, and Chittagong. Research on it has already been started at Bangladesh Agricultural Research Institute (BARI), Gazipur and the Germplasm Center, Bangladesh Agricultural University (BAU), Mymensingh. Department of Agricultural Extension (DAE) is working hard to disseminate this innovation technology at the farmers’ level. Already mass media (television and newspapers) have drawn public attention of Bangladesh regarding the cultivation of this nutritious fruit.

There are tremendous prospects of growing dragon fruit in different districts of the country as its topography and environment is suitable for the farming. It has started gaining popularity among both farmers and consumers for its high commercial and nutritional values. The number of commercial growers is gradually increasing as they are getting lucrative price of their produce in both local and outside markets.
Research and Development for Innovative Agricultural Technologies

The agricultural research organizations, specifically the National Agricultural Research System (NARS) institutions such as Bangladesh Rice Research Institute (BRRI), Bangladesh Jute Research Institute (BJRI), Bangladesh Sugar Crop Research Institute (BSRI), Bangladesh Livestock Research Institute (BLRI), Bangladesh Fisheries Research Institute (BFRI), Bangladesh Forest Research Institute (BFRI), Bangladesh Tea Research Institute (BTRI), Bangladesh Sericulture Research and Training Institute (BSRTI), Soil Resource Development Institute (SRDI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Agricultural Research Institute (BARI) and Cotton Development Board (CDB), have long been engaged in agricultural research, and have generated a significant number of problem solving technologies which have notably contributed towards elevation of agricultural productivity/farm productivity, and in attaining self sufficiency in food security. Those institutes are engaged with different researchers to innovate technologies on rice, jute, sugar crops, livestock, fisheries, forest, tea, sericulture, soil, crops, cotton respectively. To enhance production, nutrition, employment and foreign earning, it is necessary for crops, livestock, fisheries products, by-products and others related technologies to transfer to farmers. Already some matured technologies from different NARS institutes have been to DAE, Department of Livestock (DLS), Department of Fisheries (DoF) for dissemination, but the adoption rate is low, possibly due to their inadequate knowledge about the technologies and insufficient extension efforts. Some matured or promising important technologies are still not being used in field needs. So, immediate transfer of technology at farmers’ level is needed for farm productivity enhancement.

Agriculture productivity could be increased significantly by transferring technologies rapidly. That is why, after innovation of technology, the researchers should involve themselves directly in transfer activities at selected suitable locations with targeted farmers using appropriate and economic processes. Researchers then can share these farmers' accepted technologies with concerned personnel of DAE, DoF, DLS of same locations for dissemination. So, selected technologies are as follows (Table 3.3):
<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Institutes</th>
<th>Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>WRC</td>
<td>High yielding heat tolerance wheat varieties (BARI Gom 29, BARI Gom 30, BARI Gom 32 and BARI Gom 33) Mango (BARI Aam-2, 3, 4, 8), Banana (BARI Kola-1,3,4,5), Pummelo (BARI Batabilebu-3, 4), Sweet orange (BARI Malta-1), Lemon (BARI Lebu-1,2 and 3), Golden apple (BARI Amra-1/2), Sapota (BARI Safeda-3), Aonla (BARI Amloki-1) and Carambola (BARI Carambola-1), Guava (BARI Peyara-2), Wax jambu (BARI Wax Jambu-1) and Litchi (BARI Litchu- 3, 4), Coconut (BARI Narikel-1, 2). Early T. aman rice (variety: Binadhan-7/ Binadhan-17), - mustard (variety: Binasarisha-4/ Binasarisha-9) - late boro rice (variety: Binadhan-14)</td>
</tr>
<tr>
<td>2.</td>
<td>BARI</td>
<td>Early T. aman rice (variety: Binadhan-7/ Binadhan-17) - lentil (variety: Binamasur-5/Binamasur-6/Binamasur-8/) - late boro rice (variety: Binadhan-14).</td>
</tr>
<tr>
<td>3.</td>
<td>BINA</td>
<td>Early T. aman rice (variety: Binadhan-7/ Binadhan-17) - mustard (variety: Binasarisha-4/ Binasarisha-9) - late boro rice (variety: Binadhan-14)</td>
</tr>
<tr>
<td>3.</td>
<td>BSRI</td>
<td>BSRI Akh 42 and BSRI Akh 45 BSRI Power weeder</td>
</tr>
<tr>
<td>4.</td>
<td>BLRI</td>
<td>Preservation of Green grasses/fodder through Silage Technique</td>
</tr>
<tr>
<td>5.</td>
<td>BFRI</td>
<td>Culture of Pabda (<em>Ompokpabda</em>), Gulsha (<em>Mystuscavasius</em>) with Rui (<em>Labeorhita</em>)</td>
</tr>
<tr>
<td>6.</td>
<td>SRDI</td>
<td>Online Fertilizer Recommendation</td>
</tr>
<tr>
<td>7.</td>
<td>CDB</td>
<td>CB-14</td>
</tr>
<tr>
<td>8.</td>
<td>BJRI</td>
<td>Tossa jute Robi-1/BJRI tossa pat-7 and BJRI Kenaf, HC-95 of jute Bangladesh Rice Knowledge Bank (one line) Rice Knowledge Bank (Mobile Apps)</td>
</tr>
<tr>
<td>9.</td>
<td>BRRI</td>
<td>Use of ICT to give information regarding awareness ant activities to control Neck Blast of Boro rice BRRI hybridedhan 5, BRRI hybridedhan 5, BRRI dhan 87, BRRI dhan 88, and BRRI dhan 89</td>
</tr>
</tbody>
</table>
Popularization and Commercialization of Innovation Technologies

The terms innovation and commercialization are commonly used in a number of overlapping ways to refer to the process of developing new technology and incorporating it into new products, processes, and services. Confusion often results from the close ties between innovation and commercialization and from subtle differences in meaning of each term. Innovation encompasses both the development and application of a new product, process, or service. Commercialization refers to the attempt to profit from innovation through the sale or use of new products, processes, and services. The ability of the nation to sustain economic growth, increase its standard of living, and improve human health and the environment depends, in many ways, on its success in developing and commercializing new products, processes, and services.

(i) Technology: Sweet Gourd Production Using Pitcher Irrigation in Saline Area

Farmer’s name : Jarina Khatun  
Husbands’s name : Md.Jaman Ali  
Village : Shalley  
Upazila : SatkhiraSadar  
District : Satkhira  
SFG’s name : Shalley Maskhola Small Farmer’s Group  
Contact no. : 01709-312174

Jarina Khatun, a female farmer, is a direct victim of negative impact of climate change. She is living in Brammarajpur union of sadar upazila under Satkhira district where salinity is a major problem throughout the area. Jarina Khatun became a member of Shalley Maskhola Small Farmer’s Group (SFG) under Second Crop Diversification Project (SCDP) and after being enrolled she was invited to receive training on production technology of different high value crops and climate change adaptation strategies. After completion of her training she came to understand there are ways to respond to the salinity problem, and she received a demonstration plot regarding climate change adaptation where she learned how to grow crop in saline soil using pitcher irrigation technique. She sown seeds in 05 decimal of land during February 2016 and harvested in June and earned a sum of BDT
10,500. Following the pitcher irrigation techniques, there has been a revolution taking place in her locality. The soil of demonstration plot was analyzed and it was found that with having a conventional irrigation system the salinity of pit vary from 7.5 to 9.0 ds/m, but using pitcher irrigation technique the pit soil salinity remain as low as 5.5 to 6.5 ds/m, and within this range the sweet gourd grows well. Within this range of salinity it is also possible to grow watermelon, bittergourd, bottlegourd, and other crops well. She wishes other farmers in her locality should receive and begin using the same technology for improving their livelihood as well.

(ii) Technology: Vermicompost Production and Promotion

Farmer’s name : Most. Nargis Akter
Husband’s name : Md. Abul Hossain Kha
Village : Shakaridoho
Upazila : Harinakundu
District : Jhinaidah
SFG’s name : Shakaridoho Small Farmer’s Group
Contact no. : 01713-903139

Most. Nargis Akter is a 30 year old female farmer having an education level of class seven with a family size of 03 members. Agriculture is her main occupation and now she is a commercial entrepreneur of vermicompost. She joined as a SCDP’s Shakaridoho Small Farmer’s Group (SFG) member during 2013 and received training on production technology of vermicompost from Upazila Agriculture Office and later she received a demonstration on the same technology. After successful operation of demonstration she became confident and was able to produce 1500 kg vermicompost. She used 500 kg compost in her own crop field and the remaining 1000 kg she sold at BDT 10 per kg and made a profit margin of BDT 10,000. After being successful in her demonstration she was so enthusiastic and she started increasing business by making few chambers, and now has become a role model in her locality. Nargis has changed her living style and now she is better off to some extent, and able to afford the cost of better food and clothing.

(iii) Technology : Good Agriculture Practice in Mango

Farmer’s name : Md. Abdur Rashid
Father’s name : Late Joynul Abedin Molla
Village : Jahaner Para
Upazila : Sonatola
District : Bogura
SFG’s name : Jahan Para Small Farmer’s Group
Contact no. : 01710-789950

Md. Abdur Rashid (55) has an education level of Secondary School Certificate (SSC) and has a family size of 05 members. His main occupation is agriculture. He joined Jahaner Para SFG of SCDP project in August 2013 and received training on production technology of value-added crops, especially fruit. After having training, he received a loan amount of BDT 20,000 from Bangladesh Rural Advancement Committee (BRAC) and started fruit production. He also invested some BDT 40,000 from his own resources for the same purpose. He had 200 decimal of cultivable land and he bought 100 decimal of lands for fruit orchard establishment. He grew banana, papaya, mango, and vegetables, and made a good harvest out of his produce. He earned a total amount of BDT 179,000 by selling mango, papaya and banana, and made a net profit margin of BDT 119,000. Before joining SCDP, his monthly income was only BDT 6500, and now it has been increased to BDT 14,700. With the increase of his income level he has changed his lifestyle and he is now a better off farmer, and his social standing has been increased.

Table 3.4 Existing projects to facilitate Popularization of Innovative Agricultural Technologies

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>Name of Project</th>
<th>Name of Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Farmers Training at Upazila level for Transfer of Technology</td>
<td>Dissemination of innovations</td>
</tr>
<tr>
<td>2</td>
<td>Agricultural Support for Small Holder in South Western Region of Bangladesh</td>
<td>Dissemination of innovations</td>
</tr>
<tr>
<td>2</td>
<td>Enhancement of Crop Production through Farm Mechanization</td>
<td>Popularization of innovative mechanical devices</td>
</tr>
<tr>
<td>5</td>
<td>Safe Crop Production Project through Integrated Pest Management (IPM) Approach</td>
<td>Pest management innovations</td>
</tr>
<tr>
<td>6</td>
<td>Enhancement of crop production through Improved on-Farm Water</td>
<td>Water mgt. innovations</td>
</tr>
</tbody>
</table>

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### Institutional and Policy Arrangement

To generate and implement innovative agricultural technologies, mentionable agricultural policies and strategies have been developed by the Government of Bangladesh.

- The National Agricultural Policy 2018 (NAP)
- The National Seed Policy 2018
- Integrated Minor Irrigation Policy-2017
- The National Organic Agriculture Policy 2016
- The National Agricultural Extension Policy 2015

The above-mentioned policies have been implemented with the support of numerous plans, programs, and development projects under Annual Development Program (ADP). Department of Agricultural Extension (DAE) is implementing the following projects to popularize Innovative Agricultural Technologies.

#### Recommendations for Promoting Innovative Agriculture Technologies

- The Government needs to strengthen national agricultural research systems (NARS) and investments focusing on strengthening research supply by providing infrastructure, capacity, management, and policy support at the national level.
- Create linkages between its components, and the institutions and policies that constitute the enabling environment for innovation.
• Policy makers should identify weak or missing components and linkages within the innovation systems and take measures accordingly of innovations being promoted while extension administrators should building capabilities to facilitate, analyze and promote farmer innovations. Encourage and promote farmers’ and private sector innovation by enacting favorable policies (patenting, reward system), while extension administrators should build capabilities to facilitate, analyze and promote farmer innovations.

• Review agricultural knowledge systems and move away from supply-driven innovation towards a more interactive, demand-driven Agricultural Innovation Systems (AIS) approach, in response to concerns about: lack of adoption of innovation by farmers; the ability of AIS to meet emerging and pressing challenges; budget pressures; and issues related to the acceptance of innovation by consumer and civil society.

• Address the weaknesses of farmers’ knowledge and skills gaps for adopting available innovative technologies and management practices.

Potential Role to be Played by SAARC Agriculture Centre
The SAARC Agriculture Centre is promoting agricultural Research and Development as well as technology dissemination initiatives for sustainable agricultural development and poverty alleviation in the region in the following ways:

• Strengthening agricultural research and accelerate technology transfer through establishing regional networks on agricultural and allied disciplines, particularly among agricultural research and extension institutes, professionals, policy planners and stakeholders.

• Providing inputs for developing regional policies, strategies, projects, primarily through developing networks in crop, livestock and fisheries sectors; and for efficient management of soil, water and other natural resources.

• Supporting new and innovative techniques and systems in agriculture, including production, post-harvest and food processing.

• Assisting collaborative studies, inter alia, on agricultural marketing and distribution systems, harmonization of agricultural
related standards, promotion of agricultural trade, food security, risks and disaster management in agriculture.

- Helping and undertaking collaborative capacity building programs in agriculture and allied sectors with focus on skill development and research on frontier areas.
- Assembling and propagating information for agricultural advancement in the region.

**Consideration in Establishing SAARC Innovation Platform**

SAARC innovation platform (SIP) is a forum established to foster interaction among a group of relevant stakeholders around shared interest. The innovation platform uses participatory approaches in diagnosing problems, exploring joint opportunities, and investigating solutions. Innovation platform (IP) has to be established at different levels of management and governance. There are two main levels for establishment of IPs: strategic and operational levels. Regardless of the level of IP, the following items can be included for establishing a functional SAARC innovation platform.

- Vision, mission, goal and objectives;
- Policy commitment among the government;
- National agricultural innovation platform among multi-stakeholders;
- Common interest area;
- Respective division such as planning and policy division, technical division, administrative and human resource division, and monitoring and evaluation division;
- The terms of references (TORs) should be clearly defined;
- Proper and sustainable communication system; and
- Monitoring after every 6 months in SAARC countries according to alphabetical order.

**Conclusion**

Agriculture sector is very complex with various components and sub components. It has social, political, economic, and technological dimensions. In recent years it has become even more complex due to globalization and the impact of climate change. Natural resources like cultivable land, water and energy are shrinking, and demand for
food, fiber, meat, and milk is increasing. Many countries are struggling with the idea of developing a location specific technology package by multidisciplinary team of agricultural scientist with little or no success. Out of the box and new innovative technology is needed to meet the challenge. Therefore, Bangladesh agriculture is searching the innovative pathways to overcome the challenges nationally, regionally and internationally.

References
Chapter 4

Innovative Agricultural Technologies in Bhutan

Ngawang Ngawang
Agriculture Research and Development Center, Department of Agriculture, Ministry of Agriculture and Forests, Samtenling, Sarpang, Bhutan
ngawang@moaf.gov.bt

Introduction
Bhutan has an area of 38,394 square kilometers (Gilani H, 2015) and is a land locked mountainous country located between China and India. It is administratively divided into 20 districts. The elevation ranges from 200 to > 7,000 meters above mean sea level. About 95% of the country’s area is mountainous terrain. There are three broad physiographic zones: (i) the southern belt consisting of the Himalayan foothills adjacent to a narrow belt of flatland along the Indian border with altitude ranging from under 200-2000 m; (ii) the inner Himalayas made up of the main river valleys and steep mountains with Figure 4.1 Map showing geographical location altitude ranging from about 2000-4000 m; and (iii) the great Himalayas in the north along the Tibetan border consisting of snow-capped peaks and alpine meadows above 4000 m.

Figure 4.1 Map showing geographical location

Climate and agro-ecological zones According to UNEP (2009), Bhutan is broadly divided into three geographic areas and corresponding climatic zones; the southern foothills, inner Himalayas and higher Himalayas. The southern foothills, only 20 km wide, rise from 100 to 1,500 masl. The climate is hot and humid in the southern foothills, with temperatures ranging from 15 to 30°C throughout the year and precipitation between 2500-5550 mm. The inner Himalayas, which
rise to 3000 m constitute with their broad valleys, the economic and cultural heartland of the Kingdom. The central inner Himalayas are characterized by a cool temperate climate with an annual average precipitation of 1000 mm. The higher Himalayas constitute the northernmost and highest mountain ranges with elevations up to 7550 m. These northern regions, under perpetual snow, are sparsely populated and has an alpine climate with average annual precipitation of 400 mm. Bhutan has six distinct agro-ecological zones and the climate is dominated by the monsoon, with a dry winter and high precipitation during June-September. The wide climatic condition is influenced by topography, elevation and rainfall patterns (Table 4.1).

Table 4.1 Major agro-ecological zones in Bhutan

<table>
<thead>
<tr>
<th>Agro-Ecological Zone</th>
<th>Altitude (Meters)</th>
<th>Temperature (°C)</th>
<th>Rainfall (mm/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Monthly Max</td>
<td>Monthly mean</td>
</tr>
<tr>
<td>Alpine</td>
<td>3,600-4,600</td>
<td>12.0</td>
<td>-0.9</td>
</tr>
<tr>
<td>Cool Temperate</td>
<td>2,600-3,600</td>
<td>22.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Warm temperate</td>
<td>1800-2600</td>
<td>26.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Dry Sub-Tropical</td>
<td>1200-1800</td>
<td>28.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Humid Sub-Tropical</td>
<td>600-1200</td>
<td>33.0</td>
<td>4.6</td>
</tr>
<tr>
<td>Wet-Subtropical</td>
<td>150-600</td>
<td>34.6</td>
<td>11.6</td>
</tr>
</tbody>
</table>


Because of the diverse altitude (ranges from <650 to >5,500 meters above sea level, rainfall patterns and agro-zones, land use and agricultural enterprises are greatly influenced where in the higher altitudes; farming is dependent on livestock, temperate fruit crops and crops such as potato, mustard, buckwheat, wheat and barley. Further south, towards the sub-tropical areas, rice and maize dominate the farming system. Cash crops such as cardamom and citrus also find an important niche with livestock as an integral component in the overall farming system.
The alpine zone which covers the northern region is characterized by alpine meadows and is too high to grow any food crops. In the cool temperate zone, rearing livestock, mainly Yaks, is the most common way of living with some dry land farming. The main crops grown comprise wheat, potato, buckwheat, mustard and barley. The warm temperate zone has moderately warm temperature except during winter when frost occurs and agriculture is widely practiced in terraced irrigated wetlands and dry lands. In the wetland agricultural areas, rice is the main crop which is rotated with wheat, potato, seasonal fodder and several kinds of vegetables.

**Agricultural land**

The cultivated agricultural land constitutes only 2.93% (112,556.21 ha) and the forest coverage with 70.46% of the total land area accounts for its rich biodiversity with high level of species, genetic and ecosystem diversity (LCAR, 2010). In Bhutan, the natural land cover of forest, shrubs, snow cover and meadows dominate Bhutan’s landscape, while bare areas, cultivated agricultural land, water bodies, built up areas, degraded areas, marshy areas and non-built up areas take up only small areas. The snow cover constitutes 7.44% while bare areas comprise of 3.20%. Degraded areas, water bodies, built areas, marshy areas and non-built areas constitute less than 1% each.

Agriculture continues to dominate the country’s economic activities and gives employment for almost 62.2% of the population out of 727,145 (PHCB, 2017). Cereals are an important component of Bhutanese diet where rice and maize are the major crops cultivated in Bhutan. Other cultivated crops include wheat, barley, buckwheat, millets, oil seeds, legumes, potato, vegetables, apple, mandarin, cardamom and ginger. In 2016, agriculture sector accounted for about 16.52% of the total GDP of the country (National Statistics Bureau, 2017).

Figure 4.2 shows that within the 2.93% of cultivated agriculture land, dry land dominates with 61.90% followed by wetland with 27.86%.

The horticulture land constitutes of 10.24% i.e. Apple orchard (1.81%), Citrus orchard (4.52%), Areca nut plantation (0.88%), Cardamom Plantation (3.02%) and others (0.01%).

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Historical perspective of agriculture

In bits and pieces, agriculture farming prevailed with the advent of Bhutanese civilization. Until the time Bhutan remained isolated from rest of the world, agriculture farming happened exclusively in a traditional way without the use of machine or technology interventions (Figure 4.3). It was only after 1961, the year of Bhutan’s first Five Year Plan (FYP) began that efforts towards agricultural modernization was initiated (Kobayashi, M. et al, 2015). With the FYPs in place, agriculture continued to grow in terms of area and crop productivity primarily from the foremost technological interventions like introduction of High Yielding Varieties (HYV) from overseas and recruitment of overseas expertise.

With 12th FYP going on steadily in Bhutan, the policy goal of “Food Self-Sufficiency” is still being pursued. The limited available land aggravated by aging population amid ever increasing fallow land is a serious challenge posed today not only in Bhutan but also in South Asia. The roles played by both the agriculturists and the farmers to
these confronting challenges are further challenged by increased cost of productions primarily resulting from the ever-growing competitive industrialists in and around the world. However, in our own way and realizing the multiple benefits from multiple cropping, Bhutanese farmers have ventured into practicing multiple cropping systems with different combination of crops to maximize the full utilization of the land and to meet the feed requirement of livestock. The types of multiple practices are mainly determined by the environment at large, agro-ecology, types of crops, needs of the farmers, and the degree of risk of crop predation by wild animals, market demand and availability of farm labor (Katwal, 2016). The need for more imported ideas and technology, exchange of technical expertise and free flow of knowledge among regional and international food growers to ultimately keep on enhancing agriculture productivity and production are the key agenda for all.

One of the backbones to Bhutan’s economic development is agriculture and “Food Self-Sufficiency” remains to be the main policy of Gross National Happiness (GNH). As stated by Trashi D (2018), Bhutanese farmers have traditionally practiced integrated subsistence farming, producing crops and livestock and utilizing forest products. He had identified five key components like urbanization, farm mechanization, community institutions, high-value products and youth aspirations for agriculture transformation. This however entails creation of conducive environment for agribusiness in Bhutan by all the government service providers including the Non-Governmental Organizations (NGOs). For this transformation to happen, research centers and the allied institutions have a major role to play in innovating, generating, disseminating and making available the technologies that are user-friendly and cheaper.

On the other hand, as recommended by Lincoln J Young (1991), a more holistic approach and establishment of a system of environmental monitoring is needed as Bhutanese traditional sustainable agricultural systems are being influenced and Bhutan’s social and physical environment is changing concerning the displacement of hardy and resistant native varieties by HYVs of cereals. The reality we witness today is the world has become much smaller, shorter and thinner due to digitalization of all the technologies most of which are robotic in nature. On the contrary, the demand for safe, nutritious and healthy foods are becoming bigger, taller and fatter because of climatic vagaries, youths not taking over
the farming activities from the aging population and the countries all over the world focusing much on the overall GDP performances under the duress of competition attitude.

The available technologies starting from HYVs/Hybrids to automated farm mechanization when made available both through government and privatization come with huge cost which the small and marginal farmers cannot afford all the time thereby somehow resorting either to their traditional practices or improvised systems to a lesser extent.

**Agriculture development challenges**

Shortage of farm labour in the rural areas mainly due to out-migration to urban areas, coupled by production challenges and competition from growing imports of cheaper food items has adversely impacted domestic food production. Labour shortage is the top most constraints spelt by 53% of the total households in 2017 (MoAF, 2017).

*Wild Life predation on crops and livestock:* Bhutan’s policy of environment conservation and maintaining more than 70% forest cover including strong emphasis on wildlife protection has led to huge pressure from the wildlife on crops thereby resulting into substantial crop losses. Farmers have to sacrifice huge labour inputs for guarding of crops. On an average, a farmer spends about 67 days and nights guarding the crop (MoAF, 2017). Abandoning of agricultural land due to pressure from wildlife predation has increased migration rural communities to urban areas.

*Low productivity:* Use of moderate level of inputs for sustainable and stable yields.

Irrigation infrastructure, the vital input to agriculture development is challenged due to mountain terrain conditions. Shortage of irrigation water for rice and other crops has directly affected crop production. Assured irrigation covers only about 30% of the cultivated area. Fallowed lands due to water shortages and wild life crop damage are a common sight in many areas. For instance, a total of 46,704 acres of land were estimated to have left fallow in 2017 (MoAF, 2017).

Impacts of climate change pose a very big challenge to Bhutan’s mountain agriculture farming and a young research system. The loss of crops to unusual outbreaks of pest and diseases, erratic rainfalls, windstorms, droughts and flash floods/landslides are increasing every year. When land holding is small and crop yields are low, these
seasonal damages on livelihood properties have significant impact on the local food security and wellbeing.

**Topography:** Because of the rugged terrain and remoteness of production areas, marketing costs of agriculture products are high and represent a significant barrier to product competitiveness. Production areas are scattered and isolated; access by motorable road is limited. Production is still at subsistence level and getting marketable volumes is difficult. Cost of production is exorbitantly high as a result of remoteness and high labour cost.

**Agriculture development Opportunities for Bhutan**

High degree of variation of agro-ecological conditions with altitudes from 160 m to over 3500 m offers both opportunities and challenges. Opportunities include diverse agro-ecologies to grow range of cereals and horticultural crops. The country also possesses rich agro-biodiversity of crops and varieties. The main challenges are to develop suitable crop varieties and associated production technologies for the highly diverse micro-environments created due to elevation, topography, temperature differences and aspects. It is a major challenge for the small and nascent research and development system.

Highly favorable conditions for going organic (organic by default) - Long history of traditional farming practices, low use of external inputs including agro-chemicals, and a diverse agro-ecological environment are the major strengths for Bhutan to go for 100% organic farming. Bhutan is pursuing to promote organic farming on a high priority.

