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Report on Prioritization of Demand-driven Agricultural Research for Development in Bangladesh

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Preface and Acknowledgements

Reducing food and nutrition insecurity in Asia requires new solutions to the constraints of: (1) stagnating food productivity and production, (2) unconnected or fragmented food supply chains, and (3) underinvestment in agricultural research and development. Pragmatic short-term solutions are needed that target small-scale farmers who comprise the bulk of food producers in Asia. Simultaneously, the foundations must be established for long-term structural measures that promote the availability, accessibility, and utility of nutritious and safe food, especially for vulnerable groups in Asia.

In an effort to develop both short- and long-term solutions, the Asian Development Bank (ADB) enlisted the International Food Policy Research Institute (IFPRI) under the auspices of a "Regional—Research and Development Technical Assistance (R-RDTA)" agreement in 2011 to provide technical assistance for strategic research on sustainable food and nutrition security in Asia. This ADB R-RDTA addresses important challenges to reducing food and nutrition insecurity in Asia.

One component of this program—characterizing agricultural research for development (AR4D) in South Asia—is addressed in the present document. AR4D is a topic of urgent importance in South Asia. The diversification and intensification of agricultural production throughout the region are among the many issues raised in discussions around South Asia's AR4D agenda at the seminal Global Conference for Agriculture and Rural Development (GCARD) convened in Montpellier in March 2010. Efforts to make further progress on defining and executing a pro-poor and pro-growth AR4D strategy in South Asia requires more evidence on what has worked in the past, where investments are being made at present, and what priorities should be established for future research.

In an effort to support this objective, IFPRI partnered with the Asia-Pacific Association of Agricultural Research Institutions (APAARI) in 2011 to conduct a series of policy dialogues on the prioritization of demand-driven agricultural research for development in South Asia. Dialogues were conducted with a wide range of stakeholders in Bangladesh, India, and Nepal in mid-2012 and this report captures feedback from those dialogues.

This report has benefited greatly from the contributions of Raj Paroda and Bhag Mal of APAARI who were engaged in the entire process. The report has also benefited from insights provided by P. K. Joshi, Mark Rosegrant, and David J. Spielman of IFPRI, as well as technical support from Vartika Singh and Vaishali Dassani of IFPRI and Ram Niwas Yadav of APAARI.

Finally, the report has been made possible by the enthusiastic involvement of the Nepal Agricultural Research Council (NARC), the Bangladesh Agricultural Research Council (BARC), and organizations under the umbrella of the Indian Council for Agricultural Research (ICAR).

In the end, we hope that this exercise will initiate further research and inquiry on these issues and the charge for future agricultural research for development in South Asia will be taken up by researchers from both national and international systems, as well as other key stakeholders.

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Abbreviations and Acronyms

AR4D	agricultural research for development
ARI	agricultural research institute
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka
BINA	Bangladesh Institute of Nuclear Agriculture
BJRI	Bangladesh Jute Research Institute
BLRI	Bangladesh Livestock Research Institute
BoM	board of management
BRRI	Bangladesh Rice Research Institute
BSRI	Bangladesh Sugarcane Research Institute
BSRTI	Bangladesh Sericulture Research and Training Institute
CBO	community-based organization
CDB	Cotton Development Board
CEAL	community extension agent for livestock
CGIAR	Consultative Group on International Agricultural Research
CGP	Competitive Grants Program
CIG	common interest group
DAE	Department of Agricultural Extension
DLS	Department of Livestock Services
DOF	Department of Fisheries
EC	Executive Council
ERIE	Enhancing Research Institutional Efficiency
FAO	Food and Agriculture Organization of the United Nations
FIAC	Farmer's Information and Advice Center
FY	fiscal year
GB	Governing Board
GDP	gross domestic product
HIES	Household Income and Expenditure Survey
HRD	human resources development
ICT	information and communication technology
IDA	International Development Association
IPCC	Intergovernmental Panel on Climate Change
JAF	Jute & Allied Fiber Crops
KGF	Krishi Gobeshona Foundation
LEAF	local extension agent for fisheries
LFS	Labour Force Survey
MDG	Millennium Development Goal
MIS	management information system
MoA	Ministry of Agriculture
MoEF	Ministry of Environment and Forest
MoFL	Ministry of Fisheries and Livestock
NAP	National Agriculture Policy
NAPA	National Adaptation Programme of Action
NARS	National Agriculture Research System
NATP	National Agricultural Technology Project
NCA	net cropped area
NFP	National Fisheries Policy
NGO	nongovernmental organization
NLDP	National Livestock Development Policy
NRM	Natural Resources Management

NSAPR	National Strategy for Accelerated Poverty Reduction
PRSP	Poverty Reduction Strategy Paper
R&D	research and development
SAAO	subassistant agricultural officer
SAARC	South Asian Association for Regional Cooperation
SPGR	Sponsored Public Goods Research
STW	shallow tube well
USAID	United States Agency for International Development

Executive Summary

Introduction

The performance of the agriculture sector has contributed to the macroeconomic objectives of the government through employment generation and human resources development (HRD), which in turn have had a positive impact on the poverty alleviation and food security of the country. Food security remains the key objective of the government, and in achieving this, a significant increase has been made in food grain and vegetable production. Remarkable progress has been made in the fisheries subsector, and some progress has been made in the livestock subsector, particularly in poultry.

The country faces a formidable challenge: to feed its huge population in the future from an increasingly diminishing and degrading natural resource base for agriculture. The major challenges to agricultural growth and food security are land area and water resource constraints, growing water pollution and soil degradation, and the extra burden of climatic variability and climate change on the supply side tied with a rapidly increasing, increasingly urbanized, and more affluent population on the demand side.

The biggest challenge for the development of Bangladesh is poverty, although it is decreasing gradually. According to the *Human Development Report 2011* (United Nations Development Programme 2011), Bangladesh ranked 146th on the Human Development Index (0.50), with a rank on the Multidimensional Poverty Index of 0.292. Bangladesh has made progress in addressing "poverty and hunger," as set out in Millennium Development Goal 1, and the goal will be met partially. The target to reduce the proportion of people below the poverty line of 1990 to half by 2015 is on track. To achieve the targets, reduction of poverty has been given due importance in all planning strategies and documents as well as in the *Sixth Five Year Plan FY2011–FY2015* (General Economics Division 2011)

Bangladesh has made significant progress in all spheres of life during the 40 years since its independence in 1971. Life expectancy at birth for males and females has increased, which currently is 64 and 66 years, respectively. Access to education has increased substantially. The country has steadily increased its average decadal growth rate during the past 40 years. With declining population growth there has also been significant rise in per capita income growth. This has brought significant changes in many nonincome aspects of development as well. In some cases focused government policies have been crucial in bringing these positive changes.

The crops subsector dominates the agriculture sector, contributing to the agricultural gross domestic product (GDP) about 56.3 percent of total production. Contributions of fisheries, livestock, and forestry subsectors are 22.2 percent, 12.9 percent, and 8.6 percent, respectively (Finance Division 2012). The crops subsector in Bangladesh has made steady progress, especially in food production. Food grain production more than tripled in the past 40 years, from 9.889 to more than 33.71 million tonnes[1]. The growth in production is attributed to the expansion in irrigation, fertilizer management, and improved seed and an increase in the cropping intensity subsidy and availability of credit. Productivity of major crops, such as rice, wheat, maize, and potato, is increasing. Research-generated technology played a pivotal role in the growth of the agricultural sector.

There are two major types of fisheries in the country, inland fisheries and marine fisheries. Inland fisheries contribute about 80 percent and marine fisheries around 20 percent of the

[1] Throughout the text, the word tonnes implies 'metric tons'

total fish production. Due to increased profitability and technological innovation, more investment is taking place in aquaculture. Fish hatchery and feed mill investment increased significantly. The government is providing policy support in the growth of fisheries, including the conservation of fisheries. With the growth of 3 percent of open water fisheries, fisheries are facing competition from crops, shrinking water bodies, pollution, and so on.

The government is committed to achieving self-sufficiency in milk, chicken, and livestock production in the country so that the national protein demand can be met. During fiscal year (FY) 2005/06 to FY 2009/10, significant increases in the production of milk, meat (chicken, beef, and mutton), and eggs have been made. The challenges remaining with the subsector are shortages of feed and fodder, incidence of diseases, inadequate health services, low productivity, and so on.

According to the Labour Force Survey 2010, the number of economically active people (older than 15 years) is 56.7 million. Out of this, a labor force of 54.0 million (male: 37.8 million, female: 16.2 million) is engaged in a number of professions, the most (47.33 percent) in agriculture. The Household Income and Expenditure Survey 2010 indicated that at the national level, for the highest-income households, 35.55 percent of income came from professional wages and salaries, 20.44 percent from agriculture, and 19.16 percent from business and commerce.

At the national level the monthly per-household expenditure on food was BDT 6,031 (US$75.0) in 2010, of which 35.95 percent was spent on cereals. The expenditure on cereals decreased by 3.05 percent in 2010 compared to 2005. Expenditure on cereals decreased in 2010 compared to 2005 by 1.61 percent and 0.46 percent of rural and urban households, respectively. On the other hand, the percentage of expenditure on fish, meat, and eggs; condiments; and spices increased in 2010 compared to 2005 at the national, rural, and urban household levels, according to Household Income and Expenditure Survey 2010.

All development plans as well as the two poverty-reduction strategy papers recognized the importance of poverty reduction. Significant reduction in poverty has taken place in the past four decades—the incidence of poverty as measured by headcount rate declined from more than 80 percent in 1973/74 to 31.5 percent in 2010.

Per capita, per-day intake of food items has increased by about 4.3 percent, for example, from 949.0 grams in 2005 to 990.0 grams in 2010 at the national level. On one hand, the average quantity of rice intake decreased by about 5.4 percent, from 439.64 grams in 2005 to 416.01 grams in 2010. On the other hand, consumption of wheat increased to 26.09 grams in 2010 from 12.08 grams in 2005, registering a 115.98 percent increase. Per capita, per-day intake of potato increased to 70.52 grams in 2010 from 63.30 grams in 2005. Consumption of vegetables, fruits, and meat also increased in 2010 relative to 2005. During the period from 2005 to 2010, per capita, per-day intake of pulses and milk and milk products did not change much and remained 51.7 grams and 13.3 grams lower than the desirable level.

The Global Hunger Index, which reflects the multidimensional nature of hunger in the country, is declining. Although Bangladesh's score has declined from 38.1 in 1990, to 27.6 in 2001, to 24.4 in 2011, it is still rated as alarming (International Food Policy Research Institute 2011).

Challenges in Agricultural Growth

During the past decade, on average, the annual decline rate in net cropped area (NCA) has been 0.735 percent, which is more than 57.9 thousand hectares per year. The cropping intensity has now reached 185.89 percent. On the other hand, soil fertility depletion, mainly

due to exploitation of land without proper replenishment of plant nutrients, has exacerbated the problem. The government has recently reduced the price of nonurea (triple super phosphate, muriate of potash, and so on) fertilizers significantly to encourage balanced fertilizer use.

The source of irrigation water is 54.0 percent groundwater and 16.0 percent surface water. More and more areas are being irrigated with groundwater, which has become the major source of irrigation. It is feared that overexploitation of groundwater through rapid expansion of tube wells may cause a drawdown effect in the near future in the North Bengal region of the country. Besides, arsenic contamination in the groundwater across much of southern and central Bangladesh is a big problem.

The country is vulnerable to many environmental hazards, including frequent floods, droughts, cyclones, and storm surges that damage life, property, and agricultural production. Loss of food and cash crops has become a regular phenomenon that disrupts the continuing progress of the entire economy. On the other hand, about 1.056 million hectares of land are affected by different degrees of salinity. This is because unfavorable agroecological conditions of the region including coastal flooding in the monsoon, higher levels of soil salinity in the winter, and higher water salinity in winter reduce the region's potential for irrigation.

Per capita monthly income at the national level increased by BDT 1,068 (71.92 percent) in 2010 compared to 2005. It is noteworthy to mention that in 2010, rural income increased at a higher rate than did urban income. The rural income increased by 58.29 percent, whereas urban income increased by 57.45 percent. This increase of income in both urban and rural areas accelerated the process of poverty reduction in both urban and rural areas.

The high price of food often threatens food security. If income does not increase proportionately with the price increase of food, then accessibility of food decreases. Consumers cope with the rising price by reducing nonfood consumption, reducing food consumption, or a combination of both. During recent years price volatility in Bangladesh has been noticed in most food commodities. The price doubled in 2008 compared to 2001.

On top of this, climate change is now a reality and inevitable; it is evident through the increasingly erratic behavior of various climatic parameters such as temperature, rainfall, and so on. Climate change will exacerbate the above-mentioned environmental hazards, as mentioned by the Intergovernmental Panel on Climate Change (IPCC 2007). The *Fourth Assessment Report* of IPCC considers agriculture and water are likely to be the sectors most susceptible to climate change–induced impacts in Asia. Agriculture is one of the most vulnerable systems to be affected by climate change in the south Asian region. Agricultural productivity in this region is likely to suffer severe losses because of high temperature, severe drought, flood conditions, and soil degradation. According to IPCC, Bangladesh will be one of the worst victims of climate change. Sea level will be increased due to a rise in temperature, and the frequency of cyclone storms will also be increased. As a result, food security will be in jeopardy, and different types of natural calamities will put lives at risk. Besides these issues, high population density will make the problem more serious.

The people of Bangladesh have been adapting to the risks of floods, droughts, and cyclones for centuries. Rural people's heavy reliance on agriculture and natural resources increases their vulnerability to climate change. Therefore, supporting rural and urban communities to strengthen their resilience and adaptation to climate change will remain a high priority in coming decades. Disaster management, climate change, and other related issues in agriculture are crosscutting in nature. All the subsectors of agriculture are vulnerable to

natural hazards, shocks, and stresses. All the subsectors might not be affected equally; it is likely that some will be more susceptible.

Scope and Methodology of the Study

The present study has been carried out with the aim of improving the prioritization of agricultural research for development (AR4D) in south Asia and more specifically in Bangladesh. This study aims to detail priorities by proposing alternative structures and processes, funding mechanisms and financial incentives, technological opportunities, and critical partners needed for success. By examining these topics, it is expected that the exercise will significantly refine the region's AR4D agenda suggested by the Global Conference on Agricultural Research for Development 2010.

This study was based mainly on data from secondary sources. The relevant data and information were collected from government policy and strategy documents, different websites, and other relevant information sources.

Review of Key National Policies

The agricultural development of a country depends on the policy and institutional environment comprising laws, administrative directives, institutions, services, infrastructure support, and incentives. Unfortunately, after its independence in 1971, until the new policies were adopted, Bangladesh had to depend on the legacy of the policies of Pakistan. During the years, the government of Bangladesh has formulated and enacted a number of policies and strategies to stimulate agricultural growth. The government's current initiatives are targeted at preparing the sector for self-sufficiency in food and alleviation of poverty through employment generation. Collectively, these measures are expected to increase agribusiness' contribution to GDP. The major relevant national policy documents relating to crop and noncrop agriculture as well as crosscutting policies of Bangladesh formulated from 1992 to 2012 were reviewed, with emphasis on the issues related to agriculture and more particularly on agricultural research and development (R&D). Institutions and support services for the subsectors and agriculture as a whole were also considered. A total of 13 policy documents were reviewed.

Subsectoral Agricultural Policies

1. National Agriculture Policy 1999
2. National Agriculture Policy 2010 (draft)
3. National Fisheries Policy 1998
4. National Livestock Development Policy 2007
5. National Forest Policy 1994

Cross-sectoral Policies Influencing Agriculture

Besides the policies mentioned above, other national policies that may have direct or indirect impacts on the agriculture sector are the following:

1. National Land Use Policy 2001
2. National Water Policy 1999
3. Environmental Policy and Implementation Programme 1992
4. New Agricultural Extension Policy 1996
5. National Food Policy 2006
6. National Adaptation Programme of Action 2005

7. Steps Towards Change: National Strategy for Accelerated Poverty Reduction II FY 2009–11—Agriculture
8. Master Plan for Agricultural Development in the Southern Delta of Bangladesh(draft; Ministry of Agriculture and Food and Agriculture Organization of the United Nations 2012)

Compatibility, Synergies, and Contradictions

Although the overall agriculture sector includes the crops, fisheries, livestock, and forestry subsectors, the agriculture policy of the government covers only the crops subsector. Separate policies on livestock, fisheries, and forestry have been formulated by the respective ministries. Policies for the agricultural sector have been articulated within the framework of the government's policy.

The reviewed policies are generally compatible in their stated goals of accelerated poverty reduction through increasing productivity and profitability of crops, livestock, and fisheries; creating employment opportunities and income generation; widening work opportunities for rural women; and improving competitiveness of farmers. All the policy documents have important synergies within the broad objectives of attaining food self-sufficiency, food security, and accelerated reduction of poverty in rural areas. All of these policies highlight efficient use of land, water, and other natural resources and human resources, with special emphasis on women's participation and environmental protection. All these policies, especially the ones related to agriculture, express a need for strengthening the research–extension linkage and coordination among the ministries and agencies in the design, approval, and implementation of projects.

However, there are many inconsistencies or inadequacies in the subsectoral policies. There are also conflicts in implementing these policies. All these have arisen because the policies were formulated by different ministries at different times. While formulating the policy, the line ministry concentrated largely on its own domain, ignoring the crosscutting issues. Many issues, such as the impact of climate change on agriculture (crops, fisheries, and livestock) are missing in most of the policy documents. Lack of a coordination mechanism among and across ministries gives rise to incompatibilities in the implementation of the policies.

Besides, the issues related to climate change and adaptation to climate change haven't been incorporated in the policy regime. A few of the policy papers have provisions for periodic review and incorporation of emerging issues; this provides an opportunity to include policy options regarding the adverse impacts of climate change and adaptation to climate change.

Review of Structures and Issues

The agriculture sector includes the crops, fisheries, livestock, and forestry subsectors. The Ministry of Agriculture covers only the crops subsector. The Ministry of Fisheries and Livestock is the line ministry for the fisheries and livestock subsectors, and the forestry subsector is looked after by the Ministry of Environment and Forest. These ministries are the nodal agencies in the administrative structure of the government.

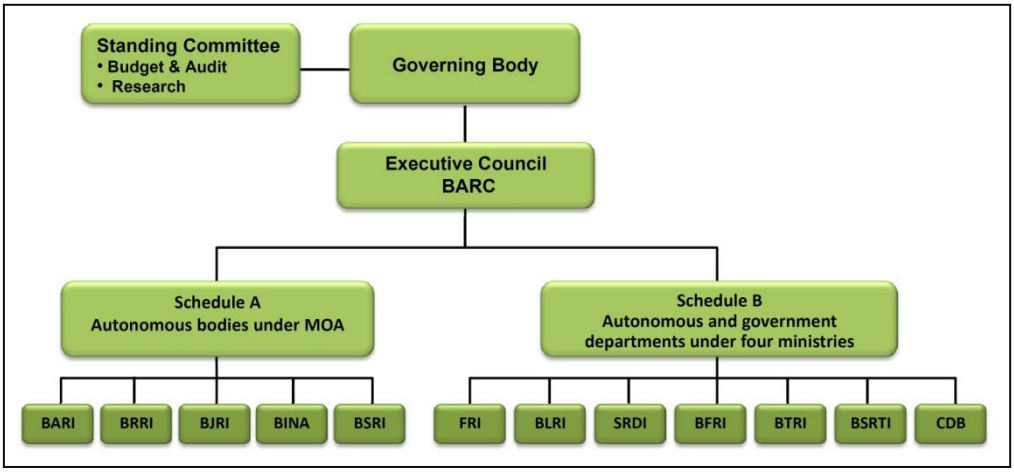
The Bangladesh Agricultural Research Council (BARC) Act of 1996 for the first time reorganized the National Agricultural Research System, comprising 10 agricultural research institutes (ARIs). The act provides a defined coordination role for BARC: a mandate to review research programs of ARIs. However, it could not give authority to BARC to allocate

resources following research review. However, the recent BARC act of 2012 reformulated a better coordination role for BARC, linking research review and resources allocation. At the same time, the new act widened the National Agriculture Research System (NARS) through incorporating two more research institutes, namely, Cotton Development Board and Sericulture Research and Training Institute.

BARC is a statutory body steered by a 31-member Governing Board (GB) under the chairmanship of the minister for agriculture. Ministers in charge of fisheries and livestock and of environment and forests are the cochairs of GB. Other members are two members of Parliament, the vice chancellor of Bangladesh Agricultural University, directors general of five ARIs, heads of extension departments, the chief conservator of forest, representatives of the business community, three renowned scientists/researchers, and farmers. The functions of GB are to control, direct, and oversee matters pertaining to research, planning, coordination, and administrative policy formulation of the council.

The second most important management tier of NARS is the 18-member Executive Council (EC) composed of the executive chairman, BARC as the chair of the council, 7 member-directors of BARC, and 12 chief executives (directors general/directors) of NARS institutes. EC is responsible to GB and assists in the formulation of various policy issues for NARS. EC reviews and recommends annual research programs and budgets of the institutes. EC is also responsible for policy formulation of HRD of NARS. The organogram of Bangladesh NARS is presented in Figure ES.1. Autonomous institutes such as the Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute, Bangladesh Institute of Nuclear Agriculture, Bangladesh Jute Research Institute, Bangladesh Sugarcane Research Institute, Bangladesh Fisheries Research Institute, and Bangladesh Livestock Research Institute are managed by their own boards of management. The Bangladesh Livestock Research Institute and Bangladesh Fisheries Research Institute have the minister of the Ministry of Fisheries and Livestock as chairman of the Board of Governors. Seven out of 12 ARIs and BARC are governed by independent acts and have separate service rules. The Boards of Management/Boards of Governors of ARIs execute the policies and undertakings of the institutes within the framework of the policy directives issued by the government.

Figure ES.1—Organizational structure of the National Agriculture Research System in Bangladesh



Source: BARC Act 2012.
Note: BARC = Bangladesh Agricultural Research Council; MOA = Ministry of Agriculture; BARI = Bangladesh Agricultural Research Institute; BRRI = Bangladesh Rice Research Institute; BJRI = Bangladesh Jute Research Institute; BINA = Bangladesh Institute of Nuclear Agriculture; BSRI = Bangladesh Sugarcane Research Institute; FRI = Bangladesh Fisheries Research Institute; BLRI =

Bangladesh Livestock Research Institute; SRDI = Soil Resources Development Institute; BFRI = Bangladesh Forest Research Institute; BTRI = Bangladesh Tea Research Institute; BSRTI = Bangladesh Sericulture Research and Training Institute; CDB = Cotton Development Board.

Major Projects to Strengthen Institutional Capacity of NARS

The International Development Association (IDA; the World Bank) and the United States Agency for International Development (USAID) have been the major donors to the Bangladesh agricultural research system. Their support has been used for the HRD of scientific capacity, infrastructural development, and research operation.

Agricultural Research Management Project (1996–2001)

The IDA-funded Agricultural Research Management Project was implemented in eight NARS institutes under the coordination of BARC. The project successfully developed the scientific skill of the institutes through trainings (higher studies and short-term training) and research infrastructures. The project also supported contract research schemes involving public, private, and nongovernmental organization (NGO) research entities. The project helped strengthen the coordination role of BARC after the promulgation of the BARC act of 1996.

National Agricultural Technology Project, 2008–2013

The National Agricultural Technology Project has been implemented in Bangladesh's agricultural technology system since 2008. The project is part of a long-term (15-year) program supporting IDA to assist Bangladesh. The project is the first of its kind to integrate research, extension, and supply chain management involving two ministries, namely, the Ministry of Agriculture and the Ministry of Livestock and Fisheries. In addition, the project has been instrumental in the development of an independent research entity called the Krishi Gobeshona Foundation (KGF; meaning Agricultural Research Foundation). The project has four components: (1) agricultural research support, (2) agricultural extension support, (3) development of supply chains, and (4) project management and coordination support.

1. The agricultural research support component has national coverage. Activities of the research component include (1) the Competitive Grants Program (CGP) implemented by KGF, (2) Sponsored Public Goods Research, and (3) Enhancing Research Institutional Efficiency of NARS implemented by BARC.

2. Agricultural extension support is being implemented by the Department of Agricultural Extension (DAE), Department of Livestock Services (DLS), and Department of Fisheries (DOF) for crops, livestock, and fisheries, respectively. This component aims to establish a decentralized, demand-led extension service that is knowledge based, has greater accountability and responsiveness to farmers, and focuses on small and marginal farmers. Extension activities covered 120 upazilas in 25 districts by DAE and DLS each in the first year. DOF covered only 95 upazilas in the first year and gradually extended its activities to 120 upazilas.

3. To effect the development of supply chains for increasing and diversifying sources of income for small and marginal farmers, development of supply chains of selected commodities has been planned on a pilot basis in 10 upazilas.

4. Project Management and Coordination Support: The project is being implemented jointly by the Ministry of Agriculture (MOA) and the Ministry of Fisheries and Livestock (MOFL). The Project Coordination Unit (PCU) is coordinating and facilitating project implementation

in collaboration with the respective Project Implementation Units (PIUs), Krishi Gobeshna Foundation (KGF) and Hortex Foundation.

KGF administers CGP research proposals based on the research priority areas set by BARC through consultation with different stakeholders following the KGF guidelines. A total of 393 proposals were received from different organizations in the public and private sectors. The KGF board constituted a 12-member multistakeholder committee tasked with screening and short-listing promising proposals for review.

Agricultural Extension Support

The activities of the extension units initially concentrated on (1) formation and mobilization of common interest groups with the help of grassroots-level extension agents such as subassistant agricultural officers, local extension agents for fisheries, and community extension agents for livestock; (2) decentralization of extension services; and (3) enhancement of institutional efficiency of the national institutions involved in agricultural extension.

Supply Chain Development Support

The main focus of this component is integrating small and marginal producers of high-value commodities (crops/horticulture, fisheries, and livestock) with the market through development of supply chains. The major subcomponents are (1) the strengthening of farmer–market linkages for promotion of contract farming, low-cost postharvest management, and improvement of sanitary and phytosanitary standards and (2) extension support using market-based methodologies (institutional strengthening, capacity building and training, and information dissemination). The Hortex Foundation is responsible for the implementation of the component by promoting more equitable supply chain governance and market linkages for selected high-value commodities in partnership with other implementing agencies of the project.

Education

There are 7 public agricultural universities out of 33 public universities. Some of the universities are offering higher education (PhD), whereas others are developing capacity to offer higher degrees. Agricultural education includes autonomous agricultural universities affiliated with the Ministry of Education and 13 agriculture training institutes, which offer diploma courses under direct control of the Department of Agriculture Extension. Agricultural universities are conducting research with different supports including BARC. BARC has no linkage in the academic curriculum and decision making of the universities.

Human Resources Management and Development

The NARS institutions have provision for 1,808 scientific posts, out of which 1,422 were filled as of June 2009. About 20 percent of the positions are vacant. Among the existing 1,422 scientists, only 350 (20 percent) have PhDs, which indicates lower educational attainment compared to the needs for successful implementation of research programs of the NARS scientists. A program for filling the vacant positions, planning for providing higher degrees, and promoting deserving candidates is important. The quality of research output would be negatively affected if human resources were not improved through implementation of a HRD program for NARS within a short period.

A significant gap in capacity at the advanced-degree level is developing and is further hampered as many of the competent scientists either have retired or have left the organization. It is important that this MSc and PhD gap be met in the near future. On the other hand, attracting top students and ensuring quality in MSc and PhD programs is of prime importance. All long-term projects funded either by the development partners or by the government must include HRD.

Research Extension Linkage

There is room for improvement in the research–extension linkage. ARIs hold seminars, training workshops, and so on to impart training and update the knowledge of extension officers about developed technologies. Local-level stakeholders including NGOs are also invited to participate in the discussion meetings. Some ARIs do not have even technology dissemination divisions. The Technology Transfer and Monitoring Unit of BARC was created to facilitate primary extension and monitoring of the transfer process. But the Technology Transfer and Monitoring Unit needs to be made more functional with adequate human resources.

The research–extension linkage should be further strengthened, particularly in the fisheries and livestock subsectors.

Farmer's Information and Advice Centers (FIACs)

FIACs have been developed as one-stop service centers for farmers at the union level. So far, 670 FIACs have been established and made functional at the newly built Union Parishad Complexes. Presently FIACs are functioning as farmers' one-stop service centers with DAE, DLS, and DOF, that is, sub-assistant agricultural officers. Local extension agents for fisheries and community extension agents for livestock are providing coordinated services to the farmers, and their production problems of crops, livestock, and fisheries are being solved effectively following the scheduled duty roster.

Review, Monitoring, and Evaluation

Review workshops are mandatory programs for the NARS institutes and are held annually at different levels. Although different NARS institutes follow different review processes, review has been institutionalized to improve the quality of research involving relevant stakeholders. BARC organizes research program reviews separately to avoid duplication of research and to ensure incorporation of national priorities. Institutional review of NARS was undertaken by independent committees of experts from outside the institutes in 1999. The recommendations were discussed in GB meetings of the council.

Most ARIs have regular monitoring programs to oversee the progress and quality of research carried out by the central as well as outreach stations. On certain occasions, scientists from BARC and some relevant ARIs are invited by the concerned ARI for monitoring. However, an organized monitoring and evaluation program has yet to be developed. Considering the importance of monitoring and evaluation for quality improvement of research, BARC has established a monitoring and evaluation cell for each of the research institutes.

Synthesis of Views on AR4D Priority Setting

Four Regional Consultation Workshops on Agricultural Research Priority Setting were organized by BARC. Representatives of different stakeholders attended these workshops. Participants were from different extension agencies; 25 percent were from research, and 10 percent were farmers and from NGOs, private organizations, and other organizations. The

outcomes of the regional workshops were rationalized and presented at the national workshop. Through these processes, a vast wealth of information was accumulated, which needed further synthesis and refinement to enable the research planners to undertake research through core programs of the ARIs and to execute grant programs under Sponsored Public Goods Research and CGP.

Priority setting was done considering researchable areas/issues under different thematic areas and the nature of the research, such as basic, strategic, applied, and adaptive. The duration of each type of research was categorized as short, medium, or long. Priority researchable areas or issues were identified for the following subsectors:

The crops subsector included major cereals such as rice, wheat, and maize; minor cereals are barley and millets. Under the noncereal crops, fibre crops, oilseeds, pulses, roots and tubers, sugarcane, spices, vegetables, fruits, flowers and ornamentals, and tea were considered.

The livestock subsector included cattle, small ruminants, and poultry.

The fisheries subsector included riverine, marine, and brackish water fisheries and both open water and capture for inland fisheries.

The natural resources subsector dealt with land and soil resources as well as water resources for agriculture and forestry.

The human nutrition subsector included matters related to food availability and consumption, postharvest losses, and agroprocessing technology; food quality, safety, and human nutrition.

The agricultural economics subsector incorporated matters relating to policy and planning, production and farm productivity, and supply chain and marketing.

The agricultural mechanization subsector considered pre- and postharvest mechanization.

The information and communication technology (ICT) and disaster management in agriculture subsector dealt with the use of ICT in the field of agriculture and management of disasters in agriculture.

Assessment of Potential Technologies

All the NARS institutes have been successfully contributing to national agricultural production by evolving commodity and noncommodity technologies that are suitable for the country's climate and appropriate for the farmers' conditions. A new group of technologies such as hybrid crop technologies, biotechnologies (including transgenics/genetically modified organisms), conservation technologies, nanotechnologies, processing and packaging technologies, biorisk management, mechanical technologies, and ICT will be required to face tougher future challenges to feed the growing population.

Potential Technologies

Agricultural biotechnology has great potential to address future challenges in agricultural sectors such as crops, livestock, fisheries, postharvest processing, and value addition. Supported by USAID, Bangladesh (through BARI) is participating in the Agricultural Biotechnology Support Project in collaboration with Cornell University in the United States. The Bt gene has been transferred in eggplants, and trials are being conducted with the Bt

gene with nine varieties against fruit and shoot borer under confined field conditions. The agronomic performance of the trials has been found to be good, having a minimum incidence of pest attack. In addition, late blight resistance in a popular potato variety has been under trial. Bangladesh is also partnering with the International Rice Research Institute in the development of vitamin A–enriched and zinc fortified golden rice. NARS should have access to other potential technologies: (1) Efficient management of energy in agriculture for various operations and new sources of renewable energy need to be explored; (2) the importance of ICT is increasing in importance for agricultural R&D, so information technology needs to be exploited to add value in research investment; (3) development of safe and energy-efficient gears and equipment for the processing and preservation of eco-friendly fishing technology development, energy-efficient fishing vessels and gears, and so on is necessary; (4) there is a need for development of pro-poor technologies for assets, less poor and marginal farmers/fishers; and (5) the country needs to get the benefit of nanotechnology in agroprocessing to enhance value addition and minimize postharvest loss. However, inadequate skill in such advanced science is lacking in the country.

Institutional Agricultural Extension

Agricultural extension services are provided basically by the public-sector agencies. In the recent past some NGOs, agribusiness enterprises, started providing limited extension services. Public institutions have traditionally been the main source of advice to farmers. Recently, a group approach for transferring technologies has been used to reach a larger number of small to medium farmers, including women. There are three main public agencies for technology transfer—DAE, DOF, and DLS.

Technology Commercialization

Generally memoranda of understanding are signed with the private sector and NGOs for the NARS institutes to receive research-generated technology, knowledge, and processes. The service is free of cost. With their limited capacity, NARS institutes provide breeders' seed to a public corporation (Bangladesh Agricultural Development Corporation) for wider multiplication. BARI has been maintaining more than 45 memoranda of understanding with different organizations for commercialization of technology.

