Research Priorities in Bangladesh Agriculture

Bangladesh Agricultural Research Council

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PIU-BARC, NATP-2

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215
Bangladesh

Printers Line

Publication No. : 19
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Citation:
Rashid, M.H., Bokhtiar, S.M., Uddin, M.J., Ali, M.S. 2023. Research Priorities in Bangladesh Agriculture. Project Implementation Unit-BARC, National Agricultural Technology Program-Phase II Project, Bangladesh Agricultural Research Council (BARC), New Airport Road, Farmgate, Dhaka-1215, Bangladesh.

ISBN : 978-984-35-4708-8

Published in May, 2023

Published by
Project Implementation Unit (PIU)
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
Farmgate, Dhaka-1215, Bangladesh

Printed by
Generation PPA
GPPA House, 188 Fakirapool, 2nd Floor, Motijheel, Dhaka.
Cell: 01819 230291, E-mail: generationppa1971@gmail.com

Minister
Ministry of Agriculture
Government of the People's Republic of Bangladesh

Message

I am delighted to know that Bangladesh Agricultural Research Council (BARC), an apex body of National Agricultural Research System (NARS), has taken a noble initiative to publish a document titled "Research Priorities in Bangladesh Agriculture, a Road Map to Vision 2041".

The Father of the Nation, Bangabandhu Sheikh Mujibur Rahman, strongly realized that the development of Bangladesh is not possible without agricultural development Therefore, after independence in 1971 he took many multidimensional initiatives and effective measures for the development of agriculture and livelihood of the farmers. Evidently, Bangabandhu initiated a great programme called "Green Revolution" and the farmers achieved its benefits in terms of crop productivity and production using HYV crops, irrigation, fertilizers and pesticides. Based on the country's current and emerging need, gene revolution and 4IR initiatives are in good progress under the dynamic leadership of the Honorable Prime Minister Sheikh Hasina following the long-waited dreams of the Father of the Nation. Government's strong political will and commitment, technological innovations and national policy reforms have made an unprecedented success in agriculture and food security.

Although much progress is visible in the agriculture sector, it is confronted by many challenges, of them increasing population, declining crop land and changing climate are the important considerations to sustain food and nutrition security over time. This documents on research priorities spells out what kind of future research and policy support are needed to address the challenges, and the way forwards to achieve the goal of food and nutrition security with safe food for all.

I believe this book will be very useful for researchers, planners, policy-makers, investors and other stakeholders involved in agriculture sector. I express my sincere thanks and congratulations to the Executive Chairman, BARC, Director, PIU-BARC, NATP-2 and the working team for the efforts and wisdom they have paid to produce this pragmatic agricultural research priority document.

Dr. Muhammad Abdur Razzaque, MP

Joy Bangla, Joy Bangabandhu
Long live Bangladesh

Secretary
Ministry of Agriculture
Government of the People's Republic of Bangladesh

Message

Agriculture in Bangladesh has made a remarkable contribution to poverty alleviation and economic growth by ensuring food and nutrition security and expanding employment opportunities led by our Honorable Prime Minister Sheikh Hasina. The country was born in 1971 as a food deficit country with a population of 75 million and today with 169 million people the country is sufficient in rice, fish, meat and egg. Bangladesh is now a global example of a substantial food grain producing country. This has been possible due to proper and timely implementation of various policies of the government in the agriculture sector.

However, the present transformation in the agriculture sector is facing many challenges, notably population growth, declining crop land and soil fertility, climate vulnerability, fragile ecosystems (e.g., coasts, haors, chars, Barinds and hills etc.), socio-economic factors and market price fluctuation. To address these challenges, the government has taken up some productive national policies and plans like National Agriculture Policy 2018, National Agricultural Extension Policy 2020, National Agricultural Mechanization Policy 2020, National Agricultural Marketing Policy 2023, 8th Five Year Plan 2021-25, Bangladesh Perspective Plan 2041 and Bangladesh Delta Plan 2100. Moreover, agricultural technology innovation by the scientists is in line with the effort to address the great challenge of nourishing the increasing population by growing more food on the decreasing arable land.

Under the perspective I am very happy that Bangladesh Agricultural Research Council (BARC) through National Agricultural Technology Program - Phase II Project (NATP-2) is going to publish a book titled "Research Priorities in Bangladesh Agriculture", as a Road Map to Vision 2041. This is undoubtedly a great endevour to produce an excellent document of research priority setting in agriculture. Obviously, this document would be very useful for the present and future researchers to design their research projects with an aim to attain sustainable and profitable agriculture.

At last, but not the least, I would like to express my sincere appreciation to Dr. Shaikh Mohammad Bokhtiar, Executive Chairman, BARC and Dr. Md. Harunur Rashid, PIU-BARC, NATP-2 to produce such an important national agricultural research document towards building a smart Bangladesh by 2041 as dream of the present government.

Joy Bangla
May Bangladesh live forever

Wahida Akter

Executive Chairman
Bangladesh Agricultural Research Council

Foreword

BARC has been functioning since its establishment in 1973 towards developing efficient, effective and sustainable agricultural research system. It plays a unique role in the advancement of agriculture in Bangladesh through technology innovation and subsequent adoption of innovated technologies by strengthening research and extension linkages. Above all, Government's policies in creating enabling environment and providing regular support to R & D have contributed to incredible success in agriculture today. Bangladesh now has got the position among top 10 producers of rice, jute, jackfruit, mango, onion, tea, vegetables, potato, and farm fish in the global arena. Nevertheless, the situation of degrading natural resources, shrinking arable land, changing climate, increasing urbanization, and ever increasing population would require more and more nutritious and safe food.

Recently, BARC has published several books in relation to achievements, challenges and opportunities in Bangladesh agriculture. The present compilation titled "Research Priorities in Bangladesh Agriculture, a Road Map to Vision 2041" is another valuable document of BARC in particular and the country at large.

It is anticipated that there is less opportunity of increasing cropping intensity in plain land ecosystem while more opportunity exists to increase cropping intensity in agro-ecologically constrained areas like Haor, Char, Barind, Coastal and Hill ecosystems. Nevertheless, our main goal now is to address the current and emerging problems of each ecosystem through pertinent research and inventing new technologies. More importantly, varietal improvement for early maturity, biotic and abiotic stress tolerance, vitamin and micro-nutrient dense together with efficient management of soil and crops for both fragile and favourable ecosystems deserve due attention for ensuring nutritious and safe food.

I sincerely believe that this compilation will serve as a valuable guide for researchers, academicians, planners, policy makers, investors, and other stakeholders involved in the agriculture sector.

Finally, I take this opportunity to extend my cordial thanks to Dr. Md. Harunur Rashid, Director, PIU-BARC, NATP-2 and his team members for their great endeavour in preparing this document focusing priority research for technology innovations in farm sector.

Joy Bangla
May Bangladesh live forever

Dr. Shaikh Mohammad Bokhtiar

Message

Director
Project Implementation Unit
NATP-2 Project
Bangladesh Agricultural Research Council

Preface

Agriculture is the mainstay of Bangladesh's economy, accounting 11.6% of GDP where the crops sub-sector contributes 7.25%. This sector is greatest potential to reduce poverty, end hunger, achieve food and nutrition security, extend employment opportunities, and supply raw materials to industries. This has to produce more food on the decreasing arable land to supply food to the increasing population. Moreover, climate vulnerability appears to be a huge limiting issue.

Prioritizing agricultural research is a major mission of the Bangladesh Agricultural Research Council (BARC). About a decade ago, BARC published a vision document titled, Agricultural Research Vision 2030, mostly followed by a top-down approach. Meanwhile, many problems and issues have arisen and several national policy documents and plans have been in place aiming to transform Bangladesh into a middle-income country status by 2031 and a developed country by 2041. Identification and prioritization of agricultural research areas are essential to undertake productive research programs aligning with the policies and plans such as National Agriculture Policy 2018, Bangladesh Delta Plan 2100, Perspective Plan 2021-2041, 8th Five Year Plan 2021-25, etc.

Considering those perspectives, the Project Implementation Unit (PIU) of the National Agricultural Technology Program (NATP) Phase II Project under BARC has taken the initiative to prepare Research Priorities in Bangladesh Agriculture following both bottom-up and top-down approaches. This document would be a good basis for research planning at the institute, regional and national levels, avoiding duplication of research and in priority project formulation and selection. This would also create opportunities for the government and donor's investment in research and development of agriculture.

Finally, I am very much grateful to Dr. Shaikh Mohammad Bokhtiar, Executive Chairman, BARC, for his great support during the entire journey of preparing such a pragmatic document. I would like to extend thanks and gratitude to the researchers, academia, representative from NGOs, private sectors, and entrepreneurs, farmer representatives for their utmost contribution.

I sincerely believe that the researchers and practitioners of NARS institutes, universities and other organizations including NGOs and private sectors will come forward to undertake research programs in line with the research priorities to solve field problems toward food and nutrition security.

Joy Bangla
May Bangladesh live forever

Dr. Md. Harunur Rashid

CONTENTS

Acronyms

4IR	:	The 4th Industrial Revolution
AERS	:	Agricultural Economics and Rural Sociology
BADC	:	Bangladesh Agricultural Development Corporation
BARC	:	Bangladesh Agricultural Research Council
BARD	:	Bangladesh Academy for Rural Development
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BDP	:	Bangladesh Delta Plan
BFRI	:	Bangladesh Forest Research Institute
BINA	:	Bangladesh Institute of Nuclear Agriculture
BIRDEM	:	Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders
BJRI	:	Bangladesh Jute Research Institute
BPC	:	Bangladesh Planning Commission
BRAC	:	Bangladesh Rural Advancement Committee
BRRI	:	Bangladesh Rice Research Institute
BSMRAU	:	Bangabandhu Sheikh Mujibur Rahman Agricultural University
BSRI	:	Bangladesh Sugarcrop Research Institute
BSRTI	:	Bangladesh Sericulture Research and Training Institute
BTRI	:	Bangladesh Tea Research Institute
BWMRI	:	Bangladesh Wheat and Maize Research Institute
CA	:	Conservation Agriculture
CARE	:	Cooperative for Assistance and Relief Everywhere
CDB	:	Cotton Development Board
CHT	:	Chattogram Hill Tracts
CRISPR	:	Clustered Regularly Interspaced Short Palindromic Repeats
CSA	:	Climate-smart Agriculture
CVASU	:	Chattogram Veterinary & Animal Sciences University
DAE	:	Department of Agricultural Extension
DoE	:	Department of Environment
DSR	:	Direct seeded rice
EBAU	:	Exim Bank Agricultural University
FAO	:	Food and Agriculture Organization
FIVDB	:	Friends in Village Development Bangladesh
FSRD	:	Farming Systems Research and Development

FYP	:	Five Year Plan
GAP	:	Good Agricultural Practice
GDP	:	Gross domestic product.
GHG	:	Greenhouse gas
GIS	:	Geographic Information System
GoB	:	Government of Bangladesh
HAU	:	Habiganj Agriculural University
HIES	:	Household Income and Expenditure Survey
HRD	:	Human Resource Development
HSTU	:	Hajee Mohammad Danesh Science & Technology University
HYV	:	High Yielding Variety
ICT	:	Information and Communication Technology
IDM	:	Integrated Disease Management
IPM	:	Integrated pest management
IPNS	:	Integrated Plant Nutrient System
IUBAT	:	International University of Business Agriculture and Technology
KAU	:	Khulna Agricultural University
KGF	:	Krishi Gobeshona Foundation
MoA	:	Ministry of Agriculture
MoWR	:	Ministry of Water Resources
NAP	:	National Agricultural Policy 2018
NARS	:	National Agricultural Research System
NATP	:	National Agricultural Technology Programme
NGO	:	Non-Government Organization
NRM	:	Natural Resource Management
OFRD		On-Farm Research Division
PIU	:	Project Implementation Unit
PSTU	:	Patuakhali Science & Technology University
RA	:	Regenerative Agriculture
RDA	:	Rural Development Academy
RDRS	:	Rangpur Dinajpur Rural Service
RU	:	Rajshahi University
SAU	:	Sher-e-Bangla Agricultural University
SDG	:	Sustainable Development Goal
SHAU	:	Sheikh Hasina Agricultural University
SLM	:	Sustainable Land Management
SRDI	:	Soil Resource Development Institute

SWOT	:	Strengths, Weaknesses, Opportunities and Threats
UMIC	:	Upper Middle-Income Country
UNEP	:	United Nations Environment Programme
WB	:	World Bank

Unit

µg	:	Microgram
Kg	:	Kilogarm
Mg	:	Miligram
M ha	:	Million hectare
M t	:	Million ton

Introduction

Agriculture is the mainstay of Bangladesh economy, accounting 11.6% to GDP where crops sub-sector alone contributes 7.25% (WB, 2022). It is the important driver of growth and rural development, extends employment opportunities for more than 40% of the country's workforce and supplies raw materials to the industries. This sector is potential to reduce poverty, end hunger, achieve food security and improve nutrition. Meanwhile, the country has attained food self-sufficiency particularly in rice, fruits, fish, meat and egg to feed the 169.4 million people. Rice production has increased by more than 3 times from 12 million tons (M t) in late 1970s to 37.6 M t in 2021 (BBS, 2022). Consequently, the country has transformed from a food deficit to a food sufficient country (Bokhtiar and Samsuzzaman, 2023). There are several drivers behind this gigantic achievement, of them agricultural policy reforms and agricultural technology innovations have played a great role. Although Bangladesh has achieved food self-sufficiecy to many extents, the country lags behind in the Global Food Security Index since the index on quality and safety of food is moderate indicating a need for its improvement.

Nevertheless, the present transformation is likely to be threatened by several challenges. The country will have to produce more food on the decreasing arable land to support the increasing population with two million per year (http://www.worlddata). Moreover, climate vulnerability appears to be a challenging issue and the consequences are sea level rise, salinity, drought and flood. Evidently, there are five fragile ecosystems across the country – Barind, Char, Coastal, Haor and Hill ecosystems where cropping intensity and crop productivity are very low (Bokhtiar *et. al.*, 2023). Future food and nutrition security depends on how effectively and maximally these ecologically constrained areas are brought under crop production. Hence, the situation claims for highly innovative research as well as productive strategies to ensure food and nutrition security, safe food production and livelihood improvement.

A Prudent planning and research priority setting could be the best instruments for improved and sustained crop productivity and production in both the favorable and unfavorable areas. In this context, identification of short, medium and long term research areas of low, medium and high priorities in agriculture are the prerequisites to undertake productive research programme aligning with the National Agriculture Policy 2018 and related plans. These national policies and plans aim to transform Bangladesh into a middle-income country status by 2030 and a developed country by 2041.

Prioritizing agricultural research vis-à-vis National Agricultural Policy guidelines is a major mission of Bangladesh Agricultural Rresearch Council (BARC). About a decade ago, BARC produced a vision document (BARC, 2012), "Research Priorities in Agriculture - Vision 2030". Till now, this Vision 2030 document is followed in planning and execution of research programs by the NARS institutes. Now, research

priority in agriculture under the auspices of NATP Phase II has been determined considering the current and emerging problems and issues in Bangladesh agriculture using both bottom-up and top-down approach.

Research priority setting in agriculture is a dynamic process. This is required to adjust with the contextual and temporal changes, and to undertake demand-driven research to address the need of the technology users and market demand. With the advancement of time, previous research priority document needs to be updated under the context of increased food demand for a soaring population, climate change, emerging changes in cropping systems, government thrust and socio-economic changes. Thus, research priority setting deserves due attention taking into account of the existing opportunities for achieving higher productivity and profitability through

a) Development of stress tolerant varieties,
b) Yield maximization using genome editing and other advanced bio-technology
c) Efficient management of natural resources (soil and water),
d) Adoption of Good Agricultural Practices (GAP),
e) Crop intensification and diversification,
f) Farm mechanization and agroprocessing, and
g) Effective market linkages.

It is presumed that research priority document will serve as a good guide for planning of research programmes and undertaking action plan to be implemented by the government and non-government organizations. Non-government organizations (NGOs) are actively engaged in improving country's farm sector alongside the government organizations. Private sector plays a significant role in the economic development through contributions to production, processing, value addition, marketing, investment and export.

In the previous document "Research Priorities in Agriculture - Vision 2030", top down approach was followed, while in the present document both bottom-up and top-down approaches have been integrated. This document will be a good basis for government and donor's investment opportunities for future research programs in agriculture towards building a prosperous farm growth and sustaining agricultural productivity. As such, the research priority setting for crop sub-sector has the following objectives:

- Identify researchable areas/issues under thematic and sub-thematic areas through stakeholders' engagement following both bottom-up and top-down approaches
- Setting priority research issues for different tenures and
- Formulate strategic frameworks to develop sustainable, effective and profitable technologies addressing the overall research needs of the country.

Agricultural Transformation in Bangladesh

Bangladesh is predominantly an agricultural country having an area of 14.85 million ha (Mha). Geo-morphologically the country has 80% lands occupied by floodplains and piedmont plains, 8% by terraces and 12% by hills (FAO/UNDP 1988). There are 30 agro-ecological zones in the country and the classification is based on physiography (land forms and parent materials), soil (soil physical and chemical characteristics), land types (land topography) and agro-climatology (kharif-1, kharif-2 and rabi cropping seasons). Khariaf-1 extends from mid-March to mid-July, Kharif-2 from mid-July to mid-November and Rabi from mid November to mid March. The country has a sub-tropical humid climate which is generally characterized by high temperature accompanied by moderately high monsoon rainfall during kharif II and low temperature in the rabi season.

According to the Agriculture Census 2019, there are about 16.88 million farm households in Bangladesh. Out of these households, 91.7% belongs to landless (0-0.20 ha), marginal (0.21-0.60 ha) and small (0.61-1.00 ha) farmers occupying 69.0% of land. On the other hand, only 7.70% of these households belongs to medium farmers (1.01-3.00 ha) covering 24.23% of land and 0.6% belongs to large farmers (>3.00 ha) occupying 6.77% of land (Table 1). Compared to Agriculture Census 2008, the strength of large and medium farm households has remarkably decreased in 2019 while that of small, marginal and landless farm households have noticeably increased.

Table 1 : Farm households and operated areas by various farmers Agriculture Census 2019:

Farmer category	Total farm households (million)	Operated area(million acre)	Total farm households (million)	Operated area (million acre)
	2008 Agriculture Census		2019 Agriculture Census	
Small, landless and marginal	12.81(84.4)*	14.43(61.4)	15.48(91.7)	14.99(69.00)
Medium	2.14(14.1)	7.09(30.2)	12.99(7.7)	5.27(24.23)
Large	0.234(1.54)	1.98(8.4%)	10.10(0.6)	1.47(6.77)
Total	15.18(100)	23.50(100)	16.88(100)	21.73(100)

*Figures in the parenthesis indicates percentage, **Farmer categories**: Landless 0-0.20 ha, Marginal 0.21-0.60 ha, Small 0.61-1.00 ha, Medium 1.01-3.00 ha and Large >3.00 ha; 1 acre = 0.40 hectare.

Crops and cropping systems

Cultivable area has declined from 9.44 million ha in 2000 to 8.77 million ha in 2020, which is due to increasing growth of settlement, roads, industries, fisheries, schools, colleges, hospitals, etc (Table 2). However, the positive side is that net cropped area has increased, and fallow land area has been decreased. The cropping intensity has increased to 198% in 2020 against 180% in 2010 and 177% in 2000 since double and

triple cropped areas have significanly increased. Fallow land remains mainly in Southern (coasts) and Sylhet (haors) regions, and also notably in high Barind Tract (AEZ 26 in Naogaon, Chapai Nawabganj and Rajshahi districts) due to long moisture stress (drought).