There is good opportunity to grow and market off-season crops particularly fruits and vegetables in the hills and mountains during hot summer seasons in the neighboring countries.

**Innovative Agricultural Technologies**

The development and advancement of agriculture in Bhutan picked up in a more or less systematic way with the beginning of the Five-Year Plan (FYP) in 1961. Based on the need to boost food production to meet the food requirement of the increasing population, research stations and demonstration blocks were established as Center for Agriculture Research and Development (CARD) at Bajo in Wangdue Phodrang district such of which was manned by the expertise from
India and Japan. The first ever agriculture technologies that got popularized were the formal or informal introduction of different types of seeds and seedlings from overseas that best fitted to the climatic condition of Bhutan. The technology dissemination and work on aggressive varietal evaluation advanced further by introducing more improved crop varieties. Through a series of research screening processes, many improved or high yielding varieties got popularized in Bhutan and are still being continued through a network of institutional linkages at regional and international levels.

There are as many as 43 improved field crop varieties (Table 4.2), 89 fruit plants (Table 4.3) and 84 vegetable seeds (Table 4.4) released in Bhutan in a span of about 30 years of agriculture research and development works from 1988-2017 (DoA, 2018). About 37 numbers are de-notified being obsolete. This offers a comprehensive basket of technological choices to our food growers today. More of the crops varieties of elite traits are being tested in the research and development centers across the country to meet the food demands both for domestic consumption and export. The varieties encompass entire cultivation domain ranging from high, mid to low altitudinal agro-eco zones in Bhutan.

Table 4.2 Number of improved field crops in Bhutan (1988-2017)

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Name of crops</th>
<th>Total varieties released</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rice</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>Maize</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Wheat</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Finger millet</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Mung bean</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Mustard</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Soybean</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>43</strong></td>
</tr>
</tbody>
</table>
Table 4.3 Number of improved fruit plants in Bhutan (1988-2017)

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Name of crops</th>
<th>Total varieties released</th>
<th>Sl.</th>
<th>Name of crops</th>
<th>Total varieties released</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Arecanut</td>
<td>1</td>
<td>15</td>
<td>Litchi</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Almond</td>
<td>4</td>
<td>16</td>
<td>Mandarin/Orange</td>
<td>10 (5 root stocks)</td>
</tr>
<tr>
<td>3</td>
<td>Apple</td>
<td>14 (3 root stocks)</td>
<td>17</td>
<td>Mango</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Apricot</td>
<td>3</td>
<td>18</td>
<td>Musk melon</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Avocado</td>
<td>2</td>
<td>19</td>
<td>Passion fruit</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Banana</td>
<td>3</td>
<td>20</td>
<td>Peach</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Cardamom</td>
<td>2</td>
<td>21</td>
<td>Pear</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Cherry</td>
<td>4</td>
<td>22</td>
<td>Persimmon</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>Dragon fruit</td>
<td>1</td>
<td>23</td>
<td>Plum</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Gooseberry</td>
<td>1</td>
<td>24</td>
<td>Pomegranate</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>Grapes</td>
<td>2</td>
<td>25</td>
<td>Strawberry</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>Guava</td>
<td>2</td>
<td>26</td>
<td>Walnut</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>Kiwi</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Lime</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>89</strong></td>
</tr>
</tbody>
</table>

Table 4.4 Number of improved vegetables in Bhutan (1988-2017)

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Name of crops</th>
<th>Total varieties released</th>
<th>Sl.</th>
<th>Name of crops</th>
<th>Total varieties released</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Asparagus</td>
<td>2</td>
<td>16</td>
<td>Cucumber</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Beans</td>
<td>9</td>
<td>17</td>
<td>Garlic</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Beetroot</td>
<td>1</td>
<td>18</td>
<td>Japanese green</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Bottle gourd</td>
<td>1</td>
<td>19</td>
<td>Ladies finger</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Brinjal (Eggplant)</td>
<td>3</td>
<td>20</td>
<td>Lettuce</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Broccoli</td>
<td>1</td>
<td>21</td>
<td>Mustard green</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Bulb onion</td>
<td>4</td>
<td>22</td>
<td>Parsley</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Bunching onion</td>
<td>2</td>
<td>23</td>
<td>Pea</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Cabbage</td>
<td>7</td>
<td>24</td>
<td>Potato</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Capsicum</td>
<td>1</td>
<td>25</td>
<td>Pumpkin</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>Chili</td>
<td>3</td>
<td>26</td>
<td>Radish</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>Carrot</td>
<td>5</td>
<td>27</td>
<td>Spinach</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>Cauliflower</td>
<td>4</td>
<td>28</td>
<td>Summer squash</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>Celery</td>
<td>1</td>
<td>29</td>
<td>Tomato</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td>Chinese cabbage</td>
<td>1</td>
<td>30</td>
<td>Turnip</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>84</strong></td>
</tr>
</tbody>
</table>
As agriculture development advanced further, government’s intervention did not limit only to HYV technology. The other technologies introduced, experimented over a period of time and made available to the food growers are farm machines and hand tools, sustainable land management tools, biogas, drip irrigation, use of poly houses for protected agriculture farming, water harvesting structures, going organic way and use of effective micro-organism, use of plastic mulches, electric and solar fencing, and multi-tier cropping. This time tested innovative technologies mostly were borrowed from other countries especially from India, experimented and are currently in operation in the farmers’ field. These popular technologies are briefly explained in Table 4.5 below.

Table 4.5 Popular innovative agriculture technologies in operation in Bhutan

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Innovative technologies</th>
<th>Purposes</th>
<th>Benefits to farming communities</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Farm mechanization (1983)</td>
<td>Drudgery reduction</td>
<td>Lessen labor shortage problems amid aging population, attraction of youth in farming</td>
<td>Throughout the country</td>
</tr>
<tr>
<td>2</td>
<td>Electric &amp; Solar fencing (2006)</td>
<td>Mitigation for Human-Wildlife conflict</td>
<td>Protection from crop depredation by wild life, lessen time spent in crop guarding, fallow land reduction</td>
<td>Installed 2,773 Km (as on May 2016) benefitting 15,041 households, covering 11,765 acres wetland and 19,899 acres dry land</td>
</tr>
<tr>
<td>3</td>
<td>Sustainable land management techniques</td>
<td>Land degradation</td>
<td>Conservation of top soil from erosion</td>
<td>Throughout the country especially in the sloppy areas</td>
</tr>
<tr>
<td>4</td>
<td>Organic agriculture &amp; use of EM</td>
<td>“Becoming a country with environmentally clean food production systems” and going organic</td>
<td>Healthy food and healthy living, opportunities for export of farm produces</td>
<td>Vegetable growers, livestock farmers</td>
</tr>
<tr>
<td>5</td>
<td>Biogas and bio-slurry (2011)</td>
<td>Cooking, reduce dependency on LPG and kerosene</td>
<td>Reduce health hazards, Forest conservation</td>
<td>Benefiting &gt; 15,000 people directly. Produces around 5000 cubic meter of biogas per day &amp; equivalent to about 60,000 LPG cylinders/yr amounting</td>
</tr>
<tr>
<td>Sl.</td>
<td>Innovative technologies</td>
<td>Purposes</td>
<td>Benefits to farming communities</td>
<td>Coverage</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>----------</td>
<td>---------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>6</td>
<td>Drip irrigation systems</td>
<td>Crop production especially vegetables</td>
<td>Less irrigation water requirement amid the drying up of water sources</td>
<td>Gaining popularity to Nu 31.4 million/yr (USD500,000/year). Firewood use reduced by about 10,000 tons per year</td>
</tr>
<tr>
<td>7</td>
<td>Use of plastic mulches and poly houses (2017)</td>
<td>Vegetable cultivation and mulching of fruit trees</td>
<td>Less labor and less irrigation with high production</td>
<td>Gaining popularity</td>
</tr>
<tr>
<td>8</td>
<td>Poly houses</td>
<td>Vegetable cultivation in higher altitude areas</td>
<td>Off-season vegetable production</td>
<td>Gaining popularity</td>
</tr>
<tr>
<td>9</td>
<td>High density multi-tier cropping (Mix)</td>
<td>More crop in a piece of land</td>
<td>Less risk from mono-cropping, more income per unit area</td>
<td>Gaining popularity</td>
</tr>
<tr>
<td>10</td>
<td>Crop propagation techniques (grafting/top working)</td>
<td>Crop improvement</td>
<td>Quality fruits</td>
<td>Throughout the country</td>
</tr>
</tbody>
</table>

**Cross border agricultural technology transfer**

Cross-border technology transfer is critical for the countries in the South Asian region to achieve SDGs and SAARC Development Goals which require greater regional cooperation in the promotion of climate-resilient and productivity enhancing technologies among the countries to which the SAC regional forum can play the major role in facilitating exchange and transfer of technologies at ease and hastened means. In the case of Bhutan, India being the nearest bordering neighbor, access to all types of their technologies is not a hindrance if appropriate mutually agreed conditions and standard norms are followed. Until today, Bhutan had been relying on their technologies and will continue to do so as the developing research centers are incapacitated in terms of capacity, advanced facilities, funds and human resources. Besides India, Bangladesh and Nepal have a share of their credit in sharing their technologies like BARI lines of mangoes and rice from the former and improved fruits like Kiwi and
vegetables from the latter. Some of the successful technologies that have been shared and that are being adopted in Bhutan are:

- Crop germplasms (cereals, vegetables and fruit plants) from India, Bangladesh, Nepal, Thailand and Japan
- Fruit crop propagation techniques from India and Japan
- Improved crop varieties from India, Nepal, Thailand and Bangladesh
- Farm machines like power tillers, mini-tractors from Japan and farm tractors, mini-tillers and hand tools from India
- Drip irrigation gadgets from India
- Poly houses and plastic mulches from India for protected agriculture
- Different types post-harvest machines like mills, shellers, dryers, dehuskers, harvesters and reapers from India and Japan
- Different types of spray machines, pumps and water storage tanks from India
- Plant protection chemical and fertilizer from India

**Research and Development for Innovative Agricultural Technology**

Formal research in the agriculture sector started with the establishment of the regional research centers in the 1980s. As pointed out by Ghimiray et al, 2013, the country has a relatively short history of institutionalised research program and research systems remains small. The overall investment in research both in terms of manpower and funds also remains small and largely inadequate to meet the aspirations of the government in enhancing food production and food self-sufficiency in the country.

These centers are located in strategic agro-ecological zones to serve local research needs. Given the infrastructure and available human resource, the emphasis of agriculture research is on adaptive research. Thus, focus of research has been primarily adapting finished or semi-finished technologies such as the on screening and selection of high yielding varieties and improved animal breeds. The agriculture research programs are implemented through the four research centers. Currently, there are four Agriculture Research and Development Centers (ARDCs) spread all across the country.
mandated to take up various research and development works primarily founded on the problems faced by the farmers. Bhutan’s very recent history in agriculture research and its rapidly evolving system is required to carry out a well-defined strategic role of agriculture research and development in the face of many emerging challenges and opportunities.

The research in Bhutan encompasses four generally accepted categories of scientific research: basic, adaptive, applied and policy research. Basic research activities are conducted in scientific laboratories of the Department of Agriculture, Livestock, Forestry and other central agencies like National Bio-diversity Center (NBC), National Soil Service Center (NSSC), National Plant Protection Center (NPPC). In Bhutan, research in agriculture focuses on conducting adaptive research while forestry and livestock research is applied and adaptive-oriented (DoA, 2011) through which the research is designed to introduce available technologies from an external environment and to test and adapt them to suit local environmental conditions. Until today research-led agricultural development has played a major role in contributing significantly to the poverty reduction and greatly helped the farmers to improve crop production for food security and income generation through modernization of farming. However, the agriculture development needs to be increasingly knowledge-based and science-intensive in this time when the world is confronted with global climate change amid the growing human and livestock population. The country is only about 50% self-sufficient in rice which is the main staple diet of the Bhutanese.

The roles played by the research centers are focused more on developing new varieties through adaptive trials, innovating new technologies like smart and automated irrigation systems and development of high density multiple cropping systems. The proven agricultural technologies are made available to the end users mostly by the National Seed Center (NSC) for different seeds and seedlings released by the research centers. The NSC operate seeds and seedlings distribution through a networks of their agents called as Agriculture Sales and Service Representatives (ASSRs) spread all across the country. There are also few private nursery operators who sell different selected seeds and seedlings to the farmers through certification system.
Popularization and commercialization of Innovative technologies

The MoAF in Bhutan is continually making strides to popularize and commercialize agriculture farming to meet the food demands not only for the domestic requirement but also for export. The ministry discharges its responsibilities of delivering and continually improving various agricultural technologies and their recommended applications and production methods by coordinating its research activities through various work processes and coordination offices, with the ultimate goal of ensuring food security and reducing poverty in the country in line with the Government’s development direction. Primarily, agricultural technologies are originated from the research centers through a series of adaptive experiments and their dissemination and transfer is done to the extension wings located in the districts while technology materials like new seeds and seedlings are disseminated to the farmers from the NSC through multiplication. It is by the researchers and the extension that the technologies are popularized through repeated on-farm trials and demonstrations involving the farmers. This has helped to strengthen the work of agro-technical popularization and application of results of agricultural scientific research and practical techniques to agricultural production thereby safeguarding the development of agriculture and realizing the modernization of agriculture. The research centers have been conducting various significant research activities and development-oriented tasks through in close collaboration with the regional and international agricultural research institutions and other relevant partners. The research has also engaged itself in the coordination of agricultural research activities throughout the country by technology pre-multiplication, pre-extension scaling out, capacity building, and provision of supports to those in need. Some of the technologies popularized and widely made available to the end users are as follows;

Rice is one of the globally important crop adopted in Bhutanese agricultural system and its adoption is immense. Rice being the most important food crop have been adopted by almost all the rice growing farmers in Bhutan. Rain-fed rice varieties like Bhur Kamjha-I (APO breeding line) having ideal yield potential of 1-3 t/Ac is popularized as it performs well in upland condition. There is an increase of about 4% paddy production of 3,053 MT in 2017 as compared to the 2016 which had the total production of 80,261 MT (MoAF, 2017). In case of
maize varieties like Yangtsepa (Suwon 1 breeding line) and Bhur Ashom 1 (Arun 4 breeding line) are popularly grown twice in mid-altitude areas and three times in foothills areas. The increase in maize production from 83,714 MT in 2016 to 94,052 MT in 2017 is about 15% (MoAF, 2017).

Thus far, the national fruit research program so far has focused on adaptation of best cultivars introduced from India, Thailand and Bangladesh countries. The important fruit crops like Mango (varieties from Thailand and Bangladesh) are popularized because of their non-alternate bearing in nature, taste and size of the fruits. These Thai and BARI lines of mango fruits are already in the farmers’ field and their choice to these varieties are immense.

Among the vegetables, Japan originated white pole beans, white dwarf beans and tomatoes are widely preferred by the farmers because of high production and good taste.

Potato varieties like Desiree (CIP 800048) and Yusi Maap (CIP 392797.22) and NaseypheyKewa Kaap (CIP 393077.159) are widely grown in all potato growing areas as potato is the main cash crop exported to India and Bangladesh.

Besides the crops, the other agricultural technologies gaining popularity are use of poly-houses and plastic mulches for protected agriculture in the mountain areas.

Use of power tillers, mini-power tillers, reapers, bed making machines, farm tractors and various spray machines are being widely used by the farmers as farm labor saving machines. There are as many as 3,655 numbers of different types of farm machines distributed by Agriculture Machinery Center (AMC) as on 2016 (Table 4.6).
Table 4.6 No. of different farm machines distributed by Agriculture Machinery Center from 2011-2016

<table>
<thead>
<tr>
<th>Sl</th>
<th>Machines</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Power tiller</td>
<td>76</td>
<td>23</td>
<td>164</td>
<td>85</td>
<td>70</td>
<td>349</td>
<td>767</td>
</tr>
<tr>
<td>2</td>
<td>Tractor</td>
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<td>27</td>
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<td>3</td>
<td>Combined harvesters</td>
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<td>-</td>
<td>6</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Power reaper</td>
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<td>-</td>
<td>6</td>
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<td>5</td>
<td>Rice transplanter</td>
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<td>Oil mill machine</td>
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<td>750</td>
<td>451</td>
<td>729</td>
<td>571</td>
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Source: AMC, MoAF

On the commercialization front, not much is advanced in Bhutan. However, in order to ensure sustainable socio-economic wellbeing of the Bhutanese people through access to food and natural resources, the Ministry of Agriculture and Forests (MoAF) has set policy goals and objectives of enhancement of food and nutrition security. Commercialization of agriculture is one of the key targets to achieve food security, and therefore, the ministry has started to commercialize rice, maize and vegetable since 2011. Over a time, it has been realized that commercialization of agriculture by the recourse poor farmers alone is adequate to meet the domestic food requirement. To hasten food production, the ministry has initiated the private sector participation in commercializing, like plantation of coffee and Mountain Hazelnut in some of the suitable places. Improving maize production through supply of improved hybrid seeds to meet the demands of the farmers for local feed industries has been initiated. For the commercialization of vegetables, since 2012, the government has provided 1,177 numbers of green houses, water saving irrigation systems, like sprinklers, drip irrigation hose pipes, besides seeds and training to farmers. In doing so, the production has increased from 35,000 metric ton (MT) in 2012 to 59,000 MT in 2014 and vegetables export increased from 973 MT in 2011 to 4,676 MT in 2015, which saw an increase in income from vegetable export of Nu 16 million in 2011.
to Nu 120 million in 2015. To move forward the commercialization, government has incorporated State Owned Enterprises (SOEs) like Farm Machinery Corporation Limited (FMCL), Bhutan Livestock Development Corporation Limited (BLDCL) and Green Bhutan Corporation Limited (GBCL) very recently.

The FMCL is mandated to provide farm mechanization goods and services to the Bhutanese farming community at an affordable price. Specifically the FMCL carries out the activities like hiring of farm machinery, sale of spare part, repair and maintenance of machines, machinery fabrication and implementation of contract farming. The BLDCL takes up the services in production and supply of quality livestock inputs especially those which are imported and help produce products that are not produced enough by the Department of Livestock (DoL). It also helps DoL to export livestock products and other value added items such as sausages, ham and bacon. As such, BLDCL attempts to produce livestock inputs enough for domestic consumption as well as strive to export them while also enhancing the contract farming system. The GBCL works with its core mandate of re-afforestation and afforestation, landscape development and greening, planting medicinal plants and ornamental plants, floriculture, providing awareness on environmental policies and programs. The corporation will take lead role in afforestation and watershed development programs in the country.

**Recommendations for promoting agricultural technologies**

Agriculture development has to take place under the emerging challenges of depleting natural resource base, increasing scarcity of water, declining soil fertility status and growing rate of land degradation, increasing cost of inputs, scarcity of farm labor, and unpredictable weather pattern and severe extreme weather events.

**Addressing Challenges of the Agriculture Research System**

Mountain environment, with wide variations of agro-climatic conditions of the hills and valleys, requires identification of location specific technologies to suit a very diverse agro-climatic mountain farming situation.

The mountain farming system has unique environment and production challenges where technologies requirements differ from those of the vast topical lowland conditions. Much of the green
revolution technologies therefore cannot be adopted for mountain system especially the farm mechanization and irrigation technologies including crop varieties. Also, technology adaptation has to depend on technologies from outside of the country. What is available outside does not always work in our situation.

We have a young research system that lacks human resource and capacity. Currently, the research system implement a multi-tasked research and development mandates in which case maintaining a proper balance between research and the development mandate is a big challenge for young research system.

Lack of investments in research for technology generation, adaptation and innovation through research is inconsistently donor dependent. Research as a priority investment gets less attention and the current budget allocation is less than 2% of total is agriculture not even enough to cover the operational costs.

There have been inadequate collaboration and linkages with the CGIAR system. In fact there has been a decline in the collaborative activities with the international and regional centers of Excellence - very important for small country like Bhutan to access information, knowledge, research materials, and new innovations.

Lack of sustained funding and commitment of the Government.

**Fixing Agriculture Research Priorities**

For the 12th FYP (2018-2023), agriculture research has been identified as one of the key programs under the Ministry of Agriculture and Forests. The main objectives of research are as follows:

- A prioritized program of high quality and relevant research need to be undertaken for Bhutan’s agriculture sector.

- Generate and disseminate suitable technologies on Field Crop Research and Horticulture Crops Research – to support crop production of priority commodities for food self-sufficiency and rural income generation.

- Identify and recommend best crop varieties and management practices for enhancing production and commercialization of the different commodities.

- Research on emerging issues- Climate change - to adapt and promote farming practices that are more resilient to climate change
• Important areas include irrigation and water use efficiency, farm mechanization, land development and management, and organic agriculture.

• Wide range of methods for control of pests, diseases and weeds avoiding the use of synthetic chemicals. Sourcing and development of inputs for organic farming and efforts put into finding alternatives and solutions to conventional plant protection and soil fertility management practices.

• Reduce post-harvest losses - Post harvest losses of crops mainly relate to crude harvesting techniques, shattering, poor storage and cooling facilities in difficult climatic conditions, infrastructure, packaging and marketing systems. The post-harvest for cereals is over 20%.

• Marketing and Value Chain studies-The market values chain studies to help in optimizing the entire commodity production chain from primary production systems, through post-harvesting, storage and preservation, transport and marketing to value addition.

Institutional and policy arrangements in technology generation

The overarching Bhutanese development philosophy of Gross National Happiness (GNH) enshrines environmental sustainability as one of the four main pillars for pursuing peace, prosperity and happiness. The Constitution of Bhutan requires the state to promote circumstances that would enable the citizens to secure an adequate livelihood, and for the Government to secure ecologically and environmentally balanced sustainable development while promoting justifiable economic and social development. The constitution also clearly states that every Bhutanese is a trustee of the Kingdom’s natural resources and environment.

The Vision 2020 and the National Philosophy of Gross National Happiness has set the overarching goal of ensuring the future independence, security and sovereignty of the Kingdom, and maximization of Gross National Happiness (GNH), with four pillars, as the guiding principle for the future development of Bhutan. RNR research can and should facilitate the achievement of each of the four pillars of GNH. There is an RNR Research Plan which is a distinct component of the National Development Plan. The Economic
Development Policy (EDP) of the Kingdom of Bhutan (2010), following on Economic Policy of the Kingdom of Bhutan (2009) is meant to lay the policy ground work to facilitate economic growth as one of the primary basis for meeting the pillars of GNH. RNR research plays a leading role in developing the technological base on which RNR sector growth and the latter’s multiplication effects in other sectors can be generated.

There are other policies and legal frameworks originating from within MoAF such as National Food Security Policy (2010), preceded by National Food Security Strategy (2006): lays out a multi-sector approach to addressing availability, accessibility, proper utilization, and stability of food to achieve food and nutrition security as well as reduce poverty. RNR research has numerous distinct roles to play in achieving food security, such as increasing productivity, improving handling and processing and value addition, improving management of environment and resources, and others. The Food Act of Bhutan 2005 subjects all food businesses in Bhutan to standards for health and safety. It is a responsibility of research to contribute to the availability of food that is healthy and safe. The Seeds Act of Bhutan (2000) regulates the quality of seeds, sale of seeds and certification of seed industry in the country to enhance rural income and livelihood. Likewise, the Plant Quarantine Act of Bhutan (1993) prevents the introduction of pests into the country through regulation of import and export of plants and plant products, and the Pesticide Act of Bhutan (2000) provides for integrated pest management. The Livestock Act of Bhutan (2001) aims to enable only appropriate and acceptable breeds of livestock, poultry and fish to be introduced in the country, and makes provisions for regulation of livestock breeding, health and production, sale of animals, animal products, feeds, drugs, and other inputs necessary for enhancing livestock production. The Cooperatives (Amendment) Act of Bhutan (2009) provides legal framework for the formation of co-operatives and farmer groups to enhance their economy of scale.

The other policies and legal frameworks from RGoB sectors include the Bio-security Policy (2008) that addresses the protection of human health from zoonotic and pest borne diseases, sustainable use of natural resources, protection of agricultural production systems from pests and diseases, and facilitation of safe and sustainable trade and tourism. The Bhutan Water Policy (2003) developed under the Bhutan Water Partnership, recognizes the role of rivers as an aquatic habitat.
as a source of food, as well as individual right to safe, affordable and sufficient quantity of potable and commercial water. It also recognizes the need for adequate water to be allocated for sustainable agriculture for achieving overall national food security. Research can make significant contributions to improving the efficiency of use of water distribution and use. Finally, the Land Act of Bhutan (2007) facilitate commercialization of agriculture while protecting Chhuzhing (paddy land). Research activities and recommendations are moderated within parameters of these Acts and Policies including conventions like fulfilling the Millennium Development Goals (MDG) and SAARC Development Goals.

Roles of SAC in promoting agricultural technologies

As a central agency of the SAARC countries, SAC has the pivotal role to play in coordinating, consolidating and integrating all the available technologies of the region and make those available to the farmers in a manner that are reached to the farmers faster at cheaper cost. Without making the technologies cheaper for the farmers, our earnest urge for making “Adequate Food for All” in the near future will be futile as it is the farmers only who will put into effective use of the technologies innovated and generated. Therefore, careful cross-border governance of science, technology and innovation including scientific collaboration will entail removal of the existing bureaucratically burdened obstacles and barriers to the movement of resources from one country to the other. SAC being a Regional Institution of the SARRC countries with a specific mandate to promote technology transfer should strive to be an enabling platform for knowledge sharing, regional networking and capacity building on the basis of the “Principle of Reciprocity”. Some of the roles that the SAC could play in the promotion of innovative agricultural technologies as heighted as below:

- Facilitate to ease the quarantine regulations in force to fast track the transfer of technologies among the SARRC countries including sharing of germplams as the existing procedures are tiring and red tapped.
- Create an web-based central digitalized technology information where technologies are made accessible to the grass root implementers anytime from anywhere.
• The interventions required for smaller holder farmers for adaptation to climate change are not adequate. Therefore, evaluation and adaptation of climate smart interventions in agriculture sector is urgently required. There is a need for a more productive and more resilient agriculture practices and technologies.