Strategic Plan for Enhancing/Strengthening AR4D

Investment

The investment trend in agricultural research in the recent past has not been encouraging. A review of the yearly budget of the ARIs of NARS for the periods 2006–07, 2007–08, and 2008–09 reveals little difference from year to year except small increases in BARI, Bangladesh Rice Research Institute, and Bangladesh Jute Research Institute budgets. Studies show that investment in agricultural research fluctuates from 0.32 to 0.40 percent of the agricultural GDP. However, the situation is improving due to the implementation of donor-supported projects such as the National Agricultural Technology Project. The government of Bangladesh has given priority to the agricultural sector to boost agricultural production. Increasing the speed of and sustaining agricultural growth are priorities for increasing food production and reducing poverty. The future challenge of increasing food production could be met through the introduction of modern and state-of-the-art biotechnology and increased investment in agricultural technology generation and transfer. To support continuous R&D,

budget provision during the plan period (FY 2011–FY 2015) will be raised to 1 percent from the current level of 0.6 percent of GDP.

Strategy to Address the Priority

Bangladesh has fairly well-developed agricultural R&D agencies and a wide network of research establishments in most of the agroecological regions. Human resources are being developed, although there has been a trend of researchers' leaving ARIs for jobs in universities and the private sector. Using the existing resources, Bangladesh can address the priorities set by BARC. However, there are some institutional issues that can further enhance the capacity of the research and extension system to address the priorities.

Potential of New Technologies and the Involvement of the Private Sector

Involvement of the Private Sector

The involvement of the private sector in agribusiness was limited until the early 1990s. Most of the agribusinesses were carried out by the public-sector enterprises dealing with sugar, jute, fertilizers, and so on. Private-sector involvement in agribusiness was relatively modest and limited to subsectors such as rice and wheat milling, tea, and marketing of agricultural products. In the 1990s, private agribusinesses, as well as trade and industry associations, began to grow. This accelerated in the second part of the decade and continued in the early part of the 2000s. Most growth took place in subsectors such as poultry, shrimp, potato and cold storage, fruit processing, and supermarket chains. Factors that accelerated the emergence/growth of private agribusiness during the 1990s included the following: (1) The government's market reform policies during the 1980s and 1990s were congenial; (2) near self-sufficiency in rice increased food security and expanded opportunities for agricultural and nonfarm diversification and increased purchasing power, particularly in urban areas, with a consequent increase in demand for nonrice foods and more processed items; (3) development of infrastructures such as roads and telecommunications, electrification, and energy and improved connectivity between the north and the rest of the market economy of the country stimulated greater trade volumes and investment; and (4) some projects facilitated the emergence of new agribusiness ventures and strengthened existing ones.

Further private–public partnerships for seed, marketing, and extension need to be explored. Targeted investments to minimize postharvest losses may be effective in increasing the availability of food. The growing telecenters in Bangladesh should be used as a vehicle for public–private partnership in this process. Farmers cannot be merely passive recipients of advice or resources from the government or other agents, private or NGO. They must have a strong organization of their own to champion the general interests of farmers, regarding such issues as the prevention of adulteration of fertilizer, pesticides, or seeds; dissemination of information about new techniques or rules; equitable access to government lands; and prevention of use of toxic chemicals for ripening or preserving food crops.

International Linkage

BARC maintains linkages with a number of international R&D agencies. Being a member of the Consultative Group of International Agricultural Research, Bangladesh is directly involved with the International Rice Research Institute, International Maize and Wheat Improvement Centre, International Food Policy Research Institute, and World Fish Centre; it is also linked with relevant CGIAR centers. Moreover, the country is a member of the following global and regional agencies: Food and Agriculture Organization of the United Nations, Asia Pacific Association of Agricultural Research Institute, Asia Pacific Centre for Agricultural Engineering and Machinery of UN, and Center for Alleviation of Poverty

through Secondary Crops Development in Asia and the Pacific of UN. Bilateral relationships are also maintained with a number of countries. USAID and Japan International Cooperation Agency partner with the R&D system in Bangladesh. Through this relationship, Bangladesh is getting substantial international knowledge and research products for the development of agriculture.

AR4D Policy Dialogue—Bangladesh

Fifty participants from civil society, NGOs, the private sector, and farmers' groups attended a daylong policy dialogue, "Prioritizing Demand-driven Agricultural Research for Development," to identify of needs of agricultural research in the process of development. After brainstorming, the following groups identified 40 options (10 items per group) and prioritized by voting (Table ES.1).

Working Group 1: Priorities of AR4D

Working Group 2: Structures and Institutions for Agricultural Research

Working Group 3: Funding and Financing Mechanisms

Working Group 4: Innovative Technology Delivery Systems

Table ES.1—Recommendations from agricultural research for development (AR4D) policy dialogue—Bangladesh

Group 1—Priorities of AR4D		
Serial number	Title	Votes
1	Genetic improvement of crops/livestock/fish/forestry through biotech	13
2	Research on unfavorable ecosystems	10
3	Input use efficiency improvement research	6
4	Appropriate technologies for mechanized farming and processing	4
5	Research on food safety issues	4
6	Feed improvement (qualitative) of livestock and fisheries	3
7	Research on emerging pests and diseases	2
8	Strengthening agricultural market research	2
9	Organic farming	0
10	Biofortification research	0
Group 2—Structures and institutions		
Sl. number	Title	Votes
1	There should be unified service rules for the scientists of NARS institutions	19
2	Governance board of BARC should be empowered to decide and approve matters related to agricultural research and development of NARS	9
3	Immediate abolition of NARS composition as Schedule A and Schedule B—there should be one composition	8
4	Undertaking future responsibility of research effort, there should be a continuous program of human resources development at home and abroad	4
5	Strong monitoring, evaluation, and impact assessment need to be inbuilt	4

	within the NARS management system	
6	ARIs management board to have all required authority to implement the programs	2
7	Scientists should be encouraged to retain in their disciplinary positions and highest scale	2
8	Regional stations of ARIs to be transformed into independent research station/center with required authority	1
9	For efficient technology generation and transfer, research extension and private partnership to be more formalized	1
10	Research endowment fund to be sponsored by government/donors for continuous fund allocation for AR4D	0
Group 3—Funding and financing mechanisms		
Sl. number	Title	Votes
1	Core funding of research to be enhanced with accountability	11
2	Multidisciplinary research through Competitive Grants Program	6
3	Encourage private-sector partnership in research funding with clear-cut cost-sharing mechanisms	4
4	New funding mechanisms such as revolving funding and cofinancing	3
5	Adequate funding at least 1 percent of agricultural GDP (AgGDP)	2
6	Adequate funding for human resources development	2
7	Establish joint research programs with developed countries through cofinancing	1
8	Flexible rules and procedures for research expenditure (local and foreign-aided projects)	1
9	Donor funding for demand-driven research for national interest	0
10	Clear-cut intellectual property rights policy to attract private-sector funding	0
Group 4—Innovative technology delivery mechanism		
Sl. number	Title	Votes
1	Ensure fair prices of all agricultural production during storage to reduce seasonal loss	11
2	Strengthening research to mitigate the impact of climate change on fish breeding (high temperature)	7
3	Incorporation of private-sector and progressive farmers in technology transfer	6
4	Directing coordinated research programs through the participation of farmers, extension, and research personnel	5
5	Ensuring technological support for lactating cow, calf rearing, and beef fattening and also ensuring the availability of feed and other relevant input	5
6	Women empowerment—training to be imparted on agricultural technology	4
7	Broodstock management and distribution system—more role of the government	4
8	Ensuring veterinary treatment and artificial insemination programs have a reach at the grassroots level	3
9	Take steps to evolve technologies of harvesting rain water and efficient use of surface water	2
10	Ensure the availability of quality seed, saplings, and other inputs at the grassroots level	0

Source: AR4D Bangladesh policy dialogue held in Dhaka on 23 June, 2012.

Note: NARS = National Agriculture Research System; BARC = Bangladesh Agricultural Research Council; ARI = agricultural research institute.

PRIORITIZATION OF DEMAND-DRIVEN AGRICULTURAL RESEARCH FOR DEVELOPMENT IN BANGLADESH

Wais Kabir[2] and Sk. Ghulam Hussain[3]

1. Introduction

Agriculture is the single most important producing sector of the economy of Bangladesh since it comprises about 20.02 percent of the country's gross domestic product (GDP) and employs more than 47 percent of the total labor force. The performance of this sector has contributed to the macroeconomic objectives of the government through employment generation and human resources development (HRD), which in turn has had a positive impact on poverty alleviation and the food security of the country. Food security remains the key objective of the government, and in achieving it, a significant increase has been made in food grain and vegetable production. Remarkable progress has been made in the fisheries subsector, and some progress has been made in the livestock subsector, particularly in poultry. Table 1.1 shows the contribution of subsectors to GDP at a constant price. Although the share of the agriculture sector in GDP is declining in relative terms, in absolute terms the amount has increased substantially.

Table 1.1—Contribution of agriculture by subsectors to gross domestic product (GDP)

Subsector	Contribution to GDP in Percentage (GDP at Constant Price—Base Year 1995/96)									
	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Crop	13.75	13.43	13.23	12.51	12.28	12.00	11.64	11.43	11.42	11.32
Fisheries	5.40	5.25	5.11	5.00	4.86	4.73	4.65	4.58	4.49	4.43
Livestock	2.96	2.93	2.91	2.95	2.92	2.88	2.79	2.73	2.63	2.58
Forestry	1.88	1.86	1.83	1.82	1.79	1.76	1.75	1.75	1.73	1.69
Total	23.99	23.47	23.08	22.28	21.85	21.37	20.83	20.49	20.29	20.02

Source: Finance Division, Ministry of Finanace (2007 & 2012).

In the past five years the economy has been growing at an average annual rate of 6.23 percent with a peak of 6.66 percent in fiscal year (FY) 2011. Bangladesh can sustain this growth rate in the long run if various factors that affect the economic growth rate, particularly those affecting natural and physical capital, do not recur frequently. Further, the economy should not experience external shocks such as a sharp increase in energy price, decline in export demand and price, and sharp decline in remittance. Table 1.2 shows the growth rate of different sectors of GDP during FY 2007 through FY 2011.

Table 1.2—Growth rate of real gross domestic product (GDP) by broad economic sectors, FY 2007–FY 2011

Sector	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Agriculture, including fisheries	4.56	3.21	4.12	5.24	4.96
Industry	8.35	6.78	6.46	6.49	8.17
Manufacturing	9.72	7.21	6.68	6.50	9.51
Services	6.93	6.51	6.31	6.47	6.63
GDP	6.43	6.19	5.74	6.07	6.66
Per capita GDP (in US dollars)	482.00	559.00	620.00	685.00	755.00

Source: General Economics Division (2012)

[2] Executive Chairman, Bangladesh Agricultural Research Council.

[3] Former Member-Director, Planning and Evaluation, Bangladesh Agricultural Research Council.

The country faces the formidable challenge to feed its huge population in the future from an increasingly diminishing and degrading natural resource base for agriculture. The population is expected to increase from 152.518 million in 2012 (Bangladesh Bureau of Statistics [BBS] 2011a) to 185 million by 2020, to 222 million by 2050 (DESA-UN 2008). The major challenges to agricultural growth and food security are land area and water resource constraints, growing water pollution and soil degradation, and the extra burden of climatic variability and climate change on the supply side tied with a rapidly increasing, increasingly urbanized, and more affluent population on the demand side (Asaduzzaman et al. 2010).

The biggest challenge for the development of Bangladesh is poverty, although it is decreasing gradually. According to the *Human Development Report 2011* (United Nations Development Programme 2011), Bangladesh ranked 146th on the Human Development Index (0.50), with a rank of 0.292 on the Multidimensional Poverty Index. Bangladesh has made progress in addressing "poverty and hunger" as set out in Millennium Development Goal (MDG) 1, and the goal will be met partially. The target to reduce the proportion of people below the poverty line of 1990 to half by 2015 is on track. The proportion of the population below the national upper poverty line (2,122 kilocalories) in 1990 was 56.6 percent (2008, estimated), which has reduced to 38.7 percent; by 2015 it will be further reduced to 29.0 percent. The poverty gap ratio has been targeted to reduce from 17.0 to 8.0 percent by 2015, and the share of the poorest quintile in national consumption is likely to increase from 6.5 percent (General Economics Division 2009). To achieve the targets, the reduction of poverty has been given due importance in all planning strategies and documents as well as in the *Sixth Five Year Plan FY2011–FY2015* (General Economics Division 2011).

Bangladesh has made significant progress in all spheres of life during the 40 years since its independence in 1971. Life expectancy at birth for males and females has increased and currently is 64 and 66 years, respectively (World Health Organization Bangladesh 2009). Access to education has increased substantially, and as a result the literacy rate at the national level rose from 18.00 percent in 1971 (Ahammed 2003) to 55.08 percent in 2010. There is some gender disparity, however, as rates are 57.56 percent and 52.54 percent among males and females, respectively. The rural literacy rate in 2010 was 51.81 percent, whereas in urban areas it was 65.83 percent (BBS 2011a).

Bangladesh has steadily increased its average decadal growth rate during the past 40 years. With declining population growth there has also been a significant rise in per capita income growth. Per capita GDP at the current price is BDT 60,400, which is equivalent to about US$755[4] ($1 = BDT 80). This has resulted in a more than 130 percent increase in real per capita income during this period. The increase in per capita income has brought significant changes in many nonincome aspects of development as well. In some cases focused government policies have been crucial in achieving these positive changes.

The crops subsector dominates the agriculture sector, contributing to the agricultural GDP about 56.3 percent of total production. Contributions of the fisheries, livestock, and forestry subsectors are 22.2 percent, 12.9 percent, and 8.6 percent, respectively (BBS 2012c).

The crops subsector in Bangladesh has made steady progress, especially in food production. Food grain production more than tripled in the past 40 years, from 9.889 to more than 33.71 million tonnes. The growth in production is attributed to the expansion in irrigation, fertilizer management, and improved seed and an increase in the cropping intensity subsidy and the availability of credit. The productivity of major crops, such as rice, wheat, maize, and potato, is increasing. Research-generated technology played a pivotal role in the growth of agriculture.

[4] All dollars are US dollars.

There are two major types of fisheries in the country, inland fisheries and marine fisheries. Inland fisheries contribute about 80 percent and marine fisheries around 20 percent of the total fish production. Fish production in FY 2009/10 was 2.9 million tonnes, of which inland and marine fisheries accounted for 1.849 million tonnes and 0.48 million tonnes, respectively; these values for 2009/10 were 2.382 million tonnes and 0.568 million tonnes, respectively. Due to increased profitability and technological innovation more investment is taking place in aquaculture. The number of fish farmers increased from 60,000 in 1980 to 140,000 in 2010. The fish farming area increased from 15,400 hectares in 1980 to 27,400 hectares in 2010; similarly, the number of ponds increased from 6,100 to 145,400 during the same period. However, pond size decreased from 0.25 hectares to 0.19 hectares in the same period. The numbers of fish hatcheries and feed mills increased significantly. As a result production is catching up with the requirement rapidly, with a growth of about 10 percent. The government is providing policy support in the growth of fisheries including conservation of fisheries. With a growth of 3 percent of open water fisheries, fisheries are facing some challenges: competition with crops, shrinking water bodies, pollution, and so on.

The government is committed to the country's achieving self-sufficiency in milk, chicken, and livestock production so that the national protein demand can be met. Estimates by the Ministry of Fisheries and Livestock (MoFL) show that during FY 2009/10 the expected number of livestock and poultry will be 50.65 million and 270.71 million, respectively. During the period from 2005/06 to 2009/10, significant increases in the production of milk, meat (chicken, beef, and mutton), and eggs were made. The challenges remaining with the subsector are a shortage of feed and fodder, the incidence of diseases, inadequate health services, low productivity, and so on.

To assess the overall situation of employment, BBS conducted the Labour Force Survey (LFS) 2010 (BBS 2011c). According to the survey, the number of economically active people (older than 15 years) is 56.7 million. Out of this, a labor force of 54.0 million (male: 37.8 million, female: 16.2 million) is engaged in a number of professions, the most (47.33 percent) in agriculture. According to LFS 2005/06, the total labor force of those older than 15 years of age was 47.4 million (male: 36.1 million, female: 11.3 million); agriculture remained the highest (48.10 percent) source of employment. Between the two survey periods, the number of agricultural workers decreased by about 1.0 percent.

According to LFS 2010, 44.4 percent (25.5 in agriculture and 18.9 percent in nonagriculture) of the labor force was self-employed, an increase from 41.98 percent according to the previous survey. It may be noted that during the two survey periods, the number of self-employed people in the labor force decreased by 2.0 percent. According to LFS 2010, 21.8 percent of the labor force consisted of daily laborers and 19.7 percent consisted of unpaid family workers, which numbers were 18.14 percent and 21.73 percent, respectively, according to the previous survey. The latest survey also indicated that 14.6 percent of people in the labor force were engaged as full-time employees, implying a decrease of 2.46 percent.

According to the Household Income and Expenditure Survey (HIES) 2010 (BBS 2011b), at the national level, for the highest-income households, 35.55 percent of income came from professional wages and salaries, 20.44 percent from agriculture, 19.16 percent from business and commerce, and the rest from housing services, gifts and remittances, and other sources. Compared to 2005, most of the values were higher in 2010. In rural areas, the share of agriculture as a source of income was 29.73 percent, whereas it was only 5.56 percent in urban areas. The percentage share of business and commerce was 15.05 percent in rural areas and 25.75 percent in urban areas.

Per capita monthly income increased by BDT. 1,068 (71.92 percent) in 2010 compared to 2005. It is noteworthy to mention that in 2010, rural income increased at a higher rate than did urban income. Rural income increased by 58.29 percent, whereas urban income increased by 57.45 percent. This increase in income in both urban and rural areas accelerated the process of poverty reduction in both urban and rural areas.

The high price of food often threatens food security. If income does not increase proportionately with the price increase of food, then accessibility of food decreases. Consumers cope with the rising price by reducing nonfood consumption, reducing food consumption, or a combination of both. During recent years price volatility in Bangladesh has been noticed in most food commodities. The price doubled in 2008 compared to 2001. The consumer general price index (base year 1995/96 = 100) rose from 126.72 in FY 2000/01 to 241.02 in 2011, whereas food prices increased from 130.30 in 2000/01 to 267.84 in 2011.

According to HIES 2010, at the national level the monthly per-household expenditure on food was BDT 6,031 ($75.00) in 2010, of which 35.95 percent was spent on cereals. The expenditure on cereals decreased by 3.05 percent in 2010 compared to 2005. Expenditure on cereals decreased in 2010 compared to 2005 by 1.61 percent and 0.46 percent in rural and urban households, respectively. On the other hand, the percentage of expenditure on fish, meat and eggs, condiments, and spices increased in 2010 compared to 2005 at the national, rural, and urban household levels. A summary of the percentage share of food expenditure by residence and major food items is presented in Table 1.3.

Table 1.1—Percentage share of food expenditure by residence and major food items

Food Item	National			Rural			Urban		
	2010	2005	2000	2010	2005	2000	2010	2005	2000
Total food expenditure (in Tk.)	6,031	3,209	2,477	5,543	3,023	2,300	7,362	3,756	3,175
Percentage of total	100	100	100	100	100	100	100	100	100
Cereals	35.95	39.00	38.02	39.62	42.25	41.23	28.41	31.30	28.87
Pulses	2.35	2.65	2.92	2.32	2.39	2.79	3.00	3.28	3.29
Fish	13.71	12.24	12.48	12.74	11.46	12.06	15.71	14.11	13.66
Meat and eggs	10.31	8.51	8.02	8.61	7.64	6.97	13.80	10.56	11.01
Vegetables	7.79	8.38	9.21	7.98	8.34	9.44	7.40	8.48	8.57
Milk/milk products	3.02	3.74	3.95	2.74	3.46	3.62	3.58	4.41	4.89
Edible oil	4.35	4.25	3.71	4.26	4.07	3.62	4.53	4.67	3.97
Condiments/spices	9.99	7.52	7.13	10.54	7.18	7.22	8.85	8.31	6.87
Fruits	4.08	3.23	2.97	3.49	2.97	2.57	5.29	3.83	4.10
Sugar/gur	1.06	1.56	1.34	1.04	1.54	1.29	1.12	1.62	1.49
Beverage	0.73	0.68	1.97	0.51	0.45	1.57	1.18	1.21	3.10
Miscellanies	5.67	8.25	8.29	6.15	8.25	7.62	6.38	8.23	10.18
Source: Bangladesh Bureau of Statistics (2011b)									

Per capita, per-day intake of food items has increased by about 4.3 percent, for example, from 949.0 grams in 2005 to 990.0 grams in 2010 at the national level. On one hand, the average quantity of rice intake decreased by about 5.4 percent, from 439.64 grams in 2005 to 416.01 grams in 2010. On the other hand, consumption of wheat increased to 26.09 grams in 2010 from 12.08 grams in 2005, registering a 115.98 percent increase. Per capita, per-day intake of potato increased to 70.52 grams in 2010 from 63.30 grams in 2005. Consumption of vegetables, fruits, and meat also increased in 2010 relative to 2005. During the period from 2005 to 2010, per capita, per-day intake of pulses and milk and milk products did not change much and remained 51.7 grams and 13.3 grams, respectively, lower than the desirable level.

The Global Hunger Index,[5] which reflects the multidimensional nature of hunger in the country, is declining. Although Bangladesh's score has declined from 38.1 in 1990, to 27.6 in 2001, to 24.4 in 2011, it is still rated as alarming (International Food Policy Research Institute 2011).

1.1. Challenges in Agricultural Growth

The total area of the country is about 14.84 million hectares, of which 3.60 million hectares (24.26 percent of total area) are not available for agriculture. The net cropped area (NCA) declined from 8.24 million hectares in 1971 to 7.94 million hectares in 2009. Although the NCA declined, the total cropped area increased to 14.41 million hectares. This increase is attributed to the increase in double- and triple-cropped areas (BBS 2011d). During the past decade, on average, the annual decline rate in NCA was 0.735 percent, which is more than 57.9 thousand hectares per year. The cropping intensity has now reached 185.89 percent. On the other hand, soil fertility depletion, mainly due to exploitation of land without proper replenishment of plant nutrients, exacerbated the problem. The situation is worse in areas where high-yielding variety crops are being grown using low to unbalanced doses of mineral fertilizers with little or no organic recycling. The government has recently reduced the price of nonurea fertilizers (triple super phosphate, muriate of potash, and so on) significantly to encourage balanced fertilizer use. Because of increasing cropping intensity and the cultivation of modern varieties of crops, the net removal of plant nutrients is far from the nutrient supply through fertilizers and manures. Like soil organic matter, soil nutrient status is declining with time. Again, land use with higher cropping intensity shows higher nutrient mining.

Currently, the total minor irrigation command area is 6.36 million hectares. Of the national irrigation coverage, groundwater and surface water cover 77 percent and 23 percent, respectively. About 70.0 percent of the total irrigated area is covered by Boro rice, which is a primarily irrigated crop grown from January through May. The source of irrigation water is 54.0 percent and 16.0 percent from groundwater and surface water, respectively. About 9.02 percent, 5.24 percent, and 5.25 percent of the total irrigated area is covered by Aman rice, wheat, and potato, respectively. The rest of the crops, including vegetables, sugarcane, and other crops, occupy only about 11 percent of the irrigated area. More and more areas are being irrigated with groundwater because it has become the major source of irrigation.

It is feared that overexploitation of groundwater through rapid expansion of shallow tube wells (STWs) may cause a drawdown effect in the near future in the north Bengal region of the country. During the dry season in the drought-prone areas of the country the water tables are lowered considerably, making lifting of groundwater by STWs impossible.

Arsenic contamination in the groundwater was reported in Bangladesh during the early 1990s. Extensive contamination in Bangladesh was confirmed in 1995, when additional surveys showed contamination of STWs across much of southern and central Bangladesh. At the same time cases of chronic arsenicosis were being recognized by health professionals (British Geological Survey 1999).

In Bangladesh, additional agricultural output will have to come from multiple cropping, which requires, among other things, increased irrigation. The problem of choosing the optimal technology is important not only because of the country's overall resource shortage

[5] The Global Hunger Index is derived on the basis of the proportion of undernourished as a percentage of the population, the prevalence of underweight in children under the age of five, and the under-five mortality rate. The Global Hunger Index combines three equally weighted indicators in one index number.

but also because other much-needed agricultural inputs such as fertilizer, pesticide, and quality seeds require considerable additional investment. There is potential for high returns in Bangladesh's agriculture sector through more efficient use of all resources.

New production technology pathways in Bangladesh will require more judicious use of scarce resources. Although Bangladesh is extremely water rich, the country faces severe seasonal scarcity. Total internal renewable surface water resources are low at 105 cubic kilometer per year because most water flows enter from upstream riparian India. A focus on river basin management, including transboundary cooperation on water resources, will be important for the country to achieve both water and food security in the future (Cenacchi et al. n.d.).

The country is vulnerable to many environmental hazards, including frequent floods, droughts, cyclones, and storm surges that damage life, property, and agricultural production. Loss of food and cash crops has become a regular phenomenon that disrupts the continuing progress of the entire economy.

More than 30 percent of the cultivable land in the country is in the coastal area. Out of 2.86 million hectares of coastal and offshore land, about 1.056 million hectares of land are affected by different degrees of salinity. Of the 151 upazilas (subdistricts) in 19 coastal districts, 93 upazilas under 18 districts are affected by salinity (Ahsan 2010). As the cropping intensity and crop yields in the coastal area are well below the country average, the contribution to the agriculture sector is not proportional to its landmass. The reason behind this is unfavorable agroecological conditions of the region. These include coastal flooding in the monsoon, higher levels of soil salinity in the winter, and higher water salinity in the winter, reducing the potential for irrigation. Crop yields decrease linearly with increasing salt levels greater than a given threshold level. The threshold level varies according to the tolerance of the crop.

On top of this, climate change is now a reality and inevitable as is evident through the increasingly erratic behavior of various climatic parameters such as temperature and rainfall. Climate change will exacerbate the above-mentioned environmental hazards, as mentioned by the Intergovernmental Panel on Climate Change ([IPCC] 2007). The *Fourth Assessment Report* of IPCC considers agriculture and water are likely to be the most susceptible sectors to climate change–induced impacts in Asia. Agriculture is one of the most vulnerable systems to be affected by climate change in the south Asian region. Agricultural productivity in this region is likely to suffer severe losses because of high temperature, severe drought, flood conditions, and soil degradation. According to IPCC, Bangladesh will be one of the worst victims of climate change. Sea level will be increased due to a rise in temperature, and the frequency of cyclone storms will also be increased. As a result, food security will be in jeopardy, and different types of natural calamities will put lives at risk. High population density will make the problems more serious.

The people of Bangladesh have been adapting to the risks of floods, droughts, and cyclones for centuries. The heavy reliance of rural people on agriculture and natural resources increases their vulnerability to climate change. Therefore, supporting rural and urban communities to strengthen their resilience and adaptation to climate change will remain a high priority in coming decades. Disaster management, climate change, and other related issues in agriculture are crosscutting in nature. All the subsectors of agriculture are vulnerable to natural hazards, shocks, and stresses. All the subsectors might not be affected equally; it is likely that some will be more susceptible.

When resources such as investment, infrastructure, and human resources are insufficient, getting priorities right is one way to improve the effectiveness of public-sector agricultural research. But informed priority setting is not a necessary and sufficient condition for effective public-sector agricultural research that is often constrained by lack of incentives, low and seasonally unavailable operating budgets, obsolete research infrastructure, and inadequate human capital (Eicher 2001). These constraints are more or less common in developing and underdeveloped countries.

1.1.1. Poverty and Inequality

Poverty reduction has been an objective of Bangladesh since its emergence as an independent nation in 1971. Starting from the First Five Year Plan (1973–1978), which emphasized poverty reduction through employment generation, all development plans as well as the two poverty-reduction strategy papers recognized the importance of poverty reduction and developed policies and strategies for poverty reduction. Consequently, significant reduction in poverty has taken place in the past four decades—the incidence of poverty as measured by headcount rate declined from more than 80 percent in 1973/74 to 31.5 percent in 2010 (BBS 2011b). Other measures of poverty such as the poverty gap and squared poverty gap, showing the depth and severity of poverty, respectively, have shown long-term trends similar to that observed for the headcount rate. Despite notable progress in poverty reduction, Bangladesh faced the stark reality that about 45 million of its people still live in poverty. The other dimensions of poverty that will make poverty reduction more challenging in the future are the rural–urban divide in poverty; regional variations in poverty, with the Western region of the country having a higher incidence of poverty; and 17.6 percent of the total population living in extreme poverty or chronic poverty. A higher dependency ratio, decline in the availability of natural and common property resources, limited access to financial and human resources, and incidence of multiple shocks such as natural and health shocks are usually correlated with extreme poverty. In addition, people living in remote char areas and remote areas of the hill tracts region and people with disabilities are victims of extreme poverty.

The benefits of economic growth do not accrue to all individuals or households equally. The households in the lower deciles thus miss the opportunity to reduce their income poverty and take full advantage of economic growth. Thus, inequality in the distribution of income has adverse effects on poverty reduction.

Inequality has been rising in Bangladesh for a long time. The Gini coefficient, which provides a measure of income inequality, increased from .36 in 1984 to .467 in 2005, thus reducing the effect of growth on poverty reduction. Apart from its negative impact on poverty reduction, inequality, especially high inequality (Gini > .50), can generate social instability. It should be noted that the Gini coefficient for 2010 is still higher than that for 2000. The challenge is to contain the increase in inequality in both rural and urban areas, which will result in a decline in national income inequality. Table 1.4 shows the percentage share of income of the lowest 5 percent and top 5 percent of households and the Gini coefficient.

Table 1.2—Percentage share of income of lowest 5 percent and top 5 percent households and Gini coefficient

Income Group	2010	2005	2000
Lowest 5 percent	0.78	0.77	0.93
Top 5 percent	24.61	26.93	28.34
Gini coefficient	.458	.467	.451

Source: Bangladesh Bureau of Statistics (2007, 2011b).

The decline in poverty has been in large part an outcome of long-term growth and employment generation in the economy. Various targeted programs of the government and nongovernmental organizations (NGOs), which improved access of the poor to education and health, water and sanitation, and microcredit and created employment, also played an important role in the process. Acceleration of growth and employment generation will remain the primary foundation of poverty reduction. The policies and strategies for growth have supported some of the major aspects of inclusive growth that ensure equal access to opportunities for all segments of society, resulting in reduction of poverty and inequality, employment-intensive growth, improved education, health and other social services, and expanded social protection. The policies and strategies supportive of inclusive growth will be continued and strengthened.

Operationally, poverty–environment linkages are evident at two levels—one is conserving nature and natural resources for sustainable livelihood, and the other is controlling and combating pollution for the maintenance of biodiversity and protection of human health.

1.2. Contents of the Article

This article is divided into six sections: (1) Introduction, (2) Review of Key National Policies, (3) Review of Structures and Issues, (4) Synthesis of Views on AR4D Priority Setting, (5) Assessment of Potential Technologies, and (6) Strategic Plan for Enhancing/Strengthening AR4D. The introduction focuses on the setting of the problems and objectives and the contents of the article. The Review of Key National Policies section critically analyses the relevant policy document and institutions vis-à-vis their influence on agricultural research for development (AR4D) priority setting, financing, and execution. The third section summarizes structures of relevant government and nongovernment stakeholders in their central, state, and public-sector enterprises: National Agriculture Research System (NARS) and so on. The fourth section covers a synthesis of views on AR4D priority setting, financing, and execution from all the stakeholders as an improvement over Global Conference on Agricultural Research for Development 1 priorities. An assessment of the potential of selected groups of technologies such as genetic improvement, natural resource management, protection technologies, processing and value-addition technologies, mechanical technologies, and frontier technologies such as biotech are covered in the fifth section. Finally the sixth section, Strategic Plan for Enhancing/Strengthening AR4D, discusses improved research prioritization (demand driven not only by farmers but by industry, traders, processors, civil society organizations, advocates of basic research to extend the limits of demand, and so on), expanded/innovative sources of funding, and investment and innovative delivery and dissemination of AR4D (extension systems with a focus on knowledge products, innovation systems with an emphasis on commercial products, media, mobile technology, and so on).

1.3. Scope and Methodology of the Study

The present study has been carried out with the aim of improving the prioritization of AR4D in south Asia and more specifically in Bangladesh. This study aims to detail priorities by proposing alternative structures and processes, funding mechanisms and financial incentives, technological opportunities, and critical partners needed for success. By examining these topics, it is expected that the exercise will significantly refine the region's AR4D agenda suggested by the Global Conference on Agricultural Research for Development 2010.

This study was based mainly on data from secondary sources. The relevant data and information were collected from government policy and strategy documents, different websites, and other relevant information sources.

2. Review of Key National Policies

The agricultural development of a country depends on the policy and institutional environment comprising laws, administrative directives, institutions, services, infrastructure support, and incentives. Unfortunately, after its independence in 1971, until the new policies were adopted, Bangladesh had to depend on the legacy of policies of Pakistan. During the years, the government of Bangladesh has formulated and enacted a number of policies and strategies to stimulate agricultural growth. The government's current initiatives are targeted at preparing the sector for self-sufficiency in food and alleviation of poverty through employment generation. Collectively, these measures are expected to increase agribusiness' contribution to GDP. This section presents an analytical review and evaluation/synthesis of the major policies relating to crop and noncrop agriculture as well as crosscutting policies of Bangladesh. It also considers the country's institutions and support services for the subsectors and agriculture as a whole. A number of relevant national policy documents were reviewed, with emphasis on the issues related to agriculture and particularly on agricultural research and development (R&D). A total of 13 policy documents have been reviewed. The documents include the following:

1. National Agriculture Policy (NAP) 1999
2. NAP 2010 (draft)
3. National Fisheries Policy (NFP) 1998
4. National Livestock Development Policy 2007
5. National Forest Policy 1994
6. National Land Use Policy 2001
7. National Food Policy 2006
8. National Water Policy 1999
9. Environmental Policy and Implementation Programme 1992
10. New Agricultural Extension Policy 1996
11. National Adaptation Programme of Action (NAPA) 2005
12. Steps Towards Change: National Strategy for Accelerated Poverty Reduction (NSAPR) II FY 2009–11—Agriculture
13. Master Plan for Agricultural Development in Southern Region (draft; Ministry of Agriculture [MoA] and Food and Agriculture Organization of the United Nations [FAO] 2012)

2.1. NAP 1999

Although overall the agriculture sector includes the crops, fisheries, livestock, and forestry subsectors, the agriculture policy of the government covers only the crops subsector. Separate policies on livestock, fisheries, and forestry have been formulated by the respective ministries. Policies for the agricultural sector have been articulated within the framework of the government's policy. MoA, with a view to increasing and sustaining agricultural growth, formulated NAP 1999. The main objective of the policy is to make the nation self-sufficient in food by boosting production of all crops including cereals and to provide a reliable food security system for all (MoA 1999). There were 18 specific objectives in this document. The major objectives were (1) to ensure a profitable and sustainable agricultural production system and to increase purchasing capacity of farmers through increasing real income, (2) to conserve and develop land productivity, (3) to create an efficient irrigation system for increasing yield and cropping intensity and to take adequate measures and encourage farmers to apply supplemental irrigation during drought, and (4) to develop a contingency management system to combat natural disasters.