Agricultural land use and distribution of cultivated crops expressed in cropping pattern (CP) constitute the base for increasing productivity. According to the study of Nasim *et. al*. (2017), 316 CPs were identified throughout Bangladesh. Out of these CPs, five CPs are only rice based which covers 51% of the net cropped area. The most dominant CP is the Boro-Fallow-T. Aman rice covering 27% of net cropped area. A list of 15 major cropping patterns in 14 agricultural regions is shown in Annexure 1.

Table 2 : Agricultural land use statistics of Bangladesh (BBS 2000, 2010 and 2020).

Land use	**Area (M ha) 2000**	**Area (M ha) 2010**	**Area (M ha) 2020**
Total area	14.85	14.85	14.85
Forest	2.26	2.60	3.10
Cultivable land	9.44	8.44	8.77
Current fallow	0.50	0.47	0.431
Single cropped area	2.87	2.85	2.11
Double cropped area	4.09	3.98	4.13
Triple cropped area	1.02	0.97	1.87
Quadruple	-	-	0.022
Net cropped area	7.97	7.81	8.13
Total cropped area	14.09	13.74	16.06
Cropping Intensity %	177	180	198

Presently, rice alone covers about 73% of total cropped area. Next to rice, the crops covering less than 6% area are wheat, maize, pulses, oilseeds, potato, vegetables, spices and jute (Table 2 and Fig. 2).

Table 3 : Area, production and yield of different crops: 2020-21 (BBS, 2022)

Crop	Area (M ha)	% of total cropped area	Production (M t)	Yield (t/ha)
Rice	11.72	72.98	37.61	3.21
Wheat	0.33	2.05	1.09	3.30
Maize	0.56	3.49	5.66	10.0
Pulses	0.79	4.92	0.93	1.18
Oilseeds	0.85	5.29	1.20	1.40
Potato	0.47	2.93	9.89	21.1
Vegetables	0.94	5.85	19.72	21.0
Spices	0.62	3.86	4.92	8.00
Sugarcane	0.05	0.31	2.14	47.0
Fibres	0.68	4.23	7.73	11.3

The average yield of aus rice is 2.52 t/ha, aman rice is 2.57 t/ha and that of boro rice is 4.15 t/ha while the average yield of rice over all seasons is 3.21 t/ha (Table 3). The current production of wheat is about 1.09 M t against the national demand of 5.4 M t. About 85% wheat is grown after harvesting T. Aman rice and about 60% wheat is sown late (BBS, 2022; Bokhtiar and Samsuzzaman, 2023). Maize is grown in two seasons - Rabi (winter) and Kharif I (summer). High price of hybrid maize seed, unavailability of short-duration high yielding dwarf maize varieties and infestation of fall armyworm appear to be the major constraints for maize cultivation in the country. Attention is needed to enhance production of pulses and oilseeds in consideration of the country's demand. The country is on the verge of self-sufficiency in vegetables production and surplus in potato. Unfortunately, sugarcane production and its area have gone down during the last two decades as farmers found sugarcane cultivation not profitable. The country's jute production is not up to the mark and mostly now concentrated in the greater Faridpur district.

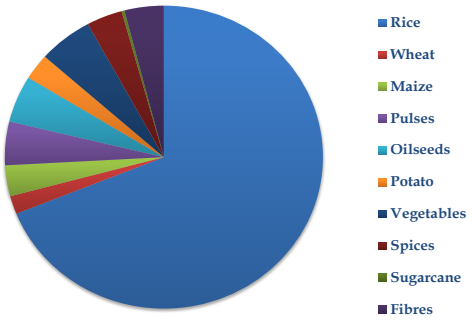


Fig. 1 Area under different crops (2020-21)

Transformation in agriculture

Transformation in Bangladesh agriculture happens principally in two forms: firstly, transformation of green revolution to gene revolution and secondly reshaping subsistence to commercial agriculture. Now, the country has entered into the era of Fourth Industrial Revolution (4IR). In the process of agricultural transformation, the agri-food system evolves from subsistence and farm oriented into more commercialized, productive and off-farm centred. Bangladesh has achieved food security to many extents and currently is giving emphasis on nutritious and safe food.

Gene revolution

Dr. Norman E Borlaug, the father of Green Revolution, led the initiatives worldwide that contributed to an extensive increase in crop production. He started this endeavor from a wheat field in Mexico in 1940 and developed semi-dwarf HYV called 'miracle wheat' in two decades through hybridization. The dramatic increases in wheat and rice production in the late 1960s have brought about a revolution in food production globally through use of HYVs accompanied with fertilizer, irrigation and pesticide use. Green revolution did not touch the soils of Bangladesh until the Father of the Nation, Bangabandhu Sheikh Mujibur Rahman initiated this revolution in the name of "Sabuj Biplob" in early 1970s. This indeed resulted in increased food production but incurred a significant loss in biodiversity.

In the 1990s, it was realized that the use of HYVs developed by traditional breeding methods was not sufficient to achieve remarkable crop production. Due to use of high inputs including synthetic pesticides and fertilizers, the health of soil and environment was deteriorated, and the slow process of conventional breeding seems unable to satisfy the expected yield gain for food security of increasing population. Consequently, the concept of biotechnology came up which made a paradigm shift from the 'Green Revolution' to the 'Gene Revolution' with the introduction of molecular breeding and genetic engineering.

In the late 20th century, advances in biotechnology, hybridization, high throughtput selection techniques, mutation, and transgenic technologies showed the way towards developing genetically improved crop varieties. The effort of transgenic breeding for resistance to insects and diseases has been strengthened. However, issues related to cost, efficiency, bioethics, regulation, and public acceptability of genetically modified crops (Golden rice) have limited the use of these techniques in crops (Mackelprang and Lemaux, 2020). Under the situation, recent advances in genome editing technologies, mainly the CRISPR-Cas9 technology, enable targeted and precise genetic modification of crop plants in a faster manner which can accelerate the transition towards precision speed breeding for crop improvement (Islam 2019, 2023).

Commercial farming

At begining higher agricultural production in Bangladesh focused subsistence farming. With the advancement of time and achievement of self sufficiency in food

(rice) production, the agricultural production system has been gradually transforming from subsistence to commercial farming. It is apparent that many farmers are giving importance to vegetables, fruits and flowers having commercial values after rice (Razzaque and Hossain, 2007). Commercialization of agriculture can be achieved by promotion of value addition to agricultural commodities, particularly horticultural products (jam, jelly, pickle, etc.), which supports agri-businesses and links farmers with local and international markets (WB, 2009).

High-value crops are at the centre of commercial farming, where educated youths are now concentrating for building their fortunes. High-value crops are fruits like dragon and strawberry, and vegetables such as capsicum, broccoli, and carrot (Masud, 2023).

Fourth Industrial Revolution (4IR)

The Fourth Industrial Revolution refers to a digital revolution based on information technologies viz. artificial intelligence (AI), robotics, Internet of Things (IoT), 3D printing, genetic engineering, quantum computing and similar other technologies.

Historically, the F**irst IR** (1760-1840) began in the 18th century in Great Britain which is characterized by the development of mass production systems through the transformation from hand and animal-driven production systems to the use of machines, steam engines, some forms of chemical energy, etc. Then, the **Second IR** (1870-1914) contributed diesel engines, widespread use of electric power, chemical fertilizers, etc., and many of these innovations are associated with the Green Revolution technologies in agriculture. The **Third IR** (1950-1999) can be branded by the use of computing and information technologies e.g. computers, satellites and internets. The 4IR was coined in 2016 by Klaus Schwab, the founder of the World Economic Forum. This concept has combined machine learning and artificial intelligence (AI), the internet of things (IoT), robotics, and gene editing that "blurs the lines between the physical, digital, and biological worlds". The 4IR has received much attention in agriculture as it can help in precision farming techniques by advanced uses of smart sensors in measuring soil moisture and pH, diagnosing insect pests, and keeping track of crop health. It also helps in providing automated smart irrigation systems, using robotics or drones as sprayers, ensuring controlled greenhouse gas emissions, and reducing the necessity of monitoring different operations (Sattar, 2023).

The country's GDP contribution has come down from mainstream farming, while the service and industry sector's contribution have come up. However, many agro-processing industries are dependent on agriculture. For example, PRAN, ACI (agricultural companies) and many small scale agro-processing industries are using farm raw materials and producing jute bag, sugar, tea, fruit juice, processed spices, etc. All these farms have taken into shape of commercial farms in the hands of many youths and progressive women entrepreneurs.

All farm sub-sectors (crop, forestry, animal farming and fisheries) have registered substantial growth. The major drivers of agricultural transformation are relative

profitability, adoption of HYVs and hybrids and expansion of irrigation facilities, increased use of fertilizers, input access, public and private investment and policy support. Sustainable as well as profitable technologies are needed to expand cropping intensity in the agro-ecologically disadvantaged areas (coasts, barinds, haors, chars and hills).

Achievements in agriculture

Crop production in Bangladesh has increased tremendously from 13.9 million tons (M t) rice in 1981 to 37.6 M t in 2021 (Fig. 2).The country is one of the top ten producers of rice (third), vegetables (third), potatoes (seventh), tropical fruits (sixth) and jute (second). The main drivers of this achievement include increased allocation of revenues to agricultural ADP (Annual Development Plan), agricultural policy reforms, technological innovations, and increased access to agricultural inputs, through price subsidy and production supports. The country has achieved self-sufficiency in rice since 2000 and become surplus from 2005 by 0.37 M t to 2021 by 7.55 M t (Fig. 3).

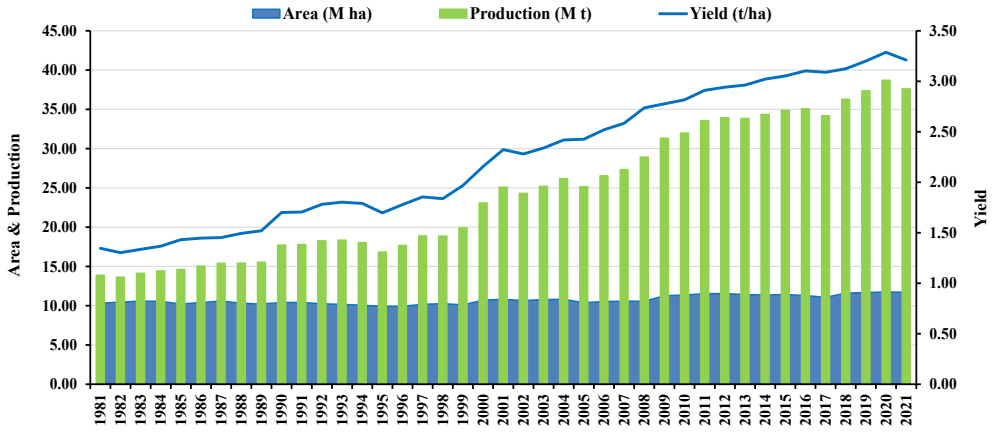


Fig. 2 Area, production, and yield of rice in Bangladesh, (BBS, 2022).

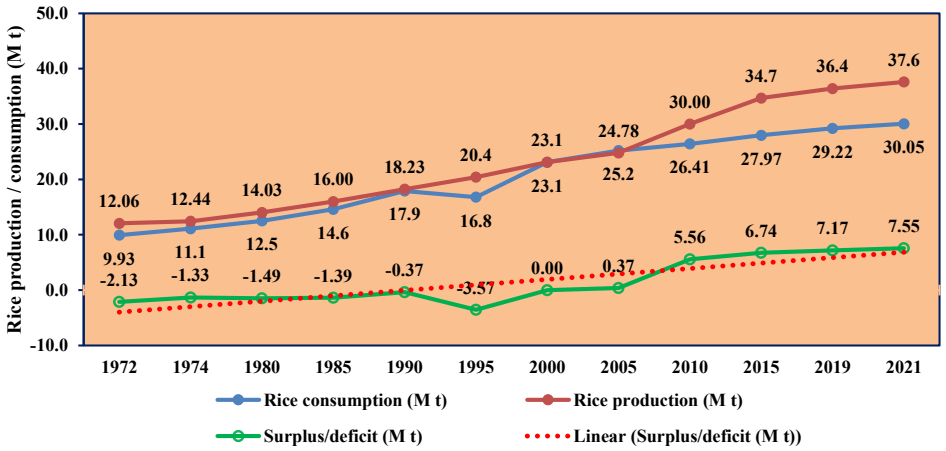


Fig. 3 Trend of rice production, deficit to surplus (Bokhtiar and Samsuzzaman, 2023)

There has also been a good progress in fruit production in the country (Fig. 4). Mango and jackfruit are the main fruits of this country. It is noteworthy that currently 72 fruits are being cultivated. Bangladesh ranks second in jackfruit, seventh in mango, eighth in guava and forteenth in papaya production globally. The cultivated areas under fruit orchards have been enormously increased and the farmers have turned these areas into commercial farming.

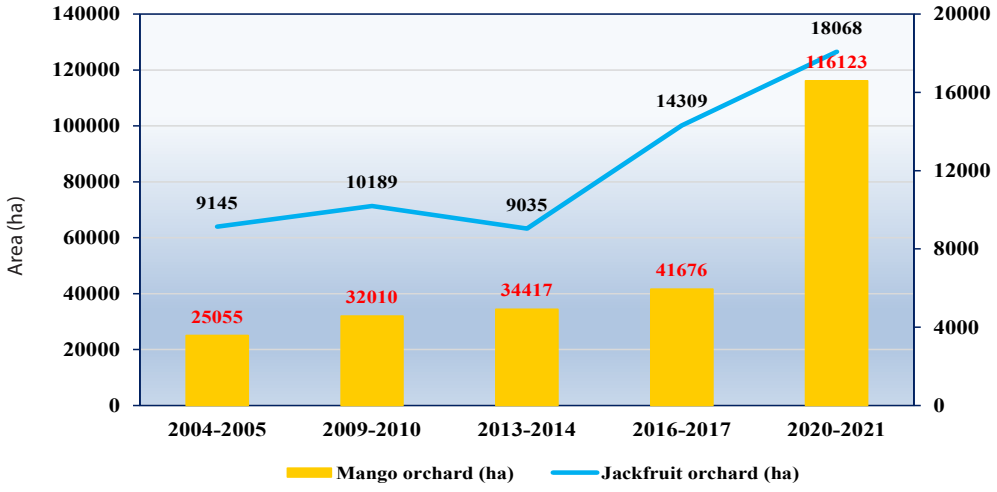


Fig. 4 Area under mango and jackfruit orchards during 2004-2021 (BBS 2005, 2011, 2015, 2017 and 2021)

Mango and jackfruit cultivation area have increased sharply by 363% and 98% from 25,055 and 9,145 ha in 2004-2005 to 116,123 and 18,068 ha in 2020-21, respectively (Fig. 4). The area under of each fruit orchard increased to the maximum level in 2020-21.

Table 4 shows that people in this country are consuming more rice, potato and edible oil while less amount of other foods viz. fruits, vegetables, and pulses than requirement.

Table 4 : Per capita per day intake of major food items

Food group	1995	2000	2005	2010	2016	2021	Requirement
Rice	464	459	440	416	367	496	350
Fruits & vegetables	180	169	190	211	203	212	400
Potatoes	49	55	63	70	65	146	60
Pulses	14	16	14	14	16	17	60
Edible oils	10	13	17	21	27	50	40

Source: HIES 2016

https://www.tbsnews.net/bangladesh/capita-rice-consumption-bangladesh-be-highest-asia-2021-fao-157333
https://www.helgilibrary.com/indicators/potato-consumption-per-capita/bangladesh/
https://thefinancialexpress.com.bd/trade/edible-oil-consumption-increases-by-20pc-in-five-years-1630503068
https://www.revistaamplamente.com/index.php/ijphrd/article/download/17345/15310
https://today.thefinancialexpress.com.bd/metro-news/bd-daily-per-capita-pulses-deficit-28-grams-1676049317

Projected demand and supply of foods/ Crops

The country's rice production has increased to a large extent with the evidence of 12.5 Mt rice in 1980 to 37.6 Mt in 2021. On the other hand, wheat production has decreased to 1.03 Mt in 2021 from 1.35 Mt in 2015. Nevertheless, food demand is increasing as the population is increasing, the current rate of increase is 1.16%. At present, the population strength of Bangladesh is 169.4 million (Bangladesh census, 2021) in 148,460 square kilometers. It is projected that the country in future will have food surplus in rice, potato, vegetables and fruits, but would face deficit in wheat, maize, pulses and edible oils (Table 5).

Table 5 : Projections of demand and supply of major plant foods and food gap during 2021-2041 (Source : Bokhtiar *et.al.,* 2022)

Food crops	2021		2030		2041		Surplus (+)/ Deficit (-)		
	Demand	Supply	Demand	Supply	Demand	Supply	2021	2030	2041
	Million metric ton (M t)								
Rice	35.2	37.45	39.1	41.0	41.26	45.86	2.25	1.9	4.6
Wheat	5.4	1.03	6.39	1.17	7.21	1.19	-4.37	-5.22	-6.02
Maize	6.5	4.21	8.43	6.19	12.09	8.96	-2.29	-2.24	-3.13
Potato	9.56	9.87	11.61	11.78	12.26	13.04	0.31	0.17	0.78
Pulses	1.61	0.39	1.79	0.55	1.89	0.77	-1.22	-1.24	-1.12
Edible oil*	1.62	1.72	2.2	2.21	3.11	2.58	0.1	0.01	-0.53
Vegetables	2.46	2.98	2.85	4.01	6.34	5.44	0.52	1.16	-0.9
Fruits	2.67	2.94	3.22	3.55	3.79	4.32	0.27	0.33	0.53

*Mustard + Groundnut

It is estimated that rice consumption has the largest share to total calorie intake. However, its share has decreased from 80.4% in 1990 to 70.5% in 2021 and will further decrease to 72.6% in 2030 and 70.4% in 2050. The share of wheat has slightly increased from 6.6% in 2010 to 6.72% in 2030 and 6.83% in 2050. During 2010-2030, maize consumption will increase from 6.0 kcal/person/day to 6.5 kcal/person/day. The contribution to calorie intake from potato and vegetables has steadily increased during 1990-2010 and is likely to increase during 2030-2050 (Bokhtiar *et. al*., 2022).

National Documents on Agriculturalpolicies and Plans

Reviewing of national agricultural policies and plans deserves attention since in the recent years the GoB has adopted some demand-driven policies and plans. The important documents are National Agriculture Policy 2018, Perspective Plan 2021-2041, Bangladesh Delta Plan 2100, 8th Five Year Plan 2021-2025, etc. which aim to increase and sutain crop productivity. Current as well as emerging situations like declining natural resources, climate change, consumer's food choices, market demand etc. invite new and productive research to develop effective and profitable technologies. However, a sound agricultural policy should be able to reconcile three basic needs a) increased production of food and agricultural products, b) the protection of the environment and c) the maintenance of the socio-economic structure of rural areas.

Agricultural policies

An overview of major goals and thrusts of various policies in agriculture formulated by the Ministry of Agriculture (MoA), Government of the People's Republic of Bangladesh is presented below.

1. National Agriculture Policy (NAP) 2018

The overall objective of NAP 2018 is to make the nation self-sufficient in food through increasing production of all crops and ensure a dependable food security system for all. An account of the key features of the policy is briefly stated below.

- Increase availability of food and right to food
- Modernize agricultural research, education, extension, input management and develop skilled manpower for sustainable technology innovation
- Increase farmer's capability through institutional infrastructure development and efficient technology services
- Adopt and implement food production plans to meet the needs of nutritious, safe and demand driven foods
- Develop agricultural research for promoting exports of products through coordination with local and international partner organizations
- Ensure marketing facilities of agricultural commodities
- Increase productivity through prudential management of natural resources
- Introduce cost saving farming systems through agricultural mechanization
- Create farm commercialization through export oriented agricultural development
- Ensure expedient use of water resources through inter ministerial/ interagency coordination

2. National Agricultural Extension Policy 2020

Climate resilient, environment friendly, safe, sustainable, nutrition rich and profitable crop production for all categories of farmers and entrepreneurs by providing demand-driven technology and information service.