• Facilitate strong advocacy and an enabling policy support to promote organic agriculture in the SRARC countries by re-orienting the current conventional research system into organic agriculture.

• The crop diversification for mountain agriculture requires seed multiplication and germplasm management. The conventional seed systems for commercial production do not meet the needs of crop diversification. Seed management technologies and systems for small holder mountain farmers are essential.

• Focus more on labor saving machines than just the varieties as people nowadays lay off mainly because of the drudgery involved in the agriculture farming.

**Consideration in establishing SAARC innovation platform**

The SAARC countries mostly remained to be under the category of low to middle income group in global scenario and poverty is one of the major challenges we are facing today. The region’s driving force to its economy if predominantly agriculture. But eradication of poverty through agriculture development interventions is still remaining as a dream as our food growers are not accessible to those technologies readily, easily and affordably thereby curtailing the growth of agriculture sector to eradicate poverty, provide livelihood security, reduce hunger and promote sustainable and inclusive growth of the regional economies. This calls for the congregation of the scientists, private entrepreneurs, NGOs and the government agencies/organizations in a common platform to unfold the reality of stagnated agriculture development process. Beyond the strong and flourishing regional cooperation that we already have in place, a further horizontal step is required to harness the challenges and threats to opportunities through vertical thinking process. It is phenomenally true that the problems are manmade, so should the solutions come from the man himself by default. It is recorded that the region is home to 1.567 billion people with geographic coverage of 3.95% of the
global land mass and having arable land of 14%. Poverty rate is high at 28.83% due to low per capita income ranging from USD 345 to USD 3,277 (SAC, 2018). Majority of the population in the region are dependent on agricultural activities as their principal source of income and employment from their small holdings.

Considering all the aforementioned factors, the need for having SARRC Innovation Platform is critical in this time of great need for the region to make our farmers happy and prosperous in the near future amid the accepted climate change reality. Such platform will also create an opportunity for the researchers to catch up, step up, upgrade and embrace the ever changing technological needs of the farmers whom we respect them as the gods and goddesses on the earth. This platform will also bring the following impacts in meeting the diverse requirements of the society;

- Maximize free exchange of new regional ideas and cross border technologies among the research fraternity including the private entrepreneurs and NGOs- a faster means of disseminating and transferring the technologies
- Facilitate expertise exchange visits within the region
- Full utilization of knowledge and skills of the researchers and scientists
- Create an opportunity to institutionalize and initiate best innovative technology award to both the research scientists and farmers
- Capacity building of the young researchers

**Conclusion**

Bhutan is primarily an agrarian country with 62.2% of the population dependent on agriculture for their livelihood. The rugged and challenging physio-geographic conditions coupled with limited arable land are the key limiting factors for modernization of agriculture through farm mechanization, development of irrigation and commercial farming. Meeting food self-sufficiency and poverty alleviation continues to remain one of the key challenges of the government. Currently, nearly half of the cereals requirement of the country is met through imports which have resulted in the negative balance of trade and shortfall of Indian Rupees as most of the goods and service are imported from India. The Department of Agriculture
under the Ministry of Agriculture and Forest is exploiting several techniques to enhance food production. Recently, the government has been emphasizing on increasing cropping intensity through multiple cropping, as one of the means to accelerate food production. Given the nature of farming practices which are mostly subsistence, small farm size and focus on sustainable agriculture such as organic agriculture; multiple cropping can be effective and efficient technique.

Cross-border technology transfer is critical for countries in the SAARC region to achieve SDGs. There is a need for greater regional cooperation in the promotion of climate-resilient and productivity enhancing technologies among countries in the region. The key focus area of agricultural science, technology and innovation development and adoption will require immense policy and bureaucratic supports from all levels of governance of the member countries to eliminate poverty and hunger by calling for actions of all stakeholders while protecting the environment.

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National Soil Service Center and the Policy and Planning Division


Chapter 5

Innovative Agricultural Technologies in India

Randhir Singh1, AK Singh1 and MJ Chandre Gowda2

1Indian Council of Agricultural Research, New Delhi, India
2Director, ICAR-ATARI, Bengaluru, India

Introduction

India is the largest country in South Asia in terms of geographical area, 3.1 million square kilometers and a population of 1.3 billion. More than 70% of India’s population lives in rural areas where the main occupation is in the agriculture sector. Since the early 1950s, India has witnessed a long history of planned agriculture extension service (AES) intervention. The national agricultural extension system with technical support from the national agricultural research system (NARS) has been credited for ushering in the Green Revolution in India in the 1960s. The Indian Council of Agricultural Research (ICAR) is the apex body for coordinating, guiding and managing agricultural research including horticulture, fisheries and animal sciences in the entire country. With more than 100 research institutes and 71 agricultural universities spread across the country, NARS is one of the largest networks in the world. The ICAR has played a pioneering role in India through its research and technology development that has enabled the country to increase the production of food-grains by 5.4 times, horticultural crops by 10.1 times, fish by 15.2 times, milk 9.7 times, and eggs 48.1 times from 1951 to 2017, thus making a visible impact on the national food and nutritional security. However, over the years, the Indian agriculture extension system has been criticized for decline in terms of quality of extension services. The estimates in India indicate that to disseminate advanced agricultural technological information to its 120 million farm holdings requires at least 1.3-1.5 million extension personnel against which present availability is only 0.1 million (Planning Commission, GoI, 2007). The National Commission on Farmers (NCF) has noted that knowledge deficits constrain agricultural productivity in India. Innovative technologies need to be promoted by adopting innovative approaches. Areas that need to be considered to strengthen extension system for popularization of agricultural technologies are discussed. Several policy priorities emerge from the review of the extension and associated research reforms and are discussed one by one.
Innovative Technologies

- Happy Seeder (HS), along with other machineries, is playing a key role in in-situ residue management in the rice wheat growing areas of Haryana, Punjab, Uttar Pradesh, Delhi and Rajasthan. HS has many advantages including cost reduction, less consumption of diesel, low water requirement, and less Phalaris minor in wheat crop. The farmers can seed crop in the standing residue which helps in improving the carbon status in surface soil (0-5 cm).

- The first zinc-rich variety IET 23832 (polished rice has 22 ppm Zn), has been developed. It has been released, notified, and recommended for South Indian states of Tamil Nadu, Andhra Pradesh, Telangana and Karnataka.

- The National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) developed NBSS BHOOMI Geo-portal to access various thematic information on major physiographic regions, sub-physiographic regions, agro-ecological regions, and agro-ecological sub-regions of the country. The NBSS & LUP developed an android-based mobile application on GIS platform to facilitate web-based decision support system (DSS) for land use planning and dissemination of soil health cards information at village and farm level for Gujarat. App displays detail of soil map unit information and suggest land use plan for that survey number. The NBSS & LUP has so far prepared Land Resource Inventory (LRI) of 99 blocks. These digitized maps of micronutrients status would be helpful in providing site-specific variable rate application of micronutrients prescription for sustainable agricultural productivity.

- A liquid Bio NPK formulation containing nitrogen fixing, P solubilizing and K solubilizing bacteria was developed and validated for performance. Bio NPK was validated for its yield contributing attributes for cereals, millets, pulses, vegetables, fibre, and oilseed crops.

- Distillers’ grains (DG) are considered good source of protein for dairy cattle, which can replace the protein source in their diets. The supplementation of molasses based multi-nutrient supplement (MMS) (250 g/buffalo/day) improved milk yield by 16-18% and can replace 7.5% concentrate mixture without having any adverse effect on lactating Murrah buffaloes. Supplementation of 10% linseed and 5% Ca-soap in the diet of
finisher lambs significantly increased ω-3 fatty acids, and Conjugated Linoleic Acid (CLA) content in adipose tissue and in Longissimus dorsi (LD) muscle of lambs. CLA enriched mutton possesses numerous health benefits, including anti-cancer properties. Nano calcium carbonate and nano calcium phosphate prepared as calcium supplement showed 15-20% better absorption than conventional calcium supplements in camels.

- Supplementation of tamarind seed husk alone or in combination with soapnut significantly reduced in vivo methane emission (22-24%), and decreased the population of rumen protozoa and methanogens. Feeding of tree leaves (Leucaena leucocephala and Ficus) based complete feed resulted in 9.8-18.93% reduction in enteric methane emission (g/day) in goats in comparison to traditional complete feed. An herbal crude powder-based bolus, consisting of three plant materials, reduced climatic stress in goats.

- A process, standardized for the production of pectin from dried kinnnow fruit waste, resulted in 10 to 11% purified pectin as compared to commercial processing (6 to 7%).

- A planting machine was developed to carry out bund forming, fertilizer placing, mulch laying, drip laying, pressing, punch planting and covering, in a single pass to reduce labor, time, and cost as compared to traditional practices. The cost of the complete system is INR 5.5 lakh and cost of controlled puddling with this system is INR 2,300/ha.

- A prolific triple breed cross of sheep ‘Avishaan’, with multiple births of 57.1% and average litter size of 1.6, indicated successful introgression of FecB gene. Under field conditions prolificacy was 50% and overall survivability 94%.

- In fisheries, surrogate broodstock of common carp, Cyprinus carpio was produced with sterile gonads using heat-chemical method. These can be used as a recipient for transplantation of donor germ cells. Production of surrogate broodstock will help propagation of commercially important fishes that are difficult to breed in confinement, and also aid in recovery of endangered fish populations.

- A rapid technique (temporary immersion bioreactor), developed for mass production of quality planting material of banana,
showed fourfold increase in cv Namwa Khom and threefold in Udhayam, compared to the standard protocol.

The top-down pipeline approach of agricultural technology development in research system and its transfer down the line through an established extension system and network has worked and given good results early on. More inclusive and network-mode technology development and application have been evolved to move away from the linear approach.

**Case 1:** Farmers participatory groundwater recharge and soil health improvement: The farmers of low-lying landscape have been facing problems of crop submergence during flash flood and or intense rainfall. The Central Soil Salinity Research Institute (CSSRI) took up participatory research in selected villages of Haryana under the Farmer FIRST project. Poor quality groundwater (high RSC>2.5 meq/l) soil sodicity (soil pH>8.2), and low water infiltration rate were the major problems. To provide location specific solution, drainage-cum-recharge structure (cavity type) was installed in the farmer’s fields. Periodic point observations through observation wells were recorded over the seasons. Results indicated that rise in water-table (up to 1 m) during the monsoon period (July-September 2017) beneath the recharge structure and improvement in groundwater quality with concomitant reduction in residual alkalinity of irrigation water (RSC: 1.5-2.5 meq/l). While immediate benefits include the minimum damage to the crops from water inundation and thus stable crop yields, this technology could bring tangible improvements in soil and groundwater quality in the long run.

**Case 2:** Collaborative efforts between research institutions and farming communities: In reclaiming and managing sodic soils of Uttar Pradesh (UP), the Central Soil Salinity Research Institute (CSSRI) Lucknow regional station worked with Mr. Abhay Shankar Trivedi, from Narsinghauli village of Sitapur district of UP to see for reviving the productivity of severe sodic lands. Gypsum application and the salt tolerant rice and wheat varieties were finalized in consultation with the farmer. Soil test-based quantity of gypsum was applied in the leveled field. A tube-well was installed to meet the water requirement necessary for leaching salts after gypsum application and for subsequent
use in irrigation. The farmer planted rice (var.NDR 359), wheat (var.Lok-1), and Sesbania (green manure crop) in the first year. In the following year, the farmer adopted salt tolerant rice variety ‘Basmati CSR 30’, and salt tolerant wheat variety ‘KRL 19’. During a short span of two years, he earned a net income of Rs. 6.0 to 8.0 lakh from the reclaimed lands. The successful reclamation and management of sodic soils with integrated packages can pave the way for other farmers to make their salt affected soil productive.

As the frontline extension system of Indian Council of Agricultural Research, KrishiVigyan Kendras (KVK) have a major mandate of identification of technologies relevant to various micro-situations in a district. Through on-farm-testing, KVKs introduce and assess the technologies available elsewhere in the national agricultural research system (ICAR Institutes, SAUs, CAUs, DUs) by comparing with the existing technology and that of the recommendations available from the agricultural university concerned. In the process, the KVKs also have an opportunity to test the farmers practices and ITKs for validation purpose. The technologies that pass the on farm test stage are then demonstrated with close participation of lead farmers and extension personnel.

**Case 1: Paddy variety Co51 spreads across states:** KVK Thiruvarur in Tamil Nadu introduced new rice variety Co-51 developed by Tamil Nadu Agricultural University. The new variety recorded 6.75 t/ha in 103 days with <3% lodging. More than 350 t seeds of Co51 variety produced through participatory approaches resulted in spread of variety in about 6000 ha by 2016-17. The Co51 rice variety has been notified in 13 states namely Uttarkhand, Haryana, Uttar Pradesh, Madya Pradesh, Andra Pradesh, West Bengal, Bihar, Maharashtra, Gujarat, Tamil Nadu, Kerala and Karnataka. More than 15000 kg of breeder seeds were produced by the Tamil Nadu Agricultural University and distributed for seed multiplication and distribution.

**Case 2: Direct/Drill sowing in command area:** Timely planting was a problem due to delay in release of water in canals and sudden demand for labor in command areas. KVK Mandya, Karnataka assessed paddy hybrids for high yield, and introduced direct seeding as an alternative to transplanting in an
effort to achieve higher yield and income. Hybrid paddy KRH-2, was tested under transplanted and drum-seeded conditions. Hybrid paddy with drum seeding and good agricultural practices enhanced the yield up to 7.5 t/ha. Additional yield, reduced labor by 37.5 man days/ha and reduced cost on seeds resulted in monetary gain up to INR 54950 per ha. The state government policy provided an additional incentive of INR 4500/ha as drum seeding saves water requirement by 15-20%. The technology spread in an area of 8400 acres by 8125 farmers. The government has included Drum-seeder under the subsidized mechanization program to further boost the area.

**Case 3: Maize + Pigeonpea intercropping for sustainable income in drylands:** Maize cultivated as sole crop under rainfed situations has poor productivity and farmers earn nothing in rain-deficit years. To minimize the risk from the sole crop, KVK Gadag, Karnataka tried intercropping with several crops and found pigeonpea as a stable and profitable alternative. Seed priming with Calcium Chloride provided initial drought tolerance, and seed treatment with *Trichoderma* protected the crop against wilt. The net income from intercropping system was more than double both in drought and normal rainfall years. The technologies have been spread in an area of more than 500 hectares during 2016-17.

**Case 4: Lac cultivation on kusum trees empowers tribal women:** Lac cultivation using kusum (*Schleichera oleosa*) trees as host plant is environment friendly, generates employment, empowers women, and has a lot of export potential. KVK Dantewada promoted lac production in tribal areas in collaboration with Dantewada district administration. The women participated in marketing activities which empowered them to have active participation in decision making in household affairs. One hectare of kusum lac cultivation generated about 620 man days of employment in a year and each unit of 40 lac trees earned an amount of INR 789646.

**Case 5: Direct seed rice with zero tillage proves economically feasible in Bihar:** The KVK Jamui demonstrated various resource conservation technologies to enhance productivity of crops at lower cost. Technology components included minimum soil tillage (minimum tillage, direct drill seeding), retention of
soil cover (crop residue) and appropriate as well as economic crop rotations to sustain high yield and to prevent disease and pest problems. As the Zero Till machine became instantly popular, the KVK had to arrange 42 zero tillage machines in collaboration with ICAR, New Delhi and CIMMYT-India. The State Government also provided subsidy for the purchase of machine.

Case 6: Micro-nutrient mixture brings Banana revolution: Micronutrient mixture product of Indian Institute of Horticulture (IIHR) has created great impact on banana cultivation in most parts of Southern India. Many KVKs in Karnataka and Tamil Nadu have procured the technology during 2010-12 and got its staff trained in its production. KVKs produced more than 100 t of micro-nutrient mixture and provided to thousands of farmers. Banana Micro-nutrient was directly contributing to healthier banana plants leading to an average 10 per cent yield improvement, uniform and good quality fruits and bunches. Healthy plants also resulted in reduced application of 5-6 kg/ha of chemical fungicides due to the application of Banana Special. Quality produce increased the market price from INR 3-5/kg due to the shining appearance of banana bunch.

Case 7: Pheromone traps proves to be a boon for cucurbit farmers: Tephritid fruit fly (Dipteratephritidae) in particular is one of the most diverse group of insects in Himachal Pradesh taking heavy toll of vegetable & fruits causing economic losses to the tune of 35 – 80%. KVK Mandi assessed different technological options from 2009-10 to 2011-12 and standardized the technology of pheromone traps to manage fruit flies. The technology was included in the package of the practices of the University for fruit fly management and was demonstrated through frontline demonstrations. Installation of fruit fly traps reduced the number of insecticidal applications, consequently minimizing input costs and environmental pollution.

Case 8: Protected cultivation booms vegetable cultivators: KVK, Sirmour, Himachal Pradesh promoted the proven technology for coloured capsicum and tomato cultivation under protected cultivation. KVK conducted market study on arrival pattern and prices of tomato and capsicum in markets of Sirmour and Solan district of Himachal Pradesh. On the basis of price trend analysis, KVK motivated the farmers to grow tomato
and capsicum in polyhouses so that the produce was harvested and marketed during July to January months for getting the premium price in the market. A total 511 polyhouses have been constructed covering an area of 17.36 ha in the district. Economic analysis revealed that the average income earned by the vegetable grower was INR125000 from 500 m² which is equivalent to INR 2400000/ha.

**Case 9: Off-season vegetable cultivation provides higher income:** KVK, Kullu promoted off-season vegetable cultivation with the formation of 20 Kisan clubs and more than 100 rural youth in collaboration with the Department of Agriculture. KVK established a knowledge hub on off-season vegetable cultivation. Literature pertaining to these technologies was developed and distributed to the farmers and extension officers. Text messages (SMSs) are also being sent to nearly 45,600 farmers of the district for timely information and alerts. The total area under off-season vegetables in the district increased from 301 ha in 1995-96 to 6046 ha in 2015-16. Adoption of vegetable cultivation resulted in net annual income of the farmers in the range Rs.1.50 to 2.00 lakh from one acre.

**Cross Border Initiatives**

Residue management is an issue in the rice-wheat growing areas in the Indo-Gangetic Plains. Through CIMMYT, zero technology has been demonstrated in Nepal and Pakistan. India is also playing an important role in improving wheat varieties in Bhutan and Nepal through mutual collaborations. Representatives from Nepal, Bangladesh and Bhutan participate in the Annual Wheat and Barley Workshop in India to share their experiences which helps in strengthening regional collaboration and technology dissemination. Monitoring of wheat crops on Indo-Bangladesh border areas can help in devising a collaborative mechanism.

**Case 1:** “Basmati” is long grain aromatic rice grown for many centuries in the specific geographical area, at the Himalayan foothills of Indian sub-continent. Basmati rice is unique with its extra-long slender grains that elongate at least twice of their original size with a characteristics soft and fluffy texture upon cooking, delicious taste, superior aroma and distinct flavor, among other aromatic long grain rice varieties. So far 29 varieties of Basmati rice have been notified under the seeds Act,
1966. The areas of Basmati Rice production in India are in the states of J & K, Himachal Pradesh, Punjab, Haryana, Delhi, Uttarakhand and western Uttar Pradesh. India is the leading exporter of the Basmati Rice to the global market. The country has exported 4056758.62 MT of Basmati Rice to the world worth INR 26870.17 crores (or US$ 4169.48 million) during the year 2017-18. Major Export Destinations (2017-18) include Iran, Saudi Arab, United Arab Emirates, Iraq and Kuwait.

R & D for Innovative Agricultural Technologies
ICAR scientists have developed nano nutrients technology through biological process after extensive research both in lab and fields, involving consortium of ICAR institutions and Agricultural Universities. The research data reveals that the nano nutrients doses are just in ppm level to meet nutrient requirement for crops, against 150 to 200 kgs traditional fertilizer dose per acre. Prathista Industries Ltd entered into a licensing agreement with Indian Council of Agriculture Research for commercialization of nano nutrients for crops which are developed under National Agricultural Innovation Project (NAIP) program. In order to have acceptance of ICAR innovation, Prathista Industries Ltd, incorporated the nano nutrients technology with their present 3G lacto-gluconates technology. The cost of these nutrient fertilizers is at par with subsidized fertilizers and computable to use with all traditional fertilizers. The scalability of technology is commercially and economically feasible and nano nutrients are 100% safe to human / livestock and 100% eco-friendly.

The Central Institute for Cotton Research (CICR), Nagpur has developed the Bt Quant Enzyme Linked Immunosorbent Assay (ELISA) kits to quantify Cry1Ac/Cry2Ab/Cry1F. Three ELISA kits have been developed for the quantification of Cry1Ac, Cry1Ab, Cry1F and Cry2Ab in Bt Cotton transgenic plants. The kits can be used as a high-through-put test for simultaneous handling of a large number of samples in routine testing.

Popularization and commercialization
The Business Planning and Development Units (BPDU) set up in most ICAR Institutes through National Agricultural Innovation Project (NAIP) have taken the research results to commercial level. Agri-business incubation through these BPDU, initially coordinated and mentored by International Crops Research Institute for Semi-arid
Tropics (ICRISAT), Hyderabad has led to successful commercialization of more than 40 technologies. Some of the successful cases are:

i) Millets recaptured in Indian diet: Millets (jowar, bajra, ragi etc.) recaptured in diet through development and commercialization of millets based multigrain flour, rawa, bakery items etc.

ii) Fiber from banana waste: Banana pseudo stem a waste now used for technical grade fiber by developing technology and machines to extract banana fiber.

iii) Jasmine flower from Indian fields to foreign markets: Packaging technology for enhancing shelf life of flowers enabled large scale export of jasmine flowers from village near Coimbatore to Gulf and USA.

iv) Health from linseed cake: Technology of Omega-3 extraction from linseed and cake used for biscuits and poultry feed developed. Omega-3 enriched eggs commercialized. Income of farmers, processors, poultry rearers increased besides nutritious Omega-3 rich products for human health.

v) Farmer from a seed producer company: A Beej India Producer Co. Ltd, for large scale production of improved seed has been registered in 2011. This started operations in selected areas of U.P. and Rajasthan for seed production of cereals, pulses and vegetables.

vi) Health and wealth from Prawn shell waste: Chitin and Chitosan valuable products from Prawn shell waste commercialized and being produced on large scale in Andhra Pradesh, Kerala and Gujarat. These products are being exported to several countries for pharmaceutical applications. Eco-Holicolours developed and commercialized enable celebration of Holi with Eco-Holicolours. The colour from flowers, seed, and leaves of different plants produced on large scale in Hyderabad and Chintapalli near Visakhapatnam.

The ICAR has registered a company to commercialize technologies developed by its institutes under one brand. The AgrInnovate India Limited (incorporated on 19 October 2011) aims to work on the strengths of DARE and ICAR and promotes, and spreads its research and development outcomes. The AgrInnovate India Limited is an extended independent commercial outfit, which is expected to
capitalize on the vast network of the ICAR institutes where the researchers are engaged in their mission to innovate and harness science to provide citizens access to food, nutrition, livelihood and income security. AgrInnovate felicitated ICAR-NBPGR in signing a memorandum of Agreement with M/s DSS Image Tech Private Ltd, Delhi to commercialize five DNA-based GMO screening technologies. The Company also initiated collaboration with various reputed organizations like Asia-Pacific Centre for Technology Transfer and African-Asian Rural Development Organization. AgrInnovate has promoted its service to various Embassies located in India which included High Commission of the Republic of Botswana, Embassy of Burundi, Bangladesh High Commission, Embassy of Italy, Embassy of the Republic of Maldives, Mauritius High Commission, etc. The Company also organized the visit of officials from New Zealand Embassy in India to explore the collaboration opportunities.

**Institutional and policy arrangements in generating and implementing innovative agricultural technologies**

**Case 1:** Innovative institutional arrangement - Agri-Clinic of KVK Mysuru: “Agri Clinic” is a ‘Demand-driven Extension System’ practiced by KVK Mysuru, Karnataka, where it provides twin services – free diagnostic services and the need-based agri inputs. The KVK staffs educate farmers for using only such inputs which are absolutely necessary. The KVK produced micronutrient formulations, quality seeds and seedlings, bio agents and many other essential agri inputs are given preference over chemical inputs of private companies. The technical staffs of the KVK attend to Agri Clinic on rotation basis and gain the ‘hands-on experience” of diagnosis and offering advisory services. The farmers footfall increased from 1838 in 2013 to more than 12000 in 2018. As many as 90% of these farmers are repeat visitors, indicating the ‘loyal and satisfied customer’. Compared to about 1,000 farmers in a year in the conventional approach, the ‘demand-driven extension system’ is reaching 12 times more farmers. The ‘smart farmers’ wielding ‘smart phones’ have started exchanging digital images and videos through ‘WhatsApp’ instead of visiting in person.