NAP also identifies 18 program areas where actions or policies might be undertaken for achieving these goals: crop production; seeds; fertilizer; minor irrigation; pest management; agricultural mechanization; agricultural research; agricultural extension; agricultural marketing; land use; agricultural education and training; agricultural credit; government support for production and contingency plan; food-based nutrition; environmental protection; women in agriculture; coordination among government agencies, NGOs, and the private sector; and reliable database.

The list of program areas shows that NAP underlines all input and support sectors involved with crop production and identifies issues whose efficiency needs to be improved. NAP emphasizes that the goal of food self-sufficiency and dependable food security can be achieved only through efficient delivery of inputs and support services such as timely supply of quality seeds in adequate quantities.

2.2. NAP 2010 (Draft)

To make the agriculture policy more befitting the national and global context, the new NAP 2010 (MoA 2010) was drafted by MoA for the crops subsector only. This document is designed to accelerate crop production through research, extension, seeds, fertilizers, minor irrigation, marketing, gender, and HRD. As the crops sector plays a major role in Bangladesh agriculture and is of the utmost importance in various agriculture-related programs of the government, this policy document for the development of the crops sector is titled the National Agriculture Policy.

NAP broadly aims at creating an enabling environment for sustainable growth of agriculture, for reducing poverty, and for ensuring food security through increased crop production and employment opportunity as envisaged in the NSAPR, MDGs, and SAARC Development Goals.

The document puts much emphasis on R&D. A well-coordinated research plan is essential to the rapid development of the crops sector. A paradigm shift from a supply-driven to a demand-driven approach to agriculture is necessary. This will require a change in focus from production level to production efficiency, productivity, and profitability. Besides, equity, employment, environmental sustainability, nutrition, food quality, trade, and so on have new areas of concern even as efforts to maintain food security continue. This demands effective introspection, reprioritization, and consolidation of R&D activities besides overall accountability.

2.2.1. Governance of Research Institutions

Strengthen coordination, planning, priority setting, and monitoring and evaluation mechanisms in NARS. Promote a research environment for better return on investment. Provide adequate research contingency support to scientists, and institutionalize project-based activities. Provisions for incentives and built-in rewards for individual researchers or research institutions for innovation and excellence in agricultural research have been suggested.

1. Upgrade the existing infrastructure for research, training, and outreach programs.
2. Empower the Bangladesh Agricultural Research Council (BARC), in cooperation with agricultural research institutes (ARIs), to develop a research system that provides sufficient social benefits per unit of research inputs and

add value for investment; it will seek to achieve small farm mechanization and precision farming.

3. Give special attention to promoting technological empowerment of women in agriculture.

In the context of research planning and funding the government will emphasize participatory research planning and prioritization as a bottom-up research initiative and recognizes the importance of adequate and timely funding for research activities.

Regarding the research focus and areas, the policy document emphasizes the intensification and diversification of research activities on whole-farm activities. To reduce postharvest loss, value addition, agribusiness management, and trade, special attention will be given to postproduction technologies.

Provide support to conduct research on emerging issues such as biotechnology; hybrid crop technologies; climate change; disaster and stress including flood, drought, and cyclone; salinity; upland/hill farming; deep water crop management; and organic farming. Strengthen interventions in rain-fed agriculture emphasizing productivity and sustainability of production. Encourage quality collaborative research to provide solutions to specific problems confronting farmers within their farming systems. Promote research undertakings to cover transboundary and crosscutting issues that have applications across one or more production systems and the sustainability of the production systems, poverty alleviation and livelihood improvement, household food security, off-farm income generation, and rural development. Support agricultural policy research and unique technology dissemination systems.

2.2.2. Agricultural Extension

The policy recognizes agricultural extension as the key driving force for the growth and development of agriculture in Bangladesh. To increase farm productivity and farmers' income, access to new technology is required. The role of extension is to deliver services and to speed up farmers' access to and adoption of new technology. The government recognizes agricultural extension as a service delivery system that will assist farmers through appropriate technical and farm management advice and information, new technology, improved farming methods, and techniques aimed at increasing production efficiency and income.

However, the research–extension linkage in Bangladesh needs to be strengthened. Already established institutional arrangements such as the Agricultural Technical Committee and National Agricultural Technical Coordination Committee need to be fully activated so that research and extension can interact effectively with each other and with farmers to address the critical needs of the production practices at the farm level. The following provisions are adopted to make extension services more efficient and effective:

1. Promote public, private, and voluntary extension initiatives to achieve diverse agricultural goals and to address needs of target populations.
2. Provide services to all categories of farmers: landless, marginal, small, medium, and large, with special emphasis on women and youths.
3. Decentralize extension activities at the grassroots level to deliver efficient and coordinated services.
4. Change the extension approach to make it a more participatory and interactive bottom-up participatory approach in which farmers, researchers, and extension workers will serve as peers.

5. Encourage the promotion of crops suitable to the agroclimatic conditions of a particular region based on crop zoning.
6. Use traditional and advanced communication media and information and communication technology (ICT) to disseminate extension services.
7. Facilitate extension events that foster government organization–NGO–private sector partnership and encourage public–private partnership for production of agricultural commodities.
8. Deliver extension services in collaboration with local government at the union and upazila levels.
9. Maintain liaison through the Department of Agricultural Extension (DAE) and allied agencies with NGOs and other development partners at the local level for cooperation and coordination.

It may be mentioned here that MoA formulated the New Agricultural Extension Policy (MoA 1996) in 1996 in harmony with the agricultural policies and priorities set out in a 15-year (1995–2010) perspective plan. The main goal of the New Agricultural Extension Policy was to encourage the various partners and agencies within the national agricultural extension system to provide efficient and effective services that complement and reinforce each other in an effort to increase the efficiency and productivity of agriculture. There were 11 policy actions, called components. The key components of the policy include the following: Decentralize efficient and integrated extension services to all categories of farmers, strengthen the extension–research linkage and training of extension personnel, use demand-led and appropriate extension methodology, and integrate environmental support.

2.3. NFP 1998

Fish is the principal source of animal protein in the Bangladeshi diet. Due to an imbalanced diet and a deficit of protein intake child mortality has increased in the country, and livestock as a source of protein is limited. For this reason dependency on fish for animal protein–rich food will increase day by day. There are many possibilities for increasing the contribution of the fisheries subsector to the socioeconomic development goals of the country; these include increasing nutrition, employment opportunities, and foreign currency earnings and establishing different industrial organizations. NFP 1998 was formulated by MoFL with the following objectives:

1. Enhance fisheries' production.
2. Alleviate poverty by creating self-employment, and improve socioeconomic conditions of the fishers.
3. Fulfill the demand for animal protein.
4. Achieve economic growth through earning foreign currency by exporting fish and fisheries products.
5. Maintain ecological balance, conserve biodiversity, ensure public health, and provide recreational facilities.

This document addresses policy measures to be undertaken in four areas or dimensions and recommends policies for several supporting services. The four dimensions of NFP are (1) policy for procurement, preservation, and management of fisheries resources of the open water bodies; (2) policy for fish culture and management in closed freshwater bodies; (3) policy for culture of shrimp in coastal regions; and (4) policy for exploitation, conservation, and management of marine fisheries resources.

To provide a strong base for the development of fisheries resources and to make NFP effective, the document suggests recommendations to remove constraints in these policy

areas. The document lists recommendations for the provision of related supporting services: (1) establishment of hygienic fish landing centers, (2) development of fish transportation and marketing systems, (3) improvement of fish processing and quality control, (4) acceleration of fish exports, (5) development of a fishery-related education policy, (6) development of a fishery training policy, (7) development of a fishery extension policy, (8) improvement of institutional facilities in the fishery sector, (9) formulation of a fishery-related environmental policy, (10) formulation of a fishery credit policy, and (11) development of a fishery-related cooperative policy.

2.3.1. Fisheries Research

The Bangladesh Fisheries Research Institute and some universities are conducting research on different aspects of fisheries in the country. To make the research and its outcomes more visible the following policies have been recommended:

1. Establish mutual linkage and cooperation between research organizations and technology user groups with emphasis on practical research rather than academic research in the universities.
2. Conduct surveys and formulate and execute research project operation with different government and private organizations, using their institutional infrastructure and capacity.
3. Carry out research based on the development needs of the county to reflect problems and identify possible solutions.
4. Provide use of the ponds and other facilities of the Bangladesh Fisheries Research Institutes to Bangladesh Agriculture University and other universities for the sake of research.
5. Follow open research policy for fisheries research with emphasis on field and practical productive research activities in addition to institutional research.
6. Patronize joint research by the government and private organizations and encourage investment in research by the commercial fish and shrimp farmers.
7. Have as research priorities relative productivity of different water bodies, employment opportunities, and economic profitability.

2.3.2. Fisheries Extension Program

The Department of Fisheries (DOF) is responsible for fisheries extension in Bangladesh. NFP recognizes that sustainable fish/shrimp production and management could be achieved through transfer of production technologies and expansion of appropriate processing and preservation methodologies among the fishers and fish farmers. In this regard, the following 11 policies have been recommended:

1. Economically feasible and successful fish demonstration farms in public places will be established in the private sector through government assistance.
2. Demonstration farms will be established in contact farmers' ponds. Contact farmers will be trained on fish culture. Emphasis will be given to ensure timely input supply. Fisheries extension officers will visit these ponds regularly to provide advice and conduct in situ training. Demonstration ponds will be established in all feasible unions.
3. In the extension program, all concerned persons in the local union will be arranged together.
4. Interested fish farmers will be organized by the extension officers and workers.
5. A training program will be delivered for the fish fat tiers, fishers, and fish shrimp fry catchers by the extension officers' workers on a regular basis.
6. Aspects of open water fisheries conservation and fish culture will be advertised attractively in different public media to accelerate the fisheries extension program.
7. Private and social organizations interested in fish culture as a tool for poverty alleviation will be emphasized for the fishers' emersion program. NGOs will get priority in this aspect.
8. Private entrepreneurs will be encouraged to make available the inputs required in shrimp culture and management.

9. Organizations engaged in fisheries resource development, extension, management, and technology development will be coordinated.
10. Establishment of different societies such as a fish farmers development association, fish farmers development association for the marine fisheries, and so on will be encouraged for the development of fisheries resources and extension.
11. Emphasis will be given to rice–fish culture.

2.4. National Livestock Development Policy (NLDP) 2007

NLDP, prepared by MoFL, was approved in 2007. This document addresses the key challenges and opportunities for the comprehensive and sustainable development of the livestock sector. It promotes sustainable improvement in the productivity of milk, meat, eggs, and so on; promotes activities to improve income, nutrition, and employment for landless and small farmers; and invites greater participation and investment of the private sector.

This policy also provides opportunities and reduces vulnerability and risk in an effort to harness the full potential of the livestock subsector, thereby accelerating economic growth for reduction of rural poverty.

This document provides a well-thought-out blueprint for the development of the livestock sector in the country. There are two distinct objectives—supply of adequate livestock and livestock products for human consumption and supply of animal power and animal waste for crop production and product processing.

The NLDP document addresses 10 thematic areas, of which 3 are concerned directly with livestock production issues and the rest are concerned with supplying supporting services.

The production-related thematic areas are (1) dairy development and meat production, (2) poultry development, and (3) breeds development. The thematic areas related to the provision of support services include (1) feeds and fodder management, (2) veterinary services and animal health, (3) hides and skins, (4) marketing of livestock products, (5) international trade management, (6) access to credit and insurance, and (7) institutional development for research and extension.

2.4.1. Dairy Development

The key constraints of the dairy sector are the following: (1) limited skill of smallholder dairy farmers, (2) scarcity of feeds and poor nutrition, (3) susceptibility to disease, (4) limited coverage of veterinary services, (5) limited credit support, (6) limited milk collection and processing facilities, (7) lack of insurance coverage, (8) absence of market information, and (9) absence of appropriate policy and regulatory bodies.

To minimize these constraints, the following recommendations are made: (1) Establish a cooperative dairy (Milk Vita model), and expand it into potential areas of the country; (2) replicate successful pro-poor models for community-based smallholder dairy development including appropriate contact farming schemes; (3) promote smallholder dairy farming, integrated with crop and fish culture; (4) promote supply chain–based production, processing, and marketing of milk and milk products; (5) establish a National Dairy Development Board as a regulatory body to promote dairy development; and (6) establish a National Dairy Research Institute to carry out research in various aspects of dairy.

2.4.2. *Meat Production*

The NLDP identifies four key constraints hindering the meat production industry in the country as follows: (1) lack of appropriate breeds, (2) knowledge gaps of farmers, (3) lack of proper veterinary services, and (4) quality feeds.

To address these constraints, the following measures were recommended: (1) Develop beef breeds for increased productivity at the farm level; (2) promote production of Black Bengal goats by ensuring disease prevention, availability of quality bucks and semen for artificial insemination, and knowledge transfer through special projects; (3) develop buffalo and sheep farming in selected high-potential areas through special projects; (4) enact the proposed Animal Slaughter Act to produce hygienic production of quality meat, (5) train butchers in scientific slaughter, processing, and meat preservation techniques; (6) establish modern slaughter houses in the private sector; and (7) develop a backward and forward linkage system to help improve the existing cattle-fattening system in private enterprises.

2.4.3. *Poultry Development*

The main constraints identified in NLDP are (1) lack of infrastructure beyond the upazila headquarters for providing services to poultry farmers; (2) shortage of skilled manpower; (3) shortage of quality chicks and breeding materials; (4) shortage of poultry, feed/feed ingredients, and high prices; (5) poor quality of inputs; (6) lack of quality control facilities for medicine, vaccines, and biological products; feed and feed ingredients; chicks; eggs; and birds; (7) drug and vaccine residues in poultry meat; (8) shortage of vaccines; (9) lack of organized marketing systems; (10) poor provision of veterinary services; and (11) insufficient credit and capital, especially for the poor. The possible threat of avian influenza exacerbates some of these concerns and shortcomings and would require that additional measures be taken.

The following recommendations have been made based on these policy issues: (1) Replicate successful pro-poor models for semiscavenging poultry development, and facilitate formation of poultry smallholder groups, community-based organizations (CBOs), and producers associations; (2) ensure quality control of poultry feeds and feed ingredients through establishment of a legal body and enforcement of regulations, and ensure production and consumption of safe meat, milk, and eggs; (3) promote organic meat, milk, and egg production; (4) establish criteria and guidelines to ensure supply of quality day-old chicks, develop and enforce specific guidelines for establishing environment-friendly commercial poultry farms, and convert small commercial farms into profit-oriented large farms following the cooperative system; (5) use Department of Livestock Services (DLS) poultry farms as breeding and multiplication farms/centers for smallholder training, technology testing and demonstration, and so on; (6) promote smallholder production and marketing of ducks and minor poultry species (for example, quail, goose, pigeon, guinea fowl) in selected areas; (7) strengthen the already declared Bangladesh Livestock Research Institute (BLRI) as a national reference laboratory with international standards for detection of the avian influenza virus and other emerging diseases; (8) implement a national avian flu preparedness plan, and for this register all commercial poultry farms with DLS; and (9) ensure that the biosafety protocol developed by MoFL is followed by concerned stakeholders.

2.4.4. *Livestock Research*

The main constraints identified in NLDP are the following: (1) Shortage of adequate scientific manpower is the major problem identified. (2) Shortage of operating funds for

research is acute in BLRI. The annual allocation shows a declining trend in real terms. BLRI has been entirely dependent on the development budget and contract research grants from BARC (also under development projects) for carrying out research. This has restricted BLRI in developing and undertaking meaningful research programs to support the poverty-reduction program of the government. (3) BLRI has problems with the training of its personnel. There is no provision for staff training or a built-in system of carrier progression within the research divisions like there is in the research institutes in the crops sector. This has created a high rate of attrition of qualified scientists.

Policy framework recommendations for livestock research are the following: (1) Address national priorities, the untapped potential of regional livestock resources, and the research capacity of BLRI headquarters to enhance BLRI's regional stations; (2) encourage and support private and NGO initiatives in livestock research; (3) sharpen the mandate, functions, and structure of BLRI with a view to enhancing the capacity to coordinate and maintain liaison with other concerned departments, and conduct livestock research for pro-poor sustainable development; (4) enhance and extend research capacities of BLRI and universities/academic institutes to ensure safe production of animal products and by-products, animal protein supplement, feed additives, premixes, probiotics, and mineral and vitamin supplements as inputs for poultry and livestock development; (5) amend the act of BLRI to give greater autonomy to the management board and institute to bring it up to par with the crop research institutes; (6) create an enabling environment to develop quality manpower in livestock research to undertake challenges for emerging livestock resource development in the context of global reformation, and reform the BLRI service structure and rules of business to improve its management and provide career development opportunities for talented scientists; (7) increase the total annual budget for livestock research to 40–50 percent to meet the research operating costs; and (8) upgrade the National Avian Influenza Laboratory established in BLRI to Biosafety Laboratory 3.

2.4.5. Livestock Extension

For the extension of livestock services the Directorate of Livestock Services was established in 1960 and renamed the Department of Livestock Services in the late 1980s. The extension service in the livestock sector has always been lacking due to multifaceted problems. The major challenges faced by DLS were identified as (1) inappropriate mandate and functions, (2) structural and organizational deficiencies, (3) thin and weak frontline services at the upazila, (4) weak linkage with research organizations including BLRI, (5) weak management system and management information system (MIS), (6) lean recruitment and promotion system, (7) shortage of skilled manpower, (8) lack of regular skill development training, and (9) limited budget allocation.

The following is the policy framework of livestock extension:

1. The private sector, NGOs, and CBOs would be encouraged to provide private goods livestock services, namely, veterinary services, vaccinations, and so on.
2. DLS would be reformed to enhance its role as a provider of public goods services, namely, regulatory measures, quality assurance and control, monitoring function, food safety function, and disease surveillance.
3. Frontline extension services of DLS would be updated and extended for rapid livestock development and sound service delivery.
4. Resource allocations to DLS would be increased to make DLS effective in delivery of public goods services.
5. An autonomous unit/institute would be established for quality assurance and certification of livestock products, vaccines and biologics, and consumers' rights protection.

6. Quality control of breeding materials would be ensured by extending the district artificial insemination center with modern laboratory facilities to all districts.
7. A long-term fodder development program would be taken throughout the country to minimize the acute shortage of feeds and fodder.
8. An analytical and diagnostic facility in the district mini-laboratory would be strengthened for full-time service with skilled manpower.
9. The district veterinary hospital would be further extended to the upazila veterinary hospital to ensure better services.
10. A special cell in all district veterinary hospitals would ensure around-the-clock service for emergency purposes.
11. A retraining program would be developed and implemented to equip DLS staff with modern knowledge and skills within the framework of a clearly defined HRD action plan.
12. Besides staff training, DLS training institutes would be opened for all eligible candidates from the private sector, NGOs, and CBOs for livestock service extension training.
13. The extension–research–NGO linkage would be strengthened for field-testing and dissemination of livestock technologies.
14. A memorandum of understanding has been signed by DLS and the Bangladesh Rural Advancement Committee to provide/extend the Artificial Insemination Programme throughout the country.
15. More administrative and financial power has been delegated/given to field-level officials and works smoothly.
16. The procurement of veterinary drugs and surgical instruments has been decentralized to district levels.

2.5. National Forest Policy 1994

The first National Forest Policy of Bangladesh was prepared in 1979. The latest forest policy came to force in 1994, 100 years after the formulation of the first forest policy (1894) on the Indian subcontinent. In the early 1990s, the government prepared a draft of a 20-year National Forestry Master Plan to tackle the natural and undesirable consequences resulting from abnormal and quick depletion of forestry resources. The current National Forestry Policy was prepared as part of that master plan in 1994. Important features of hitherto existing forest policies are outlined in brief in the following sections.

This policy focused on the restructuring of the forest department, horizontal expansion of forest, careful preservation and scientific management of forest, optimum forest extraction, and setting up of new forest-based industries. Bangladesh's first forest policy also emphasized forestry research, training, and education to meet scientific, technological, and administrative needs, but unfortunately that policy had only generalized and somewhat vague directions. The latest forest policy of Bangladesh was enacted in 1994. It marks a major departure from commercialization to recognition of rights and participation of people. Critical and careful examination of the policy statements can reveal the following main features (Alam 2009).

Out of 29 statements of the National Forestry Policy, the major ones are the following:

1. Horizontal expansion of forest to bring 20 percent of the land area under forest by 2015
2. Emphasis on planting for trees on village areas, newly built-up mudflat areas, roadsides, railway track sides, and embankments
3. Public and private participation in forest expansion and management (the government shall work jointly with NGOs/private sector and ensure people's participation; the government will undertake afforestation with people's participation and with the assistance of NGOs)

4. Emphasis on urban forestry (the government shall promote special afforestation activities in municipal areas)
5. Special attention to the Chittagong Hill tracts (in the hill districts of Banderban, Rangamati, and Khagrachari, massive afforestation programs will be undertaken in the unclassified state forest by public and private agencies)
6. Acknowledgments of the importance of biological diversity and protected areas
7. Promotion and development of forest-based small-scale enterprises
8. Implementation of the National Forestry Policy, supported by strengthening educational, training, and research organizations (this will contribute to the forestry sector's development)

However, the current forest policy is a significant move toward people-oriented forestry and shows the government's determination to protect and develop forest resources through people's participation.

2.6. Cross-sectoral Policies Influencing Agriculture

Besides the policies stated above, there are other national policies that have direct or indirect impacts on the agriculture sector.

2.6.1. National Land Use Policy (Ministry of Land 2001)

Under the auspices of the Ministry of Land, the National Land Use Policy2001 (Ministry of Land 2001) was prepared and approved by the government in 2001. The National Land Use Policy deals with land uses for several purposes including agriculture (crop production, fisheries, and livestock), housing, forestry, industrialization, railways and roads, tea, and rubber. The document basically identifies land use constraints in all these sectors. Some of the major ones include declining land productivity due to unplanned and improper uses of land and decreasing soil fertility, diminishing water land and aquatic biodiversity, and dwindling natural forest and environment.

The policy emphasizes conservation of the agricultural resource base and sustainable management of water, land, forest, and biodiversity resources. It also calls for removal of adverse impacts of interventions in water management and flood mitigation. It stresses the need for reducing the expansion of salt-affected soils and intrusion of in-stream salinity. It emphasizes the control of unplanned expansion of settlements and urbanization. Moreover, the document advocates modification of the current regulatory system. The land issues fall in the domain of many ministries, and this leads to problems of interministerial coordination of the use of land resources.

2.6.2. National Water Policy 1999

The National Water Policy was formulated in 1999 by the Ministry of Water Resources (MoWR 1999). This document aims to provide direction to all agencies working with the water sector and institutions that relate to the water sector in one form or another for achieving the following specified objectives: (1) to address issues related to the harnessing and development of all forms of surface water and ground water and management of these resources in an efficient and equitable manner; (2) to ensure the availability of water to all elements of society including the poor and the underprivileged, and to take into account the particular needs of women and children; (3) to accelerate the development of sustainable public and private water delivery systems with appropriate legal and financial measures and incentives, including delineation of water rights and water pricing; (4) to bring institutional changes that will help decentralize the management of water resources and enhance the role of women in water management; (5) to develop a legal and regulatory

environment that will help the process of decentralization, lead to sound environmental management, and improve the investment climate for the private sector in water development and management; and (6) to develop a state of knowledge and capability that will enable the country to design future water resources management plans by itself with economic efficiency, gender equity, social justice, and environmental awareness to facilitate achievement of the water management objectives through broad public participation.

The National Water Policy has 16 components that describe policy measures to be undertaken to achieve the above objectives. These policy measures include (1) river basin management; (2) planning and management of water resources; (3) water rights allocation; (4) public and private involvement; (5) public water investment; (6) water supply and sanitation; (7) water and agriculture; (8) water and industry; (9) water, fisheries, and wildlife; (10) water and navigation; (11) water hydropower and recreation; (12) water for environment; (13) water for preservation of *haors, baors,* and *beels;* (14) economic and financial management; (15) research and information management; and (16) stakeholder participation. The NFP emphasizes, among others, three interrelated issues: water and agriculture; water, fish, and wildlife; and water for the preservation of water bodies (haors, baors, and beels). One of the notable policy directions in the National Water Policy is to encourage private-sector development of groundwater for irrigation and to emphasize surface water augmentation.

2.6.3. Environmental Policy and Implementation Programme 1992

The United Nations Conference on Environment and Development, or the so-called First World Summit, was held in Rio de Janeiro, Brazil, in 1992. In the same year the Ministry of Environment and Forest (MoEF) announced the Environmental Policy and Implementation Programme 1992 (MoEF 1992) with the following objectives: to conserve and develop natural harmony through environmental conservation and development; to safeguard the country from natural hazards; to identify all forms of pollution and activities that degrade the environment; to ascertain environment-friendly development in all spheres; to ensure sustainable, long-term, and environment-friendly use of all resources; and to be actively involved in all international environmental efforts as much as possible. The domain of the policy covered 15 areas, that is, agriculture, industry, health, energy, water development and flood control, land use, biodiversity, fishery and livestock, food, coastal and marine environment, transport, housing and urbanization, education, science and technology, and legal and institutional framework. The policy also prescribed detailed activities to be undertaken by the various agencies of the government in implementing the policy.

1. The Bangladesh National Environment Policy, approved in May 1992, sets out the basic framework for environmental action, together with a set of broad sectoral guidelines (Environment and Development Alliance 1999). The key elements of the policy include the following

    1. Maintenance of the ecological balance and overall progress and development of the country through protection and improvement of the environment
    2. Protection of the country against natural disasters
    3. Identification and regulation of all types of activities that pollute and degrade the environment
    4. Ensuring sustainable use of all natural resources
    5. Active association with all environment-related international initiatives

2.6.4. *National Food Policy 2006*

The Ministry of Food and Disaster Management has prepared the National Food Policy 2006. The major objectives of the National Food Policy, which aims to ensure dependable food security for all, are the following: (1) adequate and stable supply of safe and nutritious food at affordable prices; (2) increased physical, social, and economic access and purchasing power of all people; and (3) adequate nutrition for all individuals, especially children and women.

The strategy for ensuring an efficient and sustainable increase in food production depends basically on improvement of domestic food grains production and food import. This will be achieved through (1) improvement of agricultural development and extension services; (2) efficient use of water resources; (3) availability of agricultural inputs and their efficient use; (4) agriculture diversification and improved agricultural technology promoting production of noncereal crops such as vegetables, oilseeds, pulses, and fruits and developing poultry, livestock, and fisheries; and (5) increase of agricultural productivity, reduction of postharvest losses, and prevention of losses from pests and diseases.

The second strategy is the development of an efficient food market. This will be realized by (1) developing market infrastructure, (2) encouraging private-sector involvement in storage and movement of food items, development and enforcement of quality standards, and promotion of private, liberal credit for food items; and (3) developing and disseminating early-warning and market information.

The third strategy is nondiscretionary food market intervention for price stabilization, which is to be realized through (1) price incentives for domestic food production, (2) public food grain stock, and (3) consumer price support.

The second objective—increased physical, social, and economic access and purchasing power of all people—involves three sets of strategies. The first strategy is transitory shock management, which includes (1) special measures for disaster mitigation for agriculture, (2) emergency distribution from public stock, and (3) measures for increased supply through private trade and stock. The second strategy is the effective implementation of the targeted food-assistance programs. And the final strategy is employment-generating income growth, pursued through (1) support to women in income-generating activities, (2) investment in employment-enhancing technology, (3) fiscal incentives for agro-based and rural industries, (4) education skill and HRD, and (5) broad-based, labor-intensive growth promoting macropolicy. The final objective—adequate nutrition for all individuals, especially children and women—will be achieved through the following measures: (1) sufficient macronutrients and enhanced nutrition for the vulnerable group, (2) safe and quality food supply, (3) safe drinking water and improved sanitation, (4) balanced diet containing sufficient micronutrients, and (5) adequate health status.

2.6.5. *NAPA 2005*

Besides these, for combating the adverse effects of climate change and as a commitment to the United Nations Framework Convention on Climate Change, the process of formulation of NAPA for Bangladesh began in late 2004 under the sponsorship of MoEF. A number of line ministries such as MoA, MoFL, Ministry of Water Resources, and MoEF were involved in the process. The NAPA process has been successfully completed and approved by the government. The document emphasizes the need for an enabling policy environment for mainstreaming adaptation in the development process. Through this process the deficiencies and priorities of the policy regime have been adequately covered in NAPA.

2.6.6. *Steps Towards Change: NSAPR II FY 2009–11—Agriculture*

NSAPR (General Economics Division 2011) places agriculture and rural development as the key drivers of its pro-poor growth strategy. The policy framework in place to support this strategic choice focuses on four issues: intensification of major crops (that is, cereals), diversification to high-value noncereal crops (that is, vegetables and fruits), development of noncrop agriculture (that is, fishery, poultry, livestock), and promotion of rural nonfarm activities (that is, rural construction, transport, and services). The major thrust for reduction of poverty in rural areas will be given to the crops subsector.

The government's overriding policy is to create an enabling environment and support the transformation of subsistence agriculture to a more diversified commercial agribusiness with significantly increased participation of the private sector. For crop- and noncrop-sector growth, the Poverty Reduction Strategy Paper (PRSP) puts emphasis on achieving productivity and profitability gains, broad-based support to agriculture, and diversification and commercialization of agricultural enterprises in the face of trade liberalization under globalization. PRSP also stressed crosscutting issues, that is, agricultural research and technology generation, farmers' demand-led extension services, energizing agricultural marketing and agro-processing, land use, and women in agriculture.

The most important contribution of the PRSP exercise on agriculture is the formulation of a reasonably precise and workable policy matrix, which identifies 22 crucially important strategic goals, fixes up targets against these goals, charts actions already taken, sets future policy agendas and priorities, and delineates responsibilities for the concerned ministries. The lead ministries established their ownership by playing active roles in fixing the policy priorities, which were then seeped through a wide range of participation from the mainstream ministries, agencies, academia, NGOs, and civil society groups.

2.6.7. *Master Plan for Agricultural Development in the Southern Delta of Bangladesh for Agricultural Development in Southern Region (draft; MoA and FAO 2012)*

The government of Bangladesh, with the assistance of FAO, has drafted the Master Plan for Agricultural Development in Southern Region (MoA and FAO 2012) to face the challenges specific to the region. The identified challenges are categorized as biophysical and institutional. The master plan covers a 10-year period from 2012 to 2021. The biophysical challenges are (1) poor land use and low productivity; (2) changing of fish migratory routes due to insufficient upstream flow, siltation, and pollution; (3) water logging in polders; (4) river bank erosion, siltation, and flooding; (5) water scarcity for domestic purposes and irrigation in saline area; and (6) sea level rise due to climate change. However, the institutional challenges are (1) absence of coordination among service providers, (2) conflicting demand for natural resources, (3) narrow project approach, (4) water management organizations' not having been developed or the system's collapsing after withdrawal of the project, (5) absence of accountability of service providers, (6) lack of a holistic approach to farming systems, and (7) poor access to institutional credit.

To meet these challenges, based on field study, regional consultations, and interaction with various stakeholders, 85 interventions have been identified under 26 programs across 10 components. The components are (1) crops, horticulture, and agroforestry; (2) fisheries; (3) livestock; (4) nutrition; (5) water management; (6) polder management; (7) drainage improvement; (8) agribusiness; (9) agricultural credit; and (10) capacity building. Priorities are grouped into four categories in line with the criteria used in the Country Investment Plan (Government of Bangladesh 2011). Total investment will be needed to address crops,

fisheries, livestock, agroforestry, and other components such as water and polder management, drainage improvement, and agriculture credit.

2.7. Compatibility, Synergies, and Contradictions

The policies discussed above are generally compatible in their stated goals of accelerated poverty reduction through increasing productivity and profitability of crops, livestock, and fisheries; creating employment opportunities and income generation; widening work opportunities for rural women; and improving the competitiveness of farmers. It is generally observed that most of the sectoral policies were pronounced in the 1990s, before the PRSP/NSAPR was formulated; nevertheless, the major thrusts of these policies are largely consistent with the MDGs as well as the strategies and future policy priorities of agriculture. However, the draft NAP 2010 is more befitting the national and global context for the crops subsector. This document is designed to accelerate crop production through research, extension, seeds, fertilizers, minor irrigation, marketing, gender, and HRD. NAP broadly aims at creating an enabling environment for sustainable growth of agriculture for reducing poverty and ensuring food security through increased crop production and employment opportunity as envisaged in NSAPR, MDGs, and SAARC Development Goals. The document puts much emphasis on R&D. It recognizes the requirement of a well-coordinated research plan for the rapid development of the crops sector and the need for a paradigm shift from a supply-driven to a demand-driven approach in agriculture and also suggests effective introspection, reprioritization, and consolidation of R&D activities besides overall accountability.