3. Bangladesh Good Agriculture Practices Policy 2020

- Ensure sustainable production of safe and nutrition rich crops
- Ensure climate resilient crop production, and health safety and security for the welfare of agricultural employees
- Ensure health safety of consumers
- Increase production and export of quality high value crops

4. Integrated Minor Irrigation Policy 2017

Ensure food security and poverty alleviation by increasing crop production with lower irrigation cost, increased skills and modern irrigation systems, eg, AWD (Alternate Wetting and Drying) irrigation technique.

5. National Organic Agriculture Policy 2016

- Conduct agriculture program maintaining soil fertility through integration of soilphysical, chemical and organic qualities
- Identification of zone, location and crops suitable for organic agriculture
- Development and extension of crop based organic agricultural production systems
- Make organically produced seeds easily available
- Involvement of indigenous and traditional knowledge and practices related to organic agriculture in crop production

6. National Seed Policy 2018

- The Vision of the National Seed Policy is to establish "A competitive, profitable and sustainable seed sub-sector where farmers and all seed users have access to affordable quality of seeds".
- The overall goal of the policy is to provide clear guidelines for the development and promotion of the seed industry in order to raise agricultural productivity through the provision of sustainable, adequate and high quality seeds.
- The specific objectives of the policy are to enhance appropriate and effective seed regulatory framework, enhance seed quality assurance, establish reliable and internationally acceptable seed certification system and enhance growth of the domestic seed industry.

- The policy priority areas include a) institutional, regulatory and legal framework, b) seed certification and quality control information system for the seed industry, c) production of different classes of seed, d) biotechnology and biosafety research, e) seed marketing and distribution, and f) seeds, orchards and vegetative propagated materials and integration of seed topics in education curriculum.

7. National Agricultural Mechanization Policy 2020

- Encourage the introduction of farmer-friendly agricultural machinery according to the socio-economic status of the farmers, size of the farm and fragmented land and soil type
- Accelerate agricultural mechanization for the profitable, commercial and sustainable agricultural production system

8. National Jute Policy 2018

- Ensure fair price of jute
- Extend multifaceted jute products and jute stick bi-products to the national and international markets
- Attract national and international investors by creating enabling environment and incentives, and by creating opportunities for infrastructure development
- Strengthening research for development of jute sector.

9. National Biotechnology Policy 2012

- The overarching goal is to advance the research and development of biotechnology to improve food security, increase the standard of living, and eliminate poverty
- Some specific focus areas include plant biotechnology, animal biotechnology, medical biotechnology, industrial biotechnology, bio-security, bio-ethics, as well as other topics such as nanotechnology and bioinformatics
- Some specific plant biotechnology priorities include development of nutritionally dense crops, and pest, disease, and abiotic stress tolerant crop varieties.

10. National Agricultural Marketing Policy 2023

- Its aim is to ensure fair prices by improving the marketing system for the socio-economic development of farmers.
- Ensure the minimum fair price for farmers and fix the maximum rational price of agricultural products.

- Develop the market infrastructure, increase the number of agricultural entrepreneurs including women, and ensure the development of a well-coordinated value and supply chain.
- Increase the export of agricultural products, decrease the economic disparity between rural and urban areas, and ensure accountability in agribusinesses.
- Establish a dynamic agricultural marketing system.

Agricultural Plans, Visions and SDG

1. Perspective Plan of Bangladesh 2021-2041

The government adopted Vision 2041 in March 2020 and the associated Perspective Plan 2021-2041 (PP2021-41). This plan has set up the road map for the promotion of Bangladesh to an Upper Middle-Income Country (UMIC) eliminating extreme poverty by FY2031, and to a High-Income Country (HIC) status by FY2041. Crop sub-sector priorities as per PP2021-2041 are as follows:

- Create opportunities for sustainable agriculture and green growth
- Crop zoning, land use planning and promotion of precision agriculture
- Increase access to agricultural inputs and promote agricultural diversification
- Use of water resources and water economy
- Introduction and popularization of Good Agricultural Practices (GAP)
- Farm mechanization
- Post-harvest management
- Value chain development
- Smooth flow of agricultural credit
- Agricultural research

2. Bangladesh Delta Plan 2100

Bangladesh Delta Plan 2100 (BDP 2100) has been formulated as an adaptive, holistic, and long-term integrated plan. It steers the opportunities and vulnerabilities created by the interface of water, climate change, natural disasters, environment, ecological balance, agriculture, land use and inland water management for national development. Sustainable use of water resources and prevention of water-related natural disasters provides the backbone to the Delta Plan. BDP 2100 has strongly focused climate change issues and Adaptive Delta Management (ADM) approach. It is a long-term and visionary plan covering the 21st Century. This will help the country achieve sustainable agricultural production through following the specific measures:

- Sustainable land use and spatial planning

- Agriculture, foodsecurity, nutrition and livelihoods
- Advancing blue economy
- Renewable energy

3. Eighth Five Year Plan 2021-25 (8FYP)

The 8FYP has given emphasis on promotion of agricultural research with a particular focus on the followings:

- Developing and refining technologies that will bridge yield gaps and promote diversification and intensification
- Sustainable natural resources management (e.g., rain water and river water harvesting, soil management for agricultural production)
- Disease and pest management
- Development of varieties/species with postharvest technology of high value agricultural commodities
- Addressing climate change effects by breeding and introducing saline and drought tolerant, short duration varieties, high value commodities, and low-cost, high-impact post-harvest technologies
- Researchon harvesting, food processing, packaging, market intelligence, IPM, on-farm water management, food technology etc.
- Biotechnology and biosecurity will be given special emphasis along with other contemporary issues
- Frontier research like genomics and phenomics, physiological mechanisms regulating photosynthetic efficiency, polyshed and nutrient dense culture, vertical farming, mechanization, ICT, etc.

4. Agricultural Research Vision 2030

The BARC in 2011 prepared a Vision Document 2030 as a guide for agricultural research that significantly contributed to the development of appropriate technologies by NARS institutes, agricultural universities and private organizations followed by farmers' adoption. There after, the BARC with financial support from the National Agricultural Technology Program (Phase-1) financed by the World Bank, prepared the Vision Document 2030 for agricultural research (BARC, 2012). This Vision document points out the overall research needs of the country based on key challenges in developing and scaling up farm of the country. Research needs of the crop sub-sector as per this vision document are outlined below.

Vision 1: Food security through increased production, availability, access and utilization of food crops
Vision 2: Ensure intake of safe nutritious food through diversified food production
Vision 3: Improve crop production
Vision 4: Enhance genetic resources
Vision 5: Increase breeding options for crop improvement

Vision 6: Address unfavorable agro-ecosystems
Vision 7: Efficient management of natural resources
Vision 8: Mechanization in agricultural production and processing
Vision 9: Post-harvest management and value addition
Vision 10: Climate change and bio-risk management
Vision 11: Agricultural diversification
Vision 12: Management of energy and agricultural wastes

5. SDG 2015-2030

In September 2015, the General Assembly of the United Nation adopted the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs). Agriculture has most relevance to Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. The SDG Goal 2 has focused on the following:

- End all forms of malnutrition including achieving, by 2025, targets on stunting and wasting in children under five and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons
- Double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers and fishers
- Ensure sustainable food production systems and implement resilient agricultural practices that -
    - increase productivity and production,
    - help maintain ecosystems,
    - strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters,
    - progressively improve land and soil quality, and
    - enhance technology development and establish gene banks

National Agricultural Research and Extension Systems

Agricultural system in Bangladesh has two major wings - Technology Generation System and Technology Delivery System. Technology generation is mainly done by the different NARS institutes and also by universities, non-government organizations (NGO), private organizations (PO) etc. Technology delivery system in the crop sub-sector is largely operated by the Department of Agricultural Extension (DAE) and to a smaller extent by NGOs and a few private organizations. Nevertheless, for both technology generation and delivery systems, the public institutions are playing a key role.

As per BARC Act 2012, the National Agricultural Research System (NARS) has been formed with BARC as the apex body, and 13 public agricultural research institutes are working under the umbrella of NARS. Thus, the Bangladesh Agricultural Research Council (BARC) is coordinating overall agricultural research activities of the country.

Agricultural technology generation system

Innovative technologies in agriculture are generated as an outcome of research done by NARS institutes and also many other organizations. However, lion share of the contribution is from National Agricultural Research System (NARS) which consists of 13 public research institutes and coordinated by BARC.

Research at NARS institutes

Bangladesh Agricultural Research Council (BARC) by mandate functions to coordinate, monitor and evaluate the research programmes of the NARS institutes. It formulates national agricultural research plans and administers its implementation. It gives due attention to human resource development (HRD) through arranging training and higher studies for NARS scientists. BARC has produced a vision document, "Agricultural Research Vision 2030" and prepared Fertilizer Recommendation Guide-2018 for optimum and region-specific fertilizer use for achieving sustainable and profitable crop production. It has facilitated development of more than 50 promising technologies on crops, livestock and fisheries through implementation of Sponsored Public Goods Research (SPGR) sub-projects under NATP Phase-I and similarly 116 technologies through Competitive Research Grant (CRG) and Programme Based Research Grant (PBRG) under NATP-2. It has prepared crop zoning maps for 17 crops for optimum utilization of land, soil and other natural resources with a view to maximize crop productivity. It acts as a bridge for technology transfer from the NARS institutes to the farmers via DAE.

Bangladesh Agricultural Research Institute stationed at Joydebpur, Gazipur conducts research on all food crops except rice, sugarcane, jute, cotton and tea. It has been successfully contributing to national agricultural production by developing technologies suitable for the country's climate, and appropriate for the farmer's situation.

The area of research includes variety development (tubers, oilseeds, pulses, vegetables, fruits, flowers, and minor cereals), improvement of cropping systems, crop, soil, and water management, plant nutrition, disease and insect management, development of low-cost farm machineries, postharvest processing, and farming systems research.

Bangladesh Rice Research Institute (BRRI) located at Joydebpur, Gazipur carries out research on all aspects of rice. These aspects include breeding new varieties, improvement of productivity and mechanization of rice-based cropping systems, plant protection measures, fertilizer and water management and other cultivation practices. The country has contributed to achieve food grain security, largely through cultivation of BRRI developed rice. The institute by now has developed 107 potential rice varieties including seven hybrids. For example, BRRI dhan100 is the latest zinc riched variety having 25.7 ppm Zn, 26.8% amylose and 7.8% protein (http://www.brri.gov.bd/). Research on Golden Rice (GR-2 E BRRI dhan29) with beta carotene, short duration varieties, abiotic and biotic stress tolerant varieties, genome-editing technology (CRISPR-Cas9) for genetic gains, direct seeded rice (DSR) varieties, premium quality varieties, micronutrient and protein dense varieties are the notable research thrusts of BRRI. As much as 19 BRRI developed rice varieties are cultivated in 14 countries around the world. BRRI also developed 51 profitable rice-based cropping patterns for different agro-ecological zones (30 AEZs in Bangladesh) and 32 improved agricultural machineries. It has developed producer and consumer preference model for BRRI varieties. It preserved about 8,000 rice germplasm in the BRRI gene bank collected from home and abroad.

Bangladesh Jute Research Institute (BJRI) stationed at Dhaka undertakes research to develop short duration high yielding varieties of Jute, kenaf and mesta, and develop crop production and crop protection technologies. It also conducts research on jute industry for the development of value-added and diversified jute products and improvement of traditional jute products. In addition, it works on development of jute textile particularly jutebased textile product in combination of jute, cotton, and other natural and artificial fibres. The genome sequence of tossa jute, white jute and a most devastating fungal pathogen *Macrophomina phaseolina*, the causal organism of stem rot of jute was unveiled. BJRI has a gene bank which conserves about 6,000 germplasms of jute and fibre related crops.

Bangladesh Sugarcrop Research Institute (BSRI) situated at Ishurdi, Pabna leads research on the development of varieties, production of technologies and multipurpose uses of sugarcrops. Along with sugarcane, BSRI also conducts research on other sweetener crops such as sugarbeet, palmyra palm, date palm, stevia, golpata, honeybee and liquor ice. Since its establishment, BSRI has developed 48 varieties of sugarcane including two chewing type varieties. It also developed more than 220 technologies on sugarcrop production, gur processing, preservation and marketing.

Bangladesh Institute of Nuclear Agriculture (BINA) is a research institute based in Mymensingh. It has a main mandate to undertake research and develop technologies in agriculture using nuclear and radiation techniques. The institute has developed 16 varieties of crops including 25 high yield potential rice varieties. Many of these rice varieties are salt tolerant, short duration and drought tolerant. BINA also developed four varieties of sesame. The institute conducts research to develop biological nitrogen fixation inoculum for different pulse and oil seed crops along with non-commodity technologies.

Soil Resource Development Institute (SRDI) located at Dhaka has responsibility of identifying soil characteristics, their classification, and nutrient elements for suitability of crop production. In addition to soil testing laboratories in different places, SRDI has mobile units to carry out soil testing at field level. The institute has 10 Mobile Soil Testing Laboratories (MSTL), which provide on-farm soil testing facilities including balanced fertilizer recommendations to the farmers. Some innovative technologies for slopping hill soil management and saline soil management have been generated.

Bangladesh Wheat and Maize Research Institute (BWMRI) stationed at Dinajpur has mandate to carry outbasic and applied research to develop climate-smart variety and crop management technologies. It has developed five high yielding, heat tolerant and disease-resistant wheat varieties and two hybrid maize varieties.

Bangladesh Forest Research Institute (BFRI) situated at Chattogram conducts research on scientific utilization of forest products. It also conducts research for increasing the productivity of forest land through improved management, conservation of soil and water and protection of trees from pests and diseases. BFRI uses different ways of generating varieties using conventional breeding, biotechnology and genetic engineering. It is pioneer for artificial regeneration of mangrove species and raising man-made mangrove plantations.

Bangladesh Tea Research Institute (BTRI) located at Sreemangal, Moulavibazar undertaking research to increase yield and improve the quality of tea by developing improved high yielding tea clones. It also conducts research on packaging management technologies and renders advisory services to the tea industry to transfer proven and adaptive newly innovated technologies.

Bangladesh Sericulture Research and Training Institute (BSRTI) stationed at Rajshahi is mandated to develop and transfer appropriate technologies for sericulture. It also provides technical support and develops skilled manpower through training for development and extension of sericulture in the country. BSRTI conducts research on collection and conservation of germplasm materials both for mulberry and silkworm.

Cotton Development Board (CDB, 1972) is responsible for increasing cotton production and conducting research on different aspects of cotton. It has been conducting research on development of hybrid and short duration high yielding

cotton varieties with desirable fibre characteristics. It also generates agronomic management technologies to increase productivity, improve soil fertility by integrated management of organic and inorganic fertilizers and identify bio-pesticide in controlling cotton insect pest and diseases.

Research at University

At present in Bangladesh there are 54 public universities and 111 private universities. The country has eight public agricultural universities –(1) Bangladesh Agricultural University (BAU, established in 1961), (2) Bangabandhu Sheikh MujiburRahman Agricultural University (BSMRAU, Est. 1998), (3) Sher-e-Bangla Agricultural University (SAU, Est. 2001), (4) Sylhet Agricultural University (SAU, Est. 2006), (5) Khulna Agricultural University (KAU, Est. 2015), (6) Habiganj Agricultural University (HAU, Est. 2020), (7) Kurigram Agricultural University (KAU, Est. 2021) and (8) Sheikh Hasina Agricultural University, Shariatpur (SHAU, Est. 2023). There are also five other public universities which produce agriculture graduates, namely Hajee Mohammad Danesh Science and Technology University (HSTU, Est. 1999), Patuakhali Science and Technology University (PSTU, Est. 2000), Rajshahi University (RU, Agriculture Faculty Est. 2005). In addition, there are two private universities viz, International University of Business Agriculture and Technology (IUBAT, Est. 1991) and Exim Bank Agricultural University (EBAU, Est. 2012). The Chattogram Veterinary and Animal Sciences University (CVASU, Est. 2006) offers degree in Veterinary and Animal Sciences. It is the mandate of these universities to carry out research in connection with post-graduate students' thesis and contract research project along with offering course work.

Research at Other Organizations

Rural Development Academy (RDA) is a specialized national institution engaged in rural development, training, extension and action research. It also offers post graduate diploma. RDA conducts action research covering a wide range of areas related to agriculture and rural development.

Bangladesh Academy for Rural Development (BARD) conducts training and action research in rural development. One of the priority programs is expansion of advanced agricultural technology. BARD facilitates farming that is managed through a "social enterprise" consisting of farmers.

Research at NGOs

There are few NGOs in Bangladesh that promote agricultural research and development such as BRAC, RDRS Bangladesh, ACI, PROSHIKA, Friends in Village Development Bangladesh (FIVDB) and CARE International. NGOs also deliver extension services.

Bangladesh Rural Advancement Committee (BRAC) through agriculture and food security program (AFSP) is operating farmer participatory experiments for technology validation and fast track diffusion of cutting edge agricultural and aquaculture technologies in ecologically adverse regions.

RDRS Bangladesh inspires the local farmers to grow high yielding variety of crops and to maintain ecological balance through operation of farmers' field schools. RDRS undertakes many research-based projects in the fields of agriculture, food security and climate change. It also conducts farmer-student participatory research for MS and PhD thesis/dissertation in collaboration with several agricultural universities.

Research in private organizations and companies

Government and donors not only support public-sector agricultural research, but also extend assistance for introduction of private research and technology. Technologies are developed by private agri-business industries through in-country research. For example, competing companies not only assess imported cultivars, but also breed vegetables, maize, and hybrid rice in Bangladesh for local and, in some cases, regional markets.

Overall, emphasis has been given on agricultural research and technology development in support of increased productivity in varied eco-systems in the following areas:

- Varietal development (short duration, HYVs, bio-technology under stress and favorable conditions),
- Soil and crop management,
- Crop protection (insect and disease infestation),
- Farm mechanization,
- Irrigation and water management,
- Post-harvest processing and value addition, etc.

Agricultural technology delivery system

The Department of Agricultural Extension (DAE) under the Ministry of Agriculture (MoA) is the largest extension service provider in Bangladesh. Its head office is at Khamarbari, Dhaka and it has extension offices at regional, district, upazila and union levels. Its mandate is to extend extension services and gives advice to all categories of

farmers to adopt best farming practices towards promotion of sustainable agricultural and socio-economic development. The core functions of DAE include increasing agricultural productivity, human resource development and technology transfer.

It is playing a great role in dissemination of innovative technologies to the farmers. Demonstration of technologies through field trials, management of input supply (seeds, fertilizers, pesticides, etc.), training of farmers, collection of field problems, farmer's advice, etc. are the major activities of DAE. In addition, some NGOs (BRAC, World Vision, RDRS Bangladesh etc.) and private organizations or companies (ACI, Supreme Seed, etc.) are also contributing to technology delivery system in the country. The extension services have been revitalized and reoriented through the adoption of New Agricultural Extension Policy (NAEP) 2020, where emphasis has been given on sustainable and diversified agriculture through integrated research and extension.

NARS institutes also have their own structure and mechanism to transfer their technologies. The training division of the institute principally carries out the responsibility of technology transfer through training and result demonstration at farm level in collaboration with DAE and the other extension vehicle viz, NGOs, private organizations. The training division of BRRI provides training on modern rice production and rice related issues to the farmers and extension providers of GO, NGOs, Private sectors. Concerning transfer of BARI developed technologies, the OFRD (On-Farm Research Division) via FSRD (Farming Systems Research and Development) sites and the Training and Communication Wing via BARI Technology Villages disseminate their technologies at farm level through training, demonstration, field days and awareness building through mass media.