The total transaction till date is about Rs.298 lakh. This works out to about Rs. 655 pay out per visit per farmer whereas a farmer would have spent in excess of Rs. 2,000 if he had visited private input dealers for the same purpose.
Case 2: Multi-stakeholder approach helps spread of mango in groundnut based cropping system: Groundnut is cultivated in an area of 30000 ha during kharif season, with a low productivity of 6 to 7q/ha, due to the moisture stress caused by long dry spells and agricultural drought. KVK Gadag, Karnataka assessed alternate cropping systems and found mango-based cropping system as more viable and sustainable. This started with capacity building of farmers on soil and water conservation, rain water harvesting under National Rural Employment Guarantee Programme (MGNREGP). KVK produced and supplied mango grafts and supplied to farmers with financial assistance from National Horticulture Mission. Reliance Foundation and Desphande Foundation (Private CSR units) joined hands with the KVK for providing technical support and farm advisories to mango growers. Mango Growers Associations were facilitated for direct marketing of fruits through buyers-sellers meets. Farmers were encouraged to avoid contract selling and instead to do own marketing through associations and get higher net income. Collective efforts have spread mango area to 1734 hectares covering 112 villages, which is 172% increase over a decade.

Recommendations for promoting innovative agricultural technologies

Agricultural extension system in India has the potential to reach more number of villages and farmers if mass media and ICTs are used effectively. Increasing the use of ICTs in reaching the farmers through use of mobile phones, better internet connections, and context and locality-specific portals could be useful tool to support extension. The ICAR network of research institutions and KVKs are developing and using apps to facilitate converting their research results into readily available information for farmers. Consistent investment in technology application and capacity building are needed to harness the potential of mass media and ICT. Further, only some extension agencies are able to participate and reach their stakeholders through mass media and ICT. It requires policy from the top so as to give a proper direction to the extension agencies in the use of mass media and ICTs. It is also necessary to take measures for data security while using mass media and ICTs. The use of community radio and television stations to develop locality-specific agriculture-related programs could be effective in providing knowledge and information.
to smallholder farmers. However, specific strategies for effective use of modern communications methods to support knowledge intermediaries are needed.

Farm women constitute the bulk of rural clientele system for agricultural technologies. In 2009, the panchayat raj system (local government elected body) further got a boost through an act of Parliament which approved 50% reservation for women in panchayat raj institutions. Women empowerment in India has been evolving much faster than anticipated thanks to the interest and involvement shown by women in rural areas. Women in rural India are contributing to nation’s development through their active involvement. As on March 2013, there were 1,365,000 women representatives in the country. There are panchayats where 100% members are women. Milk Cooperative Societies managed completely by women and the emerging Farmer Producer Companies owned and run by women stand testimony to the women-centric development. Surveys on women in agriculture have unequivocally depicted the importance and contribution of women in the day-to-day management of agricultural affairs of a rural household. It is high-time that the gender concerns are integrated into technology dissemination protocols and policies.

Farmer-to-farmer extension is quite efficient, cost effective and leads to good adoption. Identification of successful farmers and supporting them to organize farm schools has given encouraging results. Such farmers need to be accredited and recognized to formalize their involvement in extension services. The main aim of mobilization of such farmer’s organizations is to use them as channel for group-based technology dissemination and soliciting farmer’s feedback and ensuring their active participation in the planning and implementation of research and extension activities. It will help greatly in diversification and introduction of new commodities/areas such as seed production, organic farming, aromatic and medicinal plants, mushroom production, fisheries, floriculture, etc. Involvement of farmers in extension delivery system provides them an opportunity to highlight various problems faced by the farming community. Thus, farmers play an important role in setting extension priorities of the district. With accountability to solve farmers’ problems and in-built operational flexibility, extension system can make suitable interventions. With new institutional arrangements farmers’ position will be strengthened, with change in officials’ approach and farmers
will have some say in extension planning and officials can listen to the farmers.

In the changing global scenario, reaching all the farmers through government agencies may be difficult, therefore, private agencies including input dealers, NGOs can play an important role in technology dissemination. In this scenario, capacity development of such players is important as the farmers need one stop solution. A regular interface with these plural extension agencies will help in strengthening the current extension system.

**Potential role to be played by SAARC countries**

In the current global context, no country can progress on its own. We have a lot to learn from each other and share our experiences for nutritional food security and sustainability. India is working closely with the SAARC countries, a common platform will further boost cooperation among the member countries, learn from each other’s experiences due to similar agro-ecological situations. During the recent visit to Bangladesh, MoU was signed by India and University of Dhaka, Bangladesh and Council of Scientific and Industrial Research, India for Joint Research on Oceanography.

ICAR has been working with many countries; a landmark MoU was signed on October 2016 to establish a research platform in agriculture under BRICS. MoUs have been signed with a number of countries, Papua New Guinea-University of Technology in the field of Horticultural Science Research; Horticultural Innovation, Australia; and Ministry of Agriculture and Rural Development of the State of Israel, etc. Work Plans were developed with these countries for collaborative research and extension. A common research and extension platform with the SAARC countries could be established for developing country-location specific technologies and disseminating among the farmers using public private organizations.

**Considerations in establishing SAARC Innovation Platform**

The model of Technology Assessment and Validation achieved by KVKs can be replicated in SAARC countries. The network of KVKs provides an excellent network both in terms of multidisciplinary scientists as well as lab and farm infrastructure. The effective and efficient utilization of KVK network can also hasten participatory technology development processes. KVKs are also organizing
Innovator Farmers Meets at various levels in an attempt to mainstream the grass-root innovators and to give an official touch to farmers’ innovations. This can provide a platform both for formal researchers and informal researchers to work together in technology validation and commercialization. Establishing a SAARC Innovation Platform will help all the member countries to work on common issues providing cost efficient solutions.

**Conclusions**

The country has a rich resource of manpower, laboratories and institutional network that has engaged in agricultural research and development. The national agricultural research system comprising ICAR research institutes and agricultural universities has been striving to develop technologies and practices relevant to varied agro-climatic situations. The technologies have the potential to address the problems facing agriculture practiced by widely diversified farming community in terms of natural, social, and financial resources. The challenge lies in having an equally strong extension system and mechanisms that provide the last-mile connectivity to the end-users of these technologies. Besides the physical one-to-one contact and service, there is a need to systematize the mass-connectivity protocols. To improve the popularization of the innovative agricultural technologies, there is need of better policies and strategies for effective use of ICTs. The decentralization and farmers’ participation, increased accountability to farmers, making system demand-driven, inclusiveness of smallholder and marginal farmers, group approach needs strengthening at the block and village levels. Effective synergies need to be established with the ongoing agricultural interventions in the form of national missions for both sustainability and for leveraging the limited resources available for extension. Increasing the effectiveness of the extension system in meeting its objectives will require readdressing the above policy and programmatic interventions.

**References**


Chapter 6
Innovative Agricultural Technologies in Maldives

Gasith Mohamed
Ministry of Fisheries, Marine resources and Agriculture, Maldives
gasith.mohamed@fishagri.gov.mv

Introduction
Innovation in agriculture is not only about what happens at the farm level, there needs to be innovation all along the value chain, including at the policy level, in agribusinesses, and in government (Vanclay, et al, 2013). Traditionally, in Maldives when agricultural activities were for subsistence, it was carried out with little or no external input, which is reflected on the knowledge that has been passed down (World Bank, 1980). In the past, various local resources were used in the islands for various cropping needs. For instance, when a plot is deemed unproductive, mixing ash and dry leaves with soil during planting to extend cultivation period was practiced in some islands. Additionally, fish offal, bones, and other remains from fish processing and decomposing coconut wood had been incorporated directly to soil before planting. These practices improved nutrient recycling, resource efficiency, and lowered dependency on foreign inputs. Similarly, there were local methods for managing pest and diseases as well. These methods mostly involve preventative measures that arise from using local crop varieties. Apart from that, spreading wood smoke under canopy was practiced in some islands. Also, using local poultry breeds assisted in managing soil dependent insect pests.

In current times, since the advisory services came into being, the dichotomy between traditional farmer knowledge and researcher/extension officer knowledge has been high. This difference could be due to attempting to emulate the then trending farming practices to popularize farming. Farmers have benefited from this through quick solutions for problematic issues like newly introduced pests, marked yield differences in hybrid varieties could be also observed early on through synthetic nutrient inputs, which were alien to farmers for a long time. This process has, however, created dependency on authorities such as the Ministry and funding agencies like FAO, and could have negatively impacted the innovative capability of farmers (Simin, 2014). Top down approach in technology transfer is still the
main mode adopted, thus could also be an obstacle for innovation (Kathrin, et al. 2016). Early approaches such as farmer-field school programs were an attempt at bridging farmer and extension officer knowledge, but the highly structured nature and extensive syllabus of these programs might need to be modified to allow farmers to define and solve their own problems. Existing extension programs are mostly short-term oriented and based on five main themes. These themes are namely: pest and disease management, general agricultural practices, hydroponics production, agribusiness management and, home gardening.

Maldivian agriculture sector faces variety of challenges from lack of productive land, poor soil, lack of youth involvement, and challenges that arise from distinct geographical nature of the country. These challenges are expected to further exacerbate issues arising from climate change and food security (FAO, 2012). Innovative smart technologies and practices are needed to tackle these problems. This paper reviews the existing situation of Maldivian agriculture system with respect to innovation and innovative agricultural technologies to enable formulation of policies and expansion of collaborations within SAARC region.

**Country background**

The Maldives is an archipelago of some 1192 islands formed in 26 natural atolls set vertically across the equator in the Indian Ocean. It shares boundaries of its Exclusive Economic Zone (EEZ) with Sri Lanka and India in the north-east, and Chagos islands in the south. Islands vary in size from 0.5 km² to around 5km² and in shape from sand banks with sparse vegetation to elongated strip islands. All islands are low-lying, and none exceeds an elevation of 3m above sea level. Maldives is the smallest Asian country in terms of population. With a population of nearly 460,000, about a quarter of people live in capital Male’(FAO, 2018).

Ministry of Fisheries, Marine resources and Agriculture first established as Ministry of Agriculture in 1960s, has the mandate for sustainable management and development of nations’ fisheries, agriculture, livestock, forestry and aquaculture industries. It also has the mandate for managing uninhabited islands leased for commercial agricultural production.
Background of Maldivian agricultural system

Historically, Maldivian agriculture was one of the prominent livelihood activities in inhabited islands along with fisheries. As primary sector, agriculture contributed a large portion of food and income for households (Anon, 1994). Local livestock breeds were prevalent among the production systems with variety of crops (Liebregts, 2007). Grain crops as staples, including maize, rice and millet, were grown during those times. Since commercialization of agriculture and after the advent of tourism sector in 1970’s, agricultural production has been based mostly on horticultural crops with few goat husbandry and poultry ventures (Liebregts et al, 2005). Staple food has since been replaced for imported wheat, rice, and sugar. Due to the uniformity of cropping environment, there are no identified agro-ecological zones in the country.

Presently, the agriculture sectorial contribution to GDP is less than 4% (at constant price) (FAO, 2018). Maldives remains a net importing country, hence depends on imports for more than 90% of its annual food requirement. This is to cater for demands of locals as well as the estimated 1.5 million tourists who visit the country annually. Currently, chili, papaya, local kale, watermelon, and beetle leaves are among the economically important crops (MoFA, 2009). Production activities take place in both inhabited and uninhabited islands. As of 2017, there are around 35 uninhabited islands leased for agriculture. The lease period for these islands can be up to 21 years. Since most large agribusinesses depend on foreign investment, some of these islands are operated by Maldivian as well as foreign entrepreneurs. In the inhabited islands, community land is leased for agriculture by the respective island councils for farming on periodical basis depending on the land availability. Average leased plot size can vary from 1500–7000 square meters. Farming on community leased plots can average from 70 farmers in distinguished islands to a few farmers in small islands. Since land use regulation at island level are determined and enforced by island councils there is lack of uniformity in agricultural land use and tenure system (Building capacity and mainstreaming sustainable land management the Maldives, 2013).
Distinguishable Innovative agricultural practices

Soil-less farming
Lot of funding aid was received with the aim to move towards agricultural commercialization and production diversification. Hydroponics addresses the issue of lack of land availability. Thus, it has opened a new avenue for communities to venture into farming. Since its induction in early 2000’s it has been adopted throughout the country, including resort islands. For instance, low-cost systems (Nutrient Film Technique and Deep Water Culture systems) prepared from locally sourced materials are being adopted. In these systems, cucumber, tomato, chili, and lettuce are produced as main crops for both commercial and household use. Additionally, different shed designs can be seen to allow for reduced greenhouse effect, increased cultivable crops, and for optimum rainwater harvesting. Poly tunnel, naturally ventilated green house, fan and pad cooling green house, agri-net house, and shade house designs are also adopted. Among the notable systems include the Automatic Pot Growing system (Autopot) designs pioneered in Malaysia that were applied in Maldives under the Post-Tsunami Recovery Program by UNDP. Since customized hydroponics systems are aimed to meet local requirements, these systems have been used by both men and women in urban and suburban areas. Specifically, it is becoming popular in Male’ city in terrace or balcony gardens as a source of fresh herbs and vegetables for residents (see figures 6.1-6.8 below).

Figure 6.1 NFT system: White painted to reduce temperature. Half enclosed to reduce heat. Half-submerged tanks to cool nutrient solution.

Figure 6.2 NFT system: Multi story modified to maximize space. Support-frame built from local wood.
Figure 6.3 NFT system: Curved roofing to reduce wind effect in open spaces.

Figure 6.4 NFT system: Modified fiberglass trough for deep rooting crops and high-value crops like melon.

Figure 6.5 NFT system: Shade-net and Styrofoam used to reduce temperature.

Figure 6.6 DC system: Four slots for tomato production to maximize cropping density.

Figure 6.7 DC system: Modified for high-value crops such as melon.

Figure 6.8 DC system: Low-cost system for growing leafy vegetables.
Adoption of open-pollinated local varieties as high value crops

It is vital to have a sufficient number of commercially important crops utilized in a production system. With a narrow diversity of crops, Maldivian famers are depending on imported foreign hybrid crop varieties in their routine practice. These crops are often developed for production conditions in Thailand, China and India. However, despite the need, there have been no formal crop improvement programs in Maldives. Of the few commercially important crops cultivated throughout the country, some varieties of chili, pumpkin and local-kale remain as local varieties. These crop varieties are locally known as Githeyomirus (chili) and Dhivehibaranbo (pumpkin) and Copy-faiy (local kale). They are used by farmers for their performance, market value, and productivity in the island environment. These crops are improved through subsequent crossing within and between islands. Although farmers do not use formal institutions for the exchange of seeds and seedlings of these crops, improvements are made through informal knowledge exchange transactions between farmers. As a routine practice some farmers store seeds from high performing crops and either use it for next planting or sell/exchange with other farmers. Since these crops have several management and commercially important traits, there is huge potential for improvement and possible cross border applications.

Local resource use maximization in nutrient management

Island environments are characterized as having few natural resources. Moreover, there is low livestock presence in current production. Consequently, small farmers have been dependent on imported nutrients for farm nutritional needs. This causes a lot of challenges, including issues arising from unreliability of supply, inconsistent product quality, and fluctuating market prices. There is also the issue of potential introduction of pest and diseases via imported dung and compost. Nevertheless, with the help of government, initiatives and island level waste management effort have led to the involvement of private and cooperative entities in generating local nutrient products for farmers. Additionally, there have been efforts taken to develop commercially viable poultry feed formulations using nutrient sources (coconut, fish remains, kitchen refuse etc.) available from the island environment (see box 6.1).
Nursery business coming up in islands tied with agro-tourism

Nursery industry is a bustling and growing activity in the south Asian region. Huge investments have been carried out to improve public and private nursery businesses in resource rich countries in the region. However, in the Maldives it has only been a relatively recent business venture (last 3-4 years) that is slowly growing in Northern inhabited islands. It has tapped in to the resort market in supplying both ornamental and food crops. Previously, resorts depended entirely on imports, and as result various non-native plant species have been introduced in to the country over the years. There is also increased demand from the general public for various ornamental and garden plants (see box 6.2).

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**Box 6.1 Compost Production: The experience from Ukulhas and Felivaru island**

Aa.Ukulhas is becoming a model-island for its circular solid waste management operations. This has been a result of a project funded under the joint-UN Low Emission Climate Resilient Development (LECreD) Programme by UNDP. As the project beneficiary, the island community utilizes compost for farming or trade to nearby islands including Male’ central market. This project targets multiple sustainable development objectives such as enhancing the use of local resources, empowering local community, generating additional income sources, and reduction of dependency on foreign inputs.

Apart from that, Felivaru Island is among the two major fish processing and exporting businesses in the country. Recently they have started composting with the aim of generating additional income through utilizing waste from fish processing. As a result, their flagship Feligrow compost is being favored by farmers instead of imported manure and compost alternatives. This is because Feligrow is considered rich in phosphorus, calcium and micronutrients, such as iron, due to its inclusion of fish offal and bones.
Reinventing small-scale poultry operations

Poultry, especially chicken, duck, and geese were present in traditional farming systems. Most of the breeds were local and were reared in free range operations. Local breeds were good at consuming food scraps and leavings from households and other materials available in the island environment. Though they had much lower feed conversion capacity compared to current commercial breeds they were highly resistant to diseases and adapted to island environment. For this reason they were reared for eggs and live bird market. Even now there are no broiler poultry operations in the country. Since the start of the millennium poultry rearing as free range in the island environments have been prohibited by law, and this coupled with lack of space has led to the decline of poultry production.
However, fresh eggs and other poultry products being an important food in daily consumption, a new government initiative to reintegrate poultry in to commercial agribusinesses was started in 2014 with aid of UNDP under Support for the Development of Domestic Egg Industries in the Maldives program. The project work was carried out in F.Magoodhoo Island with the collaboration of Magoodhoo island Development Society. Apart from the establishment of two 500 bird closed litter-based sheds at the island, 10 residents were given 25 birds each to rear at their households. The chicken breed and feed used in this project was imported from Sri Lanka (see box 6.3).

**Box 6.3 Poultry production: An experience from F. Magoodhoo Island**

Magoodhoo Cooperative Society was tasked with the management of activities implemented at Magoodhoo island under the poultry development project. The cooperative society has 60 members. They manage two 1000 bird capacity sheds installed under the project. They were given the necessary training through a consultant who worked in the island for two years. The training includes layer management, light, feed and water management for hybrid breeds of chicken. The cooperative now sells fresh eggs to nearby resorts and has been able to self-sustain without any direct intervention from the Ministry and funding agency. Aside from that, some members of the cooperative were given 25 hens each to rear at their households. Some of the members are still continuing the operation at household with the assistance of cooperative society. The Coop assists in procurement of feed and birds for the farmers aside from their main operations in the two sheds. Some of the members have now increased to 50 birds’ capacity and are now trying to establish new market connections to nearby islands and resorts.

**Cross Border Innovative Agricultural Technology**

Due to low resource availability, the Maldives has benefited greatly from global trade, and especially foreign economic connections in the Asian region. Even though the rate of innovation generation is low in the country, the system here could be considered as a leading consumer of innovative technologies. For instance, application of drip irrigation technologies, hydroponics, and modern pest control
methods can be observed among the farming practices. Maldives has depended on imports for all its agricultural inputs including seeds, pesticides and fertilizers for a long time. Looking at fertilizer alone, FAO statistics shows the NPK based fertilizer imports has increased 7-fold in the twelve year period between 2002 and 2014 (FAO, 2018). Moreover, most current commercial crops are supplied by well-known companies in India, Thailand and China.

**Use of improved seeds and breeds**

Hybrid seeds are used in all type of production systems from ornamental gardening to commercial food production. It includes costly seeds—such as papaya, watermelon, melon—and relatively low-cost seeds—such as lettuce and similar leafy vegetables. There are four acclaimed agri-input suppliers in the country with few having outlets in distinguished agricultural islands. The seeds in general are suitable in Maldives climatic conditions due to its similarity in Asian region. However, additional input is often required to generate maximum potential yield due to differences in soil between Maldives and manufacturing countries. Hybrid seed-use has gained momentum in regular practices since 1980’s consequently increasing dependency on input suppliers (Anon, 1994). Nonetheless, these varieties are known for their quality and guaranteed performance with quality packaging for international market. In major single crop producing islands like Thoddoo, farmers collectively spend significant portion of seasonal expenses on procuring seeds. Most heavily cultivated varieties of watermelon, such as Christina 173, for example, are from Thailand.

In contrast, hybrid breed use is not seen in relative measure in livestock production. This is mainly because Maldivian environments lack suitable varieties of pasture/fodder, and do not have space to generate appropriate amount of feed. This is mostly the case with ruminants, but on the side of poultry, gradual adoption of hybrid breeds are seen in some islands in the central Maldives.

**Use of variety of sophisticated artificial fertilizers**

Similar to hybrid seeds, the presence of both synthetic and organic nutrient sources has been on the rise for the last 30 years. Despite the lack of livestock presence, the farmers utilize imported manure on regular basis. The manure in particular is used in the beginning of cultivation during plot preparation. Various artificial fertilizers are
then used throughout the cropping period. On average farmers use about seven NPK based synthetic fertilizers. Additionally, some farmers use hydroponics special nutrient preparation for crops in soil and pots due to its quick response. Several special fertilizers are also popular in the market for common nutrient deficiencies such as iron and manganese. Moreover, fertigation is also a common practice using NPK soluble fertilizers during irrigation. This method is often popular in islands with drip irrigation systems. In general, the fertilizers in the market are sophisticated and cater for wide range of production requirements, from gardening plants, to hydroponics, to commercial agriculture. High quality foliar and slow-releasing fertilizers are used regularly by farmers. Additionally, some farmers prefer synthetic fertilizer to on-farm composting since it saves time and effort. Some input-suppliers also sell nutrients elements separately, which then farmers could mix in various formulations. One common such formulation is the Farivalhu – a nutrient mixture developed for the island soil and promoted by the ministry. The farmers have heavily benefited from international trade of fertilizers and other agro-chemicals.

**Research and Development for Innovative Agricultural Technologies**

Currently there is no ongoing research on innovative agricultural technologies. The research work on Hanimaadhoo Agriculture Center (HAC) in the north runs under a narrow mandate with its main focus on varietal testing. Other research programs involve fertilizer and pesticide testing for most important commercial crop varieties, such as cucumber, chili, brinjal, watermelon and papaya. As a result, all the existing prominent commercial crop varieties and agrochemicals have been tested at HAC in the past. Also, in the last few years there has been work on developing new crop varieties, especially targeting floriculture and high-value crops market. These crops include orchids, grapes, and dragon fruit. Occasionally, foreign funded research is conducted based on the agreed objectives of the specific funding agency and the ministry. Of these, the most notable is the research project on virgin coconut oil and value-added materials production carried out from 2006 to 2011 (Ismail, 2016).

There is, however, potential to run programs in collaboration with farmers from the Northern region at HAC. The areas of interest for Maldives include agro-ecological farming methods, reintegration of
local crops into the production, crop diversification methods, and alternative methods of pest and disease control. Alternatively, Maldives needs innovative programs that incorporate multidisciplinary collaboration engaging various stakeholders, projects, and programs at national development level. This type of approach would be more suitable in developing agricultural innovation in resort islands and suburban settings (Kathrin, et al, 2016).

**Popularization and Commercialization of Innovative Technologies**

As a success story, the low-cost hydroponics systems have been successfully incorporated in the advisory programs and, as a result, have linked manufacturers, farmers, and consumers. Currently the hydroponics systems are designed by the producers themselves. There are no commercial manufacturers of custom hydroponics systems. Farmers design and build the systems based on the crop, market to be supplied, and environment of the production site. For example, various melon varieties are considered high value crops, and thus are grown in hydroponics for tourist market using either autopot or self-assembled low-cost systems. Apart from that, various resort islands such as Kuramathi island resort and Kuredhu Resort, are well-known for their agro-tourism concept that has hydroponics incorporated for growing fresh herbs and vegetables for tourists.

On the other hand, activities targeted for generating innovative processed food products among local island communities has not been wholly successful. The activities mainly involved application of simple food preservation and processing techniques using excess local berries, fruits, and vegetables at community level with collaboration of local NGO’s and councils (Ismail, 2016). As part of the program, technical training and materials were supplied to the participating parties. Though participation and collaboration in this program has been more than expected, the inconsistent supply of local crop varieties might have posed a significant challenge for commercialization of those products. This may be because some of the target crops for processing have been indigenous berries which are not commercially cultivated but are harvested from natural vegetation and community areas. For cultivated crops, the existing production at the island was insufficient therefore supply chain links from other islands must have been in place. Also, producers at islands
may have received better prices from selling the produce elsewhere than to the processors at the island.

**Institutional and Policy Arrangement**

Agricultural policy innovation is also important to improve overarching agricultural paradigm. This is because; there are new ideas and discoveries about regulation and governance that can be taken up in legislative reform. Moreover, policy framework may have a profound effect on innovation at points lower down the value chain. Hence, a policy can encourage and facilitate the adoption of new ideas and practices, and it can also impede adoption and innovation (Vanclay, et al, 2013).

Presently, there are no specific policies in the Maldives for generating and improving innovative agricultural technologies. Also, there is no overarching legislation on agricultural activities. However, vision and mandate of all agricultural related activities flow from the Agriculture Development Master Plan 2010-2020. Other relevant legislation that influences agricultural development include 7th National Development Plan and Maldives Land Act of 1996. Maldives Agricultural Policy and Midlives Forest Policy are still in development.

There have been few agricultural related institutions that had various mandates and contributions over the years. The first agriculture center was established in 1980, which marked the beginning of commercial agricultural practices. Subsequently, in 1982 an agricultural nursery was established at Male’ to supply agricultural inputs (mainly planting materials and agrochemicals) to farmers. Also, the first radio programs on agricultural advisory information was broadcasted around this time. Currently, there are two established agriculture centers in the country. Of these two, the northern agriculture center in H.dh Hanimaadhoo (HAC) houses extension and research officers who carry out various research and advisory activities throughout the country. The research activities are mainly focused on varietal testing trials of crops and livestock. The southern agriculture center is run under a public-private partnership. Currently, the main activity of this facility is to conduct trials with collaboration of the ministry on five selected crops (cucumber, papaya, pumpkin, watermelon and chili) under the import substitution program.
In addition to specific policy elements, a significant gap in the research mandate is the absence of farmer-led research activities. Such a research mandate, if established, would improve farmer to farmer dialogue and instill confidence in their capacities.