All the reviewed policy documents have important synergies within the broad objectives of attaining food self-sufficiency, food security, and accelerated reduction of poverty in rural areas. All of these policies highlighted efficient use of land, water, and other natural resources as well as human resources, with special emphasis on women's participation and environmental protection. All these policies, especially the ones related to agriculture, have expressed the need for strengthening the research–extension linkage and coordination among the ministries and agencies in the design, approval, and implementation of projects. There are no arrangements for monitoring and evaluating the forest policy implementation. In addition there is a serious lack of enforcement. For food security too much emphasis has been put on cereals, especially rice, and lesser attention has been given to noncereal crops, that is, vegetables, fruits, and flowers. In fisheries, not much emphasis has been put on small fishes as a positive implication for supplying protein to the poor and for maintaining biodiversity. The policies have as a major focus the role of the public sector. Although most of the policies specify the need for an increased role of the private sector, the mechanisms of its involvement are not clear. It is thus important to note that the ultimate objective of all policies is to improve the efficiency of relevant institutions or agencies.

All the subsectoral policies of agriculture emphasized commercialization. Key proposals for developing an enabling environment for agribusiness included promoting a competitive market with easy access for private-sector traders, processors, and exporters to supply inputs and purchase outputs; ensuring comparable conditions for the government, NGOs, and the private sector; and monitoring and enforcing laws and regulations.

The National Land Use Policy emphasizes conservation of the agricultural resource base and sustainable management of water, land, forest, and biodiversity resources. It also calls for removal of adverse impacts of interventions in water management and flood mitigation. It stresses the need for reducing the expansion of salt-affected soils and intrusion of in-stream salinity.

The land issues fall in the domain of many ministries, leading to problems of interministerial coordination of the use of land resources. One of the notable policy directions in the new water policy is to encourage private-sector development of groundwater for irrigation and also to emphasize surface water augmentation. The current forest policy is a significant move toward people-oriented forestry and shows the government's determination to protect and develop forest resources through people's participation.

However, there are many inconsistencies or inadequacies in the subsectoral policies. There are also conflicts in implementing these policies. All these have arisen because these policies were formulated by different ministries at different times. While formulating its policy, the line ministry largely concentrated on its own domain, ignoring the crosscutting issues. Many issues such as the impact of climate change on agriculture (crops, fisheries, livestock) are missing in most of the policy documents.

Lack of coordination among and across ministries gave rise to the noncompliance of leasing arrangements of water bodies for fish culture due to the triangular actions or inaction of three ministries: Ministry of Land, Ministry of Water Resources, and MoFL.

The review of the relevant policy documents revealed that 7 out of 12 were formulated between 1992 and 1999 and the rest between 2000 and 2010. However, most of the policies were pronounced after the United Nations Conference on Environment and Development—the First World Summit—held in Rio de Janeiro, Brazil, in 1992. It is expected that the government of Bangladesh, as a signatory to the United Nations Framework Convention on Climate Change, should incorporate the issues related to climate change in the policies, which were drafted after the event. However, issues related to climate change and the issue of adaptation to climate change haven't been incorporated into the policy regime.

A few of the policy papers have provisions for periodic review and incorporation of emerging issues; this provides an opportunity to include policy options regarding the adverse impacts of climate change and adaptation to climate change. Other than the Coastal Zone Policy (MoWR 2005), none of the policies mention climate change, its implications on the livelihood of the people, and adaptation to it. Some of the policies have options that could indirectly help in adapting to the predictable changes due to climatic variability and sea level rise.

3. Review of Structures and Issues

3.1. The Ministries

The agriculture sector includes the crops, fisheries, livestock, and forestry subsectors. MoA covers only the crops subsector. MoFL is the line ministry for the fisheries and livestock subsectors, and the forestry subsector is looked after by MoEF. These ministries are the nodal agencies in the administrative structure of the government.

3.1.1. MoA

MoA is one of the major ministries of the government. The ministry is led by a minister who is assisted by a secretary and two additional secretaries. The major responsibilities of MoA are to (1) develop agricultural policies, plans, regulations, acts, and so on for sustainable agricultural development and for food sufficiency; (2) provide support in developing new agricultural technologies to boost agricultural productivity; (3) monitor distribution of agricultural inputs and subsidies and marketing of agricultural products in local and international markets; (4) provide administrative and policy support to MoA agencies for

planning and implementation of the development programs/projects and coordinate with donors and development partners for funding and technical assistance; and (5) monitor implementation of agricultural policies, plans, projects, programs, and regulations. Eighteen agencies operate under MoA and are responsible for implementation of the different projects and plans of the ministry. Among them, seven ARIs and BARC are parts of NARS. The extension department (DAE) is also under the administrative control of MoA.

The Bangladesh Agricultural Development Corporation (BADC), an autonomous corporate body under MoA, has a nationwide network of outlying field offices. The major responsibility of BADC is to provide input such as seed, fertilizer, and irrigation. The Seed Certification Agency is the only government-authorized body for quality control of all kinds of seeds in Bangladesh produced by the public and private sectors and NGOs. The Seed Certification Agency has been performing its role of seed certification of five notified crops (rice, wheat, jute, potato, and sugarcane).

3.1.2. MoFL

MoFL is led by a minister who is assisted by a secretary. The main functions of MoFL are to preserve fisheries resources, fulfill the requirement of animal protein through proper management and planned development, increase socioeconomic conditions of fishermen, create employment opportunities for rural unemployed and landless people, expand foreign exchange earnings by exporting fish and fishery products, and innovate new technologies through research for fisheries development and preservation. Two ARIs of NARS and extension services are under the administrative control of MoFL.

The Bangladesh Fisheries Development Corporation, a public-sector organization under the ministry, maintains commercial fishing trawlers and fish processing industries. Bangladesh Marine Fisheries Academy is a government-run training institution in Bangladesh for cadets wishing to enter the fishing industry, merchant shipping, and other related maritime industries.

3.1.3. MoEF

MoEF is led by a state minister who is assisted by a secretary. The organizational structure of the ministry covers a number of divisions as well as a directorate, board, subordinate offices, autonomous institutions, and public-sector undertakings. The ministry is responsible for planning, promoting, coordinating, and overseeing the implementation of environmental and forestry programs. MoEF oversees all environmental matters in the country. One of the NARS institutes and the forest department are under the administrative control of MoEF.

Besides the above three ministries, two NARS institutes—Bangladesh Tea Research Institute and Bangladesh Sericulture Research and Training Institute (BSRTI)—are under the administrative control of the Ministry of Commerce and Ministry of Jute and Textiles, respectively.

3.2. NARS

Formal agricultural research in what is today Bangladesh had its beginning in 1880. Systematic research on jute started at the turn of the twentieth century. Planters, the tea trade, and several governmental units began tea research at about the same time. Most of the research organizations now in Bangladesh have a legacy of British colonial and Pakistani rule. After the independence of Bangladesh in 1971 several key decisions were implemented in 1973. All the provincial organizations took on national responsibilities. One of the major

events of the year in the history of agricultural research was the establishment of BARC by the President's Ordinance as a national agency to coordinate agricultural research.

BARC is an autonomous organization under MoA. BARC was established as an organization to ensure agricultural research coordination, planning, research, execution, and evaluation of the activities of agricultural institutes and associate organizations. The BARC Ordinance has undergone several amendments: in 1973, 1976, and 1988. In 1996 it was further updated. Under the provision of the BARC act of 1996, NARS was formed with BARC as the apex body and 10 ARIs as constituent units. The agricultural universities, NGOs, and private sector, although not integrated, were linked with NARS in research collaboration. Among the 11 research organizations including BARC, 6 are autonomous bodies under MoA, and the remainder are under other ministries. Two institutes, the Bangladesh Forest Research Institute and the Soil Resources Development Institute, are government departments.

Under the provisions of the BARC act of 2012 (April 2012), more responsibility is given to the council to review research and allocate resources, avoiding duplication of research, disbursing research funds among the research institutes, and approving research projects. Two more research institutions, namely, the Cotton Development Board (CDB) and BSRTI, are included in NARS.

Agricultural research in Bangladesh is mostly carried out in NARS, which comprises 12 ARIs, as stated earlier. However, there are as many as 16 public organizations that are engaged in undertaking agricultural research. Among these, 8 are research institutes, and 8 are universities. Again, the private sector has started investing in agricultural research in the country.

The Agricultural Science and Technology Indicator of the International Food Policy Research Institute has identified a total of 51 research entities involved in agricultural research including faculties/departments of universities and laboratories of the Bangladesh Council of Scientific and Industrial Research. A list is included in Appendix A.

Institutions outside NARS do not have a major mandate of agricultural research, and their work is being undertaken in isolation. The Bangladesh Academy for Rural Development and the Rural Development Academy are mostly known for organizing training courses for the staff of different public organizations and NGOs not only in agriculture but also in other disciplines. There is no functional linkage with mainstream agricultural research. The Bangladesh Academy for Rural Development and the Rural Development Academy fall under the Ministry of Local Government, whereas research institutions such as the Atomic Energy Commission and the laboratories of the Bangladesh Council of Scientific and Industrial Research fall under the Ministry of Science, Communication, and Information Technology. Institutions feel linkages with NARS are necessary not only to get the benefit of its research capacity but also to help NARS avoid duplication.

The eight agricultural universities have fairly well-developed research capacity, particularly Bangladesh Agricultural University, Bangabandhu Sheikh Mujibur Rahman Agricultural University, and Sher-e-Bangla Agricultural University. Other public agricultural universities are developing research capacities gradually through graduate studies. General universities such as the University of Dhaka and Chittagong University have specialized departments associated with agricultural research. Universities are under the overall supervision of the Ministry of Education; however, the University Grants Commission is responsible for resource allocation including modest research costs. With universities' budget constraints, the universities are participating in the grants provided by BARC through revenue and

project budgets. Moreover, universities are providing NARS scientists higher study through various projects of BARC and ARIs.

3.3. NARS Governance in Bangladesh

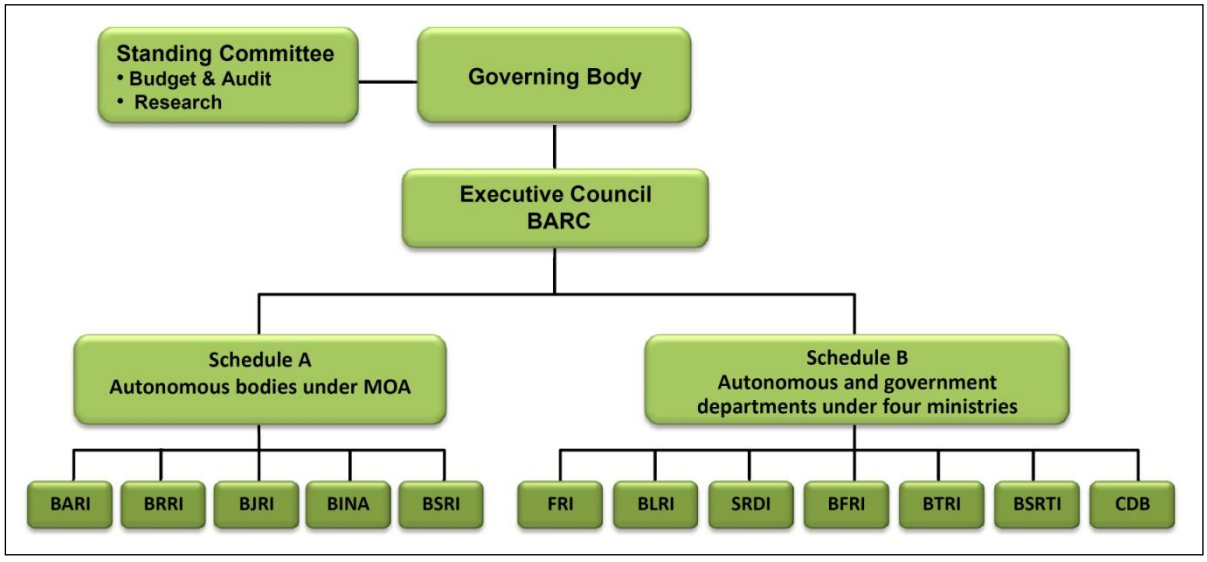
3.3.1. The Governing Board (GB)

BARC is a statutory body and is steered by a 31-member GB under the chairmanship of the minister for agriculture. Ministers in charge of fisheries and livestock and of environment and forests are the cochairs of GB. Other members are two members of Parliament nominated by the Parliament speaker, the vice chancellor of Bangladesh Agriculture University, directors general of five ARIs, heads of extension departments, the chief conservator of forest, representatives of the business community, three renowned scientists/researchers, and farmers. The functions of GB are to control, direct, and oversee the matters pertaining to research, planning, coordination, and administrative policy formulation of the council.

3.3.2. The Executive Council (EC)

The second most important management tier of NARS is the 18-member EC composed of the executive chairman, BARC as the chair of the council, 7 member-directors of BARC, and 12 chief executives (directors general/directors) of the NARS institutes. EC is responsible to GB and assists in the formulation of various policy issues for NARS. EC reviews and recommends annual research programs and budgets of the institutes. EC is also responsible for policy formulation of HRD of NARS. The organogram of Bangladesh NARS is presented in Figure 3.1.

Figure 3.1—Organizational structure of the National Agriculture Research System in Bangladesh



Source: BARC Act 2012.
Note: BARC = Bangladesh Agricultural Research Council; MOA = Ministry of Agriculture; BARI = Bangladesh Agricultural Research Institute; BRRI = Bangladesh Rice Research Institute; BJRI = Bangladesh Jute Research Institute; BINA = Bangladesh Institute of Nuclear Agriculture; BSRI = Bangladesh Sugarcane Research Institute; FRI = Bangladesh Fisheries Research Institute; BLRI = Bangladesh Livestock Research Institute; SRDI = Soil Resources Development Institute; BFRI =

Bangladesh Forest Research Institute; BTRI = Bangladesh Tea Research Institute; BSRTI = Bangladesh Sericulture Research and Training Institute; CDB = Cotton Development Board.

3.3.3. BARC

BARC is the apex organization of NARS. It also acts as the technical secretariat of MoA. The executive chairman is the chief executive officer of BARC and is responsible for the proper execution of decisions of the governing body and overall administration and implementation of programs of BARC. He is assisted by the seven member-directors and seven directors. BARC has seven divisions headed by member-directors: Crops, Natural Resource Management, Fisheries, Livestock, Agricultural Economics and Rural Sociology, Planning and Evaluation, and Administration and Finance.

Each division/unit of BARC is responsible for identifying problem areas and setting priorities for research; for examining project proposals and reports and keeping abreast of the progress of research; for monitoring and evaluating research programs, identifying deficiencies in research coverage, and suggesting means of improvement; for developing interinstitutional projects and fostering cooperation among scientists and research institutes; for preparing reports and proposals; and for arranging seminars, workshops, and international cooperation in its respective field.

3.4. NARS Institutes

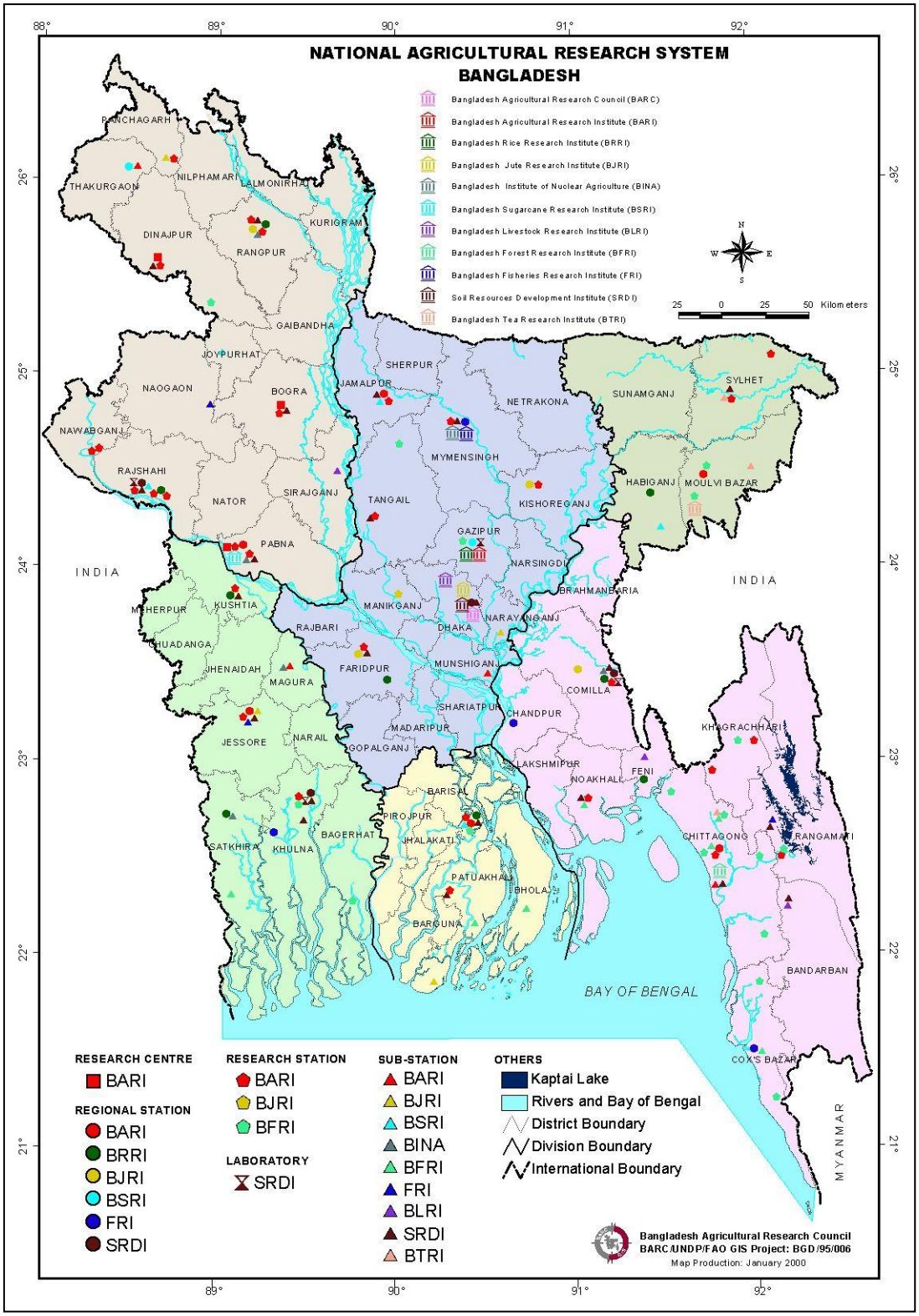
There are 12 NARS institutes, which are under the control of five ministries and differ in their statuses as autonomous or government organizations. The autonomous institutes, those that are under the control of MoA, have been categorized as schedule A institutes. The institutes that are under the control of either another ministry or a government organization have been categorized as schedule B institutes. Table 3.1 summarizes the schedule A and B institutes. The map in Figure 3.2 shows the spatial distribution of NARS institutes and their research facilities.

Table 3.1—National Agriculture Research System institutes and their statuses

Bangladesh Agricultural Research Council—National Apex Coordinating Body under Ministry of Agriculture	
Schedule A	Status
Bangladesh Agricultural Research Institute	Autonomous body under the Ministry of Agriculture
Bangladesh Rice Research Institute	
Bangladesh Jute Research Institute	
Bangladesh Institute Nuclear Research	
Bangladesh Sugarcane Research Institute	
Schedule B	Status
Soil Resources Development Institute	Government agency under the Ministry of Agriculture
Bangladesh Fisheries Research Institute	Autonomous body under the Ministry of Fisheries and Livestock
Bangladesh Livestock Research Institute	
Bangladesh Forest Research Institute	Government agency under the Ministry of Environment and Forest

Bangladesh Tea Research Institute	Autonomous body under Bangladesh Tea Board, Ministry of Commerce
Bangladesh Sericulture Research and Training Institute (newly annexed)	Autonomous body under the Ministry of Jute and Textiles
Cotton Development Board (newly annexed)	Government agency under the Ministry of Agriculture

Figure 3.2—Map showing the spatial distribution of National Agriculture Research System institutes and their research facilities


NATIONAL AGRICULTURAL RESEARCH SYSTEM
BANGLADESH
Bangladesh Agricultural Research Council (BARC)
Bangladesh Agricultural Research Institute (BARI)
Bangladesh Rice Research Institute (BRRI)
Bangladesh Jute Research Institute (BJRI)
Bangladesh Institute of Nuclear Agriculture (BINA)
Bangladesh Sugarcane Research Institute (BSRI)
Bangladesh Livestock Research Institute (BLRI)
Bangladesh Forest Research Institute (BFRI)
Bangladesh Fisheries Research Institute (FRI)
Soil Resources Development Institute (SRDI)
Bangladesh Tea Research Institute (BTRI)
25 0 25 50 Kilometers
PANCHAGARH
THAKURGAON
NILPHAMARI
LALMONIRHAT
DINAJPUR
KURIGRAM
RANGPUR
GAIBANDHA
JOYPURHAT
NAOGAON
BOGRA
SHERPUR
JAMALPUR
NETRAKONA
SUNAMGANJ
SYLHET
NAWABGANJ
RAJSHAHI
NATOR
SIRAJGANJ
MYMENSINGH
TANGAIL
KISHOREGANJ
HABIGANJ
MOULVI BAZAR
PABNA
GAZIPUR
NARSINGDI
INDIA
INDIA
BRAHMANBARIA
MEHERPUR
KUSHTIA
MANIKGANJ
NARAYANGANJ
DHAKA
RAJBARI
CHUADANGA
JHENAIDAH
FARIDPUR
MUNSHIGANJ
MAGURA
COMILLA
SHARIATPUR
CHANDPUR
MADARIPUR
JESSORE
NARAIL
GOPALGANJ
LAKSHMIPUR
NOAKHALI
FENI
KHAGRACHHARI
BARISAL
PIROJPUR
BAGERHAT
JHALAKATI
CHITTAGONG
RANGAMATI
SATKHIRA
KHULNA
PATUAKHALI
BHOLA
BARGUNA
BAY OF BENGAL
BANDARBAN
COX'S BAZAR
MYANMAR
RESEARCH CENTRE
BARI
REGIONAL STATION
BARI
BRRI
BJRI
BSRI
FRI
SRDI
RESEARCH STATION
BARI
BJRI
BFRI
LABORATORY
SRDI
SUB-STATION
BARI
BJRI
BSRI
BINA
BFRI
FRI
BLRI
SRDI
BTRI
OTHERS
Kaptai Lake
Rivers and Bay of Bengal
District Boundary
Division Boundary
International Boundary
Bangladesh Agricultural Research Council
BARC/UNDP/FAO GIS Project: BGD/95/006
Map Production: January 2000

3.4.1. *Management of ARIs*

Autonomous institutes such as the Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Jute Research Institute (BJRI), Bangladesh Sugarcane Research Institute (BSRI), Bangladesh Fisheries Research Institute, and BLRI are managed by their own boards of management (BoMs). All the BoMs have more or less similar compositions. The BoMs of schedule A ARIs are chaired by the respective director generals. BoMs of Bangladesh Fisheries Research Institute and BLRI are chaired by the minister-in-charge of the MoFL. The BoMs of the schedule A institutions are represented by eminent scientists, BARC, extension departments, farmers, NGOs, institute directors, senior scientists, MoA, and Ministry of Finance. On the other hand, the two ARIs under schedule B, namely, BLRI and Bangladesh Fisheries Research Institute, have a minister of the MoFL as chairman of the Board of Governors. Of the 12 ARIs and BARC, 7 are governed by independent acts and have separate service rules. BoMs/Board of Governors of ARIs execute the policies and undertakings of the institutes within the framework of the policy directives issued by the government.

3.4.2. *BARI*

BARI is the largest multicrop research organization in the country; it evolved from a nucleus agricultural research laboratory established in Dhaka in 1908 under the Bengal Department of Agriculture. It gained its current status in 1976 with the mandate to carry out research on a wide variety of crops such as wheat, tubers, pulses, oilseeds, spices, and horticultural crops.

The institute is organized into three wings, namely, Research, Support Service, and Training and Communications. BARI headquarters comprise 176 hectares of land of which 126 hectares are experimental fields. Its six regional stations and 28 substations are spread all over the country, including three Hill Research Stations. Seven Specialized Research Centres are conducting research on tuber crops, oilseeds, plant genetic resources, horticulture, wheat, pulses, and spices. BARI also collects, conserves, and evaluates germplasm of crops. Apart from these, the institute conducts technology validation trials and farmer's field trials through its On-farm Research Division in nine Farming System Research sites and 72 Multi-location Testing sites spread over different agroecological zones of the country. The institute employs 698 scientists working in different fields; 18 percent of them have PhDs.

3.4.3. *BRRI*

After liberation in 1971, with a research background of about 12 years, BRRI started its journey to meet the daunting challenge of a recurring annual food deficit of 1.0 to 1.5 million tonnes of clean rice in the face of a rapidly growing population. The institute operates with 18 research divisions, three support service divisions, and eight sections. Research on development of varieties and production technologies is conducted at BRRI headquarters at Gazipur and at nine regional stations situated in diverse ecosystems.

3.4.4. *BINA*

BINA began functioning as a small radio-tracer laboratory in 1961. The Bangladesh Atomic Energy Commission established the Institute of Nuclear Agriculture in 1972. It evolved as a specialized multicrop institute in 1984 to conduct research adopting nuclear techniques. To undertake research in this area, the institute has 11 technical divisions.

The institute has 13 substations for assessing the wide adaptability/location-specific performance of advanced mutant lines of different crops and other technologies generated by the scientists. The research work at the Satkhira substation is aimed at the development of salt-tolerant varieties along with improved production packages and cropping patterns suitable for the vast coastal areas across the southern belt of Bangladesh.

3.4.5. BJRI

Jute research first started in Dhaka in 1904. BJRI is the oldest monocrop research institute in the country; it traveled a long way before evolving into its current form in 1974 (modified in 1996). Research is organized into two divisions, namely, Agriculture and Technology. The Central Research Station is located at Manikgonj. There are four regional stations and two substations. Besides these stations, BJRI maintains four Farming System Research Sites and eight subcenters in jute-growing areas.

3.4.6. BSRI

Sugarcane research started in Bangladesh back in 1933. Since then, this research has undergone many changes and emerged as BSRI in 1996. The Research wings consist of eight research divisions, one quarantine station, and two regional stations. The Technology Transfer wing consists of two major divisions, six substations, and three sections. This wing organizes training for farmers, extension workers, and so on; conducts demonstrations in the farmers' fields; disseminates messages through different forms of publications; and collects feedback information. BSRI has two regional research stations, a quarantine station, and three substations.

3.4.7. Soil Resources Development Institute

In 1969, the Central Soil Research Institute was established as a follow-up to the Soil Survey Project. After the independence of Bangladesh, the Department of Soil Survey was established in 1972. By reorganizing the then Department of Soil Survey, the Soil Resource Development Institute was established in 1983 with the objectives to make inventory of soil and land resources and to investigate soil-related problems for agricultural R&D.

3.4.8. Bangladesh Fisheries Research Institute

The Bangladesh Fisheries Research Institute was established in 1984 to carry out basic and adaptive research for the development and optimum use of all living aquatic resources and to coordinate fisheries research activities in Bangladesh. The institute has five research stations, namely, the Freshwater Station at Mymensingh; Riverine Station at Chandpur; Brackish Water Station at Paikgacha, Khulna; Marine Fisheries Technology Station at Cox's Bazar; and Shrimp Research Station at Bagerhat. There are six substations: freshwater substations, Faridpur and Jessore; riverine substations, Rangamati and Patuakhali; and floodplain substations, Bogra and Khepupara.

3.4.9. BLRI

BLRI was established in 1984 with the mandates to identify livestock and poultry production constraints at the national and farm levels and solve those problems through multi- and interdisciplinary and interinstitutional research and to develop technologies to aid in food and nutrition security for the increasing population, poverty alleviation, employment opportunities, income generation, and control of environmental pollution. The institute conducts research to solve basic problems affecting livestock and poultry production at both the national and the farm level, develop techniques and knowledge pertinent to livestock

and poultry production, strengthen the research–extension–NGO linkage, and expedite quick dissemination of the locally developed and introduced techniques to end users. The institute has two substations, one at Naikhangchari, Bandarban, and other at Baghabari, Sirajganj.

3.4.10. Bangladesh Forest Research Institute

The Bangladesh Forest Research Institute was established in 1955 with the objectives to obtain increased productivity from the forestland and better use of its resources, to minimize the gap between the demand for and supply of forest products, and to provide clientele services to the forest department. The Bangladesh Forest Research Institute has 22 research stations and substations under five field divisions covering different forest types that spread over eight dendro-ecological regions. All divisions of the institute except the divisional offices of the Plantation Trial Unit and Mangrove Stations are located at headquarters. The two exceptions are at Barisal and Khulna.

3.4.11. Bangladesh Tea Research Institute

To solve various problems of growing and manufacturing tea and to establish the industry on sound scientific footing, the Pakistan Tea Board decided in 1952 to establish a tea research station. As a result the Pakistan Tea Research Station came into being in 1957. After liberation, the research station was raised to the status of an institute and named the Bangladesh Tea Research Institute in 1973. The institute has nine divisions in its headquarters and three substations (Kaliti, Moulvibazar; Sylhet Town; and Fatikchheri, Chittagong).

3.4.12. BSRTI

BSRTI was established in 1962 under the then East Pakistan Small and Cottage Industries Corporation. In 1978 it was brought under the control of the Bangladesh Sericulture Board. In 2003 BSRTI was separated from the Bangladesh Sericulture Board and established as an independent organization under the Ministry of Textiles and Jute with a mission to provide R&D services for improving the rural economy and to generate human resources to disseminate the appropriate technologies.

The institute imparts training to the extension staff to systematize silk production processes. BSRTI has a Regional Sericulture Research Centre at Chandraghona, Rangamati, and a Germplasm Maintenance Centre at Sakoa, Panchagarh.

3.4.13. CDB

CDB is the newest member of NARS (added in 2012). CDB was established in 1972 with the primary objective to introduce and promote cotton cultivation. The board organizes farmers' associations/committees for the extension of cotton cultivation and supply of agricultural inputs including quality seed, fertilizer, plant protection materials, and irrigation. CDB imparts training to cotton farmers and establishes demonstration plots. The board also has the responsibility to conduct research for continued cotton extension and production programs. The headquarters of CDB is in Dhaka. There are four regional offices in Dhaka, Jessore, Rangpur, and Chittagong and five research centers located in different parts of the country. In addition to research, the production of breeder seed and foundation seed and training programs for CDB staff and cotton farmers are implemented in these centers.

3.5. Major Projects to Strengthen Institutional Capacity of NARS

The International Development Association (IDA) (the World Bank) and the United States Agency for International Development (USAID) have been the major donors to Bangladesh's agricultural research system. The support has been used for the HRD of scientific capacity, infrastructural development, and research operation.

3.5.1. Agricultural Research Management Project (1996–2001)

The IDA-funded Agricultural Research Management Project was implemented in eight NARS institutes under the coordination of BARC. The project successfully developed the scientific skill of the institutes through trainings (higher studies and short-term training) and research infrastructures. The project also supported contract research schemes involving public organizations, private organizations, and NGO research entities. The project helped strengthen the coordination role of BARC after the promulgation of the BARC act of 1996.

3.5.2. National Agricultural Technology Project (NATP), 2008-2013

NATP has been implemented in Bangladesh's agricultural technology system since 2008. The project is part of a long-term (15-year) program supporting IDA to assist Bangladesh. The project is the first of its kind to integrate research, extension, and supply chain management involving two ministries, namely, MoA and the Ministry of Livestock and Fisheries. In addition, the project has been instrumental in the development of an independent research entity called Krishi Gobeshona Foundation (KGF). The project has four components: (1) agricultural research support, (2) agricultural extension support, (3) development of supply chains, and (4) project management and coordination support.

1. Agricultural Research Support: This component has national coverage. The activities of the research component include the (1) Competitive Grants Program (CGP), (2) Sponsored Public Goods Research (SPGR), and (3) Enhancing Research Institutional Efficiency (ERIE) of NARS.

2. Agricultural Extension Support (DAE, DLS, and DOF): This component aims to establish a decentralized, demand-led extension service that is knowledge based, has greater accountability and responsiveness to farmers, and focuses on small and marginal farmers. Extension activities covered 120 upazilas in 25 districts by DAE and DLS each in the first year. DOF covered only 95 upazilas in the first year and gradually extended its activities to 120 upazilas.

3. Development of Supply Chains: For increasing and diversifying sources of income for small and marginal farmers, the development of supply chains of selected commodities has been planned on a pilot basis in 10 upazilas. The project will finance activities related to (1) strengthening farmer–market linkages and (2) enhancing institutional efficiency.

4. Project Management and Coordination Support: The project is being implemented jointly by the Ministry of Agriculture (MoA) and the Ministry of Fisheries and Livestock (MoFL). The Project Coordination Unit (PCU) is coordinating and facilitating project implementation in collaboration with the respective Project Implementation Units (PIUs), Krishi Gobeshna Foundation (KGF) and Hortex Foundation. PCU concentrated its activities on replenishment of Project Aid fund, procurement of essential goods and services, and arrange coordination meetings to enhance interaction among the components.

Funding and Duration of the Project: The government of Bangladesh is implementing NATP with financial assistance from the World Bank (through IDA credit) and International Fund for Agricultural Development. NATP is in the first 5-year phase of a long-term (15-year) program. The project cost of phase 1 of NATP is about $90 million.

SPGR: The Project Implementation Unit of BARC is responsible for implementing the SPGR program. The objective of SPGR is to undertake medium- and long-term (3–4 years) multidisciplinary, strategic, and problem-solving research in the areas of upcoming needs, which will fill the gaps of research and technology to be adopted by the farming community for enhancing productivity. In performing the task, thematic areas of SPGR were finalized through a widely attended consultative workshop.