Methodology

In preparing this documents two approaches were followed – (i) holding stakeholder workshops and meetings at division (administrative) levels across Bangladesh and (ii) synthesis of national policies and plans in relation to agricultural development. Many diverge problems that exist in the field have been identified through workshops, where the NARS scientists, DAE personnel, university teachers, workers of NGOs and private sectors, and farmers attended. This approach of problem and research area identification is regarded as bottom-up approach. Similarly, there are many challenges for agricultural development that are well focused in the various national policy plan documents and reviewing of these policies and plans followed by integration of important research issues into this document is regarded as top-down approach. Thus, the current document of agricultural research priority setting is a novel outcome of both bottom-up and top-down approaches. It is mentionable that the previous document (Agricultural Research Vision 2030, published in 2012 from NATP Phase-1, BARC) of agricultural research priority setting was exclusively based on top-down approach.

Sharing outlines of research priority setting

The research priority setting activities were started with a stakeholder meeting at BARC in June 2022. This meeting was organized by the Project Implementation Unit (PIU) of BARC, NATP-2 and chaired by the Executive Chairman, BARC. All Member Directors of BARC, Director Generals and Directors (Research) of NARS institutes, and representatives from Agricultural Universities, NGOs and private sectors attended the meeting. The Director, PIU-BARC, NATP-2 presented an outline of approach for collection of local level researchable issues followed by a valuable discussion. However, the outline was revised with the suggestions from the participants.

Formation of thematic group

With the aim of holding regional workshops, five working groups based on the five thematic areas of crop research were constituted taking potential local participants. In each of the five groups, a good number of representatives from extension service was included with a view to grasp local problems and to get their recommendations on follow up priority research in crop sub-sector. Then, several on-line meetings were organized with the possible participants, and purposes of regional workshops were briefed to them. Every NARS institute and university was requested to nominate lead and co-lead members from among the participating members. In the online meetings,

an outline of manuscript preparation and related tables were presented before the stakeholders.

Regional workshops

The PIU-BARC, NATP-2 organized eight regional workshops across the country with an objective to identify research priorities for crops in the areas of improvement, production, protection, mechanization, irrigation, post-harvest processing and technology validation and adoption. The workshops were held in eight divisions (administrative): Barishal, Chattogram, Dhaka, Khulna, Rajshahi, Rangpur, Mymensingh and Sylhet over the 14 agriculture regions. For every regional workshop, the PIU-NATP II management formed five groups for priority setting purpose in five thematic areas and each group was led by a senior professor of university or a researcher of NARS institute or some extension personnel of DAE. Each group was constituted by 10-15 members from universities, NARS institutes, DAE, BADC, NGOs and private sectors. The groups were provided with specific formats and tables for manuscript preparation. The group leader or a member from each group gave PPT presentation under the following headings a) introduction, b) background, c) overview of activities/approaches, d) constraints and opportunities, e) possible interventions, f) existing priority research areas (crop and region/location wise), g) proposed priority research areas (high/medium/low priority) h) research duration (short/medium/long term) and i) way forward. The five defined areas of crop research were (i) genetic resources characterization, evaluation, conservation, and crop improvement, (ii) soil and crop management, (iii) crop protection, (iv)farm mechanization, irrigation, and post-harvest management and processing, and (v) technology validation and adoption. Open discussion was made after each PPT presentation and besides this, comment sheets were distributed among the participants for their written suggestions. In the eight workshops, on an average 36% of the participants were from DAE, 39% from NARS institutes, 22% from farm community and NGOs, and the rest 3% from universities (Table 6). Out of the total participants, the male participants were 89% and females were 11%. The senior level researchers were invited in the worksops and the proportion of female researchers at senior level in NARS institutes, universities and other organizations is poor (about 10%). In the workshops, the project Director, Research Management Specialist and Consultants of PIU-BARC, NATP-2 facilitated the discussion.

Table 6 Contd.

Table 6 : Share of stakeholders in the regional workshops on crop research priority setting; June - November 2022

Division	Agriculture region	NARS institute (M+F)	DAE (M+F)	University (M+F)	NGO/ Farmer (M+F)	Total (M + F)
Khulna	Khulna & Jashore	28+7	30+5	3+1	19+1	94 (80+14)
Rajshahi	Bogura & Rajshahi	33+3	25+4	0+0	6+0	71 (64+7)
Barishal	Barishal	41+3	39+6	2+0	23+0	114 (105+9)
Chattogram	Chattogram, Cumilla & Rangamati	40+3	44+4	0+1	17+0	109 (101+8)
Rangpur	Rangpur & Dinajpur	49+4	40+3	3+0	39+4	142 (131+11)
Sylhet	Sylhet	35+2	39+4	5+0	25+0	110 (104+6)
Mymensingh	Mymensingh	40+6	42+12	8+1	17+3	129 (107+22)
Dhaka	Dhaka & Faridpur	53+8	25+7	0+0	36+7	136 (114+22)
Total (M + F) (% total)	-	319+36 (35%+4%)	284+45 (31% +5%)	21+3 (2%+1%)	182+15 (20%+2 %)	905 (806+99) 100% (89%+11%)

Synthesis of national documents on agricultural policies and plans

Various government policies, plans and strategy documents in relation to Bangladesh agriculture were reviewed and synthesized for the purpose of obtaining secondary information. The research issues indicated in these documents were critically examined and the pertinent points are included in the research priority document. Synthesis of these policies, plans and related documents are briefly stated under chapter titled `National Documents on Agriculture Policies and Plans'.

Stakeholder's workshop

All the information obtained from the eight regional workshops and also from synthesis of national policy and plan documents were compiled and analyzed, and a draft research priority document was prepared. Later, the draft document was presented in the stakeholder's workshop held at BARC on 20 March 2023 with participants from NARS institutes, universities, DAE, BADC, MoA, NATP-2, KGF, NGOs and some other relevant organizations. The workshop was organized by PIU-BARC. Researchable issues were categorized by priority ranking (low/medium/high) and also by research duration (short/medium/long term). The suggestions and recommendations obtained from the day-long workshop were incorporated in the draft research priority document for its finalization.

Challenges, Constraints and Opportunities in Agriculture

Agriculture is a vital sector for people's livelihood, employment, and contribution to GDP. Bangladesh demonstrated tremendous achievements in agriculture in terms of attenuating poverty and ensuring food security. This sector provides raw materials to the industries for agro-processiing viz. jute, sugar, tea, fruit juice, spices, etc. However, the country will have to face some challenges and constraints in the coming days of the 21st century and also have opportunities to address them. The challenges, constraints and opportunities were identified from both the secondary sources (literature review) and primary sources (workshops).

Challenges and constraints

There are six significant challenges and constraints in Bangladesh agriculture, as follows:

- Meet the food demand for increasing population
- Protect arable land from non-farm activities
- Cope with the impact of climate change on food production
- Productivity of ecologically constrained or fragile ecosystems
- Arrest land and soil degradation
- Socio-economic factors of technology adoption
- Production risk factors

Population growth

Current population of Bangladesh is 169.4 million in 2021 with an addition of two million people every year. As time advances, population increases although gradually at a slower rate which is now 1.16% (Table 7). Both birth rate and death rate have decreased to 18.1% in 2021 against 45.3% in 1975 and 5.5% in 2021 against 18% in 1975, respectively. Obviously, more people will require more food and also housing, hospitals, transportation, etc. which will accelarate loss of arable land.

Table 7 : Trend of population growth in Bangladesh

Year	Population (Million)	Growth rate (%)	Birth rate (%)	Death rate (%)
1975	74.7	2.40	45.3	18.0
1980	83.9	2.47	43.0	14.4
1985	96.0	2.59	39.7	12.5
1990	107.1	2.15	35.1	10.4
1995	117.8	1.88	30.9	8.3
2000	129.2	1.92	27.5	6.9
2005	140.9	1.53	24.1	6.2
2010	148.4	1.15	21.1	5.7
2015	157.8	1.20	19.2	5.8
2021	169.4	1.16	18.1	5.5

Source: http://www.worlddata info.Population growth in Bangladesh

There is a great need for increased food production to feed the 184 million projected population in 2030, 197 million in 2040 and 204 million in 2050 and 176 million in 2100 (Fig. 5). It is being forseen that total food production needs to be increased by 29% in 2030, 43% in 2050 and 24% in 2100 if not otherwise constrained by severe impact of climate change (Bokhtiar and Samsuzzaman, 2023).

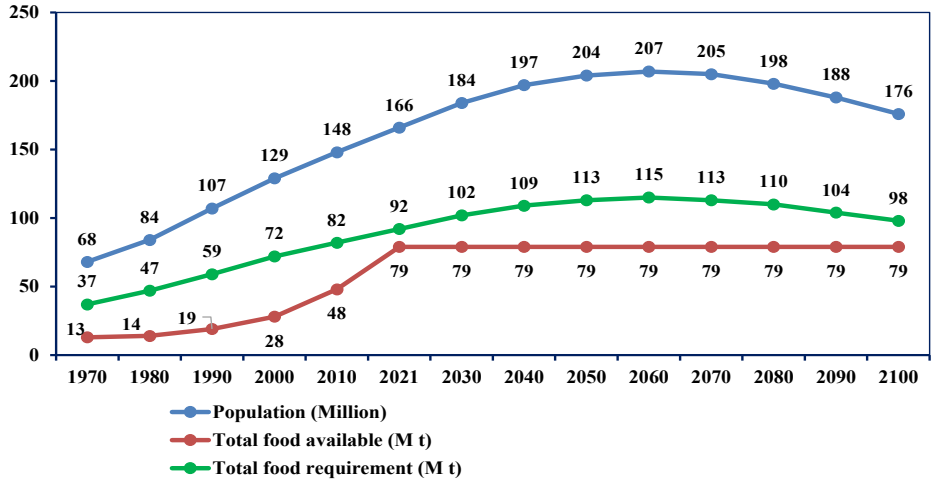


Fig. 5 Population versus food production requirement up to 2100
Source: FAO and WHO (2014), BIRDEM (2013), UNEP (2021)

Loss of arable land

Every year, huge amount of arable land is shifted to non-arable purposes, notably urbanization, human settlement and infrastructure. The annual land loss from crop land is estimated as 13,413 ha (0.137%) during 1976-2000, 68,760 ha (0.728%) during 2000-2010 and 82,173 ha (0.304%) during 1976-2010. This indicates that crop land decreased over time and this was estimated more than five times during 2000 to 2010 compared to 1976 to 2000 (Hasan *et. al.*, 2013). Overall, the country has been losing agricultural land annually by 0.24% from 9.88 million ha in 1976 to 8.33 million ha in 2021 due to the fast spread of rural settlement including human housing and urban industrial factories (Bokhtiar and Samsuzzaman, 2023). Soil erosion in hilly areas (especially in CHT due to jhum cultivation), deforestation, incessant rainfall, river bank erosion etc. are also potential way of losing farm land.

Climate vulnerability

The Climate Resilient Index analysis based on 20 years' data during 2000 -2019 indicates that the country is consistently at risk due to climate disasters which would be impacting greatly human health, education, agriculture and ecosystems (Amin, 2021). The major effects of climate change are increasing temperature, sea level rise, salinity, drought and flood. It is recorded that the mean temperature of the country is rising at 0.2°C per decade. The salinity level of groundwater along with surface water might rise rapidly due to climate change induced sea level rise (8th FYP 2021-2025). According to the Bangladesh National Adaptation Program of Action (NAPA) 2005, the sea level along the Bangladesh coast is rising at about 3 mm per year. Two-thirds of the country being less than 4.57 m above the sea level, making makes Bangladesh

one of the most vulnerable to rapid sea-level rise. In the last 35 years' salinity has increased by 26%, heavily impacting the agriculture sector. Increasing salinity also raises drinking water scarcity in coastal areas. Additionally, conversion of agricultural lands to shrimp farming has increased salinity in soil, destroyed local ecosystems, and impacted freshwater fishes. The local communities and their livelihood in the coastal areas are hugely vulnerable due to climate change (BPC, 2020). Changes in temperature and rainfall patterns netted by climate change have a great impact on agricultural production.

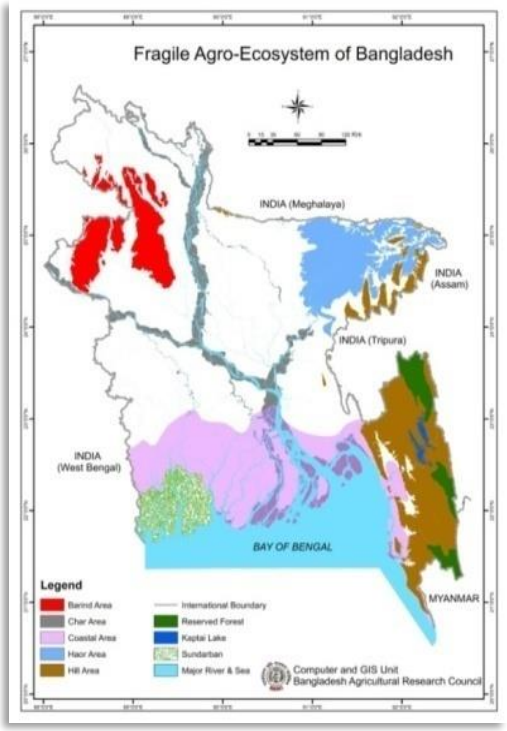
Fragile ecosystems

The "hotspots" as described in Bangladesh Delta Plan (BDP) 2100 are recognized as fragile ecosystems. Hotspots are prototypical areas where similar hydrological and climate change vulnerability characteristics and problems converge and influenced by natural hazards. In BDP 2100, hotspot is a broad grouping of districts and areas facing similar risks evolved by hydrology, climate change and natural hazards. The remaining part is identified as "cross-cutting" areas characterized by a combination of issues and challenges e.g. floods, drought, river bank erosion, sedimentation, groundwater depletion, water pollution, and water supply and sanitation. There are five fragile ecosystems across Bangladesh – Barind, Char, Coastal, Haor and Hill ecosystems. They are briefly described below.

Barind ecosystem covers the most parts of the greater Dinajpur and Rangpur districts under Rangpur division, and Pabna, Rajshahi, Bogura, Joypurhat and Naogaon districts under Rajshahi division. It is also popularly known as *Varendra Bhumi* in Bangla. Barind is a comparatively high and undulating region with reddish and yellowish clay soils. The Barind ecosystem is widely believed to have evolved from tectonic uplift and/or existed as an erosional geomorphic feature.

Char ecosystem covers the land masses formed through accretion of sedimentation of huge amounts of sand, silt and clay over time carried by three of the mightiest rivers of the world, the Padma, the Meghna, the Brahmaputra-Jamuna and their numerous tributaries (Satter and Islam, 2010). Chars in the northern regions are mostly composed of sand, those in the middle central regions are mostly silty and those downward are composed of clay particles (Karim, 2015).

The greatest spread of chars exists in the Jamalpur district, followed by the chars in Kurigram district. The Noakhali district possesses the greatest number of such coastal chars followed by Patuakhali and Bhola districts.



Coastal ecosystem consists of 19 southern districts: - Jashore, Narail, Gopalganj, Shariatpur, Chandpur, Satkhira, Khulna, Bagerhat, Pirojpur, Jhalakati, Barguna, Barishal, Patuakhali, Bhola, Laxmipur, Noakhali, Feni, Chattogram and Cox's Bazar (Abu et. al, 2003; MoWR, 2005). The western area of coasts is covered by Ganges Tidal Floodplain, the central area by Meghna estuary and the eastern area is covered by hilly areas. Mangrove forest under Satkhira district lies in the coastal region. Out of 19 coastal districts, 12 districts comprising 48 upazilas have met the sea or the lower estuary directly which are most vulnerable to natural disasters such as cyclones, tidal surges and salinity intrusion.

Haor is a wet land ecosystem in the north-eastern part of Bangladesh. The core haor area is spread over larger parts of Sunamganj, Habiganj, Moulvibazar and Sylhet districts. It also exists in Kishoreganj, Netrokona and Brahmanbaria districts. Haor is a basin like structure, which remains either stagnant or flash flooding condition during June through November. In haors, mainly boro rice is grown in the Rabi season with an advantage of longer time water retention in soil.

Hill ecosystem covers north-eastern and south-eastern part of the country. These hills exist in greater Sylhet, Chattogram and Chattogram Hill Tracts (CHT). CHT is located in the southeastern part of Bangladesh covering three hill districts - Rangamanti, Bandarban, and Khagrachari.

Every fragile ecosystem has some definite constraints, which affect crop production at varying degrees. Cropping intensity (CI) of the fragil system is much lower than the country's average CI, 199% (Table 8).

Table 8 : Major constraints of crop production in fragile ecosystems

Fragile ecosystems	Area (ha)	Constraints	Cropping intensity
Haor ecosystem	8,73,524	Flash floods, waterlogging, acid basin clay	133%
Char ecosystem	9,16,894	Riverine erosion and accretion, large sedimentation, low soil fertility	145%
Barind ecosystem	27,76,330	Hard soil clay, drought, declined groundwater level, low annual rainfall	218%
Coastal ecosystem	33,09,021	Soil and water salinity, high osmotic pressure, poor soil structure	127%
Hill ecosystem	18,36,605	Soil erosion, sloppy lands, deforestation, jhum cultivation	129%

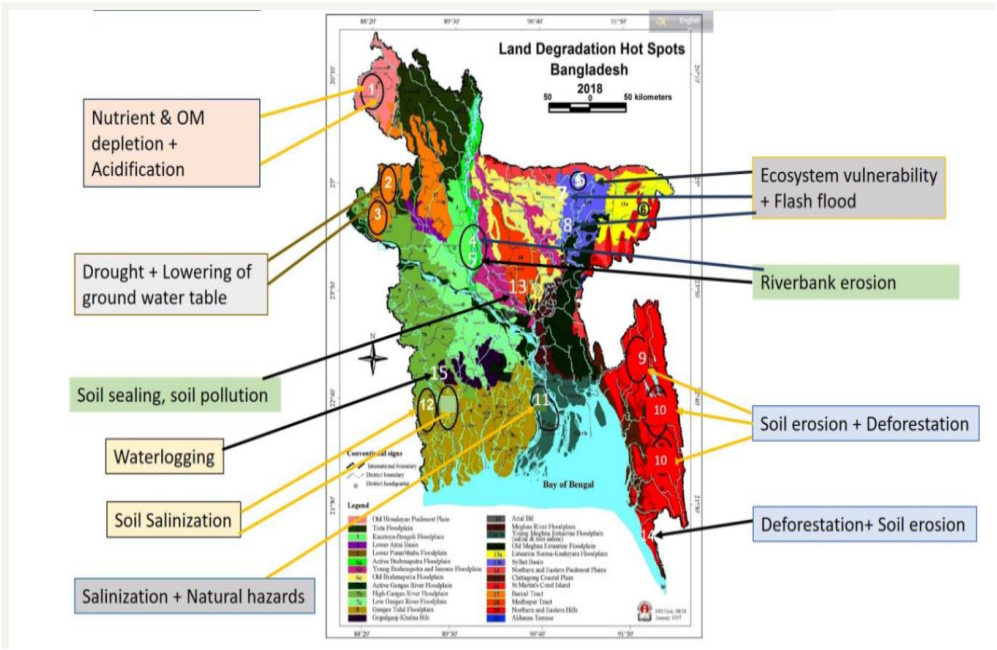
(Source: Bokhtiar *et. al*., 2023)

Land and soil degradation

Land degradation refers to a decline in the productive capacity of land. There are six major types of land degradation in Bangladesh: soil erosion, salinization, acidification, water-logging, soil fertility depletion and heavy metals contamination. The extent of soil erosion (hilly areas) is estimated 1.7 M ha, salinization 1.06 M ha, acidification 3.96 M ha and water-logging 2.6 M ha (SRDI, 2010). Concerning nutrient status in soils across the country, the very low to low P containing area is 0.889-3.43 Mha, K area from 0.287-2.43 Mha, S area from 0.726-2.58 M ha, Zn area from 0.749-2.01 M ha and B area from 0.544-2.10 M ha. Area of very low to low soil organic matter varied from 0.408 – 2.58 M ha (Hasan *et. al*., 2020). It appears that both land and soil fertility degradation increase with the passage of time. There is a need of sustainable land use for sustained crop productivity without incurring loss to soil environment. Sustainable land use is not only the basis for food, fuel and fibre production, and preserving essential ecosystem functions, it also provides the ways of adaptation to climate change.