**Recommendations for promoting Innovative Agriculture Technologies**

The following points can be considered as recommendations.

- Establishing agribusiness incubation facilities
- Improving farmer innovation capacity by improving farmer to farmer communication
- Improving technical knowledge of farmers to meet the changing environment.
- Generate incentives (such as recognition of innovators) for agricultural techniques and technologies
- Increase utilizations of context specific ecological and traditional farmer knowledge
- Improve use of context data and farmer identified issues in purposive experimentation for generating innovation
- Modify policies and regulatory framework to recognize and incentivize innovations

**Potential Roles to be Played by SAARC Agriculture Center**

SAARC Agriculture Center to promote Innovative Agricultural Technologies can play a role in:

- Providing assistance in sharing co-skills necessary for innovation among member countries
- Providing exposure to farmers between member countries in order to generate ideas for innovation
- Facilitating funding possibilities to enhance institutional capacity and research on innovation
- Streamlining current notable innovative technologies in the region
- Considerations in Establishing SAARC Innovation Platform

A platform for innovation with roles to seek knowledge, provide leadership, and catalyze action in promoting, coordinating, and
implementing agreed agendas for improving innovative agricultural technologies is important for SAARC countries. There is an immense collective potential for the generation and use of IATs in south Asian region. A collaborative platform could enable quick and efficient solutions for recurring problems in the region. On the other hand, such solution as innovations could be made as a marketable product for elsewhere. Such a platform must also on the outset consider the Sustainable Development Goals (SDGs) as well as the independent requirements of member countries. Among other mandates, the platform could act as a central environment to discuss and share ideas that lead to collective improvement of innovation capacity in the region.

Conclusion

There is a huge potential for improving innovative agricultural technologies in the Maldives. Specifically, the areas involving pest, disease, and nutrient management need immediate innovative solutions. Low-cost mechanization options are also in need of introduction to the island farming system. Even though much of the production activities can be relatively similar among islands, it is important to identify and promote context specific practices that deliver at least marginal improvements. Moreover, many of the current practices in the country can be labeled as ‘conventional,’ and thus the food system needs long-term sustainable innovative solutions. These improvements can be aimed at improving crop diversity, generating climate smart practices, and improving self-sufficiency and food security. While shortage of technical and financial resources can be attributed to current low innovative technologies, it is important to empower farmers as innovation hubs. Maldives, in this respect, would benefit from collaborations of SAARC member countries.

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Chapter 7

Innovative Agricultural Technologies in Nepal

Govinda Prasad Sharma
Ministry of Agriculture and Livestock Development, Kathmandu, Nepal
govinda.sharma@nepal.gov.np

Introduction

The Federal Democratic Republic of Nepal, landlocked between India and China, has diverse geography ranging from Himalaya to Indo-Gangetic plain. It has fertile plains (Terai), subalpine forested hills, and mountains. Nepal is a multiethnic, multi-linguistic, and multi-religious country. The total population was 26.5 million in 2011 (2018 projection: 29.62 million). The average growth rate is 1.09% per annum with higher rate in urban (3.15%) than in rural (1.03%) areas (CBS, 2018). The rural areas are gradually being developed into urban and peri-urban areas with some urban growth centers emerging in plain areas including in Indian border sites (MoUD, 2017). Ultimately, plain (Terai) region encompasses more than 50% of the population, and is more densely populated than hill and mountain regions. Migration from hill and mountains to plain areas and urban centers is increasing rapidly. Low farm income, food insecurity, and lack of employment opportunities are push factors, and increased access to education, better employment opportunity, availability of diverse facilities, and better infrastructures are the main pull factors for migration.

Nepal has recently stabilized in structural transformation after a long period of political instability as presented in figures 7.1 and 7.2 below. Components of Political Structure and Provincial Structure of Nepal is presented in Table 7.1.

Figure 7.1. Political structure of the Kingdom of Nepal
Figure 7.2. Provincial structure of Federal Democratic Republic of Nepal
Table 7.1 Components of Political Structure and Provincial Structure of Nepal

<table>
<thead>
<tr>
<th>Political Structure</th>
<th>Provincial Structure</th>
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<tbody>
<tr>
<td>Components</td>
<td></td>
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<tr>
<td>5 Development Regions</td>
<td>7 Provinces</td>
</tr>
<tr>
<td>14 Zones</td>
<td>14 Zones without any administrative structure</td>
</tr>
<tr>
<td>75 Districts</td>
<td>77 Districts</td>
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<tr>
<td>Municipalities 58</td>
<td>Local level Government (753)</td>
</tr>
<tr>
<td>Village Development Committees 3157</td>
<td>(6 Metropolitan Cities, 11 Sub-Metropolitan Cities, 276 Municipalities, and 460 Rural Municipalities)</td>
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</tbody>
</table>

Agriculture in Nepal

Nepal is blessed with geographic, climatic, and biological diversities. The unique agro-ecological zones favored by altitude, topography, and aspect within the country offer diverse agricultural potentialities. Agriculture in Nepal is characterized primarily by subsistence farming (Acharya, 2006; NARC, 2010), and partly by its semi-commercial nature of production (Brown & Shrestha, 2000; Ghimire, 2009). It is the main source of food, income, and employment for the majority of its populace. The agriculture, forestry, and fisheries together contributed 28.76% to Gross Domestic Product (at constant prices) in 2017, which is decreasing by 0.7% annually over the last decade. GDP growth rate reached 5.2% in 2017. This value averaged 4.48 from 1993 until 2017, with its lowest point of 0.1 in 2001, to a peak of 8.6 in 1993. Agriculture engages more than 60% of the labour force in the country. The average landholdings is 0.68 ha per household with an average parcel size of 0.21 hectare. The annual agricultural growth rate accounted 2.9% in the last decade with fluctuations. The land use is mainly cereal crop (paddy, maize, wheat, barley and millets) dominated covering approximately two-thirds of the cultivated land. Almost 80% of the population residing in rural area are farm households. The majority of these households are smallholders (<0.7 ha/household), and the number of households involved in farming is declining in recent decades (CBS, 2011a, 2011b). Crops (cereals, pulses, oilseeds), horticulture (vegetables, fruits and floriculture), livestock, fisheries, and other commodities such as cash and industrial crops are the major sub-sectors of Nepalese agriculture.
World Bank (2012) defined agricultural innovation system as a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance. Arnold and Bell (2001) outlined the concept of innovation system and its role in the development and transformation of agriculture sector as depicted in the Fig. 7.3. They suggested the concept of national innovation system should capture various components, have strong linkages between these components, institutions, and policies that constitute the enabling environment for innovation. The essential elements of an innovation system include (a) a knowledge and education domain, (b) a business and enterprise domain, and (c) bridging institutions to link these domains. More recently, the innovation system comes from the scientific base, the research institutions, stakeholders need, and the broader sociopolitical environment that influence policy for innovation.

Figure 7.3. A conceptual diagram of national innovation system, Arnold and Bell (2001)

**Important Innovative Agricultural Technologies of Nepal**

This section illustrates important innovative technologies that have been developed by research, development organizations, non-
governmental organizations, as well as farmers' experiences. These technologies are shortlisted based on economic value, feedback from research and extension institutions, project experiences, stakeholder engagement in popularizing innovations, and their relevancy as well as popularity among small and medium farmers.

**Protected cultivation of horticultural crops**

Protected cultivation of vegetable crops (greenhouse cultivation) started in the Lumle and Pakrhibas agriculture research center by establishing small permanent green houses for research purposes. The first bamboo plastic tunnel established in the Lumle agriculture center to grow tomato during rainy season was the take-off point of Nepal towards protected horticulture. Later on, youths returning from abroad, particularly from Israel, contributed significantly towards commercial adoption of bamboo plastic tunnel, GI poly-tunnel, naturally ventilated green house, fan and pad cooling green house, agri-net house, shade house, etc and are still expanding. The hi-tech automated structures enable controlled environment agriculture (CEA). Donor and government funded projects largely incentivize farmers to promote protected horticulture technology. Private sector suppliers are mainly engaged at technical backstopping, particularly installation of high-tech structures, net-houses, etc., while government agencies technically support for low cost structures. The technical support for crop management to both categories of farmers are provided by both government and private sector.

The high-tech protected structures are popular at urban and peri-urban centers where vegetables, fruits, and cut flowers fetch higher prices. These are mainly distributed on Province 3 (Kathmandu, Makwanpur, Sindhuli, Chitwan & Nuwakot districts), Province 4 (Lamjung, Kaski and Syanja districts), Province 5 (Palpa and Dang districts), and Province 7 (Kailai district). These structures are mainly used to grow cut flowers (Gerbera, Carnation), high value vegetables (Tomato, Capsicum, Leafy vegetables), and raising nurseries particularly for sapling production of flowers, vegetables, and fruit crops. Smallholders benefit from locally made structures while urban youth, smallholders with moderate investment capacities, and the medium farmers receive economic benefits from hi-tech structures due to higher and quality production, year round farming, and assurance of production. The sustainability remains a challenge in Nepalese context.
Transformation of poultry sector

Poultry business is the largest growing (annual growth rate 17-18%) sub-sector contributing 3.5% to national GDP. Poultry largely includes chickens, ducks, pigeon, and other varieties such as ostrich. More than 1500 commercial farms and more than 200 industries (hatcheries and feed industries) exist in Nepal. Transformation is witnessed at backward/village farming, commercial farming, and the industrialization. Besides government sector, private sector has very strong institutional networks such as Nepal Hatchery Industry Association, Nepal Feed Industries Association, Nepal Egg Producers Associations, Nepal Poultry Entrepreneur Association Forum, Poultry Federation of Nepal, and World Poultry Science Association, Nepal Branch (FAO, 2014).

Technologies for smallholders include cage farming (scavenging system) with minimal bio-security aimed for local consumption. It includes construction of a small shed and a separate house to rear up to 20 chicks and more, respectively. This is common throughout the country. However, Government’s support programs are mainly concentrated in Province 6 and 7, western Terai of province 5, and Province 2. Commercial farming includes broiler production and layers rearing for egg production using low to high bio-security, use of open shed with or no contact with other chicks, and wild lives with commercial objectives. Technologies also include breeding stock and hatching eggs production and ducks rearing, The industrial integrated production have high level of bio-security and follow well defined standard operating procedures, aim market led production, and use moderate to hi-tech automated system of technology (FAO, 2014).

The overall Nepalese poultry industry has an investment of NRs 22 billion, generating 70,000 direct and other indirect employment, produces 1,170,000 broilers and 118,000 layers chickens per week and 646,845 tons chicken feeds annually. This has contributed towards self-sufficiency in meat and egg production. A strong private sector and government institutions collaboratively work for dissemination of technology. The commercialization and industrialization are concentrated in Provinces 3, 4, and 5 (FAO, 2014). Smallholders benefits from cage farming to meet family requirement and contribute household income, while medium and large farmers benefit from commercial poultry farming and its
industry sector. Major challenges in poultry sector include unfair competition due to cross border flow of day old chicks, higher risk to producer due to sudden outbreak of avian influenza, price variability (particularly the output price), irregular supply of feed, and the dependency on foreign experts (particularly from India) for operation of high-tech systems of production (FAO, 2014).

**System of rice intensification (SRI)**

Initially developed by Henri de Laulanie in Madagascar, SRI carefully uses rapid and shallow transplanting of very young seedlings to fully explore potentiality of rice plant. Single planting (rather than in clumps of 4-6 plants/hill), spacing seedlings in square pattern (25×25 cm or wider), controlled irrigation with alternate wetting and drying during the vegetative stage but maintaining thin layer of water (moistening soil) during reproductive stage, mechanical weeding and prioritizing compost over chemical fertilizers are some of the requirements in technology. SRI gives better rice yield without any external inputs and investment which is boon for resource poor farmers. Larger root systems (Stoop, Uphoff, & Kassam, 2002), more fertile tillers per unit area (Stoop et al., 2002; Uprety, 2005), larger panicles with more grains, and higher grain weight than traditional farming system contribute to higher yield. Increased income (at least 60%) from increased yield (at least 21%) and reduced production cost (average 24%), early harvesting, and higher tolerance to drought and extreme temperature are some of the benefits of SRI (Thakur, Rath, Roychowdhury & Uphoff, 2009).

SRI was introduced in Nepal at the NARC farm Khumaltar by a government agronomist in 1999 in collaboration with the United States Agency for International Development CRSP program. Later, it was extended in eastern Nepal (Morang and adjoining districts) from 2004-2007 with almost double rice yield from this system. The research shows 6.4 and 5.5 mt/ha of rice yield respectively for spring and main season which is higher than other methods (Uprety 2015). SRI is useful for smallholders since it uses low input technology, but care should be taken on field monitoring. The technology is highly gender friendly, and helps reduce drudgery of women, particularly for planting, weeding, and harvesting. However, it has limited coverage due to low priority and specific requirement.
Mechanization

Terai is plain area of Nepal with larger plot size and better road connectivity compared to hills. Rice and wheat, ranking respectively first and third by production nationwide, are extensively grown in Terai and hills of Nepal. Farm mechanization introduced in Terai include direct seeding of rice and wheat by zero tillage four wheel operated tractor, happy seeder machine, minimum tillage by power tiller, use of mechanized rice transplanter, mechanized irrigation (by diesel/petrol/ solar/electric pump, shallow and deep tube well), inter-culture operation by power weeder, harvesting by reaper and combine harvester, threshing by multicrop thresher, and postharvest and processing by constructing Godown. In areas with larger farm size and better road connectivity, large machinery (e.g. laser land leveler, four-wheel drive tractor with attachment, reaper, combine harvesters and mobile threshers) are increasingly being used.

Mechanization in hill terrain is quite challenging due to steeply terrace, small plots (often fragmented and non-uniform in shape), poor road connectivity, farmers limited investment capacity, high transaction cost, etc. However, following are major innovations in mechanization of the hill farming of Nepal.

Cultivation by power and mini tiller

Seed sowing by power tiller with seed drill, mini tiller seeder, potato planter, maize planter (jab seeder).

- Mechanized irrigation by diesel pump, petrol pump, solar pump, electric pump and papa pump.
- Inter-culture operation by power weeder, conoweeder.
- Harvesting by power tiller reaper, mini tiller reaper, brush cutter, serrated sickle.
- Threshing by multicrop thresher, paddy, wheat, maize and millet thresher.
- Use of Godown, milling, grader, cleaner, solar dryer for post-harvest processing.
- As Nepal doesn't have its own production of machineries (except simple tools), mechanization in agriculture is largely import dependent, mainly by private sector and partly by government efforts. The agricultural engineering Directorate is mandated to
Box 7.1 Farm mechanization: An experience of RSZ, Baniyani, Jhapa

Baniyani area covering 7 wards of Kachankewal Gaupalika and 3 wards of Bhadrapur Municipality with command area of 1000 ha out of 9000 ha of rice was declared as RSZ in 2016 under PMAMP with the objective of increasing rice production, attracting youth in agriculture and strengthening rice value chain in Jhapa district of Nepal. An institutional arrangement comprising 9 members (with 4 women) of farmers management committee, RSZ program implementation office and a super zone rice research implementation unit is provisioned to implement the program. The major departure is witnessed in farm mechanization, increase in rice production through productivity enhancement, area expansion including two season rice cultivation and entrepreneurship development through innovative actors. The introduced technology comprised the use of rice transplanter, use of tractor and power tiller driven for direct seeded rice (DSR), drum seeder for puddled field (wet DSR), DSR through broadcasting, use of Nominigold (herbicide) for weed management, brown manuring, SRI technology, use of different types of reaper (tractor driven, power tiller driven and self propelled) for harvesting, use of solar irrigation (submergible and DC motor), use of power and rotary weeder, cultivation of Boro rice and the like. The farm mechanization has been influential in enhancing cost efficiency of rice production. Other support program included establishment of postharvest center, vermi compost production centre and the bio-pesticide production lab and the strengthening of technical school at community level. A rice meal has introduced brand of packaged rice ‘Steam BG Rice’ in the local market as a business promotion strategy.

The extension activities largely focus on upscaling of these technologies, technology demonstrations, establishment of field learning centre and training centre, support on irrigation and marketing. The program is largely owned by management committee where direct beneficiaries are included. The program is supposed to have sustainable impact due to reduced cost of cultivation, increased production and greater participation of stakeholders including women and youths.
develop infrastructure, farm buildings, farm roads and irrigation facilities while engineering unit of NARC and agriculture input research center is engaged in designing, testing, modification, and promotion of various tolls and equipment. NARC is collaborating with IRRI, CIMMYT and Cereal System Initiative for South Asia by identifying and popularizing conservation agriculture technologies in Nepal. Irrespective of geographic locations, mechanization has been influential in increasing efficiency in agriculture, reducing labor drudgery (particularly for women), and promoting diversification in agriculture. Mechanization saves costs and resources (labor, energy) by reducing operational time in agriculture and performing timely farm operation. It is cost efficient, helps at improving quality of the products, and enables for competitive market price of agricultural commodities. Importance of farm mechanization has further increased in context of reduced labor availability and increased wage rate. The custom hiring system offers viable economic and sustainable strategy for the smallholder and medium farmers. Cooperative farming, community-based farming, contract farming, and land consolidation are most suited in Nepal for promoting mechanization for commercialization of agriculture. Box 7.1 reveals a snapshot experience of farm mechanization in Rice Super Zone (RSZ) in Jhapa district under Prime minister Agriculture Modernization Project (PMAMP).

**Agribusiness incubation service**

Business incubators play an important role to catalyze agriculture commercialization and industrialization for job creation. Such entrepreneurship support platforms provide entrepreneurs - which include commercial farmers and agro-processors - with coaching, mentoring, co-working space, technical backstopping, and connections to networks to support business growth. The agro-entrepreneurship development, including development of agro-industry, can promote agribusiness growth leading to increased competitiveness of the sector. Agribusiness incubators focus agriculture producers with required knowledge, skill, experience, infrastructures to become successful agribusiness entrepreneurs by helping them in identifying, adapting, and commercializing value added and processed products to the market. Research and development, conceptualization, business plan development, and translating ideas into business venture are major component of business incubation.
Introduction of agribusiness incubation in Nepal is a new experience. The World Bank infoDev group introduced incubation in agribusiness sectors by mentoring, facilitation and seed funding. Lately KISAN is also offering agribusiness incubation service based on public private partnership model targeting rural Nepal and returnees migrant workers. The major beneficiaries of incubation service are agro entrepreneurs both in rural and urban areas. The objective of business incubation should focus at accelerating growth of agro-processing sector that enable to commercialize agriculture for greater socioeconomic benefits. For this, target should be on potential value chain commodities. The existing Nepalese agribusiness incubator focus on network based facilitation and lacks technology based support required for growth oriented as well as start-up entrepreneurs. A snapshot of early experience in Agribusiness Incubation in Nepal is unfolded in Box 7.2.

**Enriching soil quality through biochar**

Biochar is a charcoal, rich in carbon, fine grained residue of biomass and is produced through pyrolysis processes. Pyrolysis is the thermal decomposition of biomass at elevated temperatures in an inert atmosphere. In general, pyrolysis of organic substances produces volatile products and leaves a solid residue enriched in carbon. The quality of biochar depends on the quality of biomass and pyrolysis temperature. Biochar is used as soil amendment.

Two attributes of biochar increase its value in soil. Firstly, most of the carbon in biochar is relatively stable in the soil enabling it to mitigate climate change effects through carbon sequestration in soil. Secondly, biochar has shown dramatic effects on plant production. The effects are primarily due to increased micronutrient and nutrient availability, increased microbial activity, increased water holding capacity, reduced soil toxicity, etc. Retention of moisture in the soil is the most important function to improve and keep an overall biological function in the soil. Thus, biochar could be a way for improving marginal or low yielding soil.

Biochar has a great role in improving the physical, chemical, and biological properties of soil. It improves the soil texture and structure; maintains soil temperature, enhances the water holding capacity of soil, maintains soil moisture content, and helps to minimize soil erosion. Biochar, being alkaline in nature, improves acidic soil and enhances soil pH. Biochar increases the cation exchange capacity of
soil, improves water quality, reduces soil emissions of greenhouse gases, and reduces nutrient leaching which causes the maximum utilization of nutrients by plants. It also enhances the soil microorganisms and soil biodiversity enabling the healthy plant growth in soil.

Application rates of 2.5–20 tons per hectare (1.0–8.1 t/acre) appear to be required to produce significant improvements in plant yields. Biochar costs in developed countries vary from $300–7000/ton, generally too high for the farmer/ horticulturalist and prohibitive for low-input field crops. In developing countries, constraints on agricultural biochar relate more to biomass availability and production time. An alternative is to use small amounts of biochar in lower cost biochar-fertilizer complexes. This technology is largely limited in research stations and need to expand at farmers field.

**Post-harvest storage and drying of horticultural seeds**

High quality seeds of improved vegetable varieties are essential to enhance the production of annual horticultural crops. In tropical climates, high temperatures combined with humid conditions rapidly deteriorate quality of seeds in open storage, resulting in lost value, poor vigor, which ultimately lowers productivity. Most horticultural seeds in Nepal are locally produced or self-saved and stored without facilities for maintaining dryness that would greatly extend the seed longevity in storage particularly in rural areas.

Led by Kent Bradford at UC Davis, this international project team demonstrated a simple, inexpensive, and widely adaptable method for drying horticultural seeds and maintaining high seed quality during storage. A novel zeolite desiccant called drying beads, combined with low cost hermetic containers, can dry horticultural seeds and maintain the seeds in a dry state during storage, greatly increasing their storage lifetime.

As women perform most of seed production, harvesting, and storage operations for horticultural seeds in these regions, this improved seed drying and storage system pays for their labor in the rural areas. This simple seed drying and storage system enable the development and distribution of more productive seed varieties, leading to higher quality crops and increased incomes.
Box 7.2 Agribusiness incubation in Nepal: NABIC’s early experience

Nepal Agribusiness Innovation Centre (NABIC) is a dedicated agri-focused business incubation and innovation hub established in 2017 Project for Agriculture Commercialization and Trade supported by the World Bank Group. Practical Action UK and the Kathmandu University School of Management provide consultation services for the same. NABIC focuses on extensive business counseling, intensive business incubation and agribusiness sector ecosystem building. It seek innovation opportunity in production, marketing, technology and production methods, financing approach and methods, business plan development, execution and management. Within 18 months, NABIC has reached 744 entrepreneurs, provided business counseling to 259 agribusinesses and is working intensively with 25 agri-sector clients for deep incubation to support their expansion and growth. NABIC currently sets aside 50% of available space in its program for women-owned/managed enterprises. NABIC interacts intensively for the expansion and growth of client business before taking them for incubation to search potentiality and ensure sustainability of agro-enterprises.

Examples of NABIC’s work with commercial farmers and agro-entrepreneurs include support to a woman entrepreneur to conceive a plan for an integrated commercial farm. This led to success in obtaining commercial bank funding under the Government’s interest subsidy scheme. Other areas of NABIC support have included new product development training, support for pro-typing of new products, training in good manufacturing practices (GMP), help with developing SOPs, assistance to establish testing labs, etc. However, due to lack of abundant facilities and infrastructure, NABIC focus more on network and facility-based incubation. The technical expertise is being borrowed from available institutions available both at government organization, universities (national and international) and private sectors. Institutional sustainability remains a challenge for NABIC as complete revenue cannot be generated solely from its clients. Early experience suggests that NABIC fills a large void in the county’s agriculture sector landscape.
**Agro-tourism promotion**

Agro-tourism is a new concept materialized in Nepalese agriculture sector. The agriculture sector, which was considered an agrarian activity, is now blended with tourism. The agro-tourism incorporates agricultural activities with tourism promotion with economic potentiality harnessing landscapes of the locality, celebration of special day of agricultural activities, using special crop season such as planting and harvesting season for fun and entertainment purposes. More recently, agricultural production activities are largely integrated with tourism promotion. The agro-tourism promotion maximizes the benefits from tourism activities and farm production, and encourages youth for harnessing business potentiality with enhanced employment opportunities within country. Integrating agriculture with tourism promotes sustainable economic activities attracting both domestic and foreign tourists. Ghandruk (Kaski), Sirubari (Syanja), Rampur (Palpa) and celebration of rice planting day (National Rice Day) are being developed for agro-tourism. Box 7.3 portrays how a rainbow trout farm in Kaski has promoted agro-ecotourism.

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**Box 7.3 A rainbow trout farm becomes an eco-tourism site**

Established by two farm families at the base of Annapurna Conservation Area of Kaski district in 2010, Gandaki rainbow trout farm initially produced 15 mt of rainbow trout from 1037 m². With support of World Bank funded Project for Agricultural Commercialization and Trade, it expanded raceways area, constructed hatchery and started own feed production for fish. The farm started a restaurant at the site with small swimming pool for kids and some thatch/trust houses. The fish production has now reached about 22 mt which is consumed within farm. Additionally, trout produced by nearby farms are also brought here to offer service for visitors. The farm offers to enjoy the panoramic view of Mt Annapurna and Mt Fishtail. The business currently runs at full capacity with 75000 visitors per annum. The annual transaction has reached to 22.5 million which is more than double after project intervention. The farm permanently engages 23 peoples and offers service to additional labors in the peak business season.
Organic farming

Organic agriculture is a production system that sustains the health of soils, ecosystems, and people. Rather than the use of inputs with adverse effects, it relies on ecological processes, biodiversity, and cycles adapted to local conditions. Organic agriculture combines tradition, innovation, and science to benefit the shared environment, and promote fair relationships and a good quality of life for all involved (IFOAM 2008). Smallholders, producers, exporters, and consumers benefit from organic farming, and motivation for organic farming comes from the health consciousness, taste, freshness, and the prices. Organic farming is a sustainable farming approach as it is ecologically safe, economically viable, and socially acceptable. The farming system majority hill and mountainous areas of Nepal are organic by default. The major focus of organic agriculture are on vegetables, export commodities (tea, coffee, cardamom, ginger, honey), fruits (apple, orange and others), and medicinal herbs (Bastakoti, 2017). The major technology adopted in Nepalese organic farming system includes the use of compost, elimination of chemical fertilizers, quality control, and certification. The certification system comprises participatory guarantee system and third-party certification (personal certification and group certification). The internal control system is mainly in practice for group certification. Miss Judith Chase, an American researcher, is a pioneer of organic farming in Nepal, introducing concepts of organic garden and organic village. A gradual shift towards organic modes of production is witnessed because of adverse effect of chemicals, particularly among farmers who used pesticides haphazardly in the past. Recently, alternative agriculture, ecological/natural farming, bio-dynamic agriculture, regenerative agriculture, permaculture, and sustainable agriculture are in practice with organic agriculture in Nepal. Government of Nepal has prioritized organic farming by providing price policy support, such as in coffee, offering subsidy for export promotion, declaring crop specific organic zones, etc. Lately, Karnali Province has decided to develop a fully organic province and aims to form an organic Agriculture Production Council. However, challenges remain in the lack of professional institutions, quality assurance, trustworthiness of product at market, and product certification for market.