ERIE: Implementation of the ERIE component was initiated by PIU-BARC during the year. The focus of the program was to enhance the efficiency of BARC and ARIs by institutional reforms, timely allocation of research funds, HRD through short-term training and degree programs at home and abroad, and capacity building for research and establishment of MIS and ICT. **CGP:** CGP is a subcomponent of the research component of NATP (phase 1). It finances location-specific, demand-driven, multidisciplinary, short- to medium-term (maximum two-year) research proposals of both public- and private-sector organizations (research institutes, universities, NGOs, and so on). The research themes to be supported by CGP are those that are crucial to bridge the yield gaps and other demand-based issues for improving agricultural productivity and farm income. A major focus would be on on-farm applied and adaptive research, including marketing, socioeconomic aspects, and value addition.

KGF administers CGP research proposals based on the research priority areas set by BARC through consultation with different stakeholders. KGF prepared the guidelines following the operation manual for preparation of research project proposals, and it floated them on the website and also invited proposals from interested researchers of NARS institutes, universities, NGOs, and so on through advertisements in the national dailies in October 2008. A total of 393 proposals were received from different organizations from both the public and the private sectors. The KGF board constituted a 12-member multistakeholder committee for screening and short-listing the promising proposals for review.

In-country PhD Scholarship: After completion of all formalities BARC awarded 60 in-country PhD scholarships to scientists of NARS institutes.

3.6. Agricultural Extension Support

The activities of the extension units initially concentrated on (1) formation and mobilization of common interest groups (CIGs) with the help of grassroots-level extension agents such as subassistant agricultural officers (SAAOs), local extension agents for fisheries (LEAFs), and community extension agents for livestock (CEALs); (2) decentralization of extension services; and (3) enhancement of the institutional efficiency of the national institutions involved in agricultural extension.

During 2008/09 the extension components initiated the extension activities of CIG identification, LEAF and CEAL selection, microplan development, and establishment of Farmer's Information and Advice Centers (FIACs). The continued evolution of the social mobilization approach in extension activities developed a better understanding between farmers and extension agents and facilitated the process of establishing new media for

dialogue. CIG is a powerful instrument for pursuing the extension and business development approach in an unintrusive, intelligent, convincing, and cost-effective manner. CIG is being used to develop a microextension plan and subsequent implementation of the developed program.

3.7. Supply Chain Development Support

The main focus of this component is to integrate small and marginal producers of high-value commodities (crops/horticulture, fisheries, and livestock) with the market through the development of supply chains. The major subcomponents are (1) the strengthening of farmer–market linkages (identification of small and marginal producers), promotion of contract farming, promotion of low-cost postharvest management, and improvement of sanitary and phytosanitary standards and (2) extension support using market-based methodologies (institutional strengthening, capacity building and training, and information dissemination).

The strengthening of farmer–market linkages includes the following key interventions:

1. Identification of small and marginal producers for participation in a high-value supply chain strategy: To identify resource-poor small and marginal producers for participation in high-value agriculture, the project would facilitate risk profiling and assist with formation of CIGs and their organizations, producer groups. CIGs would be encouraged to self-select among market options and products they wish to invest in based on their own judgment of acceptable level of risk exposure. This would provide the flexibility needed for vertical integration of different segments of the poor into the selected supply chain.

2. Promotion of contract farming: To ensure that small producers have access to knowledge, assured markets, credit, inputs, and appropriate technologies, contract farming would be promoted primarily through private-sector enterprises and NGOs involved in agroprocessing for the national or export markets.

3. Promotion of low-cost postharvest management systems: Since the quality of finished products has a strong bearing on the ability of producers to market their produce, improvements through testing and demonstration of low-cost postharvest management practices, including cleaning, grading, packing, and storing and transporting, would be supported.

4. Improvement of sanitary and phytosanitary standards: The main focus would be on enabling small and marginal farmers and those involved in the marketing and processing of high-value-added products with sanitary and phytosanitary standards to sell in the local market by promoting integrated crop management practices to minimize the use of pesticides and other chemical inputs and to promote safe handling of produce to reduce risks of contamination, especially microbial contamination from unclean water, soil, or both.

3.8. Component Implementation

The Hortex Foundation is responsible for the implementation of components by promoting more equitable supply chain governance and market linkages for selected high-value commodities in partnership with other implementing agencies of the project (BARC, DAE, DLS, DOF, KGF), the private sector, NGOs, and CIGs/producer groups. It will organize training programs and knowledge sharing on issues related to supply chain development.

3.9. Education

There are 7 public agricultural universities out of 33 public universities. Some of the universities are offering higher education (PhD), whereas others are developing capacity to offer higher degrees. Agricultural education includes autonomous agricultural universities affiliated with the Ministry of Education and 13 agriculture training institutes, offering diploma courses under the direct control of the Department of Agriculture Extension. Agricultural universities are conducting research with different supports including BARC. BARC has no linkage with the academic curriculum and decisionmaking of the universities.

3.10. Institutional Innovation

Considering the needs for sustainable funding and operational flexibility of research, KGF, a nonprofit organization, was established in 2007 under the Companies Act of 1994. KGF is an independent organization implementing research under CGP. The World Bank financed NATP-initiated funding, as endowment, to support the operation of KGF and CGP. CGP provides funding of location-specific, pre-identified, high-priority, multidisciplinary, short- to medium-term, problem-solving R&D to develop a more pluralistic research system. NARS institutes, universities, other research institutes, NGOs, and the private sector have been conducting research under CGP. Since its inception it has supported 90 research projects of different entities including the private sector. KGF has one Board of Directors consisting of seven members from different stakeholders including NARS. The executive chairman of BARC chairs the board.

3.11. Human Resources Management and Development

Human resources are critical for effective agricultural research—more so when facing challenges such as the need to be globally competitive in the markets, able to conserve natural resources in agriculture, and produce safe foods. As agriculture is increasingly becoming more knowledge intensive, a skilled set of staff with state-of-the-art knowledge is essential for the NARS institutions.

The NARS institutions have provision for 1,808 scientific posts, out of which 1,440 are filled as of June 2009. About 20 percent of the positions are vacant. Among the existing 1,440 scientists, only 400 (28 percent) have PhDs, which indicates lower educational attainment compared to the needs for successful implementation of research programs of the NARS scientists. A program for filling the vacant positions, planning for providing higher degrees, and promoting the deserving candidates is important. Quality of research output would be negatively affected if the human resources were not improved through implementation of a HRD program for NARS within a short period. The scientific staff of NARS institutes, non-NARS institutes, and the private sector are presented in Table 3.2, Table 3.3, and Table 3.4, respectively, and faculty members of the public agricultural universities are presented in Table 3.5.

Table 3.2—Scientific staff of National Agriculture Research System institutes (2009)

Institute	Total	PhD	Percentage with PhD
Bangladesh Agricultural Research Council	32	24	75
Bangladesh Agricultural Research Institute	600	159	27
Bangladesh Institute of Nuclear Agriculture	81	35	43
Bangladesh Rice Research Institute	193	68	35
Bangladesh Jute Research Institute	110	20	18

Bangladesh Sugarcane Research Institute	65	21	32
Soil Resources Development Institute	139	12	9
Bangladesh Forest Research Institute (BFRI)	70	13	19
Bangladesh Tea Research Institute	22	4	18
Bangladesh Fisheries Research Institute	90	30	33
Bangladesh Livestock Research Institute	38	14	37
Total	**1,440**	**400**	**28**

Source: Rahija, et al (2011)

Table 3.3—Scientific staff of non–National Agriculture Research System institutes (2009)

Institute	Total	PhD	Percentage with PhD
Krishi Gobeshona Foundation	6	5	83
Institute of Food and Radiation Biology, Atomic Energy Research Establishment	59	13	22
Bangladesh Academy for Rural Development	93	9	10
Institute of Food Science and Technology	62	13	21
Bangladesh Council of Scientific and Industrial Research Laboratories, Rajshahi	44	18	41
Bangladesh Council of Scientific and Industrial Research Laboratories, Chittagong	29	2	7
Bangladesh Council of Scientific and Industrial Research, Dhaka Laboratories	70	13	19
Bangladesh Institute of Development Studies	45	28	62
Bangladesh Sericulture Research and Training Institute	22	7	32
Cotton Development Board	15	2	13
Rural Development Academy	43	5	12
Total	**488**	**115**	**24**

Source: Rahija, et al (2011)

Table 3.4—Scientific staff of private sector

Organization	Total	PhD	Percentage with PhD
Bangladesh Rural Advancement Committee (nongovernmental organization)	25	5	20
Lal Teer Seed Limited	29	9	31
ACI Seed	6	1	17
Total	**60**	**15**	**25**

Source: Rahija, et al (2011)

Table 3.5—Faculty members of the public agricultural universities (2009)

University	Number of Faculties or Departments	Total	PhD	Percentage with PhD
Bangladesh Agricultural University	6[a]	527	282	54
Bangabandhu Sheikh Mujibur Rahman Agricultural University	1[a]	70	42	60
Sher-e-Bangla Agricultural University	1[a]	158	28	18
Hajee Mohammad Danesh Science and Technology University	6[a]	112	30	27
Sylhet Agricultural University	4[a]	107	23	21
Noakhali Science and Technology University	1[b]	10	0	0
Chittagong University	3[b]	49	23	47
Rajshahi University	3[b]	38	22	58
Dhaka University	6[b]	122	88	72
Bangladesh University of Engineering and Technology	1[b]	17	15	88
Total		**1210**	**553**	**46**

Source: Rahija, et al (2011)

[a] Faculties.

[b] Departments.

Human resource management is the responsibility of the individual institutes under the broader provision of BARC-set criteria. The NARS institutes are operated by individual acts and separate service rules; there is no centralized provision for recruitment. Therefore, the quality of scientific staffs among the institutes varies.

BARC established a set of criteria for the recruitment and promotion of NARS scientists. A written test for eligibility in the recruitment of scientific officers was introduced recently by one external institute (Dhaka University). The final recruitment is done at the institute level (ARIs).

The promotion of scientists is based on the civil service rule, that is, availability of a vacant position. As a result, scientists are to wait until senior positions are vacant although they may have all the required qualifications and experiences for promotion. Discipline-wise promotion at one institute gives an opportunity to one scientist to advance his or her career based on vacancy, whereas his or her senior colleague in another discipline is deprived of a promotion due to the absence of a vacancy. Also, interinstitutional promotion does not exist, which causes frustration among scientists and creates unholy competition.

Higher studies are carried out with the assistance of donor support projects. IDA credit support made provision (1996–2001 and 2008–11) for HRD. Individual scientists also arrange scholarships, and the government of Bangladesh supports local higher studies. Recently, the government has been allocating funds to BARC for higher studies, leading to in-country PhD degrees.

Each organization has an organogram of its own approved by the concerned ministries such as MoA, Ministry of Finance, and Ministry of Establishment. A long process of scrutiny and

approval by the ARIs is followed after an organization's submission of requirements for additional manpower.

A significant gap in capacity at an advanced degree level is developing and is further hampered as many competent scientists either have retired or have left their organizations. It is important that this MSc and PhD gap should be met in the near term. On the other hand, attracting top students and ensuring quality in MSc and PhD programs is of prime importance. All long-term projects funded either by the development partners or by the government must include HRD (honors, MSc, PhD, and postdoctoral levels). Competitive bursaries, scholarships, and fellowships should be made available to outstanding students/scientists on the basis of merit.

3.12. Research Extension Linkage

There is room for improvement in the research–extension linkage. Some ARIs hold seminars, training workshops, and so on to impart training and update the knowledge of the extension officers about developed technologies. Local-level stakeholders including NGOs are also invited to participate in the discussion meetings. Some ARIs do not have technology dissemination divisions. The Technology Transfer and Monitoring Unit of BARC was created for facilitation of primary extension and monitoring of the transfer process. But the Technology Transfer and Monitoring Unit needs to be made more functional with adequate human resources. The research–extension linkage, particularly the fisheries and livestock subsector, should be further strengthened.

3.12.1. FIAC

FIAC was developed as a one-stop service center for farmers at the union level. So far, 670 FIACs have been established and made functional at the newly built Union Parishad Complexes, against the Development Project Proposal target of 1,200. Out of 670 FIACs, 620 have been renovated and well furnished, and the rest are yet to be renovated as these have been made operational recently. The lack of newly built Union Parishad Complexes is the main hindrance to establishing the desired number of FIACs. However, per the decision of the National Extension Coordination Committee, efforts are under way to explore the possibility of establishing FIAC offices in existing departmental facilities in unions where Union Parishad Complexes have yet to be built. Presently FIACs are functioning as farmers' one-stop service centers with DAE, DLS, and DOF; that is, SAAOs, LEAFs, and CEALs are providing coordinated services to the farmers, and their production problems of crops, livestock, and fisheries are being solved effectively following the scheduled duty roster.

3.13. Review, Monitoring, and Evaluation

Review workshops are mandatory programs for the NARS institutes and are held annually at different levels. At present, research programs are reviewed at the institute level annually. Divisional heads present the achievements and future programs of the divisions. The extension departments, universities, BARC, and NGOs are invited to participate in the research review and planning process. Different NARS institutes follow different review processes.

BRRI undertakes a research extension workshop once in two years. In the workshop, the Department of Agriculture Extension reviews field problems and provides feedback about

the performance of the technologies and knowledge gained by the farmers. The institute also organizes central review workshops once in a year where the extension department, scientists, NGOs, and the private sector participate. The annual research programs are reviewed in the workshop and finalized by incorporating feedback information from extension personnel.

BARI, the largest research institute, maintains three layers of review programs (regional, internal, and central). Regional agricultural research stations conduct regional review workshops once in a year to review regional crop performance and research programs associated with BARI-mandated crops, which are placed in the central review workshop. All scientists of the institute take part in the internal (divisional) review, which takes longer (about 6 to 8 weeks). The internal review is more rigorous in nature; all research programs and projects are reviewed in detail to improve the quality of research programs and experimental design. The external members are also invited to participate in the process. The central workshop reviews the yearly programs; external members from the extension department, universities, the private sector, and other organizations as well as retired scientists are invited to participate. Usually, the senior-level scientists present the research programs for internal review. The retired scientists of the institutes are also invited to provide input for improvement of the research programs.

Other research institutes have also institutionalized the review process to improve the quality of research involving relevant stakeholders. BARC organizes research program reviews separately to avoid duplication of research and to ensure incorporation of national priorities. Individual technical divisions are responsible for organizing such reviews in two- to three-day workshops.

Institutional review of NARS was undertaken by independent committees of experts from outside the institutes in 1999. The recommendations were discussed in GB meetings of the council.

Most ARIs have regular monitoring programs to oversee the progress and quality of research carried out by the central as well as the outreach stations. Heads of divisions and senior scientists of the concerned divisions of the ARI visit the laboratory, greenhouse, and field experiments. The number of such monitoring visits varies depending on the commodity of research, season, and other relevant considerations. On certain occasions, scientists from BARC and some relevant ARIs are also invited by the concerned ARI for monitoring. However, an organized monitoring and evaluation program has yet to be developed. Considering the importance of monitoring and evaluation for quality improvement of research, BARC has established a monitoring and evaluation cell for each of the research institutes.

4. Synthesis of Views on AR4D Priority Setting

4.1. Research Needs

National and international research institutes and NGOs have a growing interest in structured and more transparent methods of priority setting. In practice, they increasingly face similar problems in priority setting. Aside from selecting and applying appropriate methods, they have to ensure that various stakeholders are well represented. This is crucial for the results and implementation of identified priorities (Manicad 1997).

There are two major approaches in priority setting procedures—top-down and bottom-up approaches. Officials dominate the top-down approach, as do experts oriented toward

achieving government goals based on technical information provided by research leaders and scientists. Basically farmers, together with scientists, are involved in the priority setting of problems and solutions in the bottom-up approach. Farmers' needs, knowledge, and priorities are solicited to formulate research agendas and identify research priorities.

The government of Bangladesh has given priority to the agricultural sector to boost agricultural production. Increasing the speed of and sustaining agricultural growth are priorities for increasing food production and reducing poverty. The future challenge of increasing food production could be met through the introduction of modern biotechnology and an increase in investment in agricultural technology generation and transfer. NARS of Bangladesh has 12 ARIs, which are coordinated by BARC under MoA. The ARIs are mainly involved in doing agricultural research on crops, fisheries, livestock, and forestry. Technologies developed by the NARS institutes are disseminated to the farmers through the extension department and NGOs.

In meeting the demand for higher food production, thrust should be given to frontier research including genetic engineering, reduction of cultivation costs, strengthening of the technology-transfer linkage, and improvement of postharvest technology. Bangladesh NARS institutes have limited scope/facilities for conducting modern biotechnological research. Therefore, Bangladesh needs regional cooperation for capacity building and HRD to start biotechnological and other frontier research.

Research priority setting in agriculture is a dynamic process. It is required to adjust to the contextual and temporal changes and to undertake demand-driven research to address the needs of technology users. Priority setting in agricultural research has been done earlier by BARC, but recently, for the first time, besides the views of different stakeholders, views at the grassroots level were taken into consideration in the priority-setting endeavor. A hybrid approach was followed in these priority-setting efforts instead of following one of the methods that are being practiced. The detailed procedure is described in the Methodology section (4.2) of this document.

Several group meetings were held to review the research priorities at ARIs and universities. All extension agencies, for example, DAE, DOF, and DLS, and the Hortex Foundation were requested to provide information about identified field-level problems. Four regional workshops provided valuable inputs on regional issues. All these were taken into account in setting research priorities. Synthesis and finalization were done at a national workshop involving research and extension leaders.

To provide guidance and research direction to the ARIs and for funding of research, BARC needs to perform this mandated job based on analysis of the problems faced by the farming community. The government of Bangladesh and its development partners also need a set of priority issues to assist in research pursuits. Moreover, the public and private sectors should follow BARC's agricultural research priorities.

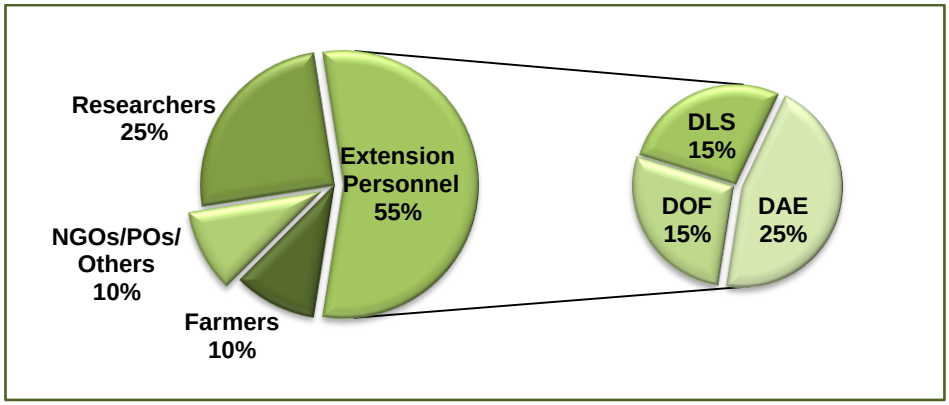
4.2. Methodology Used in Priority Setting

A priority-setting exercise for agricultural research was taken up as one of the tasks for developing the "Vision—2030 and Beyond" document, which BARC conceived recently. As a means to developing the document, detailed subsectoral studies were planned and executed, embracing the priority exercise. To accomplish the task, BARC formed and engaged 12 subsectoral working groups with specific terms of reference, each group led by an eminent scientist/professor. The groups were provided specific guidelines and the problem analysis format for their work. In this format, the type of problem, its magnitude

(percentage of total area/coverage), severity of the problem, expected beneficiary on solving the problem, and priority ranking were included. Each working group was assigned detailed subsectoral study and was asked to report on the problems, opportunities, and constraints in its respective area. Logistics were provided by BARC.

Four regional consultation workshops on agricultural research priority setting were organized by BARC. Representatives of different stakeholders attended these workshops. On average, 55 percent of the participants were from different extension agencies, 25 percent were from research, 10 percent were farmers, and the remaining 10 percent were from NGOs, private organizations, and other organizations (see Figure 4.1). In addition, most of the leaders and members of the working groups were present at the workshops.

Figure 4.1—Stakeholders' participation, by profession



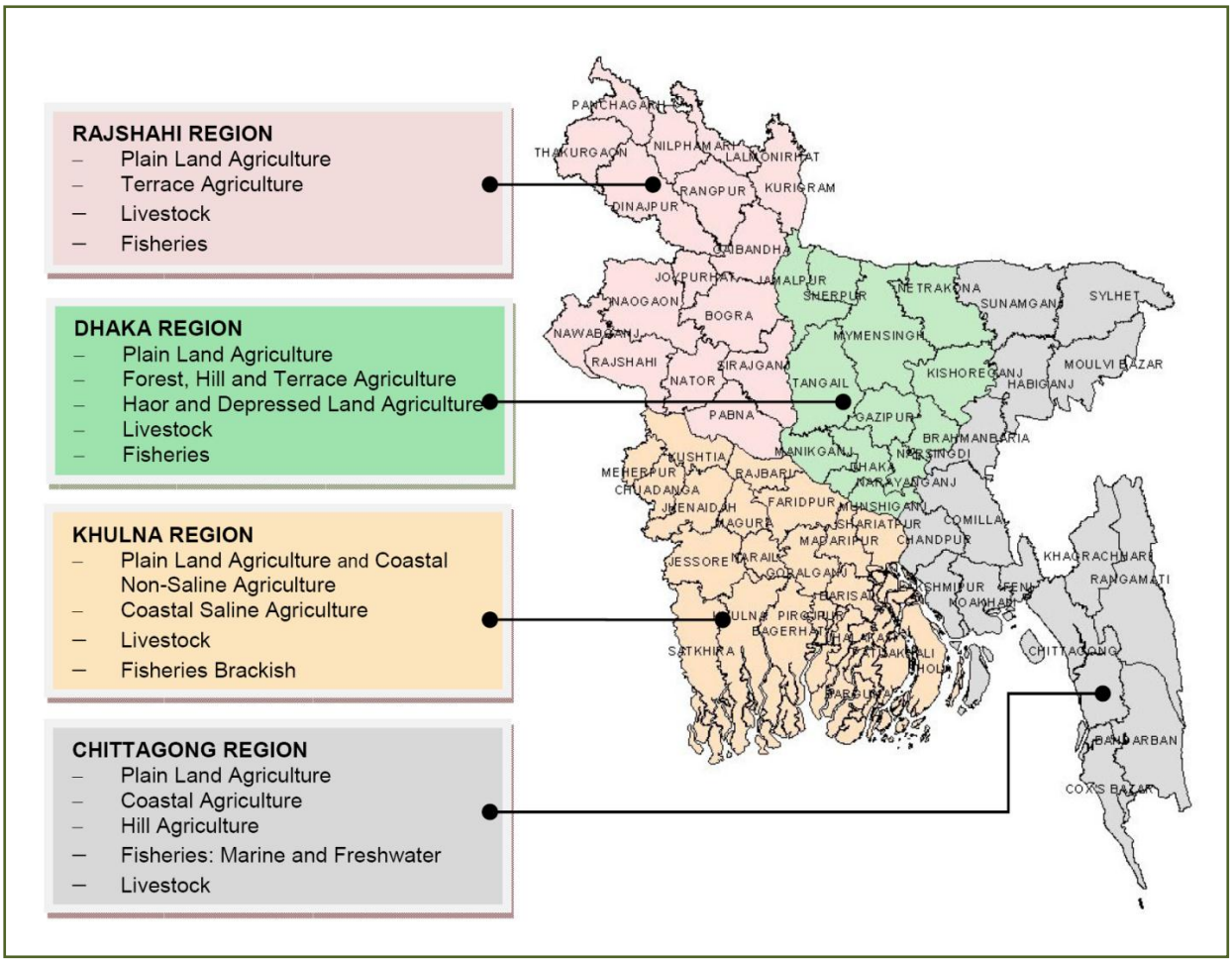
Source: BARC (2011)

Note: NGOs = nongovernmental organizations; POs = private organizations; DLS = Department of Livestock Services; DAE = Department of Agricultural Extension; DOF = Department of Fisheries.

In each of the regional workshops participants were asked to break out into thematic groups according to their preference/choice and discipline/expertise. Thematic groups varied with the region because of the agroecological settings and predominance of type of agricultural practices. The thematic areas for priority setting are presented in Figure 4.2.

The activities of the breakout groups were divided based on regional context, reality, and local expectations. The recommendations of the workshop were also made available to the group leaders for consideration.

Figure 4.2—Four regional stakeholders' consultation workshops on agricultural research priority setting with thematic areas

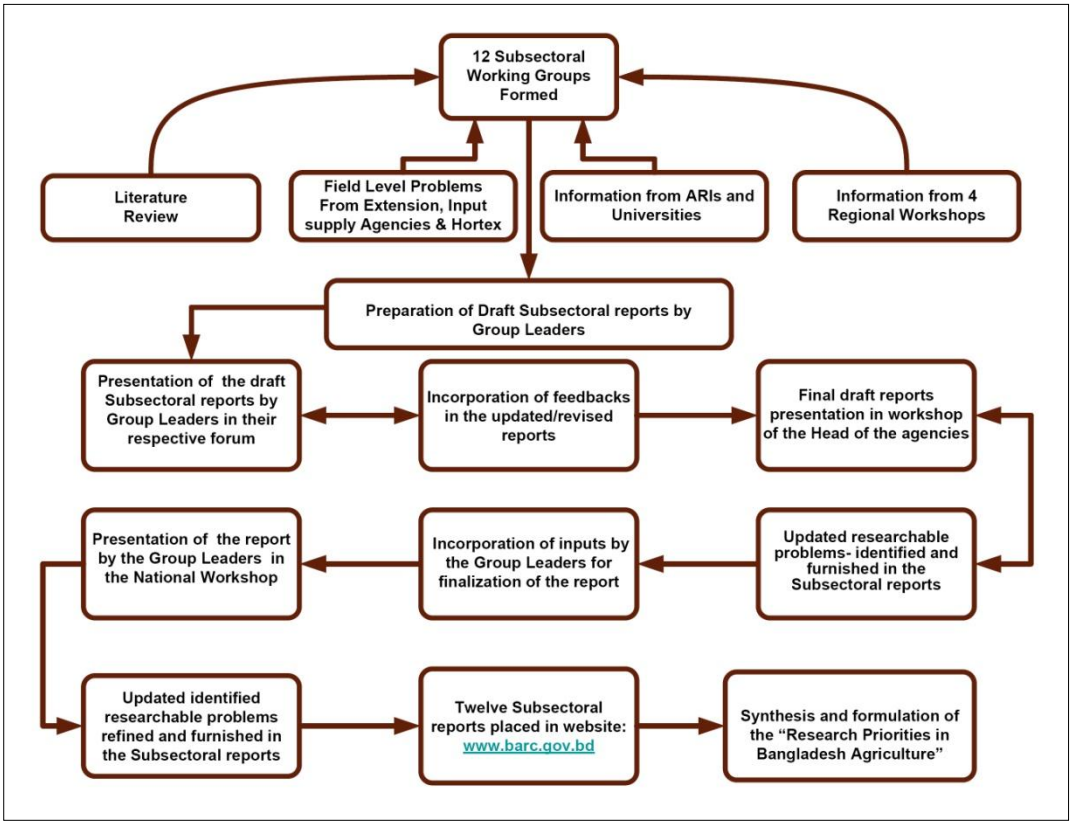


Source: BARC (2011)

After preparation of the draft subsectoral reports, the group leaders presented the draft reports in forums for their respective disciplines organized by BARC. The feedback obtained was incorporated into the updated/revised reports. Final draft reports were presented by the group leaders in the workshop for the heads of the agencies of research and extension and policy planners arranged by BARC. The inputs obtained were taken into account by the group leaders as they prepared the almost final form of the reports, which were then presented by the group leaders in the larger forum for participants and in the broader breakout groups of the national workshop on research priority organized by BARC.

To review, compile, synthesize, and formulate the research priority in all the subsectors of agriculture by thematic areas and finally transform the indicated problem into researchable issues/topics, with duration and priority ranking, a committee was formed by the executive chairman of BARC. The output of the committee per the terms of reference is furnished in this document. Figure 4.3 summarizes the processes involved in research priority setting.

Figure 4.3—Schematic representation of the processes involved in research priority setting



Source: BARC (2011)

Note: ARIs = agricultural research institutes.

The outcomes of the regional workshops were rationalized and presented at the national workshop held at BARC, Dhaka. Through these processes, a vast wealth of information was accumulated, which needed further synthesis and refinement to enable the research planners to undertake research through the core programs of the ARIs and to execute a grant program under SPGR and CGP.

Efforts were made to categorize all the researchable areas/issues under each thematic area into subclusters. The thematic areas were the following:

Crops: production—varietal improvement, production—management practices, protection—diseases and pests, and processing and marketing (value addition and supply chain development

Livestock: livestock production, feed and nutrition, livestock protection, safety, quality improvement and control, processing, and preservation and marketing of livestock products and by-products (value addition and supply chain development)

Fisheries: fish production and productivity, fisheries protection/conservation/management, fish feed and nutrition, fish health management, socioeconomics and marketing, and climate change

Food and Nutrition: food production; consumption and human nutrition; postharvest loss and agroprocessing; and food safety and quality, hazards and risk

Natural Resources—Land and Soil: soil organic matter management, soil fertility and fertilizer management, ecologically unfavorable land and soil management, biofertilizers, soil and water pollution, and impact of climate change on natural resources

Natural Resources—Water: water resources for agricultural use and on-farm irrigation and water management

Natural Resources—Forestry: forests and biodiversity conservation, low productivity, adverse effect of climate change, livelihood improvement, nontimber forest products including medicinal plants, postharvest technology, and technology transfer

Agricultural Economics: policy and planning, production and farm productivity, and supply chain and marketing

Agricultural Mechanization: preharvest farm machinery and postharvest farm machinery

ICT and Disaster Management in Agriculture: MIS for research management, databases on NRM and socioeconomics, geographic information system and remote sensing, web-enabled databases, disaster management, and HRD

Priority setting was done considering the nature of the research, such as basic, strategic, applied, and adaptive research. The duration for each type of research was categorized as short, medium, or long. Priority researchable areas or issues were identified for the following subsectors:

The crops subsector included major cereals such as rice, wheat, and maize and minor cereals such as barley and millets. The following noncereal crops were considered: fiber crops, oilseeds, pulses, roots and tubers, sugarcane, spices, vegetables, fruits, flowers and ornamentals, and tea.

The livestock subsector included cattle, small ruminants, and poultry.

The fisheries subsector considered riverine, marine, and brackish water fisheries and both open water and capture for inland fisheries.

The natural resources subsector dealt with land and soil resources as well as water resources for agriculture and forestry.

The human nutrition subsector included matters related to food availability and consumption, postharvest losses, agroprocessing technology, food quality, safety, and human nutrition.

The agricultural economics subsector incorporated matters relating to policy and planning, production and farm productivity, and supply chain and marketing.

The agricultural mechanization subsector considered pre- and postharvest mechanization.

The ICT and disaster management in agriculture subsector dealt with the use of ICT in the field of agriculture and management of disasters in agriculture.

4.3. Priority Research Areas and Issues

As stated in the Methodology section (4.2), the priority research areas and issues were identified as eight subsectors. Some high-priority research areas and issues are presented below:

Thematic Area	Researchable Area/Issue	Priority Ranking	Type of Research	Research Duration
Rice				
Production—varietal improvement	Short duration rice varieties (10–14 days shorter than the existing popular ones for all crop-growing seasons)	High	Basic/Applied	Long
	Drought tolerant/aerobic rice varieties for Aus and T. Aman seasons	High	Basic/Applied	Long
	Salt-tolerant (10–12 deciSiemens per meter) varieties for Boro and Aus seasons under tidal saline environment of the coastal region	High	Basic/Applied	Long
Production management practices	Integrated crop management practices for higher rice productivity in different rice ecosystems	High	Applied/Adaptive	Short–Medium
Wheat/Maize				
Production—varietal improvement	Early-maturing and heat-tolerant variety development	High	Basic/Applied	Long
	Abiotic stress–tolerant variety development (against drought, salinity)	Medium	Basic/Applied	Long
	Development of short-stature maize to withstand lodging due to high wind	High	Basic/Applied	Long
Production management practices	Introduction of maize after T. Aman rice in new areas, especially in southern Bangladesh	High	Applied/Adaptive	Short–Medium
Jute				
Production—varietal improvement	Molecular characterization and conservation of germplasm including released varieties of jute, kenaf, and mesta (JAF)Jute and allied fiber crops	High	Basic/Applied	Medium–Long
Production management practices	Upscaling of off-season jute seed production technology	High	Adaptive	Long
Oilseed				
Production management practices	Develop seed storage technique in groundnut, soybeans, and sunflower	High	Adaptive	Medium–Short
Pulses				
Production—	Development of short-duration-disease-	High	Basic/App	Long

Thematic Area	Researchable Area/Issue	Priority Ranking	Type of Research	Research Duration
varietal improvement	resistant (stemphylium blight, rust, and foot rot), high-yielding variety of lentil		lied	
	YMV Yellow Mosaic Virus- and cercospora-resistant high-yielding variety for mungbean and cowpea (for southern belt)	High	Basic/App lied	Long
Sugarcane				
Production management practices	Biological nitrogen fixation in sugarcane	High	Basic	Long
	Stress management research against flood, drought, water logging, and so on	Medium	Applied	Medium
Fruits				
Postharvest management and processing	Standardize maturity indices for specific fruits such as watermelon, pineapple, mango, and banana	High	Applied	Short
	Develop safe technique for ripening fruits and extending shelf life	High	Applied	Medium
Livestock				
Feed and nutrition	Commercial milk replacer and calf starters	Medium	Applied/ Adaptive	Medium
	Development of salt-, drought-, and submergence-tolerant forage/fodder varieties	High	Applied/ Adaptive	Medium
Water resources				
Water resources for agricultural use	Quantitative and qualitative assessment of surface and ground water resources for agriculture	High	Applied	Long
	Rainwater harvesting and use for agriculture	High	Applied/ Adaptive	Medium
Agricultural mechanization				
Preharvest farm machinery	Appropriate machinery/equipment for upland crops/wetland rice culture (tiller/seeder/planter/weeder/fertilizer applicator/harvester/irrigation device)	High	Applied	Medium–Long
	Renewable energy use in farm machinery/equipment	High	Applied	Medium–Long
Forestry				
Forests and biodiversity conservation	Study the drivers of deforestation and develop appropriate participatory approaches for forests and biodiversity	High	Strategic/ Applied	Medium

Thematic Area	Researchable Area/Issue	Priority Ranking	Type of Research	Research Duration
	conservation			
Low productivity management	Identification of best provenances/clones of commercial species of trees and establishment of their breeder seed orchards	High	Applied	Long
Adverse effect of climate change	Development of appropriate social forestry techniques for forest land	High	Applied	Long
	Assessment of carbon stock in different forest land	Medium	Strategic	Long
Information and communication technology in agriculture and disaster management				
Management information system for research management	Management information system of National Agriculture Research System institutes	High	Applied	Short–Medium/Long
	Databases related to research management on completed and ongoing projects of National Agriculture Research System	High	Strategic	Short–Medium
Geographic information system and remote sensing	Crop zoning for land use planning	High	Strategic/ Applied	Short–Medium/Long
Disaster management	Early warning systems for abiotic and biotic hazards (flood, drought, rainfall, pests, diseases, and so on)	High	Applied	Medium–Long
	Expert systems/decision support systems for food security and disaster management	High	Applied/Strategic	Short/Medium–Long

5. Assessment of Potential Technologies

New technologies do not always improve small farmers' well-being because the impact of adopting technologies depends on many factors such as the existence of infrastructure, policies, and institutions that are often not fully functional in developing countries. For example, if farmers do not have access to markets to sell the extra crops that they produce, technological intervention may not reduce poverty. Some studies have claimed that building capacity is more important than technology for improving livelihoods (Appiah 2012).