Degradation of land is a big concern in Bangladesh, where arable lands are degraded with time. A total of 15 land degradation hotspots are identified in this country (Fig. 6.2). Under the Land Degradation Neutrality-Target Setting Program (LDN-TSP),

Bangladesh has set a voluntary target based on the agreed indicators and in other words to attain Sustainable Development Goal (SDG) 15: Land for life in order to achieve LDN by 2030.



1 Thakurgaon, 2 Naogaon, 3 Chapai Nawabganj, 4 Tangail, 5 Sirajganj, 6 Sunamganj, 7 Netrokona, 8 Kishoreganj, 9 Khagrachari, 10 Bandarban & Rangamati, 11 Bhola, 12 Khulna & Satkhira, 13 Dhaka, 14 Cox's Bazar, 15 Jashore & Khulna.

Fig. 6: Land degradation and hotspots in Bangladesh
(Source: ENALULDEP/SLM Project, 2020. DoE, Bangladesh)

There are two options to face the challenges of land degradation. The land fit can be made through adoption of some reclamation or mitigation measures (remediation) or the crops or varieties fit (adaptation) can be made for cultivation and the latter option is found better and sustainable.

Socio-economic factors

Technology must be productive, profitable and above all acceptable to the farmers. However, many technologies have not been adopted by the farmers although these were firm sound science based. Technology adoption depends on socioeconomic factors like occupation, education, training, farming experience, income, land tenancy, size of holdings, simplicity of the technology, exposure to the technology, farmers' awareness, access to credit, access to production inputs, affordability etc. Thus, the government strategies have a major impact on activities of agricultural productivity. Other challenges in Bangladesh agriculture include gender disparity

which is a pre-existing issue in the country. Hossain (2019) reported that the incidence of adoption among the female-led households is low possibly because they are constrained by lack of access to production inputs, credit, and extension services. Das and Mondal (2021) have suggested an emphasis to eliminate gender disparity and resolve small farm holding problem to ensure farm production and income generation. Das et. al. (2021) found ensemble learning-based approach for finding the relationships between socio-economic factors and agricultural productivity. There should be a problem-driven approach, rather than a proposal-driven approach which can produce a steady stream of innovations to meet critical needs of multiple communities from multiple dimensions. Crucial to this, women from these communities should be engazed as catalysts of change. If the barriers encountered by the female- headed households can be eliminated, food security will considerably be improved as technology-intensive or commercial crop cultivation has positive relationship with food security (Hossain, 2019).

Use of inputs such as seeds, fertilizers, pesticides and its extent depend on farmer categories. For example, fertilizer use gap with recommended dose is wide for small farmers compared to that for large farmers (Islam *et. al*., 2022).

Production risk factors

There are three categories of risks for sustainable and profitable crop production. These are climatic risk, biological risk and market risk. Bangladesh often experiences vulnerable climate and consequently the country receives salinity in the coastal areas due to sea level rise, drought in the barind areas due to heat stress with low rainfall, and flood in the haor areas. The crop production is also constrained by infestation of pests and diseases including transboundary diseases.

Volatility of market price is a major factor for farmers' decision to produce crops. Agricultural commodity prices are volatile because of short term production and consumption elasticity is low. Production responsiveness is low for annual crop commodities because planting decisions are made before prices for the new crop are known. These decisions depend on expected prices and not price realizations.

An increase in the supply of agricultural produce against constant demand, then the price will tend to fall. But if there is a decrease in the quantity of agricultural produce supplied but demand remains the same, the prices will rise. Markets are always on the move, but the speed and size of price changes which creates excitement and risk for traders. The high costs and low profits of agricultural production are the major internal inhibitors of Bangladesh's agriculture sector. They are also the primary factor restricting the growth of farmers' income and leading a shrinking farm labor availability in agriculture.

The widening of the market helps in increasing the demand on a continuous basis, and thereby guarantees a higher income to the producer. An improved and efficient system of agricultural marketing helps in the growth of agro-based industries and stimulates the overall development process of the economy. Price risk management becomes an important tool for the government who wishes to avoid the adverse budgetary impact of interventions either to support export prices or cap import prices. In fact, agriculture markets have always been volatile, but if government is active then extreme price swings can be mitigated and vulnerable consumers and producers can be protected.

Alam *et al*., 2020a found that price fluctuation of rice varies with seasons, months and years. They concluded that cost minimization strategy, intensive market monitoring, regulation for rice processing industries and timely government interventions are the important factors for ensuring stability in the market. Their studies with price volatility of potato suggested steps for stabilizing potato price are: announcement of maximum and minimum support prices after setting up agricultural price commission; removal of ambiguity on production, demand, supply and price data; monitoring prices and release of potato from cold storage by government; broadcasting the true picture with data by government to counter any rumor in the market; and expanding export and processing of potato (Alam *et al*., 2020b). Concerning price volatility of onion, reduction of dependency on India for large scale import, increased domestic production, fixing onion prices throughout the year and control of the market from the invisible syndicates are recommended to avoid such unexpected price spike (Alam *et al*., 2020c).

Encouragingly, the National Agricultural Marketing Policy 2023 aimed to support enhancing links between farmers and markets, strengthening information management, improving marketing infrastructures, promoting e-agricultural marketing system and digital markets, strengthening community, group and contract-based marketing; and developing the overall supply chain as attempts to secure a healthy market. In reducing the market price volatility, the policy suggests set of farmers' price by adding 30% of production cost while the wholesalers and retailers can make 15 and 25% profit margin, respectively.

Constraints and opportunities

The constraints and opportunities, which were identified from different regional workshops, are stated below as per administrative division.

Khulna division

It has 10 districts - Khulna, Bagherhat, Sathkhira, Jashore, Magura, Jhenaidah, Narail, Kushtia, Chuadanga and Meherpur. It contains both coastal and plain lands.

Constraints	Opportunities
1. Saline soil and saline river water hinder crop productivity in the region	• Adoption of saline tolerant crops and crop varieties and management practices • Adoption of CA (conservation agriculture) • Scope of organic farming in ghers • Excavation of canal for storage of rain water (policy)
2. Farmers use unbalanced dose of fertilizers	• Impart farmer's training and field demonstration • Scaling of ICT tools
3. Low productivity of coconut due to pest Infestation	• Development of technology to control insect pests and diseases of coconut
4. Lack of Panama and Sigatoga resistant varieties of banana	• Development and availability of of Panama and Sigatoga resistant varieties of banana
5. Late blight of potato and root rot of chili	• Development of cultivars resistant to late blight of potato and root rot of chili
6. Fall armyworm damages maize in the field	• Development of fall armyworm resistant variety of maize • Management options to be developed
7. Paucity of soft loan for spice crop cultivation.	• Provision of enough credit at low-interest rate for spice crop farmers
8. Lack of seed storage facilities (cocoons) and seed drying equipment (during monsoon season)	• Ensuring supply of sufficient cocoons and seed drying equipment to seed-producing groups
9. Shortage of seeds of wheat blast and rice blast-resistant varieties	• Strategy to enhance seed availability (policy issue) • Develop blast resistant rice and wheat varieties

Constraints	Opportunities
10. Inadequate upazila level field trials of modern varieties of crops and technologies	• Strengthening modern technology transfer, minimizing yield gap and crop diversification and intensification with high-value crop.
11. Shortage of quality seed of recently released varieties	• Ensuring the supply of recently released crop varieties
12. Lack of simple mechanical technology to facilitate threshing	• Development of small farm tools and machineries for threshing
13. Shortage of seeds of dwarf variety sunflower	• Ensuring supply and extension of short and HYV sunflower seeds
14. Low yield of native minor tuber crops e.g. aroids	• Development of varieties and management practices for cassava, aroids (olkachu, mankachu), elephant foot yam etc.
15. Uneven maturity of mungbean	• Development of variety with synchronized ripening

Rajshahi division

It consists of 8 districts- Rajshahi, Natore, Bogra, Pabna, Sirajganj, Naogaon, Chapainawabganj and Joypurhat. It contains plain land, terraces and char lands.

Constraints	Opportunities
1. Low soil pH	• Liming of acid soils having pH below 5.0, at 1 t/ha dololime
2. Low soil organic matter	• Conservation Agriculture (CA) practice • Legume based crop rotation
3. Drought (climate change effect)	• Adoption of drought tolerant varieties of crop • Cultivation of less water requiring crops • Establishment of mini pond (12m x 12 m x 3m) to retain rain water, which can provide irrigation water to 1 ha land of T. Aman rice

Constraints	Opportunities
	• Buried pipeline irrigation and AWD
4. Fallow land during rabi season	• Cultivation of pulses e.g. chickpea, lentil, etc.
5. Pest and disease infestation of mango	• Adoption of preventive and control measures
6. Inadequate availability of quality seeds	• Increasing production and availability of quality seeds (policy issue)
7. Lack of sufficient credit facilities	• Expand credit facilities with minimum interest (policy issue)
8. Weak marketing system	• Strengthening market system (policy issue) • Value addition by fruit bagging (mango, litchi)
9. Lack of farmers' awareness regarding modern crop production technologies	• Arrangement of pertinent training and block demonstration (policy issue)

Barishal division

It has six districts - Barishal, Barguna, Bhola, Jhalokati, Pirojpur and Patuakhali. All are lying in the coastal zones.

Constraints	Opportunities
1. Climate vulnerabilities – consequences as tidal surge, cyclones etc.	• Development and use of climate smart technologies
2. Poor management of polders and sluicegates	• Management of polders and sluicegates by coastal community (policy)
3. Soil and water salinity	• Establish rain water harvest reservoir and excavation of canals for sweet water conservation, and irrigation (policy) • Adoption of salt tolerant varieties

Constraints	Opportunities
	• Use of mulch to conserve soil moisture and reduce salinity effect
4. Late recesion of tidal water after *Kharif*-2 season, which causes delaying of rabi crops	• Promotion of local technologies e.g. sorjan, dyke cropping for creeper vegetables, floating gardening etc. • Zero tilled cultivation (use of ZT drill)
5. Low cropping intensity	• Adoption of short duration salt tolerant crops, relay cropping (e.g. T. Aman rice – Grasspea) • Potato, garlic and sunflower cultivation under zero tillage system • Maize and sunflower cultivation through dibbling
6. Poor market facilities of agricultural produces	• Establishment of market linkage
7. Poor agricultural creditfacilities	• Enhance soft loan provision by the Government
8. Lack of agro-based industries	• Both Government and NGOs should take initiatives
9. Lack of farmers' awareness and capacity building	• Enhance capacity building and awareness of the coastal farmers by training and field demonstration • Field days and exposure visit

Chattogram division

It has 11 districts – Chattogram, Cox's Bazar, Rangamati, Bandarban, Khagrachhari, Feni, Lakshmipur, Cumilla, Noakhali, Brahmanbaria and Chandpur. It contains hills, coasts, char and plain lands.

Constraints	Opportunities
1. Long dry season, poor irrigation system, and limited surface water in hilly areas	• Watershed management • Drip irrigation, sprinkler irrigation, mulching film etc. • Growing spices (zinger, turmeric, bayleaf, cinnamon, black pepper etc.) in fringe lands using surface water irrigation from creaks and streams
2. Low cropping intensity (129%) and low crop yield in hilly areas	• Breeding HYVs crops varieties for jhum cultivation • Growing short duration vegetables • Grow fruits (mango, citrus, papaya etc.) and vegetables in higher traced land and hill slopes
3. Soilerosion in hilly areas	• Promote Village Community Forest (VCF) in the hilly areas • Establish agroforestry/horticulture, no tilling on slopes, grow hedge plants eg, leguminous shrubs/trees etc. across the slopes • Improve jhum cultivation or find alternate to jhum cultivation
4. Poor marketing facilities in hilly areas	• Establish fruit processing plant unit with cool chamber facilities • Establish community based agriculture marketing system • Establish improved market linkage
5. Unavailability of quality seeds of HYVs and hybrids	• Strengthening DAE service for increasing access of hill farmers to quality seeds of HYVs and hybrids.
6. Salinity in coastal areas (Feni, Noakhali, Laksmipur, Cox's Bazar)	• Development and adoption of salt tolerant varieties and management practices

7. Poor agricultural credit facilities	• Enhance soft loan provision by public private organizations.

Rangpur division

It consists of eight districts- Rangpur, Gaibandha, Nilphamari, Kurigram, Lalmonirhat, Dinajpur, Thakurgaon and Panchagarh. It contains plain land, piedmont, black terai and charlands.

Constraints	Opportunities
1. Low cropping intensity with two crops based cropping pattern	• Increase cropping intensity • Boro – Fallow - T. Aman rice can be replaced by Mustard - Boro -T. Aman rice
2. Ignorance of farmers on modern farming systems	• Promoting modern farming practices e.g. CA
3. Low availability of quality seeds	• Strategy development for promoting availability of quality seed
4. Minimum irrigation facility with minimum number of irrigation pumps	• Expand Government subsidy on irrigation pump (policy issue) • Increase irrigation pumps, with subsidy on diesel and provide electricity in char areas (policy issue)
5. Weak marketing system for poor transport	• Strengthening community marketing system (policy issue)
6. Lack of sufficient credit facilities	• Provide adequate loan support from credit organizations (policy issue)
7. Inadequate cold storage facility	• Establish cold storage with government loan at minimum interest (policy)
8. Lack of food processing industry	• Build up food processing unit (policy issue)
9. Fallow land and inadequate scope of growing early vegetables	• Better scope to grow pulses, oil-seeds and spices

Sylhet division

It has four districts - Sylhet, Habiganj, Moulvibazar and Sunamganj. It contains diversified landscape – haors, hills and plain lands.

Constraints	Opportunities
1. Low cropping intensity with two crops based cropping pattern	• Increase cropping intensity by inclusion of a new crop in the pattern (example, Boro – Fallow - T. Aman rice to be replaced by Mustard - Boro -T. Aman rice)
2. Flash flood in April affects Boro crop and Seasonal flood damages different crops	• Early transplantation of Boro rice, preferably in December • Promote sac gardening technology • Promote floating garden and Sorjan farming
3. Cold injury in Boro season	• Development of rice varieties with cold tolerance tarits
4. Low availability of quality seeds	• Strategy development for promoting quality seed availability (policy issue)
5. Insect pest and disease infestation	• Expansion of preventive and control measures
6. Weak marketing system and poor transport	• Strengthening community marketing system (policy issue)
7. Lack of sufficient credit facilities	• Strengthen loan support with a small interest from credit organizations (policy issue) • PPP (Public-Private Partnership) efforts to be paid for resource allocation
8. Soil erosion in hilly areas	• Contour planting • Establish agroforestry/horticulture, no tilling on slopes, grow hedge plants eg, leguminous shrubs/trees across the slopes

Mymensingh division

It has four districts - Mymensingh, Netrakona, Jamalpur and Sherpur. It contains plain land, charland and hills (very small area).

Constraints	Opportunities
1. Low soil pH in 30% land (Haluaghat)	• Application of dololime to correct soil pH
2. Rice-Fallow-Rice is the dominant cropping system	• Inclusion of mustard or legume after harvest of short duration T. Aman rice • Introduction of Conservation Agriculture (CA) practice, which will allow the second crop after T. Aman harvest
3. Insufficient supply of quality seeds	• Strengthening production and supply of quality seeds (policy)
4. Pest infestation	• Development of biotic stress tolerant varieties • Use of bio-pesticides and bio-rational based IPM system
5. Drought in char land during rabi season	• Cultivation of low water requiring crops • Cultivation of dry seeded rice (DSR) • Expansion of irrigation facilities
6. Low water holding capacity (WHC) of light textured soils	• Use of biochar to increase water holding capacity) • Cultivation of green manure (GM) crops
7. Poor credit facilities	• Expand credit facilities at minimum interest (policy issue) • PPP (Public-Private Partnership) efforts to be paid for resource allocation
8. Weak marketing channel	• Strengthening market system and value addition (policy)
9. River bank erosion	• Use of soil erosion mats or blankets (made of stabilization fabric)
10. Lack of scientific know-how of farmers	• Create awareness and build-up capacity of farmers to adopt climate resilient technologies (policy issue) • Integrated farming systems

Dhaka division

It has 12 districts - Dhaka, Faridpur, Gazipur, Gopalganj, Kishoreganj, Madaripur, Manikganj, Narayanganj, Narsingdi, Rajbari, Shariatpur and Tangail. It contains industries, terraces, haor and plain lands.

Constraints	Opportunities
1. Medium cropping intensity (199%) ;	• Promote cultivation of short duration crops and varieties • Encourage multiple cropping, inter-cropping, relay cropping and mixed cropping • Commercial farming with high value crops in peri-urban areas
2. Industrial discharge (effluent) polluting land and crops	• Industries must follow the government rules for management (policy) • Recycling of water discharge for use in urban agriculture.
3. Pest (insect and disease) infestation	• Develop and use of pest tolarant crop varieties • Use of bio-pesticides and bio-rational based IPM system
4. Scarcity of HYV quality seeds	• BADC should be pro-active for increasing seed availability (policy issue)
5. Unstable market price	• This problem is common across the country. • Market linkage is to be strengthened • Value chain for agro-products to be improved
6. Non-judicial use of fertilizers	• Farmers' awareness could be improved through training and use of social media
7. Low access to credit which limits resource- poor farmers to adopt technologies	• Governmet strategy is needed for greater access of farmers to credits with low interest • PPP (Public-Private Partnership) efforts need to be paid for resource allocation

Summary of future research priorities

As identified and suggested from regional workshops, there are many common and diverge problems existing in the field hindrering achieving sustainable and profitable agricultural production. Similarly, literatures, the national policies and plan documents indicated many challenges that are limiting prosperous Bangladesh agriculture. However, all these problems are not researchable but some are policy issue. Furthermore, some issues do not belong to classical research and many of them are action research or strategic research. Based on the collected field problems and synthesis of national plans, policies and related documents, the following priorities deserve due attention for designing future research in crops sub-sector.

- Collection and conservation of plant genetic resources
- Development of biotic and abiotic stress tolerant crop varieties
- Development of high yielding, hybrid, short duration and nutrient rich crop varieties
- Improvement of propagation techniques for fruits, flowers and ornamental plants
- Enhancing farm productivity through improved soil, water, and crop management
- Improvement of cultural practices for yield maximization of jute and cotton
- Development and up-scaling of climate smart agricultural practices
- Promoting mechanization in inter-cultural operations and solar power in irrigation
- Integrated farming system involving agricultural diversification, intensification and value chain
- Efficient pest and disease management
- Development of low cost and high impact post-harvest technologies
- Transformation of agriculture using 4IR, biotechnology, nanotechnology and precision agriculture
- Promotion of market intelligence and marketing for home and abroad facilitating commercial agriculture
- Improvement of public-private partnership for technology diffusion and entrepreneurship development
- Policy research by analyzing constraints to accelerate adoption of agricultural technologies

Research Area Prioritization

Research priority setting in agriculture is required to be adjusted under changing scenarios and to undertake demand-driven research addressing need of the farmers. With the advancement of time, research priority document needs updating under climate change, population increase, emerging cropping systems, socio-economic changes, and government policies and thrust. Thus, the current document is an update version of "Research Priorities in Bangladesh Agriculture: Vision 2030 and Beyond' that was prepared by BARC in 2011.

Vision and Mission

Vision

Technology innovations for sustainable safe food and nutrition security, and farm commercialization.

Mission

Harnessing the potential of science and technology for higher crop productivity, diversification, and livelihood improvement.

Aims

- Generate demand-driven, sustainable and profitable technologies
- Technological innovations for crop diversification, yield gap minimization, nutrient rich safe food production and climate resilient production system
- Document and disseminate research outputs to stakeholders
- Formulate strategies to improve and sustain crop productivity without affecting natural resources (soil, water, biodiversity and forests).