Climate Smart technology

Nepalese agriculture is highly climate-sensitive and adaptation to climate change has been increasingly important for farmers. The
major effects of climate are experienced with both extreme hot and cold, including rise of average temperature, change in the rainfall patterns, severe droughts, over flooding, shifting agriculture seasons, etc. These factors have created new challenges for Nepalese agriculture, particularly to agriculture dependent farm households in rural areas. The effects are expected to have adverse impact on marginal and vulnerable households and communities. This has drawn attention for a need of adaptation to climate change in agriculture. To mitigate the effects of climate change action, various Climate Smart Agriculture (CSA) have been developed. Food and Agriculture Organization (FAO) has defined Climate Smart Agriculture (CSA) as the practices that supports adaptation, mitigate the emission of GHGs and contribute to food security/Productivity.

Various climate smart (often named as champion CSA) technologies have been identified through technical appropriateness, farmer/community acceptance, climate sensitivity, and scalability of the technology. Some of the CSA technologies adopted in Nepalese condition include water smart (rainwater harvesting, alternate wetting and drying through SRI, use of cover crops), nutrient smart (integrated nutrient management, green manuring, intercropping), carbon smart (agro forestry/horticulture, fodder management, integrated pest management, biogas management), energy smart (minimum/zero tillage, solar pumps), knowledge smart (contingent crop planning, improved variety selection, seed/fodder bank, farm diversification), and weather smart (climate smart livestock housing, weather and climate information through information technology, crop insurance) technologies. All these technologies are developed based on geographic and climatic conditions. These CSA technologies range from simple adjustments in crop management practices, to transformation of agricultural production systems that demand special technology to fit into changing climatic condition (Poudel, 2017).

The above-mentioned CSA have been piloted by LiBIRD in collaboration with CGIAR, research program on Climate Change Agriculture and Food Security and CCAFS and Li-BIRD in five districts of Nepal during 2015 and 2018. The concept of Climate Smart Village (CSV) was adopted to scale up above CSA technologies for making farming community climate resilient. The CSV has six approaches viz i) CSA technologies and practices ii) Climate information, service and insurance iii) Local and national public and
private institution iv) Farmers knowledge v) Climate and agriculture development finance vi) National and sub national plan and policies. LIBIRD has piloted CSA in Lamjung, Kaski, Nawalparasi and Bardiya districts. Government of Nepal has already started the process of establishing 150 climate smart villages. The major beneficiaries of CSA are the poor and marginal farm households in rural areas. Women are also benefitted, as most of these technologies reduces the labor drudgery. However, challenge remain with the lack of strong evidence-based CSA options, as Nepal has limited work on it.

Cross Border Innovative Agricultural Technology

With the economic liberalization and globalization, cross border flow of human resources and technology has substantially increased. Agriculture is largely influenced from trans-border flow of commodities, particularly the seeds and breeds, the knowledge, and the improved technologies, including the flow of machineries. The improved seeds and breeds, the high-tech technology, and the machineries are among the important cross border innovative agricultural technology in Nepal.

Use of improved seeds and breeds

Nepal borrows improved seed and breed from India and third countries due to limited production of these commodities. The dependency is more for hybrid seeds. A high share of seed and breed flow is from adjoining states of India because of similarities in climate, easy access, and open as well as porous border. The seeds, particularly the open pollinated and hybrid seeds registered in Seed Quality and Control Center, are imported through seed companies and dealers. However, a large chunk of improved seeds and breeds enter informally in Nepalese market. Some of the requirements for import of seeds and breeds include quality certificates from producers, plant import permits, import permits seed certificates, phytosanitary certificates, custom clearances, and fulfilling other requirement set out by quarantine law. The commercial vegetable producers in urban and peri-urban areas, farmers in adjoining districts with Indian borders, benefit more from hybrid seeds. Similarly, goat rearing farmers have been benefitting from Boer goat imported from Australia. Another example is the import of semen from abroad. However, due to porous border and limited supervision, farmers are often cheated from the inferior quality seeds,
including the hybrid seeds. Strong monitoring, control of haphazard flow of seeds, and streamlining of trade and import are required to help ultimate users get benefits. Establishing the seed company and a strong collaboration with NARC for promotion of seed and breed would be a sustainable approach in this regard. Similarly, performance of some breeds are not to the standard as expected due to breeds’ genetic factor, climatic variation, farm management, and dietary requirement.

**Use of high-tech in horticulture sector**

There are several category for preparing high technology structure. The first category comprises simple structures, which are domestically prepared. However, for the construction of sophisticated and controlled environmental agriculture facilities, one must depend on foreign experts. These structures are used to optimize input resources, particularly human labor, and ultimately productivity of plants. Currently practiced structures are based on Indian and Israeli technology. For the expansion of these technologies, private sectors, particularly the Israel returnee technician and Indian company, are engaged, whereas government is promoting these technologies through subsidies to commercial farmers in potential area. As these types of structures are useful in urban and peri-urban, the youths are increasingly engaged in controlled farming of vegetable, fruits, cut flowers, and nursery plants. These types of structures have greater scope in increasing the production and productivity of horticultural commodity. However, issues remain in limited research and development, limited manpower in the Nepalese context, costs, and import dependency. Farmers and suppliers often face customs hurdles (VAT, custom charges, custom codes, taxes etc) and are supply driven to some extent. A complete technical team for installation, easy access for repair and maintenance, countryside friendly modification in the system, and grant support policy for installation from government could enhance the sustainability of this technology.

**Farm mechanization**

With the encouraging progress on farm mechanization, the mechanization is highly dependent on India and China for supply of materials. As Nepal has no factory for production of machines and tools for agricultural mechanization, this technology is often linked
with cross border issue. The major challenges remain in importing hurdles due to tax and custom clearances, utilization of these machines at their maximum capacity, repair and maintenance, high cost of purchase, soaring fuel prices, and uncertainty of availability of fuel at peak cropping season. Further, government has burden for providing subsidies to farmers. Mostly the private sectors and elite group are involved in the procurement and supply of these tools and machineries. The mechanization has made the life of the farmers easier, particularly in reducing the drudgery of women. Establishment of custom hiring centers would be sustainable for enhanced mechanization and expansion of these facilities.

**Research and development for Innovative Agricultural Technology**

Realizing the need for agricultural innovations in agricultural development, agricultural research and development institutions, along with agricultural farms and resource centers, were established in the field of agronomic, horticulture, industrial entomology, fisheries, and livestock sectors. Nepal Agriculture Research Council (NARC) was established with the main responsibility of carrying out agriculture research. The government extension organizations, such as Department of Agriculture (DoA) and Department of Livestock Services (DoLS), are particularly concentrating for technical advice, laboratory, and regulatory function. For research purpose, 18 Agriculture Research Centers and 50 Location Specific Research Stations were established in various parts of the country under NARC. Farms under NARC are mandated for research activities while farms under DoA and DoLS are mandated mainly as the resource centers for production and maintenance of quality resource materials, such as seed and breeds, respectively for crop and livestock, fisheries, honey bees and silk worms for promotion of industrial entomology for different ecological regions. Besides DoA and DoLS, Department of Food Technology and Quality Control (DFTQC) carries out service delivery to the agri-processing entrepreneurs as well as regulatory function for quality compliance of these entrepreneurs.

After the liberalization policy, the GoN recognized the role of public, private, cooperative, and many local and international non-governmental organizations in the research and development of agricultural innovations. These institutions mainly contribute to
development of agriculture sector, and some are also engaged in research activities.

**Popularization and commercialization**

Vegetable production and poultry farming have been very successful in terms of popularization and commercialization in Nepal. The enhanced production of vegetables has almost resulted in self-sufficiency. Poultry farming has been closely approaching self-sufficiency status to meet national targets. Similarly, commercial milk production and expansion of dairy processing industries at the domestic level have been increasing in a greater extent. Farm mechanization, agribusiness incubation, promotion of agro and eco-tourism are also gaining popularity and are becoming more commercialized.

There are some failure cases such as complete failure of hybrid crops in certain years (a localized problem particularly with maize) leading to income risk of farmers and complete loss of income due to epidemics such as the bird flu in poultry farming.

A low efficiency of agricultural machineries such as power and mini tillers due to shortened lifespan mainly due to limited/occasional use, lack of repair centers (Major short comings). A high-income risk to farmers due to fluctuation and competitive prices of farm products in high-tech where high prices are expected from specified markets and seasons such as festive seasons.

**Institutional and Policy Arrangement**

Agricultural innovations largely shape the extent of agricultural development. Presently, besides research-based innovations, many social and policy factors also determine use of technology. Ministry of Agriculture and Livestock Development (MoALD) formulates policies and programs, as well as carries out overall coordination of agriculture development programs in the country. MoALD aims to implement agriculture development plans, programs, and projects through its departments, provincial departments, Agriculture Knowledge Centers, Veterinary Hospital, and Livestock Experts Centers, and through the frontline extension agents placed in the Agriculture/Livestock Section of the Municipalities (as provisioned in the recently reformed federal structures). Farmers groups, farmers cooperatives, private sectors such as community-based organizations, non-governmental organizations, commercial, and commodity
alliances are also engaged in imparting innovations for agricultural development.

MoALD is an umbrella organization for NARC, corporations, companies, boards, committees and departments. The Ministry, headed by the Minister, has one administrative and 6 technical divisions. Each division is headed by the Joint Secretary. The sections in each division are headed by senior officers. The sections look after specialized tasks through internal and external coordination with other ministries and departments.

The prevailing and past policies have envisioned at developing innovations by recognizing their contribution in agriculture development. Some of the policies interlinked with strengthening agricultural innovations.

**Policy arrangements**

The GoN has formulated many policies, acts, regulations, orders, plans and programs for the development and transformation of Nepalese agriculture sector. Some important policy outlines attracted towards innovations for agricultural development are given below.

**The constitutions of Nepal, 2015**

Article 36 (1) ensures right to food for every citizen,  
Article 36 (2) ensures that every citizen have right to be protected against food scarcity that may cause threat to life,  
Article 36 (3) ensures that every citizen have right to food sovereignty in accordance with law,  
Article 42 (2) right to social justice - indigent and citizens at the verge of extinction shall have right to get special opportunities and benefits in food. includes provision on food.

*National Agricultural Policy 2004 (2061 BS)*

Development and strengthening of national resource centers for the production and supply of seed (including fish seed)/seedlings/saplings/bee/queen bee required for production materials for different development and agro-ecological zones.

Developing farm/centers as an integrated resource centers for the laboratory facility (soil, seed certification, plant protection) and capacity enhancement of farmers, agro-entrepreneurs and agricultural technicians.
*Agriculture Development Strategy (2015-2035)*

Envisions a self-reliant, sustainable, competitive, and inclusive agriculture sector that drives economic growth, and contributes to improved livelihoods and food and nutrition leading to food sovereignty.

20 years vision (2015-2035) with conceptual framework and program categories.

Components: Improved governance, higher productivity, profitable commercialization, increased competitiveness.

Flagship and core program: ADS envisages four flagship programs viz Food and nutrition security program (FANUSEP), Decentralized science technology and education program (DSTEP), Value chain development program (VADEP) and Innovation and agriculture entrepreneurship program (INAGEP ) and core program.

*Agribusiness Promotion Policy 2006 (2063)*

Encouraging establishment and development of greater production zone based on geographic, technical and economic potentiality.

Provision of registration and promotion of local, traditional and indigenous technology.

*Agricultural Biodiversity Policy 2006 (2063) revised version 2014 (2071)*

Promotion of study, research and development for the conservation, promotion and sustainable development of agrobiodiversity. Promoting market led entrepreneurship based on agricultural biodiversity.

*National Land Use Policy 2012 (2068 BS)*

Developing the effective and sustainable mechanism for the conservation and utilization of government owned land.

*Agriculture Mechanization Promotion Policy, 2014*

to promote agricultural mechanization and commercialization in agriculture.

Subsidy schemes to farmers since decades for purchase of farm machinery.

*Custom Hiring of Farm Machineries*

*Current Periodic Plan 2016/17-2018/19*

Graduating Nepal from a Least Development Country to a Developing Country by 2022 and middle-income country by 2030.
The Sustainable Development Goals, as endorsed by the UN, would be incorporated into the plans and annual program, and the development goals and strategies up to 2030 would be determined, as the President shared.

Agriculture loan, crops and livestock insurance: Collective and cooperative agriculture system would be developed to encourage mechanization of agriculture. Fertilizers, seeds, irrigation, technology and access to market of agriculture products would be ensured. Easy access of farmers to agricultural loan, crops and livestock insurance would be arranged.

Establishment of resource centre in each province: Production and distribution of high breeds of livestock such as cows, buffaloes, goats and other would be made systematic by developing Livestock Resource Centers through public, cooperative, private partnership.

Integrated program implemented to make the country self-reliant in animal products within two years through establishment of recourse centre in each province

MoALD commitments 2018

The government launched a short, medium and long-term agricultural transformation roadmap that envisions generating more jobs, making the country self-sufficient in food and boosting agro exports. The 58-point program "Prosperous Nepal: Happy Nepalese" campaign aims to usher in a new era of mechanized and modern farming to ease the country’s dependence on food imports. Some important roadmaps among all are:

- NARC to be given status of Deemed to be University in order to promote research
- Establishing warehouses to stock 25,000 tons of fertilizer in all provinces
- Emphasize Karnali an organic province and province 2 to be promoted as special food producing area.
- Reassess Birgunj Agricultural Tools Factory to be implemented on cooperative model.
- Building warehouses to store 100,000 tons of food in all provinces

70 % subsidy on agro commercial project plans launched by youths
Recommendations for Promoting Innovations

- Seed self-sufficiency program
- A national campaign program
- Development of critical monitoring, supervision and evaluation of program
- Strengthening the capacity of national resource centers, research institutes, laboratories and human resources.
- Adaptability test of fertilizer, seeds and machineries to ensure quality and efficiency.
- Developing and upgrading capacities of institution directly engaged with cross border technologies.
- Promotion of custom hiring centers for mechanization.
- Expanding and effective execution of insurance policy to protect farmers from income risk
- Roles to be Played by SAC to promote IAT
- For entire South Asia
  - Develop SAARC agriculture technology forum and organize technical working group meeting regularly.
  - Exchange of experts and travelling seminar.
  - Declaration of SAARC agricultural working policy.
  - Organize SAARC level agricultural conference annually with greater participation of researchers, development organizations, government people, farmers, NGOs, private sectors and Universities.
  - Develop a protocol to ease for the transborder flow of innovative agricultural technology.
- For own country
  - Development, revision and effective implementation of Quarantine laws.
  - Leverage the policy for innovative cross border technologies.
  - Amendments and adjustment in Taxation rules (such as GST) by respective country (applicable to host country).
- Regulate cross border flow commodities.
- Identify and listing of prominent local and indigenous technology for Nepal.
• Considerations in establishing SAARC Innovation Platform
• Government commitment and the political willpower
• The technology requirement of the particular country
• A policy to harness the potentiality of specific location.

Conclusion
South Asian agriculture is dominated by smallholders with geographic, climatic, and agro biodiversity. The problems faced by farmers and states are almost similar across the region. Achieving sustainable goals, poverty reduction, and elimination of food insecurity have been common and challenging agenda for all countries in the region. The technology developed in one country can benefit the whole region due to similarities in agro climatic conditions, and the nature of farmers. Hence, sharing of experiences for success and weakness of the innovative agricultural technology, including the experiences of cross border technology flow, provide benefits to the nations by designing applicable and acceptable broader policies at regional level that ultimately leads to the enhanced welfare of farm families.

References


Chapter 8
Innovative agricultural technologies in Sri Lanka

R.S.K. Keerthisena
Department of Agriculture, Peradeniya, Sri Lanka
keerthisenarsk@yahoo.com

Introduction
The agriculture sector contributes about 6.9% to the national GDP out of which the fisheries sector contributes around 1.3% and the livestock sector accounts for 0.6%. Over 25% of Sri Lankans are employed in the agricultural sector.

Sri Lanka’s primary food crop is rice. Rice is cultivated during two seasons. Tea is cultivated in the central highlands and is a major source of foreign exchange. Fruit, vegetables, and oilseed crops are also cultivated in the country.

Sri Lanka imports a variety of agricultural products and food, including wheat, lentils, sugar, fruit, milk, and milk products. The importation of food and beverages increased by almost 9% in 2017. Sri Lanka imports animal feed also.

Although Sri Lanka is a fertile tropical land with the potential for the cultivation and processing of a variety of crops, issues such as productivity and profitability hamper the growth of the sector, thus needing advanced technologies.

The organizations involved in agricultural research and development have been working on developing agricultural technologies to cater to the needs of the sector, and some innovative technologies/practices developed in recently are briefly presented here.

Innovative Agricultural Technologies
i) Catch Crop Cultivation in Rice-Rice Cropping: In many rice-rice systems there is at least a 2-month turnaround time between major cropping season ‘maha’ and minor cropping season ‘yala’. During this period, residual moisture is adequate for establishing a crop, and incidental rains could help to grow a 50-60 day early maturing crop, which is called as catch crop or sandwich crop. Experiments conducted in framers’ fields have shown the possibility of cultivating green gram, black gram, and cowpea to
obtain satisfactory yield with minimum resources (Jayawardena, 1986). Therefore, there is a lot of scope for cultivation of legumes in this period with minimum inputs.

Much research has been conducted to improve the technology for improving catch crop cultivation. Establishment of grain legumes 3-4 days before rice harvesting, or on the rice stubble after harvesting, without land preparation have also been tested. A total weed killer was applied immediately after seeding to control rice ratoon and weeds. Thereafter two manual weedings were found adequate. Crops were neither irrigated nor fertilized. It was found broadcast seeding was better than row seeding on rice stubble.

There have been concentrated extension efforts to popularize or establish catch crop cultivation in irrigation schemes at various occasions over the past. However, it has failed, mainly due to low yields and incomes. In recent times the extension staffs of some major irrigation schemes have again taken up the task to popularize this system.

**ii) Alternate Wetting and Drying Irrigation in Rice:** The alternate wetting and drying (AWD) irrigation for rice, developed by International Rice Research Institute (IRRI), has been tested and found to be promising. In this method, rice fields are irrigated only after a certain number of days when the ponded water disappears. With the optimal management, this technology reduces the amount of water required by about 25% without reduction in yields. A simple tool to help farmers make decisions on when to irrigate their fields makes it appropriate. They found that when field water level recedes to 15 cm below the soil surface, soil water tension in the root zone is always <10 kPa, ensuring good yield. Thus, a practical way to implement safe AWD is to monitor the depth of ponded water using a field water tube/pipe. This tube can be made of plastic pipe 30 cm long and 15 cm or more in diameter and having perforations on all sides. After transplanting, farmers would keep the field submerged for about 2 weeks to suppress weed growth. The tube is then inserted into the soil by leaving 10 cm above the soil surface. Soil inside the tube is then taken out.

**iii) Leaf Colour Chart for Fertilizer Application:** Under present system of rice cultivation, N recovery is about 30%, and as such, large amounts of applied N are lost from the system as ammonia
gas by polluting the environment. High application of N enhances the susceptibility of plants to pest and diseases, requiring farmers to use high rates of pesticides to control pests and diseases. Therefore, judicial application of nitrogen fertilizer is important to reduce nitrogen usage while reducing environmental pollutions and cost of production. Leaf color chart provides a simple tool for timely application of nitrogen fertilizers resulting in increased nitrogen fertilizer use efficiency, and the technology has been adapted to suit varying varieties and conditions in Sri Lanka. It is being promoted to farmers.

**iv) Mechanical Transplanting for Rice:** Nearly 95% of rice is established by seeding in Sri Lanka, mainly due to less labour and less cost involved. However, apart from irregular stand establishment, the most disastrous constraint in direct seeding is the invasion of weeds where excessive use of herbicides causes problems such as ground water contamination, development of herbicide-resistant weed populations, etc. Seedling broadcasting is now becoming popular since it produces better growth and high yield, but seems difficult to practice in large scale. Mechanical transplanting of rice is another feasible option which involves transplanting of young seedlings grown in a mat nursery or in seedling trays using a rice transplanter.

The self-propelled walk behind type transplanter introduced to Sri Lanka can transplant four rows at a time. It requires less labour and allows the crop to be transplanted on time while ensuring uniform plant population and better weed management. In conventional manual transplanting practice, 20-30 laborers are required to transplant one hectare. However, if a self-propelled rice transplanter is used, 2 people can transplant a hectare in a day. Mechanical transplanting can attract younger generation to rice cultivation.
through the development of custom service business. Still, this technology is associated with proper operational issues related to selection of rice varieties, raising of seedlings or nursery, preparation of land, and machine operation.

Accordingly, long or medium age rice varieties with high tillering ability and having extended vegetative growth are more suitable for mechanical transplanting. Bg 403, Bg 379-2, Bg 406, Bg 450, Bg 357, Bg 366, Bg 360, Bw 367 and At 362 rice varieties have been found to be more suitable. About 10-15 kg of good seeds are required to transplant one acre. The seeds should be pre-germinated (soaked in water for 24 hours and incubated for 24 hours) before sowing in the nursery. Optimum seeding rate for nursery to obtain healthy and vigorous seedling is 500 g m\(^{-2}\) or 125-150 g/tray. Use of a suitable seed treatment (Imidaclorprid 70% WS or Thiamethoxam 70%) is important to overcome thrips attack during the nursery period. Proper nursery management is pre-requisite for raising healthy seedlings. A mat type nursery is used for the mechanical transplanter. It can be established on a polythene sheet or on nursery trays (30 cm wide, 60 cm length). Field collected decomposed soil (should be free from plant debris or stones), or a mixture of sieved soil and compost (4:1), can be used as the nursery medium. If the nursery is established on a polythene sheet, it should be evenly perforated with tiny holes to improve drainage. A thin soil layer (1.5-2.5 cm) collected from either side of the bed should be evenly spread and levelled over the polythene. If nursery trays are used to raise the seedlings, they should be placed on the bed as two rows and the soil should be filled up to the edge uniformly. To transplant one acre, 100 seedling trays are required. The seeds should be uniformly spread over the nursery bed/seedling tray. The nursery should then be covered with a layer of banana leaves, coconut leaves, or by using polythene to avoid direct exposure to sunlight or heavy rain. They can be removed after 3-4 days once the seedlings are emerged. During the first 3-4 days, the nursery bed should be moistened at least twice a day using a water can. It can then be irrigated using flooding furrows prepared between the beds. Seedlings of 9-15 days old (15-20 cm tall) are found to be the optimum. The irrigation water should be drained 12-18 hours prior to transplanting. If the nursery is raised on a polythene sheet, mats should be cut using a sharp knife to the size fitted to the transplanter. If they need to be transported, they should be kept moist to avoid wilting.

The field should be ploughed twice, puddled, and levelled, and allowed to settle for 24-48 hours. A shallow layer of 1-2 cm of
standing water can be maintained in the field if necessary while transplanting. The within row spacing, planting depth, and per hill seedling number can be adjusted according to the requirement. Suitable within row spacings are 16 and 18 cm for 4-4½ months and 12 and 14 cm for 3½ months age rice varieties. Adjusting the planting depth for 1.5-2.5 cm (medium) and planting 4-6 seedlings/hill is identified as the optimum. Before transplanting, an area equivalent to one pass of the machine on all four sides of the field should be kept to avoid damage to already transplanted seedlings while turning the machine. The transplanting should be done parallel to the bund of the field, and every return pass should be parallel to the previous row to maintain even row distance. The four corners of the field and missing hills should be transplanted manually.

v) **Plot Consolidation:** Cost of production of rice cultivation in Sri Lanka is high compared to that of other countries in the region. Availability of labor for rice cultivation is withdrawing gradually, thus cost of labor becomes significantly high. One of the solutions is the promotion of mechanization in paddy culture. The present momentum for mechanization is substantial, but land related constrains, such as smaller plot size, remarkably reduces the efficiency and the applicability of the mechanization. However, most of the rice lands are comparatively small in many of the high potential major rice growing areas, except some rice lands in the eastern region. The consolidation of plots of smaller size into larger plots is a feasible solution to eliminate difficulties for handling of mechanical equipment. Other advantages are the increase of the land availability for cultivation by reducing the area occupied by bunds, and less labor requirement for cleaning and preparation of bunds.

It has been found that this is very feasible and economical under the present context, and consolidation is catching up fast and many organizations are promoting this.

vi) **Mini Pre-Basic (G₀) Seed Tuber Production in Potato:** Pre-basic seed tuber production of potato through
aeroponic or hydroponic repeated harvesting techniques has been developed by Department of Agriculture. The technology allows the number of tubers to be increased more than 10-fold at farmer level when compared with the conventional seed production technology.