5.1. Technologies at NARS

All the above conditions prevail in Bangladesh; however, all the NARS institutes have been successfully contributing to national agricultural production by evolving technologies that are suitable for the country's climate and appropriate for farmers' conditions.

BARI is the largest ARI. It works with 103 crops excepting rice, jute, sugarcane, and cotton; it develops a variety of cereals, tubers, pulses, oilseeds, vegetables, fruits, spices, flowers, and so on.

BINA, also a multicrop ARI, has the mandate to work on all important crops to develop mutant varieties through the use of nuclear techniques.

BRRI is a monocrop institute conducting research on all aspects of rice to develop modern varieties with high yield potential for different ecosystems, to develop component technologies for improving productivity of rice-based cropping systems, and to transfer rice production technologies through training, workshops, seminars, and publications.

BJRI conducts research on jute, kenaf, and mesta. BSRI conducts research on sugarcane and other ancillary sugar crops all over the country; limited attention is given to other ancillary sugar crops.

The Bangladesh Fisheries Research Institute conducts research to enhance the growth of fisheries production through optimal use of inland, brackish, and marine water bodies. BLRI generates and adopts technologies to solve livestock problems at the national and farm levels.

The Bangladesh Forest Research Institute conducts research to develop management practices to increase productivity of national forests and village groves and to convert wastelands and marginal lands to forestry and agroforestry uses, develop technologies for rational use of forest products, generate technologies to conserve or restore environmental balances through increasing stocking densities of both rural and urban forests, and transfer technology through extension services and other agencies to end users. The Soil Resources Development Institute is predominantly a service-oriented organization.

The Bangladesh Tea Research Institute conducts research to increase yields and quality of tea by developing improved production technologies and high-yielding tea clones. CDB introduces and promotes cotton cultivation and also is responsible for developing improved varieties. On the other hand, BSRTI conducts research to develop disease-, drought-, and water logging–resistant; high-yielding; and nutritionally rich mulberry varieties for the rearing of silkworms.

All the crop research institutes are mostly devoted to the development of varieties with high yield and other improved traits such as quality; resistance to insects, pests, and diseases; and so on. Emphasis also has been given to abiotic stress tolerance and tolerance for different agroecosystems.

These institutes also carry out research on noncommodity areas such as soil and crop management, pest management, irrigation and water management, development of farm machinery, improvement of cropping and farming system management, postharvest handling and processing, and socioeconomic studies related to production, marketing, and consumption. For field-level dissemination of NARS-developed technologies all the ARIs train research and extension officers in the improved technology of crop production and other component technologies. Table 5.1 summarizes the technologies generated and adopted/contributed to by the NARS institutes.

Table 5.1—Technologies generated and adopted by the National Agriculture Research System institutes

Institute	Research Focus	Number of Varieties/Technologies Developed	Adoption/Contribution of Technologies
Bangladesh Agricultural Research Institute	A multicrop institute, works with 103 crops excepting rice, jute, sugarcane, and cotton; develops a variety of cereals, tubers, pulses, oilseeds, vegetables, fruits, spices, flowers, and so on Researches noncommodity areas such as soil and crop management, disease and insect management, irrigation and water management, farm machinery, cropping and farming system management, postharvest handling and processing, and socioeconomic studies related to production, marketing, and consumption	• Total: 777 • Commodity: • 26 wheat, 19 maize varieties, 44 potato, 40 oilseed varieties, 30 pulse, 57 fruit, 84 vegetable, 19 spices, and 9 flower varieties • Noncommodity: • 422 technologies on different aspects of crop management	• 100% wheat, about 80% potato and radish, 70% tomato, 65% mungbean, 55% lentil, 45% blackgram, 25% mustard and brinjal, and 12% maize • Besides these, summer tomato, summer onion, and integrated pest management for vegetables are getting popular among the farmers
Bangladesh Rice Research Institute (BRRI)	A monocrop institute, conducts research on all aspects of rice to develop modern varieties of rice with high yield potential for different ecosystems, develop component technologies for improving productivity of rice-based cropping systems, and transfer rice production technologies through training, workshops, seminars, and publications	• 57 inbred high-yielding modern varieties and 4 hybrids of rice • 13 are for Boro, 8 for Aus, 25 for Aman, 10 for Boro and Aus, and 1 for Boro, Aus, and Aman seasons • BRRI-developed modern varieties are suitable for varying ecosystems and have a wide range of disease and insect resistance	• More than 65% of the rice grown in the country is covered by BRRI varieties • Most popular varieties are BRRI dhan 28, and BRRI dhan 29 in boro season • 19 BRRI varieties in 14 countries

Institute	Research Focus	Number of Varieties/Technologies Developed	Adoption/Contribution of Technologies
Bangladesh Nuclear Agriculture Institute	Specialized multicrop institute, adopts nuclear techniques	• Using radiation technique the institute has developed 55 improved mutant varieties of different crops • Iratom-24 and Binasail of rice	• Mutant varieties, such as Binamoog-2 and Binamoog-5 of mungbean; Binasarisha-3, 4, and 5 of rapeseed; Binachinabadam-2 and 3 of groundnut have created economic impact • Binadhan-7, a short-duration and high-yielding transplanted aman variety, is useful to fit into cropping patterns in economically depressed areas • Binadhan-8 is a salt-tolerant, high-yielding boro rice variety
Bangladesh Jute Research Institute	Conducts research on jute, kenaf, and mesta	• The Agriculture Research wing has developed 17 varieties of jute, kenaf, and mesta. Among these, 7 Deshi Jute (*Corchorus capsularis* L.), 5 Tossa jute (*Corchorus olitorius* L.), 3 kenaf (*Hibiscus cannabinus* L.), 2 Mesta (*Hibiscus sabdariffa* L.) varieties • The Technological wing generated 23 technologies, including jute Novotex blanket and Novotex fabric, chemical modification of jute fiber production of improved geotextiles, and so on	• 16 varieties of Deshi, Tossa, kenaf, and mesta varieties are widely cultivated • 300 memoranda of understanding have been signed, and many technologies are in use by various entrepreneurs • Technologies such as Novotex blanket and Novotex fabric, chemical modification of jute fiber production of improved geotextiles, and so on are in use
Bangladesh Sugarcane Research Institute	Conducts research on sugarcane and other ancillary sugar crops all over the country; limited attention is given to other ancillary sugar crops	• Developed and released 41 high-yielding, high-sugar varieties	• Bangladesh Sugarcane Research Institute varieties are cultivated in 99% of mill zones and about 60% of non–mill zones.

Institute	Research Focus	Number of Varieties/Technologies Developed	Adoption/Contribution of Technologies
Bangladesh Fisheries Research Institute	Conducts research to enhance the growth of fisheries production through optimal use of inland, brackish, and marine water bodies	• 35 technologies in fish breeding and seed production (11), fish culture (12), integrated farming (3), management and policy formulation (3), and biotechnology (6)	• Some of the widely used technologies in breeding and seed production of genetically improved farmed **tilapia** GIFT , induced breeding and seed production of pangasius, seed production and culture of magur and shingi have revolutionized inland cultured fisheries • Integrated rice–fish, fish culture in pen, seed production of endangered fish species through in vitro fertilization
Bangladesh Livestock Research Institute	Generates and adopts technologies to solve livestock problems at the national and farm levels	• Developed 59 technologies, 25 in animal production, including cattle fattening, calf rearing, dairy farming, and forage production and preservation • 19 in animal health such as vaccines for Peste Des Petits Ruminants PPR, salmonella, goat pox, control packages, Newcastle disease, Gumboro disease, PPR, Foot & Mouth Disease FMD, control package, and so on • 10 technologies for poultry production: hygienic and improved chick brooder, duck, quail, and pigeon rearing • 5 technologies for goat and sheep production	• Most of the technologies for animal production are in use • All vaccines are in use • Models for small farmers for rearing broiler, commercial layer, and cockerel are becoming popular • Rearing of Black Bengal goat under semi-intensive management, goat rearing under stall-feed condition helped to improve the socioeconomic conditions of the rural poor and women

Institute	Research Focus	Number of Varieties/Technologies Developed	Adoption/Contribution of Technologies
Bangladesh Forest Research Institute	Conducts research to develop management practices to increase productivity of national forests and village groves and to convert wastelands and marginal lands to forestry and agroforestry uses, develops technologies for rational use of forest products, generates technologies to conserve or restore environmental balances through increased stocking densities of both rural and urban forests, transfers technology through extension services and other agencies to end users	• 27 technologies to obtain increased productivity from the forestland and better use of the resources. A number of applied and adaptive researches have been conducted to minimize the gap between the demand for and supply of forest produces. Bangladesh Forest Research Institute's database is rich enough to cater the present information needs of forest department FD in particular and the forestry sector in general	• Micropropagation technique through tissue culture of some bamboo species has been developed • Technique for enhancement of service life of rural housing materials • Use of wood wastes for making novelty items, panel products, and particleboard • Simple technique for propagation of bamboos developed as a substitute for rhizomes • Simple, inexpensive, and effective solar kiln has been developed for seasoning timber using solar energy
Soil Resource Development Institute	Is predominantly a service-oriented organization	• Has generated huge amounts of information about the soil and land resources of the country by conducting surveys and prepared maps and reports • Provided soil and fertilizer testing services to farmers and fertilizer dealers • Published 459 "Uapzila Nirdeshika" (simplified guides to soils and agricultural development possibilities) • Provides analytical services to different stakeholders • Soil, plant, and water samples analyses to evaluate diagnostic problems, nutrient balance, lime, and fertilizers requirement of crops • Based on soil analytical results and nutrient status of soils, location-specific fertilizer recommendation cards are distributed to different stakeholders	• Survey reports and maps are being extensively used by the researchers and policy planners • 459 "Uapzila Nirdeshika" are being used for local-level planning • Analytical services for soil, fertilizers, water, and so on are being used by different stakeholders including farmers • Through 6 mobile soil testing laboratories, provide analytical services to farmers (about 3,200 soil samples per year)

Institute	Research Focus	Number of Varieties/Technologies Developed	Adoption/Contribution of Technologies
Bangladesh Tea Research Institute	Conducts research to increase yields and quality of tea by developing improved production technologies and high-yielding tea clones	• 16 improved vegetable clones, 4 biclonal seed stocks, and 1 polyclonal seed stock have been developed and released to the industry • Developed 13 high-yielding quality clones, standardizing pruning cycles and per-unit population for higher productivity; improved tea processing techniques; and introduction of an integrated pest management scheme to protect tea plants from the maladies of pests and diseases	• Mostly adaptive and field oriented in order; as such, unlike other research and development organizations of the country, goals are to carry out demand-driven research and to meet the current needs of the industry • Provides advisory service to planters through direct scientists-to-planter contact, often through a participatory approach; a large portion of resources is devoted to this important linkage • Supply of rooted and fresh cuttings of improved clonal materials to tea estates
Cotton Development Board	Introduces and promotes cotton cultivation	• So far 8 varieties have been released: CB-1, CB-3, CB-5, CB-7, SI/91/646, SA/CB-1/99, JA/CB-5/99, and AVA	• Cultivation in the country has now increased to about 34,642 hectares, producing 73,710 bales, which can meet about 16% of the total cotton requirement of the country
Bangladesh Sericulture Research and Training Institute	Conducts research to develop disease-, drought-, and water logging–resistant; high-yielding; and nutritionally rich mulberry varieties for rearing of silkworms Develops appropriate technology for quality silkworm egg and silk production through low-cost innovative technologies	• Developed 9 high-yielding (30–40 tones/hectare/year) mulberry varieties (BM-1 to BM-9), 6 varieties (BM-1 to BM-6) have been released, and 2 other varieties are awaiting release • 28 high-yielding (60–70 kilogram cocoon/100 disease free layings dfls) silkworm breeds/hybrids have been developed, of which 25 high-yielding breeds have been released; the institute has developed many appropriate and low-cost technologies for silkworm rearing and production of silk	• The other remarkable contribution of the institute is that it has trained 576 and 3,349 persons in long-term and short-term courses, respectively; all these have contributed positively to the silk industry of the country and helped in the improvement of socioeconomic conditions of the rural poor and women

5.2. Potential Technologies

A new group of technologies such as hybrid crop technologies, biotechnologies (including transgenics/genetically modified organisms), conservation technologies, nanotechnologies, processing and packaging technologies, biorisk management, mechanical technologies, and ICT will be required to face the tougher future challenges of feeding the growing population. These new technologies are raising new issues in organizing NARS related to economies of size, international collaboration, and public–private linkages (Byerlee and Alex 1998). Although efforts have already been made in some of the above-mentioned areas, stronger international alliances with advanced research organizations, required to get access to rapid advances in new technologies and knowledge (modern tools, products, and upgrade capacities to use and regulate new technologies especially in intellectual property rights and biosafety), become important to NARS (Pray and Deininger-Umali 1998).

5.2.1. Biotechnology

Agricultural biotechnology has great potential to address future challenges in the agricultural sectors such as crops, livestock, fisheries, postharvest processing, and value addition. ARIs should take advantage of this science especially to speed up breeding processes, increase yields, minimize production risk, sustain the environment, and meet consumer tastes and preferences. Transgenic research should continue and further be strengthened. Application of biotechnology to evolve new genetically engineered varieties of plants, animals, and fishes and plants of high nutritional quality, tolerant to pest and diseases, soil salinity, environmental stresses such as heat, cold, drought, flood, and foggy weather, and environmentally friendly farm practices need to be developed. While developing these, proper testing of transgenic and biosafety will have to be addressed effectively. Research efforts are also needed for increasing shelf life and converting foodstuff into more palatable, nutritious, and stable forms. Also, public awareness relating to the benefits of biotechnology and intellectual property rights issues will be necessary to harness the benefits of biotechnology.

The generation and adoption of appropriate technologies are continuous processes and have to be continually adjusted to the changing environment. More research investment is needed for breaking the yield barrier of crops, which has been stagnate recently. Using advanced breeding techniques such as biotechnology to generate suitable technologies for stress-prone ecosystems is an important area in which to initiate research. Crop improvement through biotechnology has been initiated recently in Bangladesh. Tissue culture of potato, banana, and so on has been on the commercial scale by both private and public agencies. Identification of appropriate antagonistic fungus (*Trichoderma viridii*) for inhibiting soil fungus is also a good example of biotechnological development in research in Bangladesh. Biosafety measures are also taken up for biotechnology R&D activities in Bangladesh.

Supported by USAID, Bangladesh (through BARI) is participating in the Agricultural Biotechnology Support Project in collaboration with Cornell University in the United States. The Philippines, India, and Kenya are other participating countries. The Bt gene has been transferred in eggplants, and trials are being conducted with nine varieties with the Bt gene against fruit and shoot borer under confined field conditions. The agronomic performance of the trials has been found to be good, having a minimum incidence of pest attack. Also, late blight resistance in a popular potato variety has been under trial. Bangladesh is also partnering with the International Rice Research Institute in the development of vitamin A–enriched and zinc-fortified golden rice.

5.2.2. *Management of Energy and Agricultural Waste*

Efficient management of energy in agriculture for various operations is the key R&D challenge. High dependence on oil and nonrenewable sources of energy may make agriculture more risk prone and less profitable. To efficiently manage energy, new sources of renewable energy need to be explored. Research would be targeted to develop biofuels without compromising on food security and effectively using huge agricultural waste, waste from crude oil after refinement, and solar energy. A strategy to explore new biological sources of ethanol, especially from nonfood stocks; explore management practices and opportunities to grow biofuel stocks in low productive areas; and process high-quality animal feeds from crop residues and waste from food processing industries need to be explored and adapted. New forms of machinery and equipment would also be developed for efficient use of renewable sources of energy.

5.2.3. *Use of ICT and Informatics*

Due to the advancements of science, agricultural production efficiency can be largely improved with the application of increasingly powerful computers, sophisticated software, and advance sensors. This will also contribute to a better understanding of global warming, climate change, and their drivers. The frontier sciences and techniques, such as nanotechnology, ICT, remote sensing, geographic information system, and Global Positioning System could be well integrated in the ongoing and future agricultural research for improving research efficiency, better targeting of technologies, and identifying production and marketing environments. The frontier science can also enhance progress in the application of precision and site-specific agriculture. Site-specific research activities include agroecological zone–based nutrient management, crop suitability, and integrated crop management technology development. Remote sensing techniques play an important role in crop identification, crop area inventory, crop yield forecasting, crop damage detection, soil and water resources inventory, and assessment of flood, drought, and other environmental damage. Nanotechnology can improve agriculture and resource management, particularly soil fertility, pest management, product safety and quality, and farm waste management. Adopting these technologies in phases should be given due importance to improve the research quality and to ensure the judicious use of resources.

ICT is increasing in importance for agricultural R&D. Thus, information technology needs to be exploited to add value in research investment. The issue is how to strengthen NARS information capacities and how to make strides toward a knowledge system that effectively links up to the emerging global knowledge system. Priority for greater investment in information technology infrastructure and for its appropriate HRD program having dedicated manpower will have to be developed. Electronic networking will be able to serve the cause of research as well as generation and dissemination of technology. Information modules on personnel information systems, financial information systems, library information systems, and technology information systems should be fully developed and made operational. Linking up with the global science and technology information system and instantly processing information will contribute to the efficiency and relevance of the research system. For easy access to information, libraries in various NARS institutions should be digitized. E-governance of NARS institutions should get due attention in research management. ICT should be used to strengthen research–extension linkages to speed up the technology flow from research to extension.

5.2.4. *Improve Harvest and Postharvest Efficiency*

Harvest and postharvest losses are major drawbacks of the sector that claimed heavy losses in almost every year in crops and fisheries. Inefficient crafts and gears for fisheries, inadequate transportation and preservation facilities, processing problems, and marketing structures together claim about 3.0 percent of total fish production annually. Therefore, research should be concentrated on the development of safe and energy-efficient gears and equipment for fishing, fish preservation and processing, eco-friendly fishing technology development, energy-efficient fishing vessels and gear, technology for effective use of marine bicatch and fishing waste, diversification and value-added product development, and improved quality of traditional fish products.

5.2.5. *Development of Pro-poor Technologies*

The landlessness of marginal agriculture farmers and the involvement of assetless poor people in aquaculture and capture fishing activities are continuously increasing. Poor and marginal fishers are mostly dependent on capture fisheries for their livelihoods, which demands the development of a number of pro-poor fisheries technologies with new opportunities for small-scale operation and good economic return suitable for playing a vital role for food security and rural employment. Poor or vulnerable groups will derive the benefits of technologies that will adjust to the availability of their resources. Some mentionable pro-poor technologies are carp seed nursing, seed production of aquarium ornamental fish, rice–fish integrated culture, integrated poultry-fish farming, tilapia culture, rajpunti culture, seasonal culture of short-cycle fishes, pituitary gland extract and preservation, fry/fingerling transportation, and crab fattening.

These technologies are suitable for practicing in homestead ponds, seasonal ponds, flood plains, and ditches. Vulnerable communities can derive the benefits of those technologies for family nutrition and household income. A wider range of involvement in aquaculture through the generation and adoption/upscaling of new pro-poor fish culture technologies and refinement of the previous technologies will also contribute to increases in the national fish growth, income, and livelihood of the fishers. Further research for development of community-based mechanisms to improve livelihood options for fish-dependent groups in the area of open water aquaculture and capture fisheries will produce better output.

5.2.6. *Nanotechnology*

Bangladesh needs to get the benefit of nanotechnology in agroprocessing to enhance value addition and minimize postharvest loss. However, adequate skill in such advanced science is lacking in the country.

5.3. Institutional Agricultural Extension

Agricultural extension services are provided basically by the public-sector agencies. In the recent past some NGOs and agribusiness enterprises started providing limited extension services. The public institutions have traditionally been the main source of advice for farmers. Recently, a group approach for transferring technologies has been used to reach a larger number of small to medium farmers, including women. There are three main public agencies for technology transfer—DAE, DOF, and DLS.

5.3.1. *DAE*

DAE is the largest public-sector extension service provider in the country under the control of MoA. Although it is named the Department of Agricultural Extension, it provides crop-

related services only. The core functions of DAE include increasing agricultural productivity, HRD, and technology transfer. DAE comprises seven wings with a mandate to provide technical support to field staff, extension services to farmers throughout the country, training to equip extension staff with needed skills, planning and evaluation of extension activities, and administration and personnel management. At present, DAE has a total strength of 25,000 personnel including 2,500 technical graduates at the district and upazila (subdistrict) levels and 12,000 at the grassroots level: extension workers known as SAAOs at the union (lowermost administrative unit) or blocks (two to four blocks in one union). SAAOs are working for the farmers, and their job involves facilitating change in the agricultural sector as well as socioeconomic development.

5.3.2. DOF

DOF, under the control of MoFL, is responsible for providing, among other things, fisheries extension services. There is no clearly defined setup for fisheries and aquaculture extension, but at the national level, there is a post of chief fisheries extension officer in DOF. However, DOF focuses on four ecosystems, including pond, open water, marine, and brackish water fisheries. In contrast to DAE, DOF has no staff at the union level; as such, the upazila fisheries officer, assistant fisheries officer, and fisheries assistant, aside from their other responsibilities, provide upazila-based extension services. Upazila-based officers and staff are supervised by the district and divisional-level officers. There are a total of 4,840 staff positions in DOF, including 1,560 technical staff positions.

5.3.3. DLS

DLS is also under the administrative control of MoFL. There are four divisions: (1) administration and animal health, (2) production, (3) extension, and (4) research, training, and evaluation. DLS has a central disease investigation laboratory, seven field disease investigation laboratories, and 64 district veterinary hospitals. DLS also has a number of poultry farms, duck farms, cattle-breeding and/or dairy farms, and one buffalo-breeding farm. In addition, DLS has a principal (equivalent to director) who oversees the running of the Officers' Training Institute.

Like DOF, DLS also does not have staff at the union level. All extension activities are upazila based. There are 464 offices, and each office is headed by an upazila livestock officer who is assisted by one veterinary surgeon, mainly responsible for treatment of diseases of birds (poultry) and other animals as well as artificial insemination of cows. There are a total of 8,200 staff positions in DLS, including 1,476 technical staff positions.

5.4. Technology Commercialization

Generally NARS institutes sign memoranda of understanding with the private sector and NGOs to receive research-generated technology, knowledge, and processes. The service is free of cost. With the limited capacity, NARS institutes provide breeders' seed to a public corporation (BADC) for wider multiplication. BARI has been maintaining more than 45 memoranda of understanding with different organizations to commercialize technology.

6. Strategic Plan for Enhancing/Strengthening AR4D

6.1. Investment

Policymakers are increasingly recognizing that greater agricultural research investment is essential to increase agricultural production to the levels necessary to feed a growing world population. In addition, more investments in agricultural research are required to address

emerging challenges such as adaptation to climate change, increasing weather variability, water scarcity, and increased price volatility in global markets (Beintema et al. 2010).

The government of Bangladesh has given priority to the agricultural sector to boost agricultural production. Increasing the speed of and sustaining agricultural growth are priorities for increasing food production and reducing poverty. The future challenge of increasing food production could be met through the introduction of modern and state-of-the-art biotechnology and increased investment in agricultural technology generation and transfer.

To support continuous R&D, budget provisions during the plan period will be raised to 1.0 percent from the current level of 0.6 percent of GDP (Planning Commission, Ministry of Planning 2011, *Sixth Five Year Plan FY2011-FY2015*).

6.1.1. Investment Trend

The investment trend in agricultural research in the recent past has not been encouraging. A review of the yearly budget of the ARIs of NARS for the periods 2006–07, 2007–08, and 2008–09 reveals little difference from year to year except a little increase in the BARI, BRRI, and BJRI budgets. Studies show the investment in agricultural research fluctuates from 0.32 to 0.40 percent of the agricultural GDP. However, the situation is improving due to the implementation of donor-supported projects such as NATP.

A revenue budget is prepared by each ARI and sent to MoA. MoA sends the budgets to the Ministry of Finance, where they are further revised and reduced. In fact, there is no hard-and-fast rule about financial resource allocation. The Ministry of Finance, depending on the financial situation of the country in a particular year, decides whether the revenue budgets for the various agencies of the government will increase or decrease from the previous year's budget. The rise or fall of the revenue budgets is indicated by a certain percentage point, for example, "The revenue budget this year will rise/fall by 10 percent."

For the past few years only, a lump sum amount has been allocated for implementation of the research program of each of the NARS institutes, including BARC, more than its approved revenue budget. It is clear that financial allocation has no relation to the volume of work or quality of performance. But it is to be understood that the budget of a research institute should be fixed on the basis of its research program and performance per national priorities. Also, there is opportunity to improve the financial management of NARS.

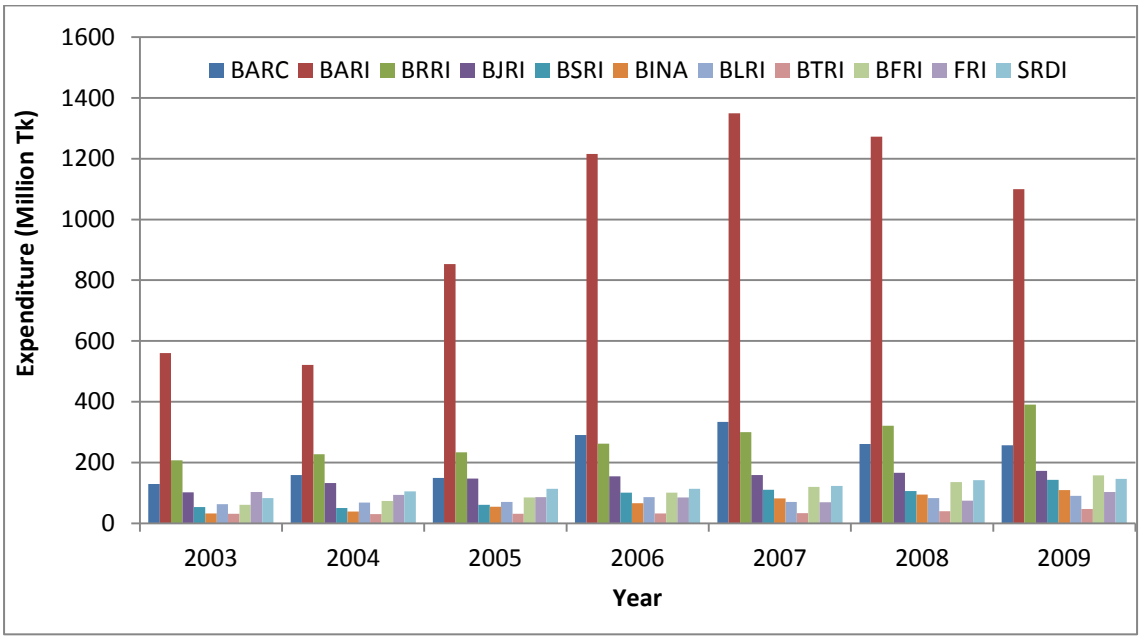
Funding of agricultural research has no uniform flow; neither is it sustainable. Research projects are supported by the government and donors. The operational budget for salaries and routine research are supported by the revenue budget, and major research undertakings are carried out by the project or program support.

The development budget is prepared by an ARI if there is a need for starting a new research project requiring extra manpower, equipment, infrastructure, facilities, operational funds, and so on. Development budgets are for a specific period of time (four to five years). Sustainability of the research or the management and use of the developed technology often becomes a problem due to discontinuity of project-based funding.

During 2009 Bangladesh invested BDT 2.9 billion or $125 million—in purchasing power parity dollars—(both in 2005 constant prices). This includes NARS institutes, universities, other government universities, and NGOs. Total agricultural R&D spending as a percentage of agricultural GDP (agricultural research intensity) fluctuated and peaked at 0.40 in 2006 and 2007 before declining to 0.32 in 2009 (Rahija et al. 2011) (see Figure 6.1 and Table 6.1).

Figure 6.2 shows the budget breakup of the largest ARI (BARI) during 2011/12. Research expenditures of non-NARS government organizations and NGOs (Bangladesh Rural Advancement Committee) as well as private-sector organizations (ACI Seed and Lal Teer Seed, in 2009) are given in Tables 6.2 and 6.3, respectively.

Figure 6.1—Expenditures (in million Bangladeshi Taka) of the total National Agriculture Research System (10) institutes and Bangladesh Agricultural Research Council (operation, capital, and so on)



Source: Rahija, et al (2011)

Note: BDT = Bangladeshi Taka; BARC = Bangladesh Agricultural Research Council; BARI = Bangladesh Agricultural Research Institute; BRRI = Bangladesh Rice Research Institute; BJRI = Bangladesh Jute Research Institute; BSRI = Bangladesh Sugarcane Research Institute; BINA = Bangladesh Institute of Nuclear Agriculture; BLRI = Bangladesh Livestock Research Institute; BTRI = Bangladesh Tea Research Institute; BFRI = Bangladesh Forest Research Institute; FRI = Bangladesh Fisheries Research Institute; SRDI = Soil Resources Development Institute.

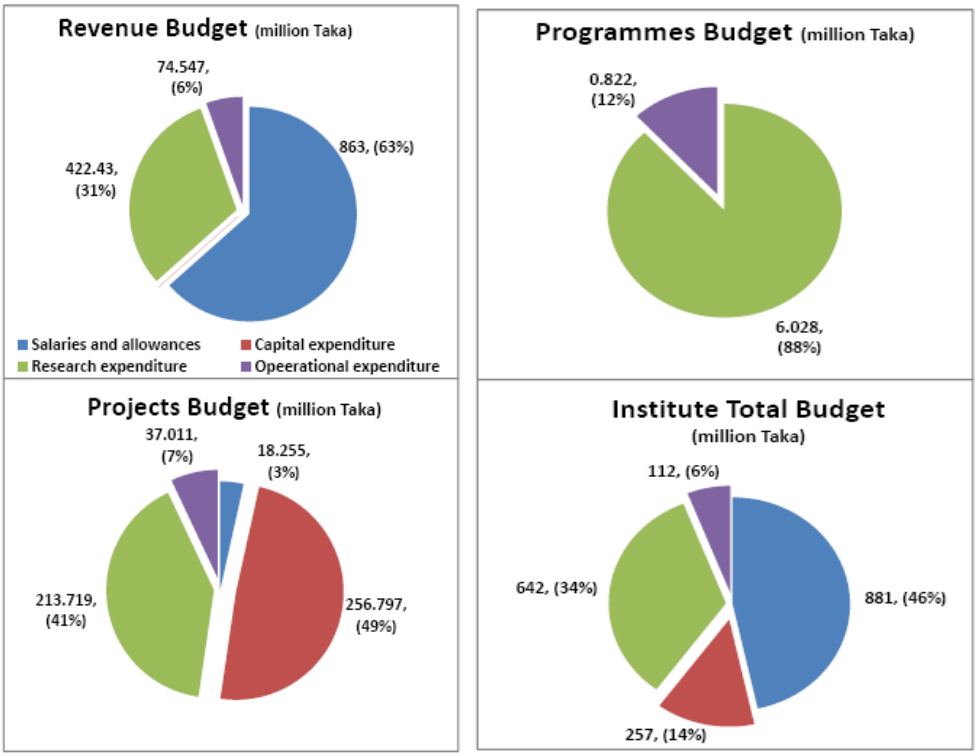
Table 6.1—Expenditures of National Agriculture Research System (in million Bangladeshi Taka)

Institute	2003	2004	2005	2006	2007	2008	2009
Bangladesh Agricultural Research Council	129.74	159.12	149.58	290.77	333.30	260.97	256.51
Bangladesh Agricultural Research Institute	560.33	520.92	852.71	1215.40	1349.43	1272.00	1099.83
Bangladesh Rice Research Institute	207.84	227.78	233.19	262.54	300.24	321.24	390.36
Bangladesh Jute Research	101.99	132.10	147.27	154.67	158.87	166.79	172.98

Institute							
Bangladesh Sugarcane Research Institute	53.19	50.29	61.14	101.30	110.85	106.33	142.78
Bangladesh Institute of Nuclear Agriculture	32.60	39.28	54.56	66.67	81.71	94.57	109.69
Bangladesh Livestock Research Institute	62.97	68.75	69.96	86.11	70.92	82.74	90.31
Bangladesh Tea Research Institute	31.63	30.66	31.74	32.04	34.01	39.52	47.36
Bangladesh Forest Research Institute	61.20	73.41	84.97	101.42	119.79	136.17	158.09
Bangladesh Fisheries Research Institute	102.89	94.08	85.98	85.02	69.44	74.82	102.56
Soil Resources Development Institute	83.37	105.33	114.03	113.45	122.66	142.51	146.17
Total	**1,427.74**	**1,501.72**	**1,885.12**	**2,509.39**	**2,751.22**	**2,697.65**	**2,716.64**

Source: Rahija, et al (2011)

Figure 6.2—Budget of the largest research institute (Bangladesh Agricultural Research Institute), 2011/12



Source: BARI (2011)

Table 6.2—Expenditures of non–National Agriculture Research System government organizations (in million Bangladeshi Taka)

Organization	2003	2004	2005	2006	2007	2008	2009
Bangladesh Council of Scientific and Industrial Research	80.62	85.33	90.57	98.80	111.98	114.67	121.15
Institute of Food and Radiation Biology	19.59	21.53	23.40	24.57	25.51	26.77	27.58
Bangladesh Academy for Rural Development	48.85	50.45	53.70	62.19	66.86	69.47	75.94
Rural Development Academy	58.62	68.15	81.16	84.80	87.37	104.25	105.70
Bangladesh Institute of Development Studies	36.11	36.38	32.86	39.50	44.16	47.36	52.71
Bangladesh Sericulture Research and Training Institute	8.22	8.28	9.61	10.69	11.80	12.56	13.74
Cotton Development Board	26.13	28.02	25.72	31.39	34.83	40.54	42.67
Total	**278.13**	**298.13**	**317.01**	**351.93**	**382.50**	**415.61**	**439.50**

Source: Rahija, et al (2011)

Table 6.3—Research expenditure of nongovernment organizations (Bangladesh Rural Advancement Committee) and private-sector organizations (ACI Seed and Lal Teer Seed), 2009

Cost Category	Expenditure in Million Bangladeshi Taka		
	Bangladesh Rural Advancement Committee	ACI Seed	Lal Teer Seed
Salaries and benefits for all personnel	68.89	2.50	6.45
Operating and program costs	119.59	3.20	6.83
Capital costs	425.86	-	8.55
Total	**614.35**	**5.70**	**21.84**

Source: Rahija, et al (2011)

6.2. Strategy to Address the Priority

Bangladesh has fairly well-developed agricultural R&D agencies and a wide network of research establishments in most of the agroecological regions. Human resources are being developed, although there has been a trend of losing staff from the institutes to universities and the private sector. Using resources can address the priorities set by BARC. However, the following institutional issues can further enhance the capacity of the research and extension system to address the priorities.