Priority Research

Research priority areas have been grouped into seven thematic areas out of which five thematic areas have two or more sub-thematic areas and the other two do not have sub-thematic area. So, specific research issues are stated under each thematic and sub-thematic area.

Thematic area	Sub-thematic area
1. Genetic Resources Characterization Evaluation, Conservation and Crop Improvement	• Stress tolerance, quality improvement ann breaking yield ceiling • Genetic resource management • Breeding value enhancement
2. Soil and Crop Management	• Soil health management for diversified cropping • Crop management
3. Crop Protection	• Pest and disease management • Bio-pesticides development • Monitoring and surveillance
4. Farm Mechanization, Irrigation and Post- harvest Management and Processing	• Farm mechanization • Irrigation and water management • Post-harvest management and processing
5. Technology Validation and Adoption	• Technology validation • Technology delivery system and assessment • Linkage improvement
6. Socio-economic and Marketing issues	• Socio-economic aspects of innovated technology • Market Research • Innovation in commercial agriculture
7. Cross-cutting issues	• Climate smart agriculture • Integrated farming Systems • Women and youth employment • Capacity development

The research issues/areas showing types of research, priority ranking and time-scale (duration) under each thematic and sub-thematic area are shown in a tabular from below:

1. Thematic area : Genetic Resources Characterization, Evaluation, Conservation and Crop Improvement

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
1.1 Stress tolerance, quality improvement and breaking yield ceiling			
1. Rice • Yield improvement of local rice germplasm (GI crops) with special characteristics and value	B	H	L
Population improvement for breeking yeild ceiling	B & A	H	L
• Breeding for premium quality rice (aromatic/non-aromatic)	B & A	H	L
• Breeding for photo-period sensitive rice	A	M	L
• Development of modern rice with nutritional and nutraceutical properties (black/purple/red)	B & A	M	L
• Development of biotic (e.g. stem borer, bacterial blight, blast etc.) and abiotic (e.g. salinity, drought, heat, cold, submergence etc.) stress tolerant HYV rice	B & A	H	L
• Breeding for early maturing HYV rice	A	H	L
• *In situ* conservation of rice germplasm			
• Breeding for high yielding direct seeded rice (Deep Water : Shallow and medium ; Upland rice : aerobic, and aerobic)	B &A	M	L
• Improvement of protein and micronutrient (Zn, Fe, etc.) rich biofortified rice	B &A	H	L
• Improvement of nutrient (e.g. N, P, K, S, Zn etc.) and water use efficient varieties	B & A	H	L
• Improving harvest index and physiological efficiencies	A	M	M
2. Wheat • Development of biotic (e.g. aphids, Bipolaris leaf blight, blast etc.) and	B & A	H	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
abiotic (e.g. heat, drought, salinity etc.) stress tolerant HYV wheat			
• Breeding for early maturing and late planting wheat	B & A	H	L
• Improvement of nutritional (e.g. protein, vitamin, Zn, Fe etc.) and industrial values (e.g. bread, biscuit, noodles etc.) of wheat	B & A	H	L
• Double Haploid breeding and speed breeding in wheat	A	H	L
• Exploitation of modern techniques for population improvement	A	M	M
3. Maize • Development of biotic (e.g. fall armyworm, leaf blight etc.) and abiotic (e.g. heat, drought, salinity) stress tolerant HYV maize	B & A	H	L
• Development of pop corn (baby corn) and sweet corn hybrid maize	A	M	L
• Improvement of nutrient (e.g. N, P, K, S, Zn, B etc.) use efficient and nutritient rich maize	B & A	H	L
4. Pulses • Development of disease (e.g. Stemphylium blight in lentil, fusarium wilt in chickpea, yellow mosaic virus in mungbean & cowpea, foot & root rot in blackgram, grasspea & field pea etc.) and abiotic (e.g. drought, salinity etc.) stress tolerant HYV pulses	B & A	H	L
• Early maturing and high yielding pulses, and development of synchronous flowering mungbean	B & A	H	L
• Improvement of protein, zinc and iron dense pulse varieties	B & A	H	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
5. Oilseeds • Development of disease (e.g. alternaria leaf blight in mustard, tikka in groundnut, yellow mosaic virus in soybean, stem rot in sesame, sclerotinia in sunflower etc.) and abiotic (e.g. drought, heat, salinity etc.) stress tolerant oilseed crops	B & A	H	L
• Improvement of short duration, low erucic acid and high yielding climate smart varieties (OP & hybrid) of mustard	B & A	H	L
• Development of dwarf hybrid sunflower varieties	A	M	M
6. Vegetables • Improvement of inbreds and hybrids of different kinds of vegetables	B & A	H	L
• Development of disease and insect pests tolerant varieties	B & A	H	L
• Breeding for vitamin and micronutrient (e.g. Zn, Fe etc.) rich vegetables	B & A	H	L
• Introduction and evaluation of potential exotic vegetables • Improvement of off-season vegetable variety	A	M	L
7. Fruits • Improvement of high yielding, good quality, regular bearing varieties of mango, jackfruit, litchi, guava, etc.	B & A	H	L
• Development of early, late and year-round varieties of mango, jackfruit and other fruits	B & A	H	L
• Development of disease (e.g. anthracnose in mango, fruit rot in jackfruit & pineapple, wilt in guava, greening in citrus, bud rot in coconut, canker in citrus etc.) resistant varieties	B & A	H	L
• Development of insect pest (e.g. mango hopper, fruit borer in litchi & jackfruit, rugose spiraling in coconut,	B & A	H	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
fruit beetle in banana, leaf miner in citrus etc.) resistant varieties			
• Improvement of propagation technique for fruits, flowers & ornamentals plants	B & A	H	L
• Development of export quality fruit varieties	B & A	H	L
• Improvement of indigenous and exotic fruits (strawberry, dragon fruit, etc.)	B & A	H	L
8. Tuber crops • Development of late blight resistant potato varieties	B & A	H	L
• Improvement of nutritional values in potato and sweet potato	B & A	H	L
• Breeding for potato varieties of export quality or industrial purpose (chips)	B & A	H	L
• Breeding for short duration high yielding potato varieties	B & A	H	L
• Breeding for high yielding taro	B & A	M	L
9. Spices • Improvement of high yielding and quality traits of spices	B & A	H	L
• Development of biotic and abiotic stress resistant varieties of spices	B & A	H	L
• Improvement of high yielding summer onion varieties	B & A	H	L
10. Fibre crops • Improvement of high yielding and poor photo sensitive white jute varieties	B	H	L
• Improvement of high yielding and vegetable type white and tossa jute varieties	B & A	H	L
• Development of drought and salt tolerant white jute varieties	A	H	L
• Improvement of high yielding and short duration mesta and kenaf (spineless) varieties	B	H	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Development of salt tolerant mesta and kenaf varieties	A	H	M
• Development of salinity and drought tolerance cotton varieties	B & A	H	L
• Development of pest (e.g. jute stem weevil, jute hairy caterpillar etc.) and disease (e.g. anthracnose, stem rot, die back etc.) resistant jute varieties	B & A	H	L
• Development of mealy bug resistant mesta and kenaf varieties	B & A	H	M
• Development of high yielding inbreed and hybrid cotton (e.g. Bt cotton etc.)	B & A	H	L
• Improvement of Phuti Karpus for special purpose fibre	B & A	H	L
11. Sugar crops • Improvement of high yielding, short duration and high sugar containing sugarcane and sugarbeet varieties	B & A	H	L
• Development of salinity, submergence and drought tolerant varieties	B & A	H	L
• Amelioration in pest and disease resistance	B & A	H	L
• Micropropogation of elite sugarcane clones for production of high quality setts	A	M	M
• Micropropagation of vegetative seed production of sugarbeet	A	M	M
• Improvement of Stevia through tissue culture and other techniques	A	M	M
• Improvement of locally adaptive arabian date palm and palmyra palm	A	M	M
• Development of date palm varieties with higher nutraceitical and medicinal properties	A	M	M
12. Tea • Improvement of high yield and quality potential tea clones	A	M	L
• Development of hybrid tea seed of biclonal and polyclonal stocks	A	H	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Standardization of vegetative propagation (VP) techniques	B & A	M	L
• Development of high value export quality tea	A	H	L
• Conservation of tea germplasm (gene bank)	A	H	L
• Breeding for stress tolerant tea	A	M	M
13. Flowers and ornamentals • Improvement of gladulous, tube rose, rose, lilium, gerbera, anthorium, marigold, ornamental foliage, etc.	A	H	L
• Developmenrt of dwarf hybrid and export suitable flowering & ornamental plants	B & A	H	L
• Introduction and evaluation of exotic ornamentals and flowering plants	A	M	M
• Development of pest and disease (e.g. aphids, corm rot, leaf spot etc.) resistant flower plants	B & A	H	L
1.2 Genetic resource management			
• Collection, evaluation and *in situ* conservation of germplasm of crops and their utilization	B & A	H	L
• Identification and exploitation of novel traits for biotic and abiotic stress tolerance and nutrient dense.	A	H	L
• Improvement of genetic resource management system	A	H	L
• Assessment of total plant genetic diversity and its extent of erosion for follow up improvement program	B	H	L
• Screenng and genotyping (allele mining) of land races	A	M	M
• Promotion of GI (Geographical index) crops			

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
1.3 Breeding value enhancement			
• Omics based gene mapping, trait stacking, genomic prediction, praisom of speed breeding	B & A	H	L
• Exploitation of high-throughput selection markers and techniques	B & A	H	L
• Molecular breeding including genome-editing technology (CRISPR-Cas9) for genetic gains	B & A	H	L
• Breaking yield ceiling, exploitation of hybrid vigor (heterosis) and mutation breeding	B & A	H	L

2. Thematic area: Soil and Crop Management

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
2.1 Soil health management for diversified cropping systems			
1. Soil organic matter • Carbon sequestration of soils through Conservation Agriculture (CA) approach	B & A	H	M
• Organic amendments of soil with FYM, poultry manure, bio-slurry, compost, green manure, city wastes, etc.	A	H	M
• Improvement of soil physical characteristics e.g. water holding capacity, soil structureetc.	A	M	M
• Soil erosion control in slopping areas	S	M	L
2. Soil fertility and fertilizer management • Fertilizer need assessment for major crops and cropping patterns for intensive cropping systems and fragile ecosystems	A	H	M
• Integrated nutrient management for rice based cropping systems	B & A	H	M

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Integrated nutrient management for sugarcane with intercrops and for chewing cane	B & A	H	M
• Fertilizer management for important fruits and vegeatables	A	H	M
• Fertilizer management for newly developed jute varieties for fibre and seed production	A	M	M
• Fertilizer management for better yield and fiber quality traits of inbred and hybrid cotton	A	M	M
• Fertilizer management for roof top gardening and floating bed	B & A	M	M
• Improvement of urea use efficiency using nano fertilizer, neem coated urea, urea deep placement, AWD irrigation, etc. in rice cultivation	B & A	H	L
• 4IR nutrient stewardship for coastal crop production	B	H	L
• Mitigation of greenhouse gas (CH_4, N_2O and CO_2) emission from wetland rice fields (anaerobic) and dryland wheat, maize and other crop fields (aeorobic)	B	H	L
3. Bio-fertilizers and microbial agents • Abundance and characterization of soil microbes	B	H	L
• Development of biofertilizers for rice (e.g. *Azotobacter*), pulses (e.g. *Rhizobium*) and sugarcane (plant growth promoting bacteria)	B & A	H	M
• Development of mycorrhizal biofertilizers for use in vegetables, fruits and forest crops	B & A	H	L
• Development of bioactivators for rapid composting or decomposition of crop residues	B & A	H	L
4. Soil and water pollution • Extent of soil and groundwater pollution from surface applied agrochemicals (fertilizers, pesticides),	B & A	H	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
industrial wastes, municipal wastes and its remediation			
• Heavy metal (As, Cd, Pb) contamination in soil from use of contaminated irrigation water and organic wastes	B	H	L
• Amendment of heavy metal conataminated soils by phytoremediation and biochar application	B	H	L
2.2 Crop management			
1. Rice • Improve nutrient dense, resource efficient and profitable rice-based cropping systems for favorable and unfavorable environments	A	H	L
• Integrated crop management (ICM) for higher rice productivity in different rice ecosystems	A	H	L
• Intensification and diversification of rice-based cropping systems in different rice ecosystems	A	H	L
• Improvement of management practices for DSR (direct seeded rice)	A	M	S
• Development of agronomic practices for quality seed production	A	H	L
• Precision agriculture in rice-based cropping systems	A& B	H	L
2. Wheat • Cultural management of wheat in coastal and barind areas	A& B	M	L
• Cultivation of low water requirng crops (e.g. wheat) in drought prone barind areas	A& S	M	L
• Adoption of CA practice in dry land crop cultivation e.g. wheat	A	M	L
• Integrated weed management including bio-herbicides	A	M	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
3. Maize			
• Introduction of maize after T. Aman rice in char and coastal areas	A	H	L
• Improvement of cultural practices for inbred and hybrid maize	A	H	L
• Develop minimum tillage plant establishment techniques for rabi crops (maize, wheat, sunflower etc.) in excessive soil moisture condition in coastal region	B	H	L
4. Pulses			
• Innovation of nutrition sensitive cropping systems with pulses	B &A	H	L
• Crop management package for inter cropping and relay cropping of pulses with other crops	A	H	L
• Application of *Rhizobium* biofertilizer in pulse cropping for new areas	A	H	L
5. Oilseeds			
• Intensification of mustard cultivation after T. Aman rice	A	H	L
• Intensification of groundnut and mustard in char areas	A	H	L
• Innovative cultural practices for sunflower, linseed and groundnut in coastal areas	A	H	L
6. Vegetables			
• Improve production technologies including micronutrient application for vegetables production	A	H	L
• Improve production of HYV and hybrid vegetables in the coastal and hilly regions	S &A	H	L
• Development of effiective organic culture for production of high value vegetables (e.g. tomato, bitter gourd, capsicum etc.)	A	H	L
• Innovative cultural practices for homestead and roof top gardening	A	H	L
• Improvement in vertical agriculture (hanging agriculture, tower gardening,	A	H	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
hydroponics, aeroponics and aquaponics)			
• Technology for year-round vegetables production	A	H	M
• Community based organic farming for safe vegetble production	A	M	S
7. Fruits • Innovative cultural practices for major fruit crops (e.g. mango, litchi, guava, pineapple, papaya etc.)	A	H	L
• Develop appropriate training, pruning, and fruit thinning for major fruit crops	A	H	L
• Improvement of PGR (plant growth regulator) for flower initiation and fruit set retention in mango, pineapple, etc.	A	M	M
• Improvement of crop management for newly introduced fruit species in hill and coastal areas	A	H	L
• Development of efficient agro-forestry practices	A	H	L
8. Tuber crops • Standardization of cultural practices including micronutrient use	A	H	L
• Standardization of zero tillage potato cultivation with mulching in the southern region	A	M	L
• Improvement in cultivation of high yielding yam, olkachu and mankachu in the homesteads	A	M	L
9. Spices • Improvement of management practices for different spice crops	A	H	L
• Introduction of zinger and turmeric in the homestead area	A	H	L
• Introduction of spices in the non-traditional areas like coastal and hilly areas	A	M	M

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
10. Sugar crops			
• Improvement of cultural practices for sugarcane intercropping with rabi crops (e.g. potato, pulses, mustard etc.) and sugarcane ratoon	A	H	L
• Ratooning ability of modern sugarcane varieties in terms of planting materials in different agroecosystems	A	M	M
• Determination of critical period of crop-weed competition in sugarcane	A	M	L
• Modern techniques and practices for hyegenic gur production and preservaton	B & A	M	L
• Development of improved techniques for Stevia production and sterioside extraction	A	M	L
11. Fibre crops			
• Improvement of cultural practices for yield maximization of jute	A	M	L
• Weeding and herbicide management of tossa jute (*Corchorus olitorius*)	A	M	L
• Top cutting of jute as year round vegetable (leaf) production	A	M	L
• Quality seed production of jute	A	M	L
• Development of bacterial consortia for retting of jute, mesta and kenaf	B	M	L
• Improvement of cultural practices for yield maximization of cotton	A	M	L
12. Forestry			
• Improvement of cultural practices for promising bamboo species in coastal and hilly areas	A	M	{L
• Development of agro-forestry models	A	H	L
• Improvement of forestry management system			
• Improvement of cultural practices for major medicinal plants	A	M	M
13. Tea			
• Determination of pruning cycle for optimum crop production	A	M	M

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Identification of suitable methods of crop harvesting to optimise yield and quality	A	M	M
• Determination of ideal plant population and planting methods	A	M	M
• Improvement of grafting method for rapid mother bush establishment	A	M	M
14. Flowers and ornamental plants • Standardization of cultural practices for commercial cultivation of major flowers (e.g. gladulous, tube rose, rose, lilium, zarbera, anthorium, marigold etc.) and ornamental foliage	B & A	H	L
• Improvement of seedling raising technique	A	H	L
• Improvement of pot culture technique (eg, pot size, soil amount, compost, fertilizers etc.)	A	H	L

3. Thematic area: Crop Protection

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
3.1 Pest and disease management (general)			
• Mapping of pest status and exploitation of pest resistance using molecular technique	B	H	M
• Improvement of IPM and nanotechnology	B	H	L
• Ecosystem based location specific pest management system	A	H	M
• Sensor-based pest diagnosis and pesticide recommendation	B	M	L
• Develop, calibrate and validate pest management framework	S	H	M
• Epidemiology of crop pests and diseases with climate change interactions	A	M	M
3.2 Pest and disease management (Crop specific)			

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
1. Rice • Optimum dose of pesticides and alternative cultural (e.g. waterlogging) and biological management of rice pests e.g. rice hispa, stem borers, brown planthopper (BPH) etc.	B & A	H	M
• Bio-pesticides and bio-rational based IPM for rice pests	A	H	M
• Integrated Disease Management (IDM) including planting time, cultural practices (e.g. weeding, flood irrigation etc.) and fungicides for management of rice diseases (e.g. neck blast, bacterial leaf blight, sheath blight, tungro, etc)	A	H	M
2. Wheat • Development of bio-pesticide based management (e.g. aphids, green bug, etc)	B & A	L	M
• Promotion of IDM for control of wheat diseases (e.g. blast, bipolaris leaf blight, rust, black point, etc.)	B & A	H	M
3. Maize • Bio-pesticide based management (e.g. fall armyworm, cut worm, etc.)	A	H	M
• IDM for maize diseases (e.g. fall armyworm, leaf blight, fusarium stalk, etc.)	A	H	M
4. Pulses • Development of IPM against major pests (e.g. aphids in blackgram & lentil, pod borer in chickpea, etc.)	A	H	M
• Biological control of foot and root rot in pulses (e.g. blackgram, grasspea, field pea, etc.) by *Bacillus* & *Pseudomonas* bacteria and *Trichoderma* fungus	B & A	H	M
• Appropriate chemical control of major disesaes (e.g. fungicides for stemphylium blight in lentil, fusarium wilt in chickpea and insecticides for yellow mosaic virus in mungbean & cowpea)	A	H	M