Pest and disease-free potato meristem plants produced in the tissue culture labs and they are grown in protected houses to obtain Rooted Stem Cuttings (RSC). RSC are grown in protected houses using aeroponic or hydroponic techniques to produce potato mini pre-basic seed tubers (G₀ Seeds). Liquid fertilizer added water is sprayed directly to the root system of RSC using nozzles in the aeroponic system. Root system is covered by black polythene. Mini-tubers can be harvested at 3-4 days intervals. One plant produces 80-120 mini-tubers.

Root system of RSC is dipped in PVC pipe where circulating liquid fertilizer added water in hydroponic system. Root system is covered by black polythene. In this system, one plant produces 300-350 mini-tubers.

For curing, harvested mini-tubers must be kept on a net just above a wet floor. G₀ pre-basic potato seed tubers can be used to produce own seeds for farmers in their lands. For seed production, it is important to select suitable sites where solanacea crops were not cultivated in previous two years. Soil sterilization is carried out after preparation of 1 m width beds. Planting space is 30 cm x 15 cm and planting depth is 5 cm. Crop is hauled at 80% yellowing.

However, farmers do not have the other facilities like storage to keep the seeds till next season, or medium term storing. Therefore, the popularization of this technology has been affected. The technology must go to the farmers/seed producers as a full package.
vii) Straw Mushroom Cultivation: Straw mushroom, also known as “warm mushroom,” is a popular edible mushroom which can be successfully cultivated in tropics and subtropics. It is commercially cultivated using poly bag technique. New technology involving opening of poly bag at both ends or removing it totally after mycelium fully colonized in the bag and spraying lime after first harvest has been introduced resulting higher yields and income for mushroom farmers in Sri Lanka.

Conclusion

Several technologies have been introduced to farmers by the development agencies recently. However, their adoption is questionable. The implementation of technologies ultimately has to be considered at the farm level. The issues and challenges in adoption of technologies on wide scale could be technical, economic, and social/institutional. Technical issues include - mismatch between the prevailing technology and local needs, poor or lack of after sales services for maintenance and repairs, irregular or non-availability of energy, and limited research and development efforts in bridging the technology gaps. Economic issues are – high cost of technology, low investment capacity of farmers, lack of investment support, lack of access to market, and low returns on investment in agriculture. Social/institutional issues include small and fragmented land holdings, poor infrastructure and communication facilities in rural areas, and lack of access to technologies.

Farmers and field level staff are at the center of any process of change and need to be encouraged and guided through appropriate technologies and practices. The extension services should try to promote/transfer the technologies to farmers and field staff on
continuous basis. Capacity building of local academic/research institutions, besides farmers, is essential for development and adoption of the technologies.

Better research–extension–farmer linkage and policies to stimulate adoption of technologies that improves system operation, efficiency, crop productivity and eventually farm income are needed. Effective financing system for purchase of equipment and tools by small holder and resource poor farmers is required.

**Reference**

Chapter 9

Innovation in production and access to quality farmer training videos to support South-South learning: the case of Access Agriculture

Paul Van Mele¹,², Florent Okry³,⁶, Jonas Wanvoeke³, Nafissath Fousseni Barres³, Phil Malone¹,⁴, Jo Rodgers¹,⁴, Ahmad Salahuddin⁵, Evana Rahman⁵

¹Access Agriculture, P.O. Box 66158 code 00800 Westlands, Nairobi, Kenya paul@accessagriculture.org;
²Agro-Insight, Mgr Broekxstraat 2, 3990 Peer, Belgium
³Access Agriculture, Station IITA, Abomey-Calavi, Benin
⁴Countrywise Communications, 103 Main Road, Wilby, Northants NN8 2UB, UK
⁵Access Agriculture, IRRI, Dhaka, Bangladesh and c/o, Practical Action
⁶National University of Agriculture, Porto Novo, Benin. 041BP 13 Cotonou, Benin

Introduction

The Internet and mobile phone services have enabled farmers across developing countries to pro-actively seek information themselves. However, the key problem is little content of relevance. This paper introduces the Access Agriculture model that enables farmers’ access to training videos. The paper then elaborates on the Access Agriculture model, as one that supports South-South learning between farmers. Careful attention to content, style and format during video production results in quality videos that are eagerly used by any organisation, TV or radio station. Translated upon demand into any local language, the use of quality training videos is highly cost-effective. Five years after being established, the Access Agriculture video platform hosts over 175 farmer training videos in 75 languages for anyone to view and download for free. About 44% of the nearly 200,000 visitors to the video platform come from Africa, and 23% from Asia. The percentage of people accessing the video platform via their mobile has increased from 30% in 2016 to 42% in 2018. Farmers are the largest professional group registering to the platform to download videos, fact sheets and audio files. Small livestock, vegetable production and food processing are popular topics, appealing to rural women and youth in particular. While smallholder farmers need relevant content, this does not mean that all
training materials have to be developed locally. The growing body of evidence of cross-cultural, farmer-to-farmer learning is steadily changing this misperception. Examples are given of cost-recovery and private sector engagement in distributing, selling and showing quality videos hosted on the Access Agriculture platform. The paper ends by providing key lessons learned and challenges to support South-South learning between farmers at a scale previously unseen.

**ICT opportunities and challenges to support farmer learning**

With a changing climate, farmers across the globe are forced to experiment with new crops and cropping practices, including technologies that make better use of water and improve the soil health. The changes in farming conditions and global market dynamics have also required extension service providers to broaden their skills and form partnerships with other specialized service providers. The need to embrace information and communication technologies (ICT) to address these challenges has become even more apparent with the growing realization that extension services in developing countries reach only a small fraction of the farmers. Countries in Asia have the largest extension systems in the world. For example, China has more than 610,000 extension workers, while India has more than 90,000 extension workers (Swanson & Davis, 2014). Nevertheless, given the sheer number of farmers, the ratio of public extension worker to farmers is very low. For instance, across India there is on average only one extension officer per 12,000 farmers (Sulaiman, 2012).

Despite the increasing feminisation of agriculture and their crucial roles in food production and processing, rural women have remained deprived of extension services (Paris et al., 2005; Jafry & Sulaiman, 2013). Rural women want to learn about agriculture, even those who are not directly involved in it. In a study covering three villages in northern Bangladesh, hardly any of the young rural women were involved in agriculture, but nearly all respondents (87%) said they needed agricultural information, followed by information on animal husbandry (83%), food and nutrition (75%), health (75%) and education (58%). Very few required information on obtaining loans (17%), or on weather and entertainment (8%) (Hossain & Islam, 2012). A recent survey among women farmers in Karnataka showed that the majority wanted information on crop varieties (84%) and crop health.
(69%), while only 11% were interested in information on where to sell their produce (Govil & Rana, 2017).

Developments in ICT are providing opportunities to reduce transaction costs of farmers and other value chain actors in acquiring and sharing farming knowledge, getting daily updates on market prices and weather forecasts, as well as making safer and faster money transfers. The pace at which mobile phones and mobile broadband use has grown in developing countries, has not yet been fully valorised for agricultural sector development.

By the end of 2013, 3.4 billion people across the world had a mobile phone, which is just under half of the global population. Apart from using mobiles to talk to friends and family, and listen to the radio, mobile money transfer systems soon emerged in countries where the need and potential were highest. While sub-Saharan Africa has long been the epicentre of mobile money, by 2017 South Asia was the fastest growing sector, representing 34% of the 690 million mobile money accounts registered globally (GSMA, 2018a). Scale was a critical factor for mobile money providers to achieve profitability. However, as providing agricultural advice is much more intricate, successes with ICT have been more variable and at much smaller scales.

Many agricultural service providers desperately lack suitable content to train their farmers (Van Mele, 2013). In a lead article in the Boston Review on the role of information and communication technology in global development called “Can Technology End Poverty?” Kentaro Toyama (2010) states that ICT technologies are only as useful as the content they carry and the intent and skills of the people using them. India has more than twenty nationally recognised languages, yet most software is in English, making it difficult for those literate only in their local languages to use computers. Rural telecenters connected to the Internet are often mainly used by young men playing games, watching movies, or consuming adult content. Few people use ICT for self-improvement, which can be attributed to historical circumstances, social structures, and the rich world’s unwillingness to invest in high-quality, universal education (Toyama, 2010).

Lower literacy rates of rural women and other gender-based restrictions have also limited the effectiveness of ICTs. In Africa, women who use their mobile phone to exchange information on farm and agricultural products may end up having marital problems, due
to suspicions of infidelity by their husbands (FAO, 2018). It is argued that radio is much more accessible to women as they can listen to it while doing chores, but local radio stations are mainly owned by men, the radio broadcasters are men, and the topics are chosen by men (FAO, 2018).

The number of mobile broadband connections grew tenfold from just over 200 million in 2008 to well over two billion by 2013 (GSMA, 2014). In Egypt and various other Arab countries, only about 25% of women had smart phones compared to some 75% of all men (Broadband Commission for Digital Development, 2013). In sub-Saharan Africa, there are twice as many men as women on the internet. If women fail to go online, they will miss out on opportunities of accessing information, earning more income, starting a new business and forging new contacts. Apart from China, where mobile internet use by women and men were about the same, at slightly over 70%, in most countries use by women was much lower. The gender gap was largest in South Asia. In India, 26% of men and only 8% of women used mobile internet (GSMA, 2018b). Out of the different ICT initiatives in India, only community radio and rural knowledge centres were found to have an agenda and a mechanism for addressing the locally relevant information needs of rural women (Sulaiman et al., 2011).

Currently, most mobile services for agricultural advice are based on SMS and voice-based messaging (GSMA, 2017). A recent review on how farmers in India and elsewhere have benefitted from mobile phones indicates that they have done so through improvements in production planning, use of inputs, management of weather-related risks, and greater ease in receiving money, but improvements in agricultural knowledge overall varied greatly between initiatives (Baumüller, 2018). The Lifelong Learning for Farmers initiative by the The Commonwealth of Learning (COL) disseminated recorded training modules to female livestock producers via mobile phones in India. The women found it useful and more convenient than face-to-face training because they could access the recordings at a time and place that suited them (Balasubramanian et al., 2010).

As smart phones get cheaper and mobile broadband penetration increases in rural areas, more options for delivering multi-media content are opening up. While new apps with video content won’t plough the fields, videos engage the youth in farming and help them
do a better job (Saravanan & Suchiradipta, 2015). In Karnataka, India, 66% of the women surveyed preferred receiving agricultural information through television, so various initiatives have started to screen short videos to disseminate information on agricultural activities among women farmers (Govil & Rana, 2017). Audio-visual learning tools also help extension service providers expand from mere provision of advice to facilitating group formation, addressing community conflicts and establishing linkages to other services (Zossou et al., 2010). A study covering over 500 extension service providers across the South indicated that most (82%) public and private service providers wanted a new web-based platform devoted to agricultural training videos. Youtube did not do the job as there was too much irrelevant content (Van Mele, 2011). In what follows, we describe what makes content relevant, and zoom in on Access Agriculture as an enabler of South-South learning between farmers.

**Relevance of content**

Initial enthusiasm of the potential of ICT to support agricultural advisory services quickly led to insights that there was not sufficient content of relevance to farmers. In 2004, the e-Sagu project in India recruited agricultural experts to give generic pre-existing scientific advice over the internet to help cotton farmers trapped in “the pesticide treadmill” to fight the cotton bollworm. After four years the project realised that farmers are experts in farming and that scientists excel in doing research, but not in farming (Stone, 2011).

When women overcome the various barriers to get connected to the internet, they may find content and services that are not as relevant to their lives. In addition to reliable, affordable and fast access, the Broadband Commission for Digital Development (2013) concluded that access to content relevant to specific contexts and languages is critical. The need for local language content has also been stressed by scholars: “Digital content initiatives are founded on the understanding that connectivity will be meaningless for the world’s poorest people who will find very little information of relevance to their lives and almost nothing in their own language in the absence of a complementary investment in digital content creation” (Scarf, 2012).

Glendenning & Ficarelli (2012) state that the extent to which content is customised and localised to a farmer’s condition influences its relevance. Yet a narrow interpretation may lead one to assume that
farmers only learn from peers in their immediate locality. Being aware of the pitfalls of a narrow interpretation of local content, the authors rightly continue saying that “local content includes external or global content that has been transformed, adapted, and assimilated”. Pinning down local content to a narrow geographical interpretation would indeed not do justice to the ingenuity and creativity of farmers to adapt ideas from elsewhere to their own context. Relevance also means the extent to which farmers can apply the information to fit their own resource situation (Sulaiman et al., 2012).

The debate on relevance of content is an important one, as it underlies the core concept of South-South learning. The many experiences from partners of Access Agriculture have shown how farmers eagerly learn through video from their fellow farmers across the South as long as they relate to the topic (Bentley et al., 2016a). To increase the local relevance of “global content” one needs to consider various dimensions, such as:

- Farmers learn best by listening to and watching other farmers facing similar challenges;
- Farmers like to see how things are done, so having good visual images matter;
- The more examples that are presented on a specific topic, the more it may inspire farmers;
- Farmers learn and adapt ideas to local conditions better if sufficient background information is given as to why things work in a particular way, not just how things are done; and
- Videos have more impact when translated in the local language.

Inspired by experiences with videos for rural women in Bangladesh (Van Mele et al., 2005a; Van Mele et al., 2005b), Access Agriculture emerged as a development organisation over the past decade that focused on farmer training videos in local languages.

**Access Agriculture approach**

Developing quality farmer training videos requires specialised skills. While farmers are expert in farming, they are all very busy people and instilling video production skills in farmers is not a sustainable investment. It is better to instill these skills in organizations with a clear mandate to train farmers.
Access Agriculture’s philosophy and model are to train local partners to produce well-researched, scripted farmer training videos in international languages (either English or French, and occasionally in Spanish). The videos are locally appropriate and regionally relevant because they are based on discovery learning principles, much like in farmer field schools, and merge scientific and local knowledge (Van Mele, 2006, 2010). Videos are seen as a tool to support South-South learning between farmers, to stimulate farmer experimentation, trigger social innovations (Bentley et al., 2017) and give farmers confidence to seek out additional advice and services (Chowdhury et al., 2011; Zossou et al., 2012).

Table 9.1 Production model of farmer-to-farmer training videos

<table>
<thead>
<tr>
<th>Access Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video production</td>
</tr>
<tr>
<td>Following the zooming-in, zooming-out approach, topics are identified based on farmers’ learning needs</td>
</tr>
<tr>
<td>Trained partners use a simple fact sheet to test their ideas with farmers before writing a script</td>
</tr>
<tr>
<td>Script is modified by engaging with farmers during video production</td>
</tr>
<tr>
<td>Video format</td>
</tr>
<tr>
<td>Structured with introduction, main learning part and recap session</td>
</tr>
<tr>
<td>Voice over interspersed with farmer interviews</td>
</tr>
<tr>
<td>Length of video</td>
</tr>
<tr>
<td>8-15 minutes; average 12 minutes</td>
</tr>
<tr>
<td>Learning</td>
</tr>
<tr>
<td>Principles of “how to do” are complemented by “why things are done in a particular way in a particular context”</td>
</tr>
<tr>
<td>Attention to discovery learning encourages farmers to experiment and adapt the learning to their conditions</td>
</tr>
<tr>
<td>Farmers</td>
</tr>
<tr>
<td>Each video features various farmers, men and women, and presents multiple options, practices and ideas, including local innovations</td>
</tr>
<tr>
<td>Quality control of content</td>
</tr>
<tr>
<td>Farmers validate ideas before and during video production, while script is shared with various local and international specialists</td>
</tr>
<tr>
<td>Localisation of content</td>
</tr>
<tr>
<td>As the focus is on learning, farmers adapt content to their own context</td>
</tr>
<tr>
<td>Local language translations help to localise content</td>
</tr>
</tbody>
</table>

Source: Van Mele, 2011
Videos made according to the Access Agriculture model are meant to allow wider geographical spread. Videos are translated into local languages based upon demand, and fully costed, ensuring that whoever pays for a translation will play a vital role in distributing and using the videos. Although quality videos may be of interest to a wide range of traditional and non-traditional services providers (Van Mele et al., 2016; Zoundji et al., 2016), the distribution and monitoring in a hands-off, open access mode comes with its own challenges.

Table 9.2 Delivery model of farmer-to-farmer training videos

<table>
<thead>
<tr>
<th>Access Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Translation</strong></td>
</tr>
<tr>
<td>Final scripts serve as basis to translate videos in any language requested by clients.</td>
</tr>
<tr>
<td>Translations and voice recordings involve trained local extension and media professionals</td>
</tr>
<tr>
<td><strong>Storing and retrieval</strong></td>
</tr>
<tr>
<td>Videos are hosted on a mobile-enabled video platform, and are searchable by category, topic and language</td>
</tr>
<tr>
<td>All videos are freely downloadable by farmers, entrepreneurs and extension service providers</td>
</tr>
<tr>
<td><strong>Distribution</strong></td>
</tr>
<tr>
<td>Any service provider can distribute or sell videos on DVD, USB sticks, memory cards and via blue tooth from mobile to mobile</td>
</tr>
<tr>
<td><strong>Screening</strong></td>
</tr>
<tr>
<td>Service providers use their own devices to screen videos in villages</td>
</tr>
<tr>
<td>Specially designed smart projectors (solar powered) allow service providers to screen any video hosted on the Access Agriculture video platform in any of the 75 languages available without being connected to the grid and internet</td>
</tr>
<tr>
<td>Because TV stations appreciate the quality of the videos, they broadcast the videos at no cost</td>
</tr>
<tr>
<td><strong>Facilitation</strong></td>
</tr>
<tr>
<td>Videos are made as such that they can be watched without the need for facilitation</td>
</tr>
<tr>
<td><strong>Monitoring</strong></td>
</tr>
<tr>
<td>Using Mergdata a tailor-made, cloud-based monitoring app is made available for clients interested in monitoring</td>
</tr>
<tr>
<td><strong>Farmers pay for service</strong></td>
</tr>
<tr>
<td>Farmers want to have their own DVDs or videos copied onto their mobile phones, for which they pay rural entrepreneurs</td>
</tr>
</tbody>
</table>

Source: Van Mele, 2011;
As the focus of this paper is on video as a tool to support South-South learning, in what follows we will further elaborate on the Access Agriculture model.

**Access Agriculture: a global enabler of South-South learning**

*i) Building local capacities to produce quality farmer training videos*

The international NGO Access Agriculture was established in 2012 and has since trained 20 local organisations across Africa and South Asia to produce quality farmer-to-farmer training videos. All have been fully equipped and many of the organisations continue to produce quality content with the backing of Access Agriculture. Other research and development organisations have engaged professional video companies to produce farmer training videos to the Access Agriculture standards. In Bangladesh, Access Agriculture trained CCDB, Agricultural Information Services (AIS), and Practical Action Bangladesh teams. Practical Action Nepal team was also trained. In India, Access Agriculture trained MSSRF in Tamil Nadu and WOTR in Maharashtra. MSSRF continues to produce videos in English and Tamil on major plant health problems. One of the trained video partners, Atul Pagar, left WOTR to set up his own business focusing on the production of quality training videos for farmers. For technical expertise he collaborates with local subject matter specialists, including experts on ethno-veterinary medicine from Anthra. Some of the experiences of partners to produce and use farmer training videos in agricultural extension and higher education are captured in the captivating story book “A Passion for Video” (Bentley et al., 2016a).

*ii) Major partners in south Asia*

Working through partnership is one of the core strategies of Access Agriculture. Partnership is formed for different purposes. One of the reasons, as stated in the previous section, is to develop capacity of a smaller number of organizations in strategic countries for quality farmer to farmer video production. With the second group of partners, Access Agriculture aims to work with to reach to many hundreds and thousands of farmers across southern countries. The third group of partners is world leader agencies in research, extension, education, communication, business, development and grants. In south Asia alone Access Agriculture has 22 partners, 14 in
Bangladesh, 7 in India and one in Pakistan. Among these, four of the partners are already producing farmer to farmer videos and the rest are expected to mainly disseminate the videos to as many as farmers they can reach in their projects and programs.

**iii) A video platform with a global perspective**

Based on the demand of the global extension community (Van Mele, 2011), in 2013 the Access Agriculture video platform was created. By 2018, over 175 quality training videos are available in some 75 languages for anyone to view and download for free.

Technically, the video platform uses an interface built within Drupal\(^1\) for uploading and managing the videos on the platform, utilising various services from Amazon Web Services (AWS) to transcode, host and stream the media content. Video content is uploaded via the Drupal CMS, in the process also creating a Drupal node which is used to house and display the video content throughout the website. The Drupal node contains various options for categorising and tagging the content, uploading accompanying files and scripts, creating multiple language versions of an upload and more. Video files uploaded via Drupal are pushed to AWS where they are passed through AWS’ Elastic Transcoder Service (ETS). The ETS takes the uploaded video and converts it into multiple video files of different formats and qualities. This provides a range of different formatted files for display on different browsers and devices, while the different video quality versions give us smaller and larger file versions of each video to use depending on the viewing user’s connection type and speed.

By June 2018, five years after it being established, the platform has attracted 165,000 people, mostly from Africa and Asia, from thousands of development organisations and education institutes. Thirty-five countries each have over 1,000 visitors, who appreciate the site’s easy search function, the quality and relevance of the videos.

Although the bulk of videos have been produced in Africa, the overview in Table 9.3 shows the global interest. Despite the few activities undertaken in South Asia so far, already the region is among the three top areas where visitors to the Access Agriculture video platform came from. Visitors from Latin America have been limited, because relatively few people speak English. The Spanish interface of

\(^{1}\) Drupal is a free and open source platform for web content management, written in Hypertext Preprocessor (PHP), a server-side scripting language designed for web development.
the platform was launched only in June 2018, so the platform will increasingly attract visitors from Spanish-speaking countries in the coming years.

Table 9.3. Number of visitors to the Access Agriculture video platform (n = 165,000 June 27, 2018)

<table>
<thead>
<tr>
<th>Region</th>
<th>Visitors (n)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Africa</td>
<td>31,100</td>
<td>18.7%</td>
</tr>
<tr>
<td>Western Africa</td>
<td>28,500</td>
<td>17.2%</td>
</tr>
<tr>
<td>Southern Asia</td>
<td>25,500</td>
<td>15.4%</td>
</tr>
<tr>
<td>Western Europe</td>
<td>21,500</td>
<td>13.0%</td>
</tr>
<tr>
<td>Northern America</td>
<td>16,300</td>
<td>9.8%</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>7,600</td>
<td>4.6%</td>
</tr>
<tr>
<td>Central Africa</td>
<td>5,300</td>
<td>3.3%</td>
</tr>
<tr>
<td>Northern Africa</td>
<td>5,200</td>
<td>3.2%</td>
</tr>
<tr>
<td>Western Asia</td>
<td>3,300</td>
<td>2.0%</td>
</tr>
<tr>
<td>South America</td>
<td>3,200</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

In Table 9.4, an overview is given of how the platform has attracted visitors from India. More than 50% of the visitors came from Maharashtra, Tamil Nadu, Delhi, Karnataka and Telangana. The states that attracted the highest number of visitors to the Access Agriculture platforms correspond to a great extent to those states having the highest mobile broadband registrations. By February 2018, India had 392 million broadband subscribers, of which 43% were rural subscribers. About 95% of all subscriptions were on mobile devices (phones and dongles) (TRAI, 2018). Sensitising people about the video platform is crucial. A short description of Access Agriculture was posted on the Vikaspedia.org, the Indian Government’s official portal, and both WOTR and MSSRF have regularly shared video linkages via their social media. Most people find Access Agriculture videos via an organic search using Google. As only a few farmer training videos have been translated into Bangla which is a language that covers both India and Bangladesh (69), Hindi (53), Marathi (9), Tamil (17), and Kannada (1), we expect the number of visitors to continue to rise as the numbers of translated videos increase.
Table 9.4 Number of visitors to the Access Agriculture video platform in the top 10 States of India. Total number of visitors across India is 18,300 (June 27, 2018)

<table>
<thead>
<tr>
<th></th>
<th>Number of Visitors</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Maharashtra</td>
<td>4,000</td>
</tr>
<tr>
<td>2.</td>
<td>Tamil Nadu</td>
<td>2,500</td>
</tr>
<tr>
<td>3.</td>
<td>Delhi</td>
<td>2,200</td>
</tr>
<tr>
<td>4.</td>
<td>Karnataka</td>
<td>2,100</td>
</tr>
<tr>
<td>5.</td>
<td>Telangana</td>
<td>1,300</td>
</tr>
<tr>
<td>6.</td>
<td>Gujarat</td>
<td>900</td>
</tr>
<tr>
<td>7.</td>
<td>Uttar Pradesh</td>
<td>700</td>
</tr>
<tr>
<td>8.</td>
<td>West Bengal</td>
<td>600</td>
</tr>
<tr>
<td>9.</td>
<td>Madhya Pradesh</td>
<td>600</td>
</tr>
<tr>
<td>10.</td>
<td>Kerala</td>
<td>600</td>
</tr>
</tbody>
</table>

Globally, most people still access the video platform from a computer, but the proportion of people accessing it via their mobile has increased from 30% in 2016 to 42% in 2018. The majority (71%) of these use an android system, with fewer people (16%) using iOS. Given that the Access Agriculture video platform is fully mobile enabled and that mobile broadband subscriptions in rural areas rapidly increase, we expect this trend to continue.