Bangladesh has to produce enough food for the growing population of a diversified nature. With limited land and natural resources, research for development must be intensified, with national capacity and global knowledge, to accelerate production and postproduction management. Adequate reform in the agricultural science and technology system will be required to address the challenges of production and postproduction management.

Project-based funding hinders sustainable research endeavors. Funding may be made through government core budgetary allocation to ensure sustainability and efficiency of resources.

The research capacity of the research institutes must be enhanced. Skill-enhancement training programs, particularly in the emerging areas of science, need to be made. The number of quality scientists should also be increased in the institutions.

Bangladesh's agriculture is transforming from subsistence to commercial agriculture. In response to income growth, quality and safety have become major concerns. Adulteration of input (seed, fertilizer, feed, and vaccine) as well as agricultural produce are becoming major concerns. Diagnostic capacity and mitigation measures have to be in place to safeguard consumers of all categories.

The incidence of plant and animal disease that is transboundary in nature has been widespread recently. The diagnostic capacity of both research and extension should be strengthened by providing logistic and training support.

Annual revenue allocation to DLS has declined from 0.57 percent of the annual national budget in 1997 to 0.38 percent in 2003/04. The annual operating cost available for DLS from the revenue budget is only 4.7 percent and 5.6 percent for BLRI. DLS has to heavily depend on a development budget that comes through time-bound projects. The same is true for crops (DAE) and fisheries (DOF) extension departments, which need to be addressed properly.

Research institutions under NARS are scattered under the administrative control of five ministries. This creates a problem of proper coordination of research resources allocation, HRD, and management.

Modern human resources management should be introduced in the country to enhance the accountability of the scientific staff. Human resources management should also ensure retention of quality professionals. A unified service rule should be introduced among the institutes of NARS to maintain uniformity of quality and lateral movement of scientists.

The quality of agricultural education, particularly at the tertiary level, should be improved to render better-quality research support.

A strong linkage should be established among the research, extension, and farmers in all subsectors of agriculture. Adequate funding and institutional mechanisms may establish the linkage. Farmers' organizations may be developed to voice the problems of the growers. NATP has established CIG in the project areas (25 districts), which may be institutionalized.

International linkages such as the Consultative Group of International Agricultural Research are maintained by the individual NARS institutes. For better coordination and effective use of international research services, BARC may be given the responsibility to maintain international research linkages.

International centers working in Bangladesh may be encouraged to work in collaborative and participatory mode with the national centers (NARS) rather than implement research in isolation. This is required to ensure sustainability and capacity development of local institutions.

Research priority setting is not an ad hoc exercise; rather it should be institutionalized with wider participation of stakeholders, particularly technology users.

Monitoring and evaluation of research programs must be done regularly with a view to quality improvement and investment justification. For this to happen, research managers should be adequately trained with modern tools to affect the assessment of research.

The technology delivery system should be equally strengthened with adequate technical staff. Extension departments such as DOF and livestock are suffering from lack of manpower, particularly at the field level.

The regulatory environment must be strengthened to ensure safety and quality standards of agricultural inputs and agroproducts.

Lack of coordination among relevant ministries and departments still remains a problem in development.

For development of AR4D, the issues of autonomy of the research institutions, incentive structure, talent hunt, HRD, facilities, and so on need to be addressed. The dynamic life cycle of scientific research requires a quick decisionmaking system. To allow quick decisionmaking, the research institution needs adequate autonomy within the national policy framework.

An incentive mechanism for creating intellectual property of high financial value has not yet developed fully. As a result, many scientists prefer to work for institutions abroad or for private organizations. Many are leaving the institutions to work in the universities. Adequate incentives should be provided to retain scientists in the public-sector agencies. Awards for outstanding performance should be institutionalized.

More women are entering agriculture, education, research, and extension. The number of women enrolled in the universities is increasing. The same is true for the research and extension delivery system. Adequate service space may be created in the research and extension service to address nutrition, participatory varietal selection, homestead farm income, postharvest management, women's empowerment, and so on.

6.3. Potential of New Technologies and the Involvement of the Private Sector

6.3.1. Involvement of the Private Sector

Globally, breeding of improved crop varieties has been dominated by the public sector, whereas the private sector mainly has focused on developing fertilizers, pesticides, and machinery for irrigation and cultivation. However, the first hybrid rice in China, developed in 1974 with substantial support from the government, quickly spread among farmers. In 2007, 55 percent of the rice area was covered by hybrid rice (Pandey and Bhandari 2010).

Agriculture is the largest private sector in the country as it employs a huge number of people, and without their help, the government's efforts may have only limited impact. The involvement of the private sector in agribusiness was limited until the early 1990s. Most of the agribusinesses were carried out by public-sector enterprises dealing with sugar, jute, fertilizers, and so on. Private-sector involvement in agribusiness was relatively modest and limited to subsectors such as rice and wheat milling, tea, and marketing of agricultural products. In the 1990s, private agribusinesses, as well as trade and industry associations, began to grow. This accelerated in the second part of the decade and continued in the early part of the 2000s. Most growth took place in subsectors such as poultry, shrimp, potato and cold storage, fruit processing, and supermarket chains (United Nations Development Programme 2007).

The following are factors that accelerated the emergence/growth of private agribusiness during the 1990s:

Congenial market reform policies of the government during the 1980s and 1990s encouraged private-sector involvement in agribusiness, which the public sector previously had controlled. This included private-sector distribution of agricultural inputs and exports.

Near self-sufficiency in rice achieved during this period increased food security and expanded opportunities for agricultural and nonfarm diversification. Sustained growth of the economy has increased purchasing power, particularly in urban areas, with the consequent increase in demand for nonrice foods and more processed items.

Development of infrastructures such as roads and telecommunications, electrification, and energy improved opportunities for enterprise development. Improvement of connectivity between the impoverished north and the rest of the market economy of the country has stimulated greater trade volume and investment.

Some projects have facilitated the emergence of new agribusiness ventures and strengthened existing ones. The most important example of these projects was the agro-based Technology Development Project I, funded by USAID from 1996 to 2001.

From the supply point of view, the key challenges to agricultural growth in the country are water resource and land area constraints, soil degradation, and recurring natural hazards coupled with increasing demand as a consequence of a rapidly growing, increasingly urbanized, and more affluent population with changing tastes. Addressing these challenges will require new thinking about how domestic food security goals can be met while sustaining an increasingly fragile environment and a large population dependent on agriculture for its livelihood.

The resolution of these challenges will require interventions mediated by the government and involving the private sector, including both policy actions and the necessary investments in relevant areas.

Agricultural growth is dependent on a wide-scale switch to high-yielding variety seed, but seed quality in general remains a major problem. BADC, which has the mandate to supply quality seeds, can supply only a miniscule part of the total demand. For example, there is a need for 600,000 tons of potato seeds, but BADC's capacity is only 18,000 tons. Various related investments are needed to enhance provision of quality seeds in adequate quantities. Some of the NGOs and the private sector have started to enter the seed sector with positive impacts on availability, although quality still remains a troublesome issue in some cases. Further private–public partnerships for seed, marketing, and extension need to be explored.

Postharvest losses are conventionally thought to be high in Bangladesh. Loss in rice is around 7–8 percent of production, around one-fourth the losses in nonrice crops, particularly high-value and highly perishable crops such as fruits and vegetables. Losses may be higher for particular groups, such as marginal and small farmers, or in areas where insect damage or weather-related factors (high humidity, for example) cause spoilage in storage. In such cases, targeted investments to minimize postharvest losses may be effective in increasing the availability of food.

Besides quality seeds, a reliable supply of inputs such as fertilizer, irrigation, and pesticides are the key elements of production for any crop. This may require substantial expansion of capacity for seed multiplication as well as the establishment of a new system of seed collection, preservation, multiplication, certification, and regulation—not only for seeds developed in the conventional manner but also for genetically modified crops, ICT, and biotechnologically developed quality planting materials. Quality seeds of various kinds of food crops and nonfood crops should be preserved, multiplied, certified, and made available through large-scale dealership, in a public–private partnership system. As with seeds, there is a long-standing need for strong regulatory and certification mechanisms for ensuring quality of fertilizer and pesticides. Here there is a role for a strong farmer-level organization to work with a centralized regulatory authority.

In addition to the substantial expansion of the extension system, the quality of extension services needs major improvement. While continuing with conventional extension, the quality, skills, and knowledge of extension personnel need to be upgraded through training, including redesigning the syllabus of training schools. Extension must increasingly use ICT and related technologies, including an information bank for use by the general public and farmers in particular. The growing telecenters in Bangladesh should be used as a vehicle for public–private partnership in this process.

Farmers cannot be merely passive recipients of advice or resources from the government or other agents, private organizations, or NGOs. They must have a strong organization of their own to champion the general interests of farmers regarding such issues as prevention of adulteration of fertilizer, pesticides, and seeds; dissemination of information about new techniques or rules; equitable access to government lands; and prevention of use of toxic chemicals for ripening or preservation of food crops.

6.4. International Linkage

BARC maintains linkages with a number of international R&D agencies. Being a member of the Consultative Group of International Agricultural Research, Bangladesh is directly involved with the following centers:

International Rice Research Institute
International Maize and Wheat Improvement Centre
International Food Policy Research Institute

World Fish Centre

Bangladesh is linked with other relevant CG centers. Moreover, the country is a member of the following global and regional agencies:

FAO
Asia Pacific Association of Agricultural Research Institute
Center for Alleviation of Poverty through Secondary Crops Development in Asia and the Pacific of UN
Asia Pacific Centre for Agricultural Engineering and Machinery of UN

Bilateral relationships are also maintained with a number of countries. USAID and Japan International Cooperation Agency also partner with the R&D system in Bangladesh. Through this relationship, Bangladesh is getting substantial international knowledge and research products for the development of agriculture.

6.5. AR4D Policy Dialogue—Bangladesh

A daylong policy dialogue, "Prioritizing Demand-driven Agricultural Research for Development," was organized to explore the future path for AR4D: to look for a new vision and structure for AR4D and to further identify current issues, future challenges, and creative solutions. Fifty participants from civil society, NGOs, the private sector, and farmers' groups were invited to identify the needs of agricultural research in the process of development. The process of needs assessment was demand driven and prioritized by the stakeholders. The program was designed in a highly flexible manner so that the participants could get fully involved and determine the content.

Dr. Wais Kabir, executive chairman of BARC, presented the draft report and the major issues of concern for AR4D in Bangladesh. After discussion of and clarification about the presentation, the participants formed the following four working groups:

Working Group 1: Priorities of AR4D

Working Group 2: Structures and Institutions for Agricultural Research

Working Group 3: Funding and Financing Mechanisms

Working Group 4: Innovative Technology Delivery Systems

Participation in these groups was absolutely voluntary. Each group was requested to come up with 10 recommendations. After brainstorming, the groups were able to settle on 10 priorities for their respective issues, and they posted them on a board for display. Then all the participants took part in a gallery walk to review the recommendations made by the other working groups. This was followed by open discussion and a question-and-answer session.

Altogether there were 40 options, but each participant got to vote for only 10. Thus, each participant was given 10 stickers, and he or she put them on the 10 items/priorities that the participant thought the best. After counting the votes, each item/priority was ranked. The results are presented in Table 6.4.

Table 6.4—Recommendations from agricultural research for development (AR4D) policy dialogue—Bangladesh

Group 1—Priorities of AR4D		
Serial number	Title	Votes
1	Genetic improvement of crops/livestock/fish/forestry through biotech	13
2	Research on unfavorable ecosystems	10
3	Input use efficiency improvement research	6
4	Appropriate technologies for mechanized farming and processing	4
5	Research on food safety issues	4
6	Feed improvement (qualitative) of livestock and fisheries	3
7	Research on emerging pests and diseases	2
8	Strengthening agricultural market research	2
9	Organic farming	0
10	Biofortification research	0
Group 2—Structures and institutions		
Sl. number	Title	Votes
1	There should be unified service rules for the scientists of NARS institutions	19
2	Governance board of BARC should be empowered to decide and approve matters related to agricultural research and development of NARS	9
3	Immediate abolition of NARS composition as Schedule A and Schedule B—there should be one composition	8
4	Undertaking future responsibility of research effort, there should be a continuous program of human resources development at home and abroad	4
5	Strong monitoring, evaluation, and impact assessment need to be inbuilt within the NARS management system	4
6	ARIs management board to have all required authority to implement the programs	2
7	Scientists should be encouraged to retain in their disciplinary positions and highest scale	2
8	Regional stations of ARIs to be transformed into independent research station/center with required authority	1
9	For efficient technology generation and transfer, research extension and private partnership to be more formalized	1
10	Research endowment fund to be sponsored by government/donors for continuous fund allocation for AR4D	0
Group 3—Funding and financing mechanisms		
Sl. number	Title	Votes
1	Core funding of research to be enhanced with accountability	11
2	Multidisciplinary research through Competitive Grants Program	6
3	Encourage private-sector partnership in research funding with clear-cut cost-sharing mechanisms	4
4	New funding mechanisms such as revolving funding and cofinancing	3
5	Adequate funding at least 1 percent of agricultural GDP (AgGDP)	2
6	Adequate funding for human resources development	2
7	Establish joint research programs with developed countries through cofinancing	1

8	Flexible rules and procedures for research expenditure (local and foreign-aided projects)	1
9	Donor funding for demand-driven research for national interest	0
10	Clear-cut intellectual property rights policy to attract private-sector funding	0
Group 4—Innovative technology delivery mechanism		
Sl. number	Title	Votes
1	Ensure fair prices of all agricultural production during storage to reduce seasonal loss	11
2	Strengthening research to mitigate the impact of climate change on fish breeding (high temperature)	7
3	Incorporation of private-sector and progressive farmers in technology transfer	6
4	Directing coordinated research programs through the participation of farmers, extension, and research personnel	5
5	Ensuring technological support for lactating cow, calf rearing, and beef fattening and also ensuring the availability of feed and other relevant input	5
6	Women empowerment—training to be imparted on agricultural technology	4
7	Broodstock management and distribution system—more role of the government	4
8	Ensuring veterinary treatment and artificial insemination programs have a reach at the grassroots level	3
9	Take steps to evolve technologies of harvesting rain water and efficient use of surface water	2
10	Ensure the availability of quality seed, saplings, and other inputs at the grassroots level	0

Source: AR4D Country policy dialogue held in Dhaka on 23 June 2012.

Note: NARS = National Agriculture Research System; BARC = Bangladesh Agricultural Research Council; ARI = agricultural research institute.

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Appendix A: List of Research Entities in Bangladesh

Supervising Agency	Government Agency Involved in Agricultural Research and Development	Research Focus
Ministry of Agriculture	Bangladesh Agricultural Research Council	Crops, livestock, natural resources
Bangladesh Agricultural Research Council	Bangladesh Rice Research Institute	Crops, natural resources, agricultural engineering, socioeconomics
Bangladesh Agricultural Research Council	Soil Resource Development Institute	Natural resources
Bangladesh Agricultural Research Council	Bangladesh Jute Research Institute	Crops, off-farm postharvest, natural resources, socioeconomics
Bangladesh Agricultural Research Council	Bangladesh Institute of Nuclear Agriculture	Crops, natural resources
Bangladesh Agricultural Research Council	Bangladesh Fisheries Research Institute	Fisheries
Bangladesh Agricultural Research Council	Bangladesh Forest Research Institute	Forestry, crops, natural resources
Bangladesh Agricultural Research Council	Bangladesh Sugarcane Research Institute	Crops, socioeconomics
Bangladesh Agricultural Research Council	Bangladesh Livestock Research Institute	Livestock, pastures and forages, socioeconomics
Bangladesh Agricultural Research Council	Bangladesh Tea Research Institute	Crops
Ministry of Science and Information & Communication Technology	Bangladesh Council of Scientific and Industrial Research, Dhaka Laboratories	Crops, off-farm postharvest, livestock
Ministry of Science, Information and Communication Technology	Bangladesh Council of Scientific and Industrial Research, Rajshahi Laboratories	Crops, off-farm postharvest, medicinal
Ministry of Science and Information & Communication Technology	Bangladesh Council of Scientific and Industrial Research, Chittagong Laboratories	Off-farm postharvest, medicinal
Atomic Energy Research Establishment	Institute of Food and Radiation Biology	Off-farm postharvest, crops, livestock, natural resources
Bangladesh Council of Scientific and Industrial Research	Institute of Food Science and Technology	Off-farm postharvest
Ministry of Local Government, Rural Development and Cooperatives	Rural Development Academy	Crops, agricultural engineering, livestock, off-farm postharvest, natural resources, socioeconomics
Ministry of Local Government, Rural Development and Cooperatives	Bangladesh Academy for Rural Development	Socioeconomics
Ministry of Textiles and Jute	Bangladesh Sericulture Research and Training Institute	Livestock
Ministry of Agriculture	Cotton Development Board	Crops
Ministry of Planning	Bangladesh Institute of Development Studies	Socioeconomics

Supervising Agency	Higher Education Agency Involved in Agricultural Research and Development	Research Focus
Bangladesh Agricultural University	Faculty of Agriculture	Crops, forestry, off-farm postharvest, natural resources
Bangladesh Agricultural University	Faculty of Veterinary Science	Livestock
Bangladesh Agricultural University	Faculty of Agricultural Engineering & Technology	Agricultural engineering, off-farm postharvest
Bangladesh Agricultural University	Faculty of Fisheries	Fisheries
Bangladesh Agricultural University	Faculty of Agricultural Economics and Rural Sociology	Socioeconomics
Bangladesh Agricultural University	Faculty of Animal Husbandry	Livestock, pastures and forages
Bangladesh Agricultural University	Research System	Crops, livestock, fisheries, natural resources, socioeconomics
Sher-E-Bangla Agricultural University	Faculty of Agriculture	Crops, natural resources, livestock, off-farm postharvest
Sher-e-Bangla Agricultural University	Faculty of Agribusiness Management	Socioeconomics
Bangabandhu Sheikh Mujibur Rahman Agricultural University	Faculty of Agriculture	Crops, off-farm postharvest, natural resources, forestry, socioeconomics
Hajee Mohammad Danesh Science and Technology University	Faculty of Agriculture	Crops, natural resources
Hajee Mohammad Danesh Science and Technology University	Faculty of Veterinary and Animal Science	Livestock, pastures and forages
Hajee Mohammad Danesh Science and Technology University	Faculty of Fisheries	Fisheries
Hajee Mohammad Danesh Science and Technology University	Faculty of Agroindustrial and Food Processing Engineering	Off-farm postharvest, agricultural engineering
Sylhet Agricultural University	Faculty of Veterinary and Animal Science	Livestock, veterinary medicine
Sylhet Agricultural University	Faculty of Agriculture	Crops, natural resources, forestry, off-farm postharvest, socioeconomics
Sylhet Agricultural University	Faculty of Fisheries	Fisheries
Sylhet Agricultural University	Faculty of Agricultural Economics and Business Studies	Socioeconomics
University of Dhaka—Faculty of Biological Sciences	Department of Botany	Crops, off-farm postharvest
University of Dhaka	Institute of Nutrition and Food Security	Food safety and nutrition, off-farm postharvest
University of Dhaka—Faculty of Biological Sciences	Department of Aquaculture and Fisheries	Fisheries, socioeconomics
University of Dhaka—	Department of Soil, Water &	Natural resources

Supervising Agency	Higher Education Agency Involved in Agricultural Research and Development	Research Focus
Faculty of Biological Sciences	Environment	
University of Dhaka—Faculty of Biological Sciences	Department of Genetic Engineering and Bio-Technology	Crops, livestock, fisheries
University of Chittgong—Faculty of Science	Institute of Forestry and Environmental Sciences	Forestry, natural resources
University of Chittgong—Faculty of Science	Institute of Marine Science and Fisheries	Fisheries, off-farm postharvest, natural resources, socioeconomics
University of Chittagong—Faculty of Biological Science	Department of Soil Science	Natural resources
Bangladesh University of Engineering and Technology—Faculty of Civil Engineering	Department of Water Resources Engineering	Natural resources
Bangladesh University of Engineering and Technology	Institute of Water and Flood Management	Natural resources
University of Rajshahi—Faculty of Agriculture	Department of Fisheries	Fisheries
University of Rajshahi—Faculty of Agriculture	Department of Crop Science and Technology	Crops, natural resources

Supervising Agency	Higher Education Agency Involved in Agricultural Research and Development	Research Focus	Head Count	Full-time Equivalents	Year
University of Rajshahi	Institute of Biological Sciences	Crops	6.0	1.2	2009
Noakhali Science and Technology University	Department of Fisheries and Marine Science	Fisheries	10.0	2.0	2009

Supervising Agency	Agency Involved in Agricultural Research and Development	Research Focus
Bangladesh Rural Advancement Committee	Agriculture and Food Security Program	Crops

Private for Profit					
Supervising Agency	**Agency Involved in Agricultural Research and Development**	**Research Focus**	**Head Count**	**Full-time Equivalents**	**Year**
	Lal Teer Seed	Crops	29.0	8.7	2009
	ACI Seed	Crops	6.0	1.8	2009

Appendix B: List of Research Priorities in Bangladesh Agriculture

Table B.1—Priority researchable areas/issues for rice (*Oryza sativa* L.)

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Rice production—varietal improvement	1.1. Short-duration rice varieties (10–14 days shorter than the existing popular ones for all crop-growing seasons)	High	Basic/Applied	Long
	1.2. Hybrid rice varieties (shorter duration with 20 percent higher yield than the existing best varieties) for Boro and T. Aman seasons	High	Basic/Applied	Long
	1.3. Super-high-yielding rice varieties (30 percent higher yield than the existing varieties) for Boro and T. Aman seasons	High	Basic/Applied	Long
	1.4. Salt-tolerant (10–12 deciSiemens per meter) varieties for Boro and Aus seasons under tidal saline environment of the coastal region	High	Basic/Applied	Long
	1.5. Submergence-tolerant (10–14 days) rice varieties for nonsaline tidal coastal wetland/flash food/moderate stagnant conditions	High	Basic/Applied	Long
	1.6. Drought-tolerant/aerobic rice varieties for Aus and T. Aman seasons	High	Basic/Applied	Long
	1.7. Resistant rice varieties to major diseases and insect pests such as BLB Bacterial Leaf Blight, BLS Bacterial Leaf Streak, and BPH Brown Plant Hopper	High	Basic/Applied	Long
	1.8. Identification of races and biotypes of major diseases and insect pests of rice; mapping of R-genes and genes pyramiding	High	Basic	Long
2. Rice production—management practices	2.1. Integrated crop management practices for higher rice productivity in different rice ecosystems	High	Applied/Adaptive	Short–Medium
	2.2. Yield gap minimization in rice and rice-based cropping systems using management practices through participatory on-farm research	High	Applied/Adaptive	Short–Medium
	2.3. Management practices for direct seeded rice—dry/wet	High	Applied/Adaptive	Short–Medium
3. Rice protection	3.1. Appropriate management practice for major diseases, insects, and weeds in rice and rice-based cropping systems	High	Applied/Adaptive	Short–Medium

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	to minimize yield loss			
	3.2. Integrated pest management in rice and rice-based cropping systems	High	Applied/Adaptive	Short–Medium
	3.3. Minimization of postharvest and storage loss in rice	High	Applied/Adaptive	Short–Medium
4. Rice processing and marketing (value addition and supply chain development)	4.1. Rice milling for higher recovery	High	Applied/Adaptive	Short–Medium

Source: BARC (2011)

Table B.2—Priority researchable areas/issues for wheat

Thematic Area	Researchable Area/Issue	Priority Ranking	Type of research	Research Duration
1. **Wheat production—varietal improvement**	1.1. High-yielding, disease resistant (LR Leaf Rust, BPLB Bipolaris Leaf Blight, BP) variety development	High	Basic/Applied	Long
	1.2. Early-maturing and heat-tolerant variety development	High	Basic/Applied	Long
	1.3. Quality seed production	High		
2. **Wheat production—management practices**	2.1. Yield gap minimization of wheat through farmers' participatory research	High	Adaptive	Short
	2.2. Introduction of wheat in potential areas	High	Adaptive and applied	Medium
	2.3. Refined and improved management package for high-yield goal through farmers' participatory research on regional basis	High	Applied	Short
	2.4. Water resource management and promotion of water-saving technology, especially in the drought-prone areas such as Barind Tract by replacing Boro rice with wheat	High	Adaptive	Medium
3. Wheat protection—diseases and pests	3.1. Survey and monitoring of new diseases and new races, especially Ug-99	High	Basic	
	3.2. Identification of pathogenic races using molecular	High	Basic and Applied	

Thematic Area	Researchable Area/Issue	Priority Ranking	Type of research	Research Duration
	techniques			
	3.3. Cultural, chemical, and integrated control of major diseases	High	Applied	

Source: BARC (2011)

Table B.3—Priority researchable areas/issues for maize

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of research	Research Duration
1. Maize production—varietal improvement	1.1. Development of disease resistant hybrids for human consumption and poultry industry	High	Applied	Long
	1.2. Development of abiotic stress–tolerant hybrids (water logging, salinity) for kharif season	Medium	Applied	Long
	1.3. Development of short-stature maize to withstand lodging due to high wind	High	Adaptive	Long
2. Maize production—management practices	2.1. Development of maize-based cropping pattern to sustain and improve soil fertility	High	Applied	Medium
	2.2. Introduction of maize after T. Aman rice in new areas, especially in southern Bangladesh	High	Adaptive	Medium
	2.3. Development of refined, improved management packages for high-yield goal on regional basis	High	Adaptive	Medium
	2.4. Determination of optimum planting time for maximum seed setting of inbreds and F1s first filial generation	High	Applied	Medium
	2.5. Research on seed quality, seed health, vigor, seed abnormality, and so on in storage	High	Basic	Medium
3. Maize protection—disease and insect pests	3.1. Surveillance of diseases and insect pests and new races of disease pathogens	High	Basic	Long
	3.2. Cultural, chemical, and integrated control of major disease and insect pests, if any	High	Applied	Short–Medium

Source: BARC (2011)

Table B.4—Priority researchable areas/issues for jute and allied fiber crops

Thematic Area	Researchable Area/Issue	Priority Ranking	Type of research	Research Duration
1. Jute production—crop improvement	1.1. Molecular characterization and conservation of germplasm including released varieties of jute, kenaf, and mesta (JAF)	High	Basic/Applied	Medium–Long
	1.2. Development/screening of high-yielding varieties of jute, kenaf, and mesta that are resistant against various stresses (biotic and abiotic)	High	Basic /Applied	Long
	1.3. Upscaling of off-season jute seed production technology	High	Adaptive	Medium
	1.4. Development of genetically modified jute with desirable traits	High	Basic	Long
2. Processing marketing (value addition)	2.1 Development of fungal inoculum packages for acceleration of jute retting	High	Basic and Applied	Long
	2.1. Improvement and scaling up of ribbon-retting technology	High	Adaptive	Short–Medium
	2.2. Manufacturing of fancy jute products using jute yarns blended with other textile fiber	High	Applied	Medium
	2.3. Improvement of jute fiber using chemicals and blended with other natural and synthetic fibers for diverse use in textile sectors	High	Applied	Medium

Source: BARC (2011)

Table B.5—Priority researchable areas/issues for oilseed crops: oilseed, mustard (*Brassica comprestis*), sesame (*Sesamum indicum*), groundnut (*Arachis hypogaea*), soybean (*Glycine max*), sunflower (*Helianthus annuus*)

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Crop production—crop improvement	1.1. Development/screening of disease-resistant, high-yielding varieties of oil crops	High	Basic/Applied	Long
	1.2. Hybrid variety development for sunflower	High	Basic/Applied	Long

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	1.3. Short-duration variety development of mustard for specific niches	High	Basic/Applied	Long
	1.4. Development of water logging/submergence–tolerant, wilt and stem rot–resistant variety of sesame	High	Basic/Applied	Long
2. Crop management	2.1. Intensification of short-duration mustard cultivation in between Aman and Boro rice	High	Applied/Adaptive	Medium
	2.2. Standardize fertilizer package, especially micronutrients, for different oil crops in deficient areas	High	Applied	Medium
	2.3. Adaptive trials on yield maximization of oil crops to minimize yield gap	High	Adaptive	Medium–Short
	2.4. Development of seed storage technique in groundnut, soybean, and sunflower	High	Adaptive	Medium–Short
	2.5. Upscaling of seed production of new varieties through block demonstration	High	Adaptive	Medium
	3.1. Surveillance of new diseases/pathogenic races of oil crops	High	Basic	Long
	3.2. Development of control measures against major insect pests of oil crops (such as aphid, hairy caterpillar, hawk moth in sesame, thrips in soybean, and termite and white grub in groundnut)	High	Applied	Medium
	4.1. Upscaling of the different food products produced from soybean	High	Adaptive	Medium

Source: BARC (2011)

Table B.6—Priority researchable areas/issues for pulses: Lentil (*Lens culinaris*), lathyrus (*Lathysus sativus*), field pea (*Pisum sativum*), chickpea (*Cicer arietinum*), mungbean (*Vigna radiata*), blackgram (*Phaseolus mungo*), cowpea (*Vigna unguculata*)

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Crop production—crop improvement	1.1. Collection, evaluation, and conservation of germplasm from different sources including international centers	High	Basic	Long

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	1.2. Development of short-duration-disease-resistant (stemphylium blight, rust, and foot rot), high-yielding variety of lentil	High	Basic/Applied	Long
	1.3. Development of BGM Botrytis gray mold -resistant variety of chickpea	High	Basic/Applied	Long
	1.4. Downy and powdery mildew–resistant, high-yielding variety for relay cropping of lathyrus	High	Basic/Applied	Long
	1.5. YMV Yellow Mosaic Virus - and cercospora-resistant, high-yielding variety for mungbean and cowpea (for southern region)	High	Basic/Applied	Long
	1.6. Short-duration, powdery mildew– and sclerotinia-resistant blackgram variety for late planting (postflood)	High	Basic/Applied	Long
	1.7. Short-duration, powdery mildew–resistant variety of field pea	High	Basic/Applied	Long
	1.8. Molecular characterization of released varieties and local cultivars of pulses	Medium	Basic	Long
	1.9. Development of abiotic stress–tolerant pulse variety for specific niches	Medium	Applied	Long
2. Crop production— crop management	2.1. Introduction of short-duration pulse varieties (lentil, mungben) in appropriate cropping system, especially mungbean in kharif-1 season in new areas	High	Applied	Medium
	2.2. Validation of economic advantages of pulses over Boro through participatory adaptive research	High	Adaptive	Medium
	2.3. Design of new cropping patterns including short-duration pulses such as lentil, pea, and grasspea (as fodder) in between Aman and Boro rice	High	Applied	Medium
	2.4. Design of new cropping patterns for incorporating short-duration pulses such as lentil, pea, and grasspea (as fodder) in between Aman and Boro rice	High	Applied	Medium
	2.5. Relay cropping of lentil, chickpea, field pea, and backgram in suitable areas	High	Adaptive	Medium
	2.6. Introduction of biofertilizer in pulse, especially in nontraditional areas	High	Adaptive	Short