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
5. Oilseeds • Development of IPM against major insect pests (e.g. aphids in mustard, hairy caterpillar in soybean)	A	H	M
• Development of IDM for major diseases (e.g. alternaria leaf blight in mustard, tikka in groundnut, yellow mosaic virus in soybean, stem rot in sesame, sclerotinia in sunflower etc.)	A	H	M
6. Vegetables • Integrated pest management (IPM) for major insect pests (e.g. aphids in country beans, fruit fly in cucurbits, white fly in tomato, cutworm in cabbage & cauliflower)	A	H	M
• Integrated disease management (IDM) for major diseases (e.g. bacterial wilt in brinjal, mosaic virus in tomato & okra, black rot in cabbage & cauliflower, anthracnose in cucurbits., flea beetle in radish etc.)	A	H	M
7. Fruits • Integrated pest management (IPM) for major insect pests (e.g. mango hopper, fruit borer in litchi and jackfruit, rugose spiraling in coconut, fruit beetle in banana, leaf miner in citrus etc.)	A	H	M
• Integrated disease management (IDM) for major diseases (e.g. anthracnose in mango, fruit rot in jackfruit and pineapple, wilt in guava, bud rot in coconut, canker in citrus etc.)	A	H	M
8. Tuber crops • Improvement of measures against late blight of potato (*Phytophthora infestants*) and potato cyst nematode (*Globodera* sp.)	A	H	M
• Improvement of measures against potato bug and potato tuber moth	A	M	M

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
9. Spices • Management for diseases in spices e.g. purple blotch in onion, tip burn in garlic, corm/rhizome rot in ginger & turmeric and stem gall in coriander	A	H	M
• Managing thrips (pest) of onion and garlic	A	H	M
10. Sugar crops • Use of bio-agents and IPM for managing major pests (e.g. top shoot borer) and IDM for major diseases (e.g. red rot & wilt in sugarcane)	A	H	L
• Indegrated disease management (IDM) for major diseases (e.g. red rot & wilt in sugarcane)	A	H	L
• IPM for managing red palm weevil in date palm	A	H	M
11. Fibre crops • Use of bio-pesticides for managing jute hairy caterpillar, mites, spiral borer, mealy bug, etc.	A	H	M
• Use of nematicides for managing root knot of jute and fungicides for managing *stem rot, anthracnose and* soft rot of jute	A	H	M
• Appropriate application of bio-pesticides for managing pests (e.g. aphids, bollworm etc.) and diseases (*Ascochyta* blight, *Cercospora* leaf spot) of cotton	A	H	M
12. Forestry • Management of major pests and diseases of forests and nurseries	A	H	M
• Identify natural regeneration potentials of different forest species and its restoration methods	A	H	M
13. Tea • Bio-ecology of major insect pests	A	H	M
• IPM techniques for pest (insect & disease) management	A	H	M
• Identification of bio-control agents and their predatory efficiency	B	H	M

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Evaluation of plant originatedbio-pesticides	A	H	M
14. Flowers and ornamental plants • Develop control measures for major insect pests (e.g. aphids) of flowers of commercial importance	B & A	H	M
• Standardize control measures for major diseases (e.g. corm rot of gladiolus, leaf spot of rose etc.)	B & A	H	M
3.3 Bio-pesticides development			
• Development of bio-pesticide based sustainable pest management	A	H	M
• Appropriate bi-control agents (Pollinators, parasitoids & predators)	A	H	M
• Sterile insect technology for pest suppression	B	H	M
• Potential botanicals for pest management	B & A	H	M
3.4 Monitoring and surveillance			
• Pest and disease surveillance, early warning (forecasting) system and pest resurgence	A	H	M
• Digitalization of pests mapping over eco-systems and regions	B & A	H	M
• Assessing ecological, environmental and economic damage (e.g. Remote sensing, GIS technology, etc.)	A	H	M
• Population dynamics and biology of major pests	B & A	M	M

4. Thematic area: Farm Mechanization, Irrigation and Post-harvest Management and Processing

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
4.1 Farm mechanization			
• Development of farm machineries for rice and other crops for haor and char land	A	H	L
• Introduction of conservation agriculture (CA) based tillage machineries e.g. seeders, fertilizer applicators, etc.	A	M	L
• Efficient use of renewable energy (solar, biogas, and CNG-powered machinery) in agriculture	A	H	L
• Introduction of need-based digital technologies and farming practices in relation to smart farming and precision agriculture (e.g. machine vision, robotics, drone, nano-technologies etc.)	A	M	L
• Intervention for a favorable business system with local manufacturing of machineries and spare parts	S	H	L
• Locally designed, development and fabrication of location-specific farm machineries	S	M	L
• Development of remote control rice transplanter, combined harvester, dryer and rice mill for precision transplanting, harvesting, drying and milling	A	H	L
• Crop simulation modeling and big data analysis to mitigate theimpact of climate change	S	M	M
• Yield forecast of crops using drone and AI based crop survey program	A	M	M
• Development of automatic grader of crops, fruits and vegetables using mechanization vision	A	M	L
• Automation of postharvest machinery (vegetable washers, fruit cleaners, winnowers, cashew nut shellers, etc.)	B &A	M	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Application of robotic vision system for detecting soil nutrient status	B	M	L
• Identify fast-moving parts and ensure production of locally developed network between machinery researchers, extension workers and manufacturers	S	M	M
4.2 Irrigation and water management			
• Mapping of surface and ground water availability for irrigation	S	H	M
• Aquifer dynamics based on recharge-depletion trend	B &A	H	L
• Improving water productivity through water-saving irrigation techniques (e.g. AWD technology, intermittent irrigation, drip irrigation, sprinkler irrigation,etc.) for field crops	A	H	L
• Use of alternative energy (e.g. CNG, wind and solar energy etc.) for pumping and automation in irrigation and water management systems	A	H	L
• Efficient water management techniques using simulation modeling for major crops	B &A	H	L
• Efficient irrigation and water management for coastal, hilly & char areas and for other emerging agriculture system (e.g. poly house, rooftop, vertical crop production etc.)	A	H	L
• Water footprint and water productivity benchmark values for crop production	B &A	M	S
• Drainage management system in flooded/waterlogged crop lands	A	H	L
• Use of GIS, remote sensing and computational modeling to assess the surface water-groundwater interactions, feasibility of conjunctive use of surface and groundwater and climate change impact evaluation	A	H	L
• Assessment of water quality	A	H	L

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Water & soil salinity dynamics in drought and coastal areas	A	H	L
• Conjunctive use of surface & groundwater	A	H	L
4.3 Post-harvest management and processing			
• Minimization of postharvest loss with a maintenance of nutritional quality	A	H	L
• Enhancing shelf life of fruits, vegetables, root and tuber crops, and flowers by vapor heat reatment (VHT) or any other techniqe	A	H	L
• Development of short-term storage technologies for perishable commodities	A	H	M
• Hazard analysis of fresh produce, processed food and food products in supply chain (e,g. producer, traders, wholesalers, street vendors, retailers, etc.)	A	H	M
• Development of smart postharvest technologies for processing and value addition	A	H	L
• Prototype development using big data analysis (artificial intelligence and machine learning algorithm) for identification and quantification of food adulterants and contaminants	B &A	M	M
• Development of sensor based technology for assessing maturity indices of horticultural crops	B &A	M	M
• Fortification of micronutrient (e.g. zinc) in cereals, legumes and horticultural crop produce	B &A	M	M
• Small scale industrial processing of seasonal fruits like mango, pineapple, jackfruits, etc. for export	B &A	H	L
• Utilization of agro-wastes/food wastes (e.g. seed, peel, shell , whey etc.) for developing diversified products	A	M	M

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Testing phyto-toxin and myco-toxin in food items and feeds, and mitigation measures	B &A	M	M
• Micro-emulsion technology for preparing edible wax coating materials and improving quality of fresh fruits/vegetables and their processed product.	B &A	M	M
• Low-cost ethylene gas based ripening technology for safe ripening of fruits	B &A	M	M
• Innovative circular food systems (resources are reused, nutrients recycled and by-products reduced)	B	M	M

5. Thematic area: Technology Validation and Adoption

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
5.1 Technology validation			
• Development of technology hubs as validation and dissemination platforms	A	H	M
• Participatory technology generation and validation	B & A	H	M
• Adaptation of short duration, low water requiring crop varieties and techniques	A	H	S
• Validation of blast resistant rice varieties, wilting resistant tomato and brinjal varieties and greening resistant citrus varieties	A	H	S
• Validation of simple and easy operable machines e.g. drier, winner, potato harvester, rice transplanter, etc.	A	H	S
5.2 Technology delivery system and assessment			
• Evaluation of current extension tools and improvement of technology uptake/diffusion pathways	S & A	M	M

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Development and introduction of innovative digital technologies for wider scale dissemination	B & S	M	M
5.3 Linkage improvement			
• Improvement of public-private partnership for technology diffusion and entrepreneurship development	A	H	S

6. Thematic area: Socio-economic and Marketing Issues

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Socio-economic aspects of innovated technologies and perception	S & A	M	L
• Market research aiming at devising means to facilitate marketing of quality agricultural products	A	M	L
• Macro and micro level studies for improving efficiency in production and marketig of agricultural commodities	B	M	L
• Improvement of supply chain, value chain and marketing of farm produce	A	H	S
• Market analysis and promotion of safe agro-products	A	M	L
• Pro-poor and pro-gender socio-economic analysis in crops sub-sector	B	M	M
• Promotion of market intelligence and agro-product marketing for home and abroad facilitating commercial agriculture	B	M	M
• Agri-business framework model	B	M	L
• Identification of potential agri-horti products for export	B& S	M	L
• Innovation of agribusiness and viable rural industrial cluster	S	M	L

7. Thematic area: Cross-cutting Issues

Researchable Areas/Issues	Types of research	Priority ranking	Time scale (duration)
• Development of climate smart agricultural practices and technologies	A	H	S
• Appropriate agricultural transformation system for small holder farmers	S & A	M	L
• Integrated farming system involving agricultural diversification, intensification, value chain and market linkage	A	H	S
• Policy research about constraints to adoption of agricultural technologies	B & S	M	L
• Generation of employment opportunity and retention of women and youth in farming	S	L	L
• Socio-economic analysis of gender, youth, disable and ethnic people for employment generation and enhancing farmer's well-being in the agricultural production system	S & A	M	L
• Capacity building in terms of infrastructure (research lab, farm, etc.) and human resource development	S & A	M	L
• Transformation of food production system through environment friendly and climate-smart systems under changing climate	S & A	M	L
• Innovative, profitable, commercial and environmentally sound agri-food system linking with an improved value chain and market	S & A	M	L

Types of research
Basic research (B): Increase understanding of fundamental knowledge, concept and scientific principles.
Applied research (A): Application of the results derived from basic research to generate technologies.
Strategic research (S)**:** It is a kind of research, which addresses policy issues of the Government.
Priority rankings (Vestola, 2010)
High – Critical issues to be addressed in immediately
Medium – Potentially critical to be addressed in near future
Low – Not critical but to be addressed, if resources permit
Time-scale (BARC, 2012)
Short term (S): < 3 years; **Medium term (M):** 3-5 years; **Long term (L): >**5 years

Strategy and Framework

Bangladesh has achieved self-sufficiency in foods, especially rice, fruits, fishes, meat, and eggs. However, there remains a great challenge to nourish the increasing population from decreasing arable land. Thus, the situation claims for highly innovative research and productive strategies to ensure food and nutrition security and safe food production. The following strategies could be implemented to achieve the vision and objectives of the research priorities and to increase efficiency and effectiveness of the approaches for execution of research priority areas with the expected outcomes (Matrix 1).

Strategies

1. **Develop efficient and effective technologies to improve crop production and productivity**
   - Formulate participatory, group-based, target-oriented and ecosystem-wise demand- driven technology development programmes
   - Focus on smallholders and emerging market demand in undertaking research on research priority areas.
   - Emphasize technology development for submergence, rainfed, saline and other fragile ecosystems.
   - Create enabling environment for effecive collaboration among stakeholders in developing improved technologies and generating knowledge and information.

2. **Develop and strengthen infrastructure for efficient and appropriate technology development**
   - Establish laboratories and farm facilities for smooth conduction of basic and applied research.
   - Strengthen social infrastructure (e.g. groups, apex of groups etc.) for linking research and technology development.
   - Establish storage and processing infrastructure for generation of high value technologies.
   - Develop electronic communication facility centre for improved information and knowledge access.

3. **Facilitate transfer of technologies, knowledge and information.**

- Develop effective linkages among NARS institutes, universities, international organizations, private sectors, NGOs, farmers and other stakeholders
- Develop information and communication technologies (ICT) and e-extension for quick adoption and efficient marketing
- Enhance forward and backward linkages by establishing institutional mechanism and policy framework for linking between technology generation and dissemination system
- Establish effective linkage of research and extension system with the social infrastructures (e.g. groups, apex of groups etc.) for communication, awareness and sensitization

4. **Improve quality of human resources**

- Arrange short term and long term training including higher studies (MS and PhD) for enhancing capacity in research and extension.

- Improve quality of higher agricultural education through Participatory Monitoring and Evaluation System (PME) to meet future challenges.

5. **Establish efficient and effective management practices in agricultural research**

- Formulate an action plan by individual institute for implementation of research as per research priority areas identified.

- Develop institution-wise Management Information System (MIS) and Participatory, Monitoring and Evaluation (PME).

- Conduct research through group-based multi-stakeholder, multi-disciplinary, and multi-institutional platforms.

- Create gender-friendly environment for technology development.
- Ensure an efficient administration and management systems by strengthening information and communication technology (ICT).
- Strengthen incentives- and rewards system for the best research performance.

6. **Ensure intellectual property rights and benefit-sharing system for technology commercialization**
   - Develop intellectual property rights-compatible work-culture and win-win environment.
   - Strengthen technology development system following intelectual property rights for benefiting farmers and the society.
   - Harmonize Bangladesh's laws of intellectual property rights with those of other parallel countries.

Strategic Framework

Approaches for execution of research priority areas to achieve the objectives and corresponding performance measures or outcomes are stated in the strategic framework (Matrix 1).

Matrix 1. Strategic Framework

Objectives	Approaches	Performance measures/Outcomes
1. Improve crop productivity and production	• Promote high yielding stress (abiotic and biotic) tolerant crop variety development and diffusion • Improve and ensure quality seeds and planting materials • Ensure efficient management of fertilizers, pesticides and irrigation water • Increase crop intensification/diversification through introduction of suitable technologies (e.g. short duration and saline, submergence, and drought tolerant varieties) in fragile ecosystems	• High yielding and stress tolerant (e.g. salinity, submergence, drought, cold, disease, etc.) crop varieties developed and expanded • Adequate availability of quality seeds ensured • Judicial uses of fertilizers, pesticides and irrigation water ensured • Cropping intensity in fragile ecosystems (coasts, chars, haors, barinds and hills) increased

Objectives	Approaches	Performance measures/Outcomes
2. Improve access to crop genetic material, knowledge and information	• Conserve and promote access to genetic and genomic resources • Improve access to information through efficient use of ICT (remote sensing, AI, GIS, big data management, etc.) • Policy frameworks in conservation and utilization of crop germplasm	• Crop germplasm between organizations shared • Strong websites developed for sharing technologies, knowledge and information
3. Enhance nutrient rich and safe food production, and value added products	• Enhance plant breeding efforts for high yielding nutrient rich varieties • Promote crop diversification with pulses, oilseeds, vegetables and fruits • Develop hazard free food (safe food) production system • Improve agro-products by value addition, preservation and processing • Develop research model linking production, value addition and marketing • Formulate policies for commercalization of technologies through local and overseas marketing • Develop intellectual property rights and benefit sharing system	• Availability of protein and micronutrient rich crop varieties ensured • Cultivation of diversified high value crops increased • Availability of safe food and value added agro-products in the market is increased • Production-value addition-marketing model developed • Linkage with researchers, industries and farmers in agro-processing established • Safe food processing techniques improved
4. Improve risk management	• Promote adaptation and preparedness for addressing challenges of climate change • Address market risks through improved market intelligence, market access, and fair pricing	• Variety and management practices to address drought, flood and salinity etc. improved • Market intelligence and access improved, and price volatility reduced

Objectives	Approaches	Performance measures/Outcomes
5. Improve and conserve quality of natural resources	• Improve management options to conserve soil and land quality in intensive cropping and disadvantageous ecosystems • Develop techniques to enhance water use efficiency, water quality, and conserve soil moisture • Develop technological solutions to improve air quality by reducing GHG emissions • Formulate policies for monitoring ecosystem services and trading carbon credits • Improve *in situ* conservation	• Water and fertilizer use efficiencies improved • Degraded soil, land and water resources recovered • Carbon sequestration enhanced and carbon credits gained • Greenhouse gas (CO_2, CH_4, N_20) emissions from crop fields reduced. • Crop germplasm conservation is improved
6. Ensure smart crop farming	• Develop efficient farm mechanization towards resource optimization and farm productivity improvement • Establish mechanisms for maximum use of green/ renewable energy in farm sector • Develop efficient agricultural waste management system	• Precision farming increased • Use of renewable energy (e.g. solar energy) increased in farm operations • Waste management technologies and facilities improved
7. Establish robust technology transfer system	• Build up net-working of agricultural research and extension with forward and backward linkages • Promotion of technology delivery systems by improved mass communication tools, bulk demonstration etc. • Conduct policy research for technology dissemination to reduce adoption lag	• Strong linkage established among researchers, extension personnel and farmers • Yield gap reduced • Early adoption of technologies increased
8. Establish an effective Human Resource	• Strengthen scientists' knowlege and skills through effective	• Qualified and skilled manpower in crop

Objectives	Approaches	Performance measures/Outcomes
Development (HRD) plan to address emerging challenges	training and higher studies (MS and PhD) at home and abroad • Create provision of reward system for innovative research and technology • Modernize education systems with up-to-date course-curricula, qualified teachers, and adequate laboratories and farm facilities	research and agri-business increased • Research efficiency improved • Potiential technology innovations increased

SWOT analysis

A SWOT analysis is done to determine the scope of achieving the vision of sustainable safe food and nutrition security taking into account of strengths (S), weaknesses (W), opportunities (O) and threats (T). The current analysis indicates that there are potential scopes of achieving the 2041 vision for safe food and nutrition security provided the government policy and scientists' devotion complement each other.

A. Strengths (positive)	B. Weaknesses (negative)
• Long established NARS institutes (13 NARS institutes and BARC as the apex of NARS institutes) • Strong coordination and monitoring by BARC • Qualified and skilled human resources, 40% scientists have PhD • Modern and equipped laboratories in some NARS institutes • Good farm facilities for field research • Have international linkage and collaboration (at institutional and scientist level) • Good allocation of revenues to ADP • Agro-friendly policies are in place • Competency in formulating and implementing R & D projects • Government's strong comitmentfor agricultural development	• Insufficient sophisticated research laboratories with equipment facilities • Lack of laboratories and service delivery facilities at the sub-stations • Weak ICT facilities • Shortage of skilled manpower in advance sciences and techniques • Inadequate linkage with international research and donor organizations • Lack of internationally patented technologies • Inadequate mechanization and agro-processing • Wide yield gap at farm level

C. Opportunities (positive)	D. Threats (negative)
• Strengthening NARS institutes with talented scientists and international standard laboratories. • Establishment of accredited laboratories. • Development of short duration and stress tolerant crop varieties • Development of climate resilient technologies • Enhancement of micronutrient rich and safe crop production • Crop diversification and intensification • Disease and pest management • Strengthening scientists' capacity through higher education & training to address future challenges • Development of robust technology delivery system	• Occurrence of strong natural disasters, e.g. tidal surge, cyclones, tornado, earthquake, floods, drought, etc. • Outbreak of transboundary disease infestation (e.g. wheat smut in 2017) and insect attack (e.g. fall army worm in maize in 2018) • Resignation of skilled and competent scientists for better job • Competitiveness and compliance of agro-products in the global market • Degrading natural resource base • Lack of region based market intelligence

Way Forward

Bangladesh observed an opulent progress in food production wherein adoption of agricultural policies and innovation of agricultural technologies exerted a significant role. Current attention is directed paid to nutritious and safe food production and transforming subsistence into commercial agriculture. Nevertheless, the present transformation is exposed to many challenges such as population growth, declining arable land, land and soil degradation, climate change effects and occurrence of fragile ecosystems. Considering these challenges, the government has formulated National Agriculture Policy 2018 and adopted strategies to make agriculture sustainable and profitable. Consequently, future food and nutrition security relies on how effectively and maximally these ecologically challenged areas are brought under crop production. Proper planning and research priority setting could be the best revolutionary choice for improved and sustained crop productivity.