Anyone can watch the farmer training videos online, but to download them a registration is requested. This is free of charge. By May 2018 about 7,000 people had registered to the platform: about 1,000 people from Kenya, 800 from Benin, 600 from Nigeria, 400 from Uganda, 300 from India, between 200 to 250 each from Ethiopia, Ghana, Mali, Burkina Faso, Côte d’Ivoire and Cameroon, and 150 people each from Bangladesh, Senegal, Togo, Tanzania and Malawi.

iv) Farmers use of the video platform

With growing investments in ICT technologies and infrastructure (such as rural learning centres) farmers have started to pro-actively seek information themselves. Since 2017, farmers have become the largest professional group registering to use the Access Agriculture video platform. Of the 1,500 farmers who have registered, 20% are members of a farmers’ organisation.
Asked how they learned about the Access Agriculture platform most farmers (49%) said from the Internet, followed by friends (10%), social media (9%) and training centres (7%) (Bentley et al., 2018).

Vegetables were by far the favourite topic, favoured by 57% of users (respondents could select more than one category). This may be explained by the fact that small-scale farmers are nowadays devoting a large part of their limited resources to highly productive crops like vegetables. This is also a response to an increased demand for healthy vegetables in the cities of developing countries. Small livestock and food processing are also popular topics, appealing to rural women and youth in particular.

About 72% of the registered farmers watched or downloaded videos on a computer (most likely in a rural learning centre), and 43% on a smart phone. Over half of the respondents (57%) downloaded the videos to watch later, which suggests that some farmers have a good enough internet connection for downloading and that farmers are interested to have their own copies of videos that are of interest to them. Half (53%) watched the videos on the site. Slightly more farmers share the actual videos (36%) than the links (27%), but they were able to forward video links to their friends (Bentley et al., 2018).

v) Farmers are willing to pay for quality services

Sulaiman (2012) refers to an earlier study from 2000, wherein 48% of farmers in three states of India expressed willingness to pay for agricultural information. Farmers as a group were also willing to share the costs for bringing expert advice. The willingness to pay was more for services in non-food grain crops, especially fruits, vegetables, flowers, spices and oilseeds. Sulaiman observed that pay-worthy services are generally absent in India and that there is an urgent need to create quality services to meet the increasing demand.

Farmers need a range of support that improves their capacity to access, adapt and use knowledge, inputs and services. This includes building farmers’ capacities to seek relevant information on market prices, as well as new farming enterprises and technologies. Experiences from West Africa show that individual farmers paid for training videos on high value commodities (Zoundji et al., 2016), but also for videos on food security crops (Zoundji et al., 2018b). Forty-one percent of those who bought the DVD on vegetable production borrowed DVD players from friends or family to watch the 9 videos contained on the DVD. About 20% even bought a DVD player to be
able to watch the videos. About 64% wanted to know where they could get more videos (Zoundji et al., 2016).

**vi) Commercial distribution of farmer training videos**

Farmers never rely on a single source of information and learn through multiple means. The Access Agriculture model is based on the assumption that numerous public and private rural service providers are interested to make use of freely available quality farmer training videos. Tapping into existing social networks and allowing the private sector to earn a little money for making videos available to farmers is part of this model.

Van Mele et al. (2016) present a diverse range of experiences of how farmer-to-farmer training videos have been distributed or sold. Experiences from five countries in Africa and South Asia show that volunteer service providers helped farmers to access training videos, because the content was relevant, of good quality and the videos were in the enlightened self-interest of the farmer and the agency.

In Malawi, more than 10 private TV stations have emerged over the past decade. The government renews their annual licenses upon proof that they broadcast at least 70% local content. By 2018, over 40 videos from the Access Agriculture video platform have been translated into Malawian languages (Chichewa, Tumbuka, Sena and Yao) and local language videos are considered as local content. Already 5 TV stations in Malawi signed contracts with Access Agriculture to receive packages of broadcast quality, local language videos and broadcast them for free.

Young people who are already running ICT services in rural areas are well-placed to expand their services to include agriculture. In many towns and villages of Malawi, young men who call themselves “DJs” have set up small digital entertainment businesses. They copy movies and music videos onto their computers, convert them to mobile phone format and then install videos onto the phones (10 US$ ones, not smart phones) of rural persons. When supplied with farmer-to-farmer training videos in local languages, half of the DJs sold the videos. Other DJs distributed the videos out of a sense of community service, or as a way of attracting and retaining customers. The videos helped to build community respect for entrepreneurs offering entertainment and ICT services. In a trial in southern Malawi, Access Agriculture gave 95 DJs three DVDs on rice, chilli and managing the parasitic weed striga. Apart from one video, all 30 farmer-to-farmer training
videos compiled on these DVDs were made in other parts of Africa and Asia and translated into local languages of Malawi. Some DJs copied the DVDs and sold them between 30 and 70 US dollar cents depending on whether people brought their own empty DVD or not. The majority copied the converted videos on memory cards, USB flash drives or directly onto people’s mobile phone, charging between 5 and 20 US dollar cents per video (Bentley et al., 2016b).

In Benin, most community radios distributed farmer-to-farmer training videos free of charge, whereas commercial radio stations developed persuasive advertisements and sold most of the videos to farmers and extension services, suggesting that farmers are eager to invest in acquiring knowledge (Okry et al., 2014). In another experiment in Benin, agro-dealers and mobile video vendors selling entertainment videos quickly sold out their over 700 DVDs with farmer-to-farmer training videos. Sales of learning videos through commercial channels reached more serious users, increased farmers’ self-determination for learning and farmers were more motivated to provide feedback than viewers who received DVDs for free via projects, NGOs or farmer organisations (Zoundji et al., 2016). While 86% reduced their expenses for pesticides after watching the videos, 56% started putting insect nets over their seedbeds and 18% invested in a drip irrigation kit (Zoundji et al., 2018a).

In southern Bangladesh, CIMMYT distributed DVDs and engaged a local service provider to screen a farmer training video on conservation agriculture. Each occupational group acted differently. Shop keepers, tillage service providers, agricultural input and machine dealers reached fairly small audiences. Tea stall owners had large, male audiences. Non-governmental organisations and community-based organisations, reached more women. The cable TV (dish-line) operators showed the videos on local TV, but broadcasting for free is more likely to happen when training videos are given to the cable TV manager by a community-based organisation rather than by a project. The Union Information Service Centres showed the videos and reached women viewers. Half of the official government extension agents surveyed also showed the videos publicly (Bentley et al., 2015).

In Tamil Nadu, MSSRF has started sharing videos through their plant clinics, village knowledge centres, village resource centres and farm schools. Given the cultural context, MSSRF has progressively
encouraged women to take an active part in agriculture by providing them relevant content and appropriate tools to access, such as the Access Agriculture video platform. MSSRF also started sharing with community radio stations the downloadable Tamil audio files from the Access Agriculture video platform. As more videos become available on pest management, this creates opportunities to sell DVDs through community plant health clinics across India and other countries in the South.

The need to be self-supporting has often forced rural telecentres to drop their initial objective of supporting socio-economic development and social inclusion, in favour of selling goods and services (Gurumurthy, 2006). Successful telecentres have found ways to generate some revenue by diversifying their services. They are well positioned to sell DVDs with farmer training videos in local languages, copy videos onto farmers’ mobiles or organise public screenings at a modest fee.

While farmers are willing to buy training videos on DVD, memory cards or USB flash drives, asking them to pay to watch videos can be a little more complicated. For systematically screening quality videos to farmer groups and cooperatives it may make more sense for farmers to contribute to such service through their annual membership fee. Companies and cooperatives can also screen videos as a way to build loyalty among their members. The Indian company Govind Milk and Milk Products in Maharashtra used the hydroponic fodder video in about 50 of their farmer training programmes, reaching around 1000 farmers. The link to the Marathi language version of this video on the Access Agriculture video platform was further shared with the Facebook group ‘Govind Dairy Innovative farmer Group’ which has around 4,000 farmers.

In northern Uganda, with large displaced populations from years of civil war, the Gulu Agricultural Development Company (GADC) received DVDs on chilli, sesame and various other crops from Mercy Corps. The DVDs contained over 40 videos made in different countries by different organisations. The videos were translated into the local language (Luo) and compiled by Access Agriculture. After witnessing the power of these videos, GADC decided to buy an Access Agriculture smart projector to reach large groups of people in areas where there is no electricity. From January 2016 to May 2018, with only few field agents GADC reached over 80,000 people, of which 46% were women. The company does not charge farmers to
watch videos, but invested itself in organising video events because it had a vested interest. Within a very short time the company was able to mobilise farmers, build their capacities (e.g. none of the farmers had ever grown chillies before) and gain their trust to grow organic crops for export markets.

vii) Impact of videos on smallholder farmers

In Bangladesh, video-mediated group learning enhanced women’s knowledge about seed health to a level that about 95% of the women who had watched a series of videos on rice seed health answered all 10 knowledge statements correctly, significantly better than the control group. Adoption was 24% for the tedious practice of manual seed sorting and 99% for improved storage (Van Mele et al., 2007). A follow up study revealed that women who watched these videos had a 15% increase in rice yields, with no changes in control villages (Chowdhury et al., 2011). Video viewing in the communities also stimulated reciprocal sharing of new knowledge and skills between them, other farmers and service providers.

A similar positive effect on social learning was found in Mali where over 70% of those who watched farmer-to-farmer training videos on striga and improved soil fertility gained confidence to interact with extension workers (Zoundji et al., 2018b). More than 95% of farmers applied climate-smart technologies, such as intercropping, crop diversification, improved short-cycle varieties, and soil and water conservation and as a result, sorghum, millet and maize yields increased by 14%, 30% and 15% respectively. About 60% of those who watched the videos, mainly women, started to do cost-benefit analysis to run their farm and household, while 30% of farmers began to engage with village saving and loan associations (Zoundji et al., 2018b).

In Benin, after watching a series of videos on vegetable cultivation 73% of the respondents said they can now recognise nematodes and control them, while 86% said they spent less money on pesticides. Adoption of non-chemical practices increased significantly, with 92% of farmers rotating their crops, 97% starting to use compost and 56% using insect nets over their seedbed (Zoundji et al., 2018a).

An on-line survey targeting farmers who registered to the Access Agriculture video platform, indicated that videos helped 40% of the respondent farmers to improve their crop yields, 29% to improve their pest management, 26% their soil, and 24% to care for animals. One in
five said they used less chemicals, used less irrigation water and had more confidence to contact an extension worker after having watched training videos, among other impacts (Bentley et al., 2018).

**viii) Key learnings and challenges**

Quality farmer-to-farmer training videos made according to the Access Agriculture model allow farmers to learn from their peers across the South. While early experiences in Benin show that farmers do learn from videos in foreign languages, the level of learning improves by having either outside facilitation (Bentley et al., 2014) or by watching videos in a group so that farmers can exchange between themselves (Okry et al., 2014). However, videos in local languages allow farmers to be more pro-active in deciding when and how to watch which videos, as facilitation by an outside agency or group membership is no longer crucial. That is assuming farmers are able to access the videos.

Enabling farmers’ access or last mile delivery is a challenge. Access Agriculture uses multiple video formats and aims to motivate the global community of already established local service providers to distribute and use the videos at their own will and effort. In collaboration with a private company, the Access Agriculture smart projector is marketed among the development community to allow community-based organizations and rural service providers to screen any of the videos on the platform in any language off the grid and off the internet.

Access Agriculture also aims to enable farmers to directly access the videos without needing an intermediary. Translating the interface of the open access video platform in Hindi, Bangla and Arabic are some of the targets set by Access Agriculture in order to enable a broader access by farmers directly.

In a global survey conducted in 2015, three-quarters of the respondents (n = 612) had no suggestions for improving the website. There are complaints from different parts of the world about the difficulty of downloading videos (5%). However, Access Agriculture is conscious of the fact that internet is not available everywhere and that farmers who have access are data conscious. Having made the video platform mobile-enabled and videos downloadable in compressed format for mobile viewing was a first step in that direction. Access Agriculture, in collaboration with a private company, will launch an app to allow people to tap into the Access
Agriculture video platform to download and share videos with limited data consumption and occasional internet access. This will be a game changer in South-South learning, as it will no longer be up to service providers or projects to decide what is relevant for their farmers.

Access Agriculture’s focus on quality videos has made a real difference in international development, attracting thousands of individuals, organizations and companies to make use of its global resource platform. To strengthen social inclusion, all videos hosted on the platform have a pro-poor focus. As direct access through the internet and mobile phones may favour certain sections of the community, Access Agriculture also strives to establish partnerships with organizations that target women in particular.

Youth are ICT-savvy and farmer-to-farmer training videos have inspired youth across the South to either take up agriculture for a living or to play a role in agricultural advisory service delivery.

While quality videos continue to be added to the platform and delivery channels and tools have been established, a remaining challenge is to convince organizations and companies to invest in translating already available training videos. Apart from a lingering (and luckily eroding) disbelief that videos have to be made locally to be of local relevance, many organizations operate in a project mindset and are encouraged by donors to attribute all achievements to their investments. This makes people less prone to use what is already available. While this may be all right for printed materials, great cost-savings can be made by simply investing in translating already available training videos. Organizations and companies that operate within a narrow commodity-focused outlook are at times hard to convince to take a livelihood perspective in building the capacities of rural communities.

**Conclusion**

Access Agriculture videos are like innovation hubs containing stories of the farmers from all around the world. Different farmer practices and experiences are being documented as farmer innovations and are made available to other farmers across continents. When they are being translated into local languages of new countries to match to the local cultures they are becoming strong innovation tools for the new groups of people. Continuous inclusion of new videos and new translations can make this more dynamic.
Videos made along the Access Agriculture model are learning-centred and encourage farmers to experiment and adapt ideas to their own context, making these videos more suitable for South-South learning. Access Agriculture is a global service provider that encourages any organization or company to make use of available quality farmer training videos in international and local languages. Existing rural service providers, such as rural radio stations, TV stations, rural knowledge centres, village DJs and cooperatives (among others) have shown, distributed or sold quality farmer training videos hosted on the Access Agriculture video platform. Youth entrepreneurs are ICT-savvy and start to see business opportunities in making farmer training videos available to farmers in the format farmers want. The vested self-interest of rural entrepreneurs is a key driver for continued use.

Increased competition between mobile and financial service providers to draw in and retain millions of rural customers will soon turn them towards exploring multimedia to provide agricultural information and knowledge. It will be a key advantage to have video content of high quality and in sufficient number and in many languages, including local ones.

Commercial models underpin the long-term sustainability of any service. Given the increased penetration of mobile broadband in rural areas and the decreasing cost of smart phones, innovative business models combining quality content providers and mobile service providers will help to reach the millions of smallholder farmers, men and women, and to engage youth in agriculture.

Acknowledgements

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Note

A slightly different version was originally published as:


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Brief Report: Regional Expert Consultation Meeting

“Formulation of Enabling Policy Recommendations and Project Concept for Popularization of Innovative Agricultural Technologies in South Asia

Regional Expert Consultation meeting on “Formulation of Enabling Policy Recommendations and Project Concept for Popularization of Innovative Agricultural Technologies in South Asia” was conducted at Galadari Hotel, Colombo, Sri Lanka on 28-31 October, 2018. The meeting was jointly organized by the SAARC Agriculture Centre (SAC), Dhaka, Bangladesh and Institute of Policy Studies (IPS) of Sri Lanka supported by Winrock International and Access Agriculture.

The objectives:

a. To identify innovative agricultural technologies
b. To review the policy initiatives and business models for popularization and commercialization of small and medium scale agricultural technologies and innovative technologies
c. To prepare a project proposal and plan of action for establishing of SAARC Innovation Platform

The consultation meeting was divided into three sessions: (1) inaugural, (2) technical, and (3) group work for recommendations.

Inaugural session

Inaugural Session was started at 9:00 am in the conference room of Hotel Galadari on 28 October 2018 with the traditional lamp lighting. Mr. William Sparks of Winrock International presided over the session. Welcome address was delivered by Ms. Kanchana Wickramasinghe, Research Economist, IPS, Sri Lanka. Dr. Amitha Benthota, country coordinator, International Rice Research Institute (IRRI) and Former Director Rice Research Institute, Sri Lanka graced the occasion as Chief Guest. A presentation on innovative technologies was delivered by Dr. Ahmad Salahuddin, Consultant, Access Agriculture. Dr. Nasreen Sultana, Senior Program Specialist (Horticulture), delivered the inaugural speech on behalf of SAC and Ms. Nimesha Dissanayake, Research Assistant, IPS made the vote of thanks. Dr. Spark provided an overview of innovation platform formulation process. The whole program was coordinated by Fatema Nasrin Jahan, Senior Program Officer, SAC, Dhaka.
Technical Session

The first technical session was chaired by the consultant Dr. Punya Prasad Regmi, Adjunct Professor, Agriculture and Forestry University (AFU), Nepal. In this session, three country papers were presented by the focal persons of Afghanistan, Bangladesh and Bhutan. The first country paper was presented by Mr. Sabawoon Chakhansuri, Acting Director of Statistics and Information System, Ministry of Agriculture, Irrigation and Livestock Kabul, Afghanistan followed by the presentation made by Mr. Abdul Jalil Deputy Chief (Policy Planning), Planning, Project Implementation, ICT wing, DAE, Dhaka, Bangladesh and Mr. Ngawang Ngawang, Program Director, Agriculture Research & Development Center (ARDC), Sarpang, South Bhutan. After each presentation, participants took part in open discussion on the topic.

The second technical session was held after lunch. Dr. Govinda Prasad Sharma, Joint Secretary, Ministry of Agriculture and Livestock Department, Nepal and Dr. RSK Keerthisena Assistant Director General of Agriculture (Research), Department of Agriculture Peradeniya, Sri Lanka presented their country papers sequentially.

In the third technical session, on 30 October, 2018, Dr. Regmi made the presentation on behalf of Maldives, India, and Pakistan. Mr. Gasith Mohamed Agriculture Officer, Fisheries Management Section, Ministry of Fisheries and Agriculture had sent a country paper for Maldives. Dr. Regmi, also presented some promising agro-technologies from India and Pakistan during his consolidated presentation on innovative agro-technologies in eight SAARC countries.

Group Work and Recommendations

Group work was designed to accumulate ideas by brainstorming of SAARC country representatives to establish a regional agriculture innovation platform. Group was facilitated by Mr. William Sparks. To facilitate the brainstorming process, Mr. Sparks divided the discussions into four topics: (1) Sourcing, (2) Validation, (3) Scaling and (4) Platform. He also has divided participants into three groups and asked each group to write at least five ideas in five separate pieces of paper. Hence, there were altogether 15 ideas for each topic. Mr. Sparks organized participant recommendations based on the similarities. Then he asked each participant to vote on three ideas.
what he/she though most important/relevant/efficient to establish the platform.

**SOURCING**

It can be any forum/organization/individual from where innovative technologies can be collected/accumulate for the platform. After voting, ideas were organized into three categories:

**Global source**

1. Establish a global network
2. Identify validated innovation sources, such as videos of Access Agriculture, and knowledge hubs in different countries of the world;
3. Facilitate SAARC participation in different global events, organize global outreach activity (organizing innovation fair), create a SAARC innovation-pedia

**Regional source**

1. Fund opportunities for development of technologies
2. Organize exhibitions to showcase technologies in the region

**In-country source**

1. In country workshop with farmers and other actors are the primary source of innovation;
2. Annual technical pitching
3. Collections/documentations of in-country consultation/workshop including all stakeholders of agricultural system and compilation of the information to share

**Other sources**

1. Exposure visit / Seminar / Workshop
2. Innovative technology website
3. Accumulation of innovative stories from media sources and compile them for further validation and use
4. Catalogue of innovative technologies
5. Ask centre of excellence in research (e.g. CPD, IRRI, CIMMYT) to share region or country specific innovations and make a regional innovation innovative bank.
VALIDATION
In this stage, promising innovative agro technologies will be prioritized and validated.

Prioritizing
1. Prioritization of innovations through multi-stakeholder consultation meetings (in country/region)
2. Platform provides the standard protocols for validation
3. Create the validation network list (university, research station, private sector, NGO)

Demonstrating
1. On farm trials
2. On station trials and fine tuning
3. Conducting adaptive research with farmers through lead actions
4. Ecologically identified regions are selected for pilot testing innovations

Secondary data
1. Reports from the original source of technology/testing in country

Third parity engagement
1. Platform provides funding for third party to validate the technology
2. Economic, social (gender, youth) and environmental assessment
3. Market opportunity and sustainability
4. Collection of evidence from secondary sources regarding sources and innovations
5. Country’s policy compliance
6. Platform provides the technical expert
7. Identification and selection of innovation based on countries needs through expression of interests.

SCALING
In this step, validated technologies will be piloted in SAARC countries for adoption.

Through government support
1. Policy influencing to individual (for example subsidy), government or other related organizations
2. Establish linkages between cells, national, regional institutions

**Promotional activities**
1. Organize promotional activities
2. Market through local channels (TV, radio, newspaper)
3. Production and dissemination of technologies through media
4. Success story of technologies to the farmers

**Organizing Training**
1. Training of Trainer - Developing master trainers (agencies of government and private entrepreneurs)
2. Organize training, workshop or stakeholder meeting
3. Exposure visit/training
4. Three months free trial of technology - guarantee money back if not satisfied

**Other ideas**
1. Identification of focal agency in respective countries Agri Ministry (Planning and Policy Division)
2. Design specialized (Phd program focusing on innovative technology)
3. Success use of technology by farmers or government (free seed, fertilizer etc.)
4. Organizing market place for innovation fair for inviting donor / development partners / research / university / farmers organization, etc.

**PLATFORM**
Five components (5 Ss) of platform were reviewed: (1) Strategy, (2) Structure, (3) Systems, (4) Staffing, (5) Status

**Engagement**
1. Vision, mission, goal, objective should be clearly defined.
2. Strengthening policy commitment among the SAARC Member States.
3. Establish national agricultural innovation platform (multi-stakeholders)
4. Steering committee should be established.
5. Members should be included from all stakeholders’ groups, such as research, extension, farmer organizations, private sector, NGOs, etc.
6. SAARC Innovation Platform can be constituted by the representatives of each SAARC Member State.

Communication
1. Establish proper, sustainable communicative system (focal point in each country)

Measures
1. Monitoring and evaluation division

Way forward
After group works, for compilation of all documents of this meeting and to proceed further, following deadlines were set:
1. 15th November 2018: Submission of final version of country paper by focal persons to Consultant and SAC.
2. 30th November, 2018: Submission workshop report and complied country papers to SAC and Winrock International
3. 31st December, 2018: Finalization the project proposal
4. January 2019: Submission of the project proposal to SDF or USAID for SAARC establishing Agriculture Innovation platform

Sight Seeing
On 31 October, the whole group visited to Institute of Policy Studies (IPS) and around the city of historical places of Colombo, Sri Lanka.
List of the Participants

AFGHANISTAN
Mr. Sabawoon Chakhansuri
Acting Director of Statistics and Information System,
Ministry of Agriculture, Irrigation and Livestock
Email: sabawoonh@gmail.com

BANGLADESH
Mr. Abdul Jalil
Deputy Chief (Policy Planning), Planning, Project Implementation,
ICT wing, DAE, Dhaka
Email: jalilplaning@gmail.com

BHUTAN
Mr. Ngawang Ngawang
Program Director
Agriculture Research & Development Center (ARDC) Sarpang,
South Bhutan
Email: ngawang@moaf.gov.bt

NEPAL
Dr. Govinda Prasad Sharma
Joint Secretary, Ministry of Agriculture and Livestock Department,
Nepal
Email: govinda.sharma@nepal.gov.np

SRILANKA
Dr. RSK Keerthisena
Assistant Director General of Agriculture (Research)
Department of Agriculture
Peradeniya, Sri Lanka
Email: keerthisenarsk@yahoo.com

FAO
Mr. Chandana Kumara
Programme Associate
Email: Chandana.Kumara@fao.org
IRRI
Dr. Amitha Benthota
International Rice Research Institute (IRRI)
Scientist/Former Director Rice Research Institute of Sri Lanka
Email: amithabentota@gmail.com

Access Agriculture
Dr. Salahuddin Ahmed
Regional Coordinator South Asia, IRRI-Bangladesh office and consultant, Access Agriculture
Email: salahuddin@accessagriculture.org

Government of Sri Lanka
Dr. Yasantha Mapatuna
Programme Director, SAP,
Presidential Secretariat, Sri Lanka

Mr. Rohitha Wickramarathne
Director (Agriculture),
National Planning Department, Sri Lanka
Email: npdrohitha2@gmail.com

Ms. Yasantha Munasinghe
Assistant Director (Agriculture),
National Planning Department, Sri Lanka
Email: yasanathamunasinghe@gmail.com

INSTITUTE OF POLICY STUDIES (IPS)
Ms. Kanchana Wickramasinghe
Research Economist, IPS
Email: kanchana@ips.lk

Dr. Manoj Thibbotuwawa
Research Fellow, IPS
Email: manoj@ips.lk

Ms. Nimesha Dissanayake
Research Assistant, IPS
Email: nimesha@ips.lk

Ms. Anita Perera
Project Officer, IPS
Email: anita@ips.lk
CONSULTANT
Prof. Dr. Punya Prasad Regmi
Adjunct Professor, Agriculture and Forestry University (AFU), Nepal
Email: punyaregmi@gmail.com

WINROCK INTERNATIONAL
Mr. William Sparks
Project Director, USAID Feed the Future Asia Innovative Farmers Activity,
Winrock International
Email: william.sparks@winrock.org

Dr. Shamsul Kabir
Country Director, Bangladesh,
USAID Feed the Future Asia Innovative Farmers Activity, Winrock International
Email: skabir@winrock.org

Kim Fooyontphanich, phd
Agriculture Specialist
Winrock International
USAID, Feed the Future Asia Innovative Farmers Project
Email: kim.fooyontphanich@winrock.org

SAARC Agriculture Centre
Dr. Nasreen Sultana
Senior Program Specialist, (Horticulture), SAC
Email: nasreen_sultana@sac.org.bd

Ms. Fatema Nasrin Jahan
Senior Programme Officer, SAC
Email: nimmy_301@yahoo.com