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	2.7. Yield maximization of pulses through optimum management practices	High	Adaptive	Medium
3. Crop protection—diseases and insect pests	3.1. On-farm chemical control of major diseases of pulses such as stemphylium and rust of lentil, BGM in chickpea, YMV in mung and black gram, and powdery mildew in field pea, blackgram, mungbean	High	Adaptive	Medium
	3.2. On-farm chemical control of major insect pests of pulses such as pod-borer complex of mungbean, chickpea, and cowpea; aphids in lentil and lathyrus, thrips, mites; and apion in mungbean	High	Applied/Adaptive	Short
	3.3. Development of integrated pest management against major pests of pulses	High	Basic	Long

Source: BARC (2011)

Table B.7—Priority researchable areas/issues for tubers and root crops: potato (*Solanum tuburusum*), sweetpotato (*Ipomea batata*), aroid (*Araceae*), yam (*Dioscrea sps.*), cassava (*Manihot esculenta*)

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Crop production—crop improvement	1.1. Germplasm collection and evaluation, conservation of root and tuber crops	High	Basic	Long
	1.2. Disease-resistant and stress-tolerant, high-yielding variety development for roots and tuber crops	High	Applied	Long
	1.3. Disease-resistant variety for specific purposes such as potato variety for export, for starch, for flakes, for chips (less sugar and high dry matter)	High	Applied	Long
	1.4. Development of genetically modified potato against late blight, early blight, and so on	High	Basic/Strategic	Long
	1.5. Early-maturing, high-yielding variety of Mukhikachu and high-yielding variety of stolon (Loti) and other aroids	High	Applied	Long

2. Crop production—crop management	2.1 Standardized cultivation practices for higher yield of potato, Mukhikachu, and Panikachu	High	Applied	Medium
	2.2 Standardized zero-tillage potato cultivation with mulching, especially for southern region	High	Applied	Medium
	2.3 Introduction of high-yielding yam, Olkachu, Mankachu varieties in the homestead throughout the country	High	Applied	Medium
	2.4 YMV-free seed tuber production of potato through tissue culture and enhanced breeders' seed production	High	Applied	Medium
3. Plant protection—diseases and pests	3.1 Survey of the disease status of roots and tuber crops such as aroids and yams and development of control measures for major diseases	High	Basic/Applied	Long
	3.2 Survey of the insect pest status of yams and aroids and identification of the major and minor pests	High	Basic	Long
	3.3 Updated control measures against major insect pests of potatos	High	Applied	Medium
4. Postharvest processing and marketing (value addition)	4.1 Low-cost potato storage technique for farmers	High	Applied	Medium
	4.2 Preparation of various food products such as potato chips, finger chips, and noodles for commercial use	High	Applied	Medium
	4.3 Development of delicious foodstuff from potatos as a substitute for rice and popularization of it among farmers and urban consumers	High	Applied	Short

Source: BARC (2011)

Table B.8—Priority researchable areas/issues for sugarcane and other sugar crops

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	1.1. Genetic enhancement through interspecific crosses	High	Basic	Long
	1.2. Development of red rot–resistant, high-sugar, flood- and salinity-tolerant, high-yielding varieties using conventional and biotechnological tools	High	Basic/Applied	Long
	1.3. Molecular characterization of sugarcane varieties	High	Basic	Medium
	1.4. Exploration of the possibility of growing sugar beet as a substitute for sugarcane	High	Adaptive	Medium
1. Crop production—crop management	2.1 Farmers' participatory adaptive research on multiple cropping with sugarcane, intercropping with high-value winter crops, Ratoon management, and yield maximization with appropriate nutrient management packages	High	Adaptive	Short/Medium
	2.2 Biological nitrogen fixation in sugarcane	High	Basic	Long
	2.3 Crop management research for enhancing yield and sugar content	High	Applied	Medium
2. Crop protection—diseases and pests	3.1 Search for resistant sources against major disease and pests of sugarcane	High	Basic	Long
	3.2 Integrated control of major insect pests such as borers, root borers, scale insect, and pyrilla	High	Applied	Long
	3.3 Control of major insect pests using bioagents	High	Basic	Long

Source: BARC (2011)

Table B.9—Priority researchable areas/issues for spice crops

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Crop production—crop improvement	1.1. Germplasm collection, evaluation, and conservation	High	Basic	Long
	1.2. Development of disease-resistant, high-yielding varieties of spice crops	High	Applied	Long
	1.3. Development of high-yielding varieties and hybrids of chili for different planting times and for different regions	High	Applied	Long
	1.4. Seed production technique for onion, especially summer onion	High	Applied	Medium
2. Crop production—crop management	2.1 Standardization of production packages (including micronutrients) for different spice crops	High	Applied	Medium
3. Plant protection—diseases and pests	3.1 Survey and identification of major and minor diseases of the spice crops	High	Basic	Long
	3.2 Control-measure development of major diseases such as rhizome rot of ginger, leaf blight of turmeric, and Alterneria leaf blight of onion and garlic	High	Applied	Medium
	3.3 Validation and upscaling of controlling alterneria blight of onion and garlic	High	Adaptive	Medium
	3.4 Survey of insect pest and mites status of spice crops	High	Basic	Medium
	3.5 Development of control measures of major insect pests of spice crops	High	Applied	Medium
	3.6 Validation and upscaling of controlling thrips of onion and garlic	High	Adaptive	Short
4. Processing and marketing	4.1 Processing of different spices for powder and paste products, development and design of suitable packing materials (packets, cans, and so on)	High	Applied	Long

Source: BARC (2011)

Table B.10—Priority researchable areas/issues for vegetables: brinjal (*Solanum melongena*), cucurbits, tomato (*Lycopersicon esculantus*), okra (*Abelmoschus esculentus*), country bean (*Lablab niger*), bushbean (*Phaseolus vulgaris*), radish (*Raphanus sativus*)

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Crop production—crop improvement	1.1 Collection, evaluation, and conservation of all local vegetables and exotic germplasm of selected crops	High	Basic	Long
	1.2 Development of hybrids in cucurbits, tomato, and brinjal	High	Basic/Applied	Long
	1.3 Development of major disease–resistant, high-yielding varieties of brinjal, okra, country bean, bush bean; YMV-resistant variety of tomato, okra bush bean, and country bean	High	Basic/Applied	Long
	1.4 Development of short-duration varieties to fit into special niches (such as summer radish, tomato, and year-round brinjal) and specific purpose	High	Basic/Applied	Long
	1.5 Quality seed production and preservation techniques at farmers' level	High	Adaptive	Medium
2. Crop production—crop management	2.1 Refined production technologies especially for micronutrients for commercial vegetables	High	Applied	Medium
	2.2 Upscaling of high-yielding varieties and hybrids of vegetables in the southern regions and hilly regions	High	Adaptive	Short
	2.3 Development of pot culture techniques and potting medium for selected vegetables such as tomato, capsicum, and chili for roof gardening	Medium	Applied	Short
	2.4 Study of irrigation requirement, mulching techniques, and weed control for vegetable crops	High	Applied	Medium
3. Plant protection—diseases and pests	3.1 Management of fungal/bacterial/nemic disease of cucurbits (especially pointed gourd), solanaceous vegetables, and virus (tomato, okra, cucumber, and leguminous vegetables such as country bean, powdery mildew in sweet pea, and so on)	High	Applied	Long
	3.2 Integrated disease management of major vegetables	High	Applied	Medium
	3.3 Control of foot rot, stem rot, die back of betel leaf (for example, Rajshahi and Barisal regions)	High	Applied	Short–Medium
	3.4 Identification of major insect pests (including mites) of major vegetables	High	Basic	Long
	3.5 Chemical, biological, and integrated pest management of major vegetables (brinjal, country bean, cabbage, cauliflower, tomato, and so on)	High	Applied	Medium–Short
	4.1 Development of appropriate packaging and transportation system	High	Applied	Medium

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	for local and export market			
	4.2 Value addition and supply chain development for selected vegetables	High	Applied	Short
	4.3 Preservation technique development for increasing shelf life of vegetables	High	Applied	Short

Source: BARC (2011)

Table B.11—Priority researchable areas/issues for fruits: mango (*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), litchi (*Litci chinensis*), banana (*Musa sapientum*), pineapple (*Ananas comosus*), guava (*Psidium guajava*), citrus (*Citrus sps.*), melons (*Cucumis sps.*), coconut (*Cocos nucifera*)

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Crop production—crop improvement	1.1. Germplasm collection, evaluation, and maintenance of different fruits	High	Basic	Long
	1.2. Development of high-yielding, good-quality regular bearing varieties of mango, jackfruit, litchi, guava (year-round), and coconut, with regional suitability	High	Basic/Applied	Long
	1.3. Development of virus-resistant varieties of papaya using conventional molecular techniques	High	Basic/Applied	Long
	1.4. Selection of suitable melon varieties for different planting times from within the local germplasms	High	Basic/Applied	Long
	1.5. Hybridization of underused fruits such as latkon (*Baccaurea sapida*), Karanda (*Carissa carandas*), Rose Apple (*Syzygium jambos*), Satkara (*Citrus macroptera*), and so on	High	Basic/Applied	Long
2. Crop production—crop management	2.1. Standardize management packages for major fruits and coconut	High	Applied	Medium
	2.2. Yield decline in BAU Bangladesh Agricultural University and Apel kul(kul= jujube) (Rajshahi region)	High	Applied	Short
	2.3. Use of growth regulators for flower induction, fruit set, and fruit retention in mango, pineapple, and so on	High	Applied	Short

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	2.4. Introduction of grafting technique of jackfruit	High	Adaptive	Medium
	2.5. Introduction of improved fruit species in hills and saline coastal area	High	Adaptive	Medium
3. Crop protection—diseases and pests	3.1. Development of control measures for major diseases of mango, jackfruit, guava, banana, watermelon	High	Applied	Medium
	3.2. Dropping of flower and fruits of mango	High	Applied	Medium
	3.3. Die back, gummosis in mango, jackfruit, citrus, and canker disease in lime	High	Applied	Short
	3.4. Powdery mildew in BAU and Apel kul (Dinajpur)	High	Applied	Short
	3.5. Management of mites in coconut, chili, watermelon, and so on	High	Adaptive	Short
	3.6. Management of fruit borer in mango, jackfruit, BAU, and Apel kul	High	Applied	Long
	3.7. Pest risk assessment of exotic fruits	High	Strategic	Long
	3.8. Integrated pest management for major insect pest of fruits	High	Applied	Medium
4. Postharvest management and processing	4.1. Standardized maturity indices for major fruits such as watermelon, pineapple, mango, and banana	High	Applied	Short
	4.2. Standardized postharvest handling, packaging, transportation, and storage techniques for selected fruits	High	Applied	Short
	4.3. Study of postharvest loss of different fruits and development of techniques to minimize losses through pre- and postharvest treatments	High	Basic/Applied	Medium
	4.4. Development of safe technique for ripening of fruits and extending shelf life	High	Applied	Medium

Source: BARC (2011)

Table B.12—Priority researchable areas/issues for flower and ornamental: gladiolus (*Gladiolus communis*), rose (*Rosa sps.*), marigold (*Tagetes sps.*), orchid (Orchidaceae), chrysanthemum (*Chrysanthemum sps.*), dahlia (*Dahlia sps.*), cactus (Cactaceae), gerbera (*Gerbera sps.*), tuberose (*Polianthes tuberosa*)

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Crop production—crop improvement	1.1. Collection, evaluation, and conservation of germplasms (local and exotic)	High	Basic/Applied	Long
	1.2. Development of hybrids (in selected flowers such as marigold, dahlia, and chrysanthemum), especially dwarf plants with large flowers	High	Applied	Long
	1.3. Development of flower varieties for local and export market with desired traits	High	Applied	Long
2. Crop production—crop management	2.1. Standardized cultivation practices for commercial cultivation of major flowers (from seedling to harvest)	High	Applied	Medium
	2.2. Development of tissue culture technique for rapid multiplication	High	Applied	Medium
	2.3. Standardized seedling-raising techniques	High	Applied	Short
	2.4. Standardized pot culture technique, pot size, and potting media using commercially available compost and mix fertilizers	High	Applied	Medium
3. Crop protection—diseases and pests	3.1. Survey of diseases of major flowers and ornamentals	High	Basic	Medium
	3.2. Standardized control measures for important diseases of commercial flowers of the country	High	Applied	Medium
	3.3. Survey and identification of major pests of commercially cultivated flowers	High	Basic	Long
	3.4. Development of control measures for major insect pests of commercial as well as pot plants of flowers and ornamentals	High	Applied	Long
	4.1. Standardized packaging, transportation, and preservation of flowers for local as well as export market (such as tissue culture seedlings with culture media)	High	Applied	Medium

Source: BARC (2011)

Table B.13—Priority researchable areas/issues for tea *(Camellia sinensis* L.*)*

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Tea production—varietal improvement	1.1. Evaluation and selection of exotic and indigenous high-yielding bushes and their multiplication	High	Basic/Applied	Long
	1.2. Physiology of tea in local environment and improvement of harvest index	High	Basic/Applied	Long
	1.3. Use of biotechnology for plant improvement	High	Basic/Applied	Long
	1.4. Drought-resistant varieties	High	Basic/Applied	Long
	1.5. Intercropping in initial stage of plantation	High	Applied	Short–Medium
2. Tea production—management practices	2.1. Raising of organic matter status of degraded tea soils	High	Applied/Adaptive	Short–Medium
	2.2. Drainage, irrigation, and drought management	High	Applied/Adaptive	Short–Medium
	2.3. Crop diversification/intercropping	High	Applied/Adaptive	Short–Medium
	2.4. Energy source use and efficiency	High	Applied/Adaptive	Short–Medium
	2.5. Nursery raising and its management	High	Applied/Adaptive	Short–Medium
	2.6. Development of cultural practices with proper maintenance of sick and low-yielding tea gardens	High	Applied/Adaptive	Short–Medium
	2.7. Soil organic matter on productivity	High	Applied/Adaptive	Short–Medium
3. Tea protection	3.1. Integrated pest management with emphasis on biological control	High	Applied/Adaptive	Short–Medium
	3.2. Integrated pest and weed management	High	Applied/Adaptive	Short–Medium
	3.3. Integrated disease management and ecology	High	Applied/Adaptive	Short–Medium
4. Tea processing and marketing (value addition and supply chain development)	4.1. Marketing and sales promotion	High	Applied/Adaptive	Short–Medium

Source: BARC (2011)

Table B.14—Priority researchable areas/issues for livestock

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Livestock production	1.1. Baseline survey on the productive performances of cattle and buffalo at all stages of productive life in Bangladesh	High	Strategic	Long
	1.2. Characterization, conservation, and improvement of local/native animal/poultry genetic resources for increasing meat, milk, and egg production	High	Basic	Long
	1.3. Standardization of embryo transfer technology for livestock	High	Strategic	Long
	1.4. Evaluation of existing artificial insemination service and factors affecting infertility in cattle and buffalo	High	Applied/Adaptive	Medium
	1.5. Assorted dairy cattle/beef cattle/buffalo breed development and production	High	Basic	Long
2. Feed and nutrition	2.1. Feed information, feeding standard, and feeding system development for cattle/buffalo/sheep/goat/poultry/duck	High	Applied/Adaptive	Medium
	2.2. Development of salt-, drought-, and submergence-tolerant forage/fodder varieties	High	Applied/Adaptive	Long
	2.3. Development of cost-effective complete feed formulations for cattle, buffalo, sheep, goat, and poultry for different productive functions	High	Adaptive	Medium
	2.4. Development of suitable fodder/forage crops in the forestlands, tree plantations, fruit plantations, sugar cane areas, *haors* and *baors,* roadsides, and bund areas	High	Applied/Adaptive	Medium
	2.5. Development of appropriate technology for the use of NCFR Non-Conventional Feed Resources such as algae, duckweed, water hyacinth, silkworm pupae, tree leaves, herbs, and shrubs	High	Applied/Adaptive	Long
3. Livestock protection	3.1. Development of vaccine against mycoplasmosis	High	Basic	Long
	3.2. Development of antiserum against different types of FMD virus	High	Basic	Long
	3.3. Development of new vaccine seed viruses against emerging diseases	High	Basic	Long

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	3.4. Development of recombinant vaccine for important viral and bacterial diseases	High	Strategic	Long
	3.5. Sero-surveillance of important (zoonotic) diseases of public health significance	High	Strategic	Long
	3.6. Studies on repeat breeding and retention of placenta in cattle and buffalo and development of mitigation measures	High	Strategic	Medium
	3.7. Cell culture techniques for diagnosis of viral diseases and vaccine production	High	Basic	Long
	3.8. Development of appropriate cost-effective, zoo-sanitary, and biosecurity measures for farm animals and poultry	High	Adaptive	Medium
	3.9. Development of reproductive health management system (hormone assay, artificial insemination service quality and efficiency, ovulation synchronization, tools for predicting bull fertility, application of ultrasonography, color dopler, and so on)	High	Applied/Adaptive	Medium
	3.10. Development of new vaccine seed viruses against emerging viral diseases	High	Basic	Long
	3.11. Identification of causes of high calf mortality, especially in crossbreed cattle and buffalo and their mitigation measure	High	Applied	Medium
4. Safety, quality improvement and control	4.1. Quality improvement of local vaccine and drugs following OIE World organization for animal health standard guidelines	High	Strategic	Medium
	4.2. Safety, potency, and efficacy of locally produced and imported vaccines	High	Applied/Adaptive	Medium
	4.3. Development of effective biosecured housing system for rural poultry	High	Adaptive	Medium
	4.4. Quality control of different vaccines, drugs, biologics, and diagnostics available in Bangladesh	High	Strategic	Medium
	4.5. Quality control of livestock products and by-products, seed materials, feed, and fodder	High	Strategic	Medium
	5.1. Development of an effective milk marketing system with special emphasis on small and medium dairy farms	High	Applied/Adaptive	Medium

Source: BARC (2011)

Table B.15—Priority researchable areas/issues for fisheries

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Fish production and productivity	1.1. Development of improved brood fish and breeding protocol for commercial, threatened, and endangered fish species	High	Basic	Medium–Long
	1.2. Intensification and zoning of fish culture practices in different agroecological zones for productivity enhancement	High	Adaptive/Applied	Medium
	1.3. Development of culture and management practices for commercially important marine fisheries resources	High	Adaptive/Basic	Medium–Long
	1.4. Biotechnology and genetic engineering for development of high-yielding fish varieties	High	Basic/Strategic	Long
2. Fisheries protection/conservation/management	2.1. Design of sanctuaries for conservation and biodiversity of fisheries resources	High	Adaptive/Applied	Medium–Long
	2.2. Effect of pollution of water bodies on fish health, habitat, and their management	High	Strategic/Basic	Long
	2.3. Sustainable management of hilsa fisheries	High	Strategic/Applied	Long
	2.4. Harvesting, handling, processing, and preservation of fish and fisheries products to HACCP Hazard Analysis & Critical Control Points standard	High	Applied/Adaptive	Medium
3. Fish feed and nutrition	3.1. Cost-effective quality feed development for diverse aquaculture practices	High	Adaptive	Medium
	3.2. Standardization of feeding and fertilization principles/techniques of aquaculture for sustainable environment	High	Adaptive	Medium
4. Fish health management	4.1. Fish diseases diagnosis and treatment and development of fish health management protocol	High	Applied/Adaptive	Medium–Long
	4.2. Identification, characterization, and treatment of shrimp diseases and health management	High	Applied/Basic	Medium–Long
	5.1. Value addition in fish and fish products and development of supply chain	High	Applied/Strategic	Short–Medium
	5.2. Social and economic implications of adopted technologies on productivity and livelihood	Low	Strategic	Medium–Long

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
5. Climate change	6.1. Impact of climatic factors on fish migration, breeding, growth, and productivity	High	Basic/Strategic	Long
	6.2. Fish migration, breeding, and propagation in extreme and diverse climatic conditions	High	Basic/Strategic	Long

Source: BARC (2011)

Table B.16—Priority researchable areas/issues for land and soil resources

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Soil organic matter management	1.1. Conservation agriculture with minimum tillage, mulch, cover crops, and so on for upland crops under light textured soil	High	Applied	Medium-Long
	1.2. Organic amendments with FYM Farm Yard Manure /PM Poultry Manure /bioslurry/green manuring including Dhaincha (*sesbania sp.*), crop residue/compost, and so on for intensive cropping systems	High	Applied	Medium–Long
	1.3. Carbon sequestration in soils under single, double, and triple cropping systems	High	Basic	Long
2. Soil fertility and fertilizer management	2.1. Fertilizer need assessment for major crops and cropping patterns	High	Applied/Adaptive	Medium
	2.2. Integrated nutrient management for major crops and cropping patterns	High	Applied/Adaptive	Medium
	2.3. Nutrient use efficiency for major crops and cropping patterns	High	Applied/Adaptive	Medium
	2.4. Micronutrient management for major crops and cropping patterns	High	Applied/Adaptive	Medium
3. Ecologically unfavorable land and soil management	3.1. Adaptation of crops with soil and water management in coastal saline environment	High	Applied/Adaptive	Medium
	3.2. Adaptation of crops with land/soil and watershed management in hilly areas	High	Applied/Adaptive	Medium
	3.3. Sedimentation, nutrient accretion, crop adaptation, and soil–	High	Applied/Adaptive	Medium

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	crop management in char lands			
	3.4. Adaptation of crops with soil amendment, nutrient, and water management in different agroecosystems such as peat and piedmont areas, char lands, hills, terraces, and so on	High	Applied/Adaptive	Medium
	3.5. Soil organic matter and water management for major crops and cropping patterns in Barind areas	High	Applied/Adaptive	Medium
4. Biofertilizers	4.1. Microbial inoculants for Nitrogen and Phosphorus in legume/rice/wheat/sugarcane	High	Applied	Medium–Long
	4.2. Bioactivators for rapid composting/decomposition of crop residues and methane bacteria for biogas production	Medium	Applied	Medium–Long
5. Soil and water pollution	5.1. Heavy metal/arsenic contamination and its management in water, soils, and crops in arsenic-contaminated areas	High	Applied	Medium–Long
	5.2. Pesticide residues in soils and crops (vegetables and fruit)	High	Applied	Medium–Long
6. Impact of climate change on natural resources	6.1. Climate change effects on soil and water salinity/drought/inundation regimes and crop production practices in coastal, drought, and flood-prone areas	Medium	Applied	Long
	6.2. Estimation of CH_4 and N_2O emission from rice field	Medium	Basic	Medium

Source: BARC (2011)

Table B.17—Priority researchable areas/issues for water resources for agriculture

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Water resources for agricultural use	1.1. Quantitative and qualitative assessment of surface and groundwater resources for agriculture	High	Strategic	Medium–Long
	1.2. Watershed management for hilly areas	High	Applied/Adaptive	Medium
	1.3. Rainwater harvesting and use for agriculture	High	Applied/Adaptive	Medium
	1.4. Decline in groundwater resources and associated pollution	High	Applied/Adaptive	Medium

2. On-farm water management	2.1. Increasing water productivity through water-saving techniques (increasing irrigation water use efficiency/alternate wetting and drying technology) for major crops and cropping patterns	High	Applied/Adaptive	Medium
	2.2. Cost-effective and high-efficiency irrigation system for upland crops (including high-value crops) and wetland rice	High	Applied/Adaptive	Medium
	2.3. Development of water management techniques for major cropping patterns as a way toward adaptation to climate change	High	Strategic/Applied	Medium
	2.4. Use of alternative energy (CNG **Compressed natural gas** and solar energy) for pumping	High	Applied/Adaptive	Medium
	2.5. Water management for coastal saline soil, methods of reducing water logging in cultivable land, technology for conversion of sweet water from saline water	High	Applied/Adaptive	Medium
	2.6. Modeling of crop–soil–water–weather system	High	Strategic	Medium

Source: BARC (2011)

Table B.18—Priority researchable areas/issues for forestry

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Forests and biodiversity conservation	1.1. Study of the drivers of deforestation and development of appropriate participatory approaches for forests and biodiversity conservation	High	Strategic/Applied	Medium
	1.2. Study of the biodiversity resources (flora and fauna including soil microbes) of different forest types including home gardens	High	Strategic	Long
	1.3. Inventory and assessment of wildlife species and their keystone species in different forests (and wetland areas) of Bangladesh	High	Strategic	Long
	1.4. Assessment of ecological impacts of different exotic species including rattan in forests	High	Strategic	Long
2. Low productivity management	2.1. Identification of best provenances/clones of commercial species of trees and establishment of their breeder seed orchards	High	Applied	Long
	2.2. Establishment of a seed bank for a sustained supply of quality planting stock	High	Applied	Medium

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	2.3. Collection and testing of seeds collected from plus trees and mother trees and development of storage techniques in seed bank	High	Applied	Short
	2.4. Development of high-yielding clones of bamboo and cane (rattans)	High	Applied	Long
	2.5. Establishment of germplasm center of endangered indigenous species in different ecological regions	High	Applied	Long
	2.6. Identification/standardization of control measures for major insect pests and diseases of important tree species in the forests and homestead areas	High	Applied	Long
	2.7. Development and screening of disease- and pest-resistant tree species	High	Applied	Long
	2.8. Screening of disease- and pest-resistant tree species and their expansion	High	Applied	Long
	2.9. Identification of pests and diseases of nurseries and their control	High	Applied	Long
	2.10. Identification and economic analysis of existing (traditional, introduced, farmer-innovated) agroforestry practices in Bangladesh and development of improved agroforestry practices	High	Strategic/Applied	Medium
	2.11. Development of agroforestry models for forest and newly accreted land	High	Applied	Long
	2.12. Development of improved shifting cultivation in the hilly areas	High	Applied	Long
	2.13. Development improved management technique for degraded forest land	High	Applied	Long
3. Adverse effect of climate change	3.1. Development of appropriate social forestry techniques for forest land	High	Applied	Long
	3.2. Mitigation of impact of climate change on food security of forest-dependent people	High	Applied	Long
	3.3. Assessment of climate change impact on forests using remote sensing and geographic information system	High	Strategic	Long
	3.4. Investigation of possible impacts of climate change and sea level rise on different forest types with particular emphasis on mangrove forests	High	Strategic/Applied	Long
4. Nontimber forest products including medicinal plants	5.1. Selection of appropriate varieties of commercially important medicinal plants for their best medical efficacy and higher yield	High	Applied	Long
	5.2. Development of mass propagation techniques including tissue culture of commercially important medicinal plants	High	Applied	Long
	5.3. Development of end-use-specific silvicultural/agronomic management packages for commercial production of important medicinal plants	High	Applied	Long

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	5.4. Development of appropriate technologies (processes, equipment) for processing of commercially important medicinal plants	High	Applied	Long
	5.5. Screening of effective biopesticides for medicinal plants and other crops	High	Applied	Long
5. Value addition and technology transfer	6.1. Packaging of mature technologies for dissemination to clienteles through training, advisory services, and information supply	High	Applied	Long

Source: BARC (2011)

Table B.19—Priority researchable areas/issues for human nutrition: Food availability and safety, agroprocessing, and postharvest loss

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Food production, consumption and human nutrition	1.1. Reorientation of agricultural extension approach focusing on both production and consumption of nutritious foods for balanced nutrition	High	Applied	Medium
	1.2. Integrated farming of crops, livestock, fisheries, and agroforestry for improved nutrition and livelihood	High	Basic	Medium
	1.3. Food-based approaches to alleviating nutritional problems and sustainable improvement of nutritional status	High	Basic	Long
	1.4. In-depth national survey to determine nutritional status and factors associated with malnutrition to take necessary remedial measures	High	Basic	Long
	1.5. Formulation of low-cost, balanced, nutritious, and safe diet including street food with multiple options for the vulnerable section of the population	High	Basic	Long
	1.6. Comprehensive analysis of different food items for determining their nutritional values including flatulent and antinutritional factors of existing and newly developed varieties	High	Basic/Applied	Medium–Long
	1.7. Determination of nutrient loss of different food items in cooking, marketing, transportation, and handing processes	High	Basic/Applied	Medium–Long

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	and development of measures for their retention			
2. Postharvest loss and agroprocessing	2.1. Popularization of appropriate technologies for practicing at farmers' level to minimize the postharvest losses of agricultural commodities	High	Applied	Medium–Long
	2.2. Development of low-cost processing technologies for crop, livestock, and fisheries products	High	Basic/Applied	Medium–Long
	2.3. Development of traceability system in agroproducts and development of value chain for improved marketing system for processed agroproducts	High	Basic/Applied	Medium–Long
3. Food safety and quality, hazards and risks	3.1. Development and adoption of appropriate standards for various foods and additives	High	Applied	Medium
	3.2. Study on contaminants (arsenic/heavy metals), adulterants, and additives and their implications for human health	High	Basic/Applied	Medium–Long
	3.3. Sanitary and phytosanitary measures for protection of food-borne diseases	High	Basic/Applied	Medium–Long
	3.4. Identification of phytotoxin and mycotoxin in food items and feeds and development of mitigation measures	High	Basic/Applied	Medium–Long
	4.1. Harnessing of alternate sources and means to reduce dependency on naturally occurring food product	High	Applied	Long

Source: BARC (2011)

Table B.20—Priority researchable areas/issues for agricultural economics

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Policy and planning	1.1. Policy impact on farm productivity, output, and resource management	High	Strategic	Medium
	1.2. Policy investigation on price of inputs and outputs toward productivity and profitability	High	Applied	Medium

	1.3. Production and business model development for crops (seed and high-value crops), livestock, and fisheries	High	Strategic	Medium
	1.4. Impact of research innovations on return on investment including factors effecting their adoption	High	Applied	Medium
	1.5. Impact of research and development programs/projects on productivity, profitability, and environment	High	Strategic/Applied	Short
	1.6. Assessment and policy direction in research–extension–farmers linkage contributing to productivity and income	High	Applied	Short
	1.7. Agricultural subsidy, insurance, and credit and their impact on small, medium, and commercial enterprises	High	Strategic/Applied	Short
2. Production and farm productivity	2.1. Managing risk factors in agriculture with appropriate coping mechanisms	High	Applied	Medium
3. Supply chain and marketing	3.1. Empirical mapping of supply chain analysis for high-value added commodities	High	Strategic	Long
	3.2. Development of market chain for farmers' participation in all types of markets (local and city markets)	High	Strategic	Medium

Source: BARC (2011)

Table B.21—Priority researchable areas/issues for agricultural mechanization and farm machinery

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Preharvest farm machinery	1.1. Appropriate machinery/equipment for upland crops and wetland rice culture (tiller/seeder/planter/weeder/fertilizer applicator/harvester/irrigation device) including their marketing	High	Applied	Medium–Long
	1.2. Development of different tillage and weed control equipment and techniques (power operated weeder/furrower for maize, wheat, potato, and sugarcane; laser leveler)	High	Applied	Medium–Long
	1.3. Hydraulic design and manufacture of irrigation equipment	High	Basic/Applied	Medium–Long
	1.4. Investigation of appropriate pump zoning and tube well spacing	High	Basic/Applied	Medium–Long
2. Postharvest farm machinery	2.1. Small- and medium-scale machinery/equipment for crops (threshing/sorting/cleaning/storage device/drying/rice parboiling and milling)	High	Applied	Medium–Long
	2.2. Appropriate machinery and equipment for agroprocessing (crops/livestock/fisheries/forestry)	High	Applied	Medium–Long

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
3. Use of renewable energy	3.1. Renewable energy (solar, wind, biofuel, biogas, and so on) use in farm machinery/equipment and application (rice drying and parboiling, irrigation of selected crops)	High	Applied	Medium–Long
4.	5.1. Use of vast fallow land through mechanization in specific areas	High	Strategic	Short–Medium

Source: BARC (2011)

Table B.22—Priority researchable areas/issues for information and communication technology and disaster management in agriculture

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
1. Management information system for research management	1.1. Management information system of NARS institutes	High	Applied	Short–Medium
	1.2. Database of equipment/laboratories of NARS institutes	Medium	Applied	Short
	1.3. Databases related to research management on completed and ongoing projects of NARS	High	Strategic/Applied	Short–Medium
	1.4. Database on monitoring and evaluation	High	Strategic/Applied	Short–Medium
	1.5. Database on financial management	High	Strategic/Applied	Short–Medium
2. Databases on Natural Resource Management and socioeconomics	2.1. Updating of agroecological zone database with land, soil, climate, and hydrological parameter	High	Strategic/Applied	Medium–Long
	2.2. Development of variety/agricultural technology database	High	Applied	Short–Medium
	2.3. Development of socioeconomic database	High	Applied	Short–Medium
3. GIS and remote sensing	3.1. GIS-based information system on surface and groundwater resources	High	Strategic	Short–Medium
	3.2. GIS-based pest and disease information system	High	Applied	Short–Medium
	3.3. GIS-based information system for agroecological constraint areas	High	Strategic	Medium–Long
	3.4. GIS-based information system on plant/animal genetic resources	High	Applied/Adaptive/Strategic	Short–Medium/Long
	3.5. Assessment of climate change impact on agriculture/forests	High	Strategic/Applied	Medium–Long

Thematic Area	Researchable Area/ Issue	Priority Ranking	Type of Research	Research Duration
	using remote sensing and GIS			
	3.6. Development of remote sensing and GIS-based applications for crop agriculture	High	Applied/Adaptive	Short–Medium
	3.7. Assessment of agroecological-zone-based suitability of major crops	High	Strategic/Applied	Medium–Long
	3.8. Crop zoning for land use planning	High	Strategic/Applied	Short–Long
4. Web-enabled databases	4.1. Web-based agromarket intelligence systems	High	Applied/Adaptive	Short–Medium
	4.2. Web-based information systems for natural resources	High	Applied/Adaptive	Short–Medium
5. Disaster management	5.1. Early warning systems for abiotic and biotic hazards (flood, drought, rainfall, pests, diseases, and so on)	High	Applied/Strategic	Medium–Long
	5.2. Expert systems/decision support systems for food security and disaster management	High	Applied/Strategic	Medium–Long

Source: BARC (2011)

Note: NARS = National Agriculture Research System; GIS = geographic information system.