Novel strategic plans and programmes are needed emphasizing sustainable and profitable crop intensification, development of biotic and abiotic stress tolerant varieties and quality seed production. The target level of food production may be possible using advance technique like genome editing such as Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR/Cas9) and site directed nucleouse and oligonucleotide-directed mutagenesis. Application of genome editing technologies could shorten time requirement (Friedrichs *et. al.*, 2019; Shao *et. al.*, 2020).Technological advancement is needed for year-round production of crops, especially vegetables and fruits for steady nutrient availability.

About 30% of the population in this country are undernourished with 70 percent of the diet comprising cereals, inadequate protein and micronutrient intake. To improve nutrition, crop diversification with inclusion of pulse, oilseed, vegetables and fruit crops should receive due attention. Considering good food as health caring, development and introduction of high yield potential micronutrient rich crop varieties could contribute to an expected balance diet.

The following action plans can be undertaken to achieve the strategic objectives.

- Promote nanotechnology research in agriculture (e.g. fertilizers, pesticides etc.) for increasing input efficiency and reducing production cost.
- Ensure safe crops food production free from chemical residues, pollutants, heavy metals (e.g. As, Cd, Pb, Hg), insect pests, pathogens, physical injuries, etc. as per Good Agriculture Practices (GAP) 2020.

- Improve access to genetic material and knowledge with the use of ICT.
- Effective strategies and plans are needed to address risk from biotic abiotic stresses market, climate change and adaptation.
- The approach of Conservation Agriculture (CA), having productivity, economic and environmental benefits, could receive due attention for research and practice.
- Attention is needed for Climate-Smart Agriculture (CSA) initiatives which refer to sustainably increase productivity, enhance resilience and reduce emission of greenhouse gases (GHGs), and require planning to address tradeoffs and synergies among productivity, adaptation and mitigation.
- Strengthening of climate information services to make them easily accessible to improve farmers' capacity to adapt their farming practices under changing climate.
- A systematic study is needed to assess the volume of CO_2 emission and its consumption by the crops in order to obtain benefit from CO_2 trading.
- The government may adopt an adequate HRD Plan to build up capacity of researchers on advanced sciences in genome editing technology, cutting edge technology, precision agriculture, safe food production, farm machinery development, green farming, post-harvest processing, diversified and integrated farming, crop modeling, socio-economic modeling etc.
- Recruitment of additional qualified researchers is essential for improving climate smart technologies to achieve the Vision 2041.
- Strengthening research for developing HYVs and hybrids using advanced breeding and improved management technologies.
- Public and private organizations should be encouraged to work together in a project/program through joint funding by the government, international development partners and private companies to innovative technologies and rapid diffusion process to accelerate commercial farming.

In conclusion, the food production growth attained in the recent past cannot be continued without technological break through which is vitally needed to shift the yield frontier through advanced breeding and improved management technologies. To narrow down the yield gap technology needs to be validated at farm level followed by refinement before a technology is disseminated widely.

References

Abu, M., Kamal, U. and Rob, K. 2003.Delineation of the coastal zone Dhaka, PDO-ICZMP, Bangladesh. Coast Zone Management 22(1): 466.

Agriculture Census. 2019. Structure of Agricultural Holdings and Livestock & Fisheries. National Series Volume-1. Bangladesh Bureau of Statistics (BBS). Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Alam, J., Salam, Sarkar, M. A, Rahman, M. S., Islam, S., Molla, M. M. U., Rahman, M. S., Rahman, M. M., Khan, M. R. A., Obaidulla, K., and Khan, M. A. H. 2020a.Availability and price volatility of rice in Bangladesh: An inter-institutional study in 2020. AERS Division, BARC, Dhaka.

Alam, J., Sabur, S. A., Miah, M. A. M., Begum, M. E. A., Rahman, M. S., Molla, M. M. U., Islam, M. R., Ahmed, E., Rahman, M. S. and Hasan, A. S. M. K. 2020b. Availability and Price Volatility of Potato in Bangladesh: An Inter-Institutional Study in 2020. AERS Division, BARC, Dhaka.

Alam, J., Hasan, M. K., Rashid, M. A., Huda, F. K., Moniruzzaman, Molla, M. M. U., Khatun, S. and Sultana, R. 2020c. Availability and price volatility of onion in Bangladesh: An inter-institutional study in 2020. AERS Division, BARC, Dhaka, Bangladesh.

Amin, A. M. 2021. Bangladesh remains 7th most vulnerable to climate change. www.tbsnews.net/environment/climate-change/bangladesh.

BARC (Bangladesh Agricultural Research Council). 2012. Agricultural Research Vision 2030 and beyond: Research Priorities in Bangladesh Agriculture, Bangladesh Agricultural Research Council, Farmgate, Dhaka 1215.

BBS (Bangladesh Bureau of Statistics). 2000. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2005. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2010. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2011. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2015. Yearbook of Agricultural Statistics. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2017. Yearbook of Agricultural Statistics. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2020. Yearbook of Agricultural Statistics. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2021. Yearbook of Agricultural Statistics. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2022. Yearbook of Agricultural Statistics. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BDP (Bangladesh Delta Plan) 2100. General Economics Division (GED) Bangladesh Planning Commission Government of the People's Republic of Bangladesh Sher-e-Bangla Nagar, Dhaka 1207, Bangladesh. Vol. 4. pp.1-6.

BIRDEM (Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders). 2013. A study conducted on desirable diet for Bangladesh with the support of National Food Policy Capacity Strengthening Program (NFPCSP), June 2013

Bokhtiar, S. M., Molla, M. M., Islam, S. M. F., Sabur, S. A., Rashid, M. A., Salam, M. A., Rahman, M. S., Islam, S. and Hossain, S. 2022. Projections of Supply and Demand for Selected Food Crops in Bangladesh by 2030 and 2050. Agricultural Economics and Rural Sociology Division, Bangladesh Agricultural Research Council, Dhaka.

Bokhtiar, S. M. and Samsuzzaman, S., 2023. A development Trajectory: From Food Deficit to Surplus. Bangladesh Agricultural Research Council, Farmgate, Dhaka 1215.

Bokhtiar, S. M., Samsuzzaman, S., Jahiruddin, M and Panaullah, G. M. 2023. Agricultural Development for Fragile Ecosystems in Bangladesh. Bangladesh Agriculural Research Council, Farmgte, Dhaka 1215.

BPC (Bangladesh Planning Commission). 2018. Bangladesh Delta Plan 2100. General Economics Division (GED), Government of the People's Republic of Bangladesh.Dhaka.

BPC (Bangladesh Planning Commission). 2020. Bangladesh Perspective Plan 2021-2025. General Economics Division (GED), Government of the People's Republic of Bangladesh.Dhaka.

Das, S. and Mondal, P. 2021. Socio-economic factors affecting agricultural production and income in Bangladesh. J. Agril. Socio-Econ. 2(2): 56-63.

Das, P. B., Naik, B., Nayak, J. and Shanmuganathan, V. 2021. Socio-economic factor analysis for sustainable and smart precision agriculture: An ensemble learning approach. Computer Communications 182(5).doi: 10.1016/j.comcom.2021.11.002.

FAO/UNDP. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development, Report-2,
Agro-ecological Regions of Bangladesh, BGD/81/035.

FAO (Food and Agriculture Organization) and WHO (World Health Organization). 2014. Country Nutrition Paper: Bangladesh. InProc International Conference on Nutrition 21 Years Later, November 19-21, 2014, Rome, Italy

Friedrichs S, Takasu Y, Kearns P, Dagallier B, Oshima R, Schofield J, et. al. 2019.Meeting Report of the OECD Conference on Genome Editing: Applications in Agriculture-Implications for Health, Environment and Regulation. Transgenic Res 28: 419–463. doi:10.1007/s11248-019-00154-1

Hasan, M. N., Hossain, M. S., Islam, M. R. and Bari, M. A. 2013.Trends in the Availability of Agricultural Land in Bangladesh.FAO Project Completion Report.

Hasan, M. N., Bari, M. A. and Lutfar, M. R. 2020.Soil Fertility Trends in Bangladesh 2010 to 2020.SRSRF project. Soil Resource Development Institute, Ministry of Agriculture. 84pp.

HIES (Household Income and Expenditure Survey) 2016. Bangladesh Bureau of Statistics (BBS).

Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Hossain, M. 2019. SAARC does gender influence farm households' decision to adopt technology and commercial agriculture: Implication for household food security in rural Bangladesh. J. Agric., 17(1): 219-226.

Islam, T. 2019. CRISPR-Cas technology in modifying food crops. CAB Reviews 14(50): 1– 16.

Islam, M. S., Bell, R. W., Miah, M. A. M. and Alam, M. J. 2022. Unbalanced fertilizer use in the Eastern

Gangetic Plain: The influence of Government recommendations, fertilizer type, farm size and cropping patterns. PLoS ONE 17(7): e0272146.

Islam, T. 2023. Genome Editing (in Bangla). Matrivasha Prokash, Banglabazar, Dhaka, Bangladesh.

Karim, M. A. 2015. ChorerProkriti-Jibon O Krishi (in Bengali). Prokritibarta. (3): 34-37.

Macklprang, R. and Lemaux, P. G. 2020. Genetic engineering and editing of plants: An analysis of new and persisting questions. Annu. Rev. Plant Biol. 71: 659-687.

Masud, M. M. 2023. High value crops lure youths into commercial agriculture. The Business Standard, 02 February 2023.

MoWR (Ministry of Water Resources). 2005. Coastal Zone Policy 2005. Govt. of the People's Republic of Bangladesh.

National Agriculture Policy 2018.Ministry of Agriculture.Govt. of the People's Republic of Bangladesh. 53p.

Nasim, M., Shahidullah, S. M., Saha, A., Muttaleb, M. A., Aditya, T. L., Ali, M. A. andKabir, M. S. 2017. Distribution of crops and cropping patterns in Bangladesh.RiceJ.21(2):1-55.

Razzaque, M. A. and Hossain, M. G. (2007). Country report on the state of plantgenetic resources for food and agriculture, Bangladesh: Ministry of Agriculture, Government of the People's Republic of Bangladesh.

Sattar, S. A. and Islam, M. N. 2010. Char lands of Bangladesh: their extent, management and future research needs. Paper presented at workshop on Soil Fertility, Fertilizer Management and Future Strategy held at Bangladesh Agricultural Research Council, Dhaka, 8-19 January, 2010.

Sattar, M. N. 2023. Time to think about 4IR benefits in farm mechanization. The Business Standard. 02 February 2023.

Shao X, Wu S, Dou T, Zhu H, Hu C and Huo H. 2020. Using CRISPR/Cas9 genome editing system to create MaGA20ox2 gene-modified semi-dwarf banana. Plant Biotechnol J. 18: 17–19. doi: 10.1111/pbi.13216

SRDI, 2010. Land and Soil Statistical Appraisal Book of Bangladesh. Soil Resource Development Institute (SRDI), Dhaka.

UNEP (United Nations Environment Programme).2021. (www.unep.org/resources/report/unep-food-waste-index-report-2021).

Vestola, M., 2010.A comparison of nine basic techniques for requirements prioritization, Helsinki University of Technology, Finland.

WB (World Bank). 2009. World Development Indicators. Washington, D.C.

WB (World Bank). 2022. Bangladesh Country Climate and Development Report. CCDR Series; World Bank Group, Washington, DC.

Annexure 1.

List of cropping patterns in different regions in 2014-15 (Nasim *et.al.,* 2017)

Mymensingh region			Jashore region		
Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
01	Boro–Fallow–T. Aman	471550	01	Boro–Fallow–T. Aman	237850
02	Boro–Fallow–Fallow	218650	02	Boro–Fallow–Fallow	39010
03	Mustard–Boro–T. Aman	22270	03	Wheat–Jute–T. Aman	30300
04	Boro–Aus–T. Aman	21750	04	Lentil–Jute–T. Aman	29650
05	Boro–Jute–T. Aman	18150	05	Mustard–Boro–T. Aman	22600
06	Fallow–Aus–T. Aman	12110	06	Boro–Aus–T. Aman	20350
07	Mustard–Boro–Fallow	12090	07	Vegetables–Vegetables–Vegetables	19170
08	Fallow–Fallow–T. Aman	11180	08	Boro–Aus–Fallow	17000
09	Vegetables–Vegetables–T. Aman	8910	09	Tobacco–Jute–T. Aman	12180
10	Vegetables–Vegetables–Vegetables	8500	10	Maize–Aus–Fallow	10850
11	Vegetables–Fallow–T. Aman	7460	11	Onion–Jute–T. Aman	10740
12	Wheat–Jute–T. Aman	7150	12	Mustard–Jute–T. Aman	10710
13	Potato–Boro–T. Aman	6080	13	Maize– Jute–Fallow	9900
14	Fallow–Jute–T. Aman	5540	14	Maize–Fallow–T. Aman	9000
15	Vegetables–Boro–T. Aman	4730	15	Boro–B. Aman	8250

Cumilla region			Bogura region		
Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
01	Boro– Fallow–Fallow	114780	01	Boro–Fallow–T. Aman	146250
02	Boro–Fallow–T. Aman	87410	02	Potato–Boro–T. Aman	88610
03	Boro–Aus–T. Aman	64830	03	Mustard–Boro–Fallow	50940
04	Boro–B. Aman	38360	04	Mustard–Boro–T. Aman	40110
05	Mustard–B. Aman	9690	05	Boro–Fallow–Fallow	37300
06	Potato–Maize–Fallow	7050	06	Boro–Aus–T. Aman	19700
07	Vegetables–Vegetables–Vegetables	7030	07	Boro–B. Aman	18650
08	Vegetables–Vegetables–Fallow	6840	08	Vegetables–Vegetables–Vegetables	16030
09	Boro–Aus–Fallow	4670	09	Wheat–Jute–T. Aman	14540
10	Potato–Boro–Fallow	4250	10	Onion–Jute–Fallow	10080
11	Fallow–Aus–T. Aman	4160	11	Onion–Jute–T. Aman	9330

12	Potato–Jute–Fallow	3870	12	Wheat–B.Aman	7920
13	Chilli – B. Aman	3820	13	Boro–Jute–T. Aman	7020
14	Mustard–Boro–Fallow	3810	14	Lentil–Jute–Fallow	6650
15	Potato–B. Aman	3720	15	Grasspea–B. Aman	6470

Rajshahi region			**Sylhet region**		
Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
01	Boro–Fallow–T. Aman	158390	01	Boro–Fallow–Fallow	304800
02	Boro–Fallow–Fallow	50130	02	Boro–Fallow–T. Aman	121020
03	Wheat–Fallow–T. Aman	30130	03	Fallow–Fallow–T. Aman	117560
04	Mustard–Boro–T. Aman	25650	04	Fallow–Aus–T. Aman	97055
05	Boro–Aus–T. Aman	25290	05	Boro–B. Aman	23830
06	Fallow–Fallow–T. Aman	19100	06	Boro–Aus–T. Aman	17840
07	Wheat–Aus–T. Aman	16010	07	Vegetables–Fallow–T. Aman	15495
08	Potato–Boro–T. Aman	15610	08	Fallow–B. Aman	10140
09	Mustard–Boro–Fallow	13050	09	Vegetables–Aus–T. Aman	9130
10	Wheat–Mungbean–T. Aman	12570	10	Vegetables–Vegetables–Fallow	5890
11	Wheat–Aus–Blackgram	12030	11	Vegetables–Vegetables–T. Aman	5780
12	Boro–B. Aman	11650	12	Vegetables–Vegetables–Vegetables	5395
13	Vegetables–Vegetables–Vegetables	10715	13	Vegetables–Fallow–Fallow	5370
14	Wheat–Jute–T. Aman	10270	14	Mustard–B.Aman	2690
15	Mustard–Boro–Aus	10200	15	Fallow–Vegetables–T.Aman	2470

Dinajpur region			**Rangpur region**		
Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
01	Boro–Fallow–T. Aman	215850	01	Boro–Fallow–T. Aman	371370
02	Wheat–Fallow–T. Aman	46660	02	Maize–Fallow–T. Aman	37630
03	Maize–Fallow–T. Aman	45980	03	Potato–Boro–T. Aman	35960
04	Potato–Boro–T. Aman	26590	04	Boro–Fallow–Fallow	28320
05	Potato–Maize–T. Aman	26330	05	Mustard–Boro–T. Aman	22840
06	Wheat–Jute–T. Aman	23960	06	Wheat–Jute–T.Aman	22660
07	Mustard–Boro–T. Aman	18720	07	Potato–Maize–T.Aman	12720
08	Wheat–Maize–T. Aman	11520	08	Potato–Jute–T.Aman	10790
09	Wheat–Aus–T. Aman	9990	09	Vegetables–Vegetables–Vegetables	10590

Rajshahi region			Sylhet region		
Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
10	Chilli–Fallow–T. Aman	7560	10	Maize–Jute–T. Aman	9760
11	Wheat–Mungbean–T. Aman	6280	11	Tobacco–Maize–T. Aman	6880
12	Vegetables–Vegetables–Vegetables	5070	12	Potato–Aus–T. Aman	6470
13	Vegetables–Fallow–T. Aman	4460	13	Boro–Aus–T. Aman	5640
14	Groundnut–Fallow–T.A man	3700	14	Vegetables–Vegetables–Fallow	4670
15	Mustard–Maize– T. Aman	3590	15	Maize–Fallow–Fallow	4220

Dhaka region			Khulna region		
	Cropping pattern	Area (ha)	Cropping pattern		Area (ha)
01	Boro–Fallow–T. Aman	147820	01	Fallow–Fallow–T. Aman	96900
02	Boro–Fallow–Fallow	109530	02	Boro–Fallow–T. Aman	80420
03	Mustard–Boro–Fallow	51300	03	Boro– Fallow	31400
04	Boro–B. Aman	40050	04	Boro–Fallow–Fallow	27850
05	Mustard–Boro–B.Aman	26600	05	Fallow –T. Aman	20400
06	Vegetables–Vegetables–Vegetables	26050	06	Vegetables–Vegetables–Vegetables	12060
07	Mustard–Boro–T. Aman	22400	07	Fallow–Sesame–T.Aman	10170
08	Potato–B. Aman	19960	08	Grasspea–Fallow–T.Aman	8390
09	Potato–Sesbania	10220	09	Boro–Aus–Fallow	7670
10	Fallow–Fallow–T.Aman	9650	10	Boro–Fallow–T. Aman	5410
11	Vegetables–Vegetables–Fallow	8750	11	Boro–Aus–T. A man	3895
12	Vegetables–Fallow–Fallow	6980	12	Fallow–B. Aman	3520
13	Onion–B. Aman	5230	13	Boro–B. Aman	3500
14	Boro–Jute–T. Aman	4780	14	Mustard–Jute–T. Aman	3210
15	Boro–Sesbania–Fallow	4410	15	Boro–Jute–Fallow	2800

Chattogram region			Chattogram Hill Tract region		
Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
01	Boro–Fallow–T. Aman	150280	01	Boro–Fallow–T. Aman	19400
02	Fallow–Fallow–T. Aman	125600	02	Fallow–Fallow–T. Aman	17610
03	Boro–Fallow–Fallow	48710	03	Fallow–Aus+Non-rice (zhum)	11900

04	Grasspea–Fallow–T. Aman	30640	04	Vegetables–Fallow–Fallow	6310
05	Fallow–Aus–T. Aman	27140	05	Vegetables–Fallow–T. Aman	5450
06	Soybean–Aus–T. Aman	22600	06	Boro–Fallow–Fallow	4950
07	Soybean–Jute-T. Aman	19400	07	Vegetables–Vegetables–Fallow	4890
08	Soybean–Fallow–T. Aman	18670	08	Tobacco–Aus–Fallow	2250
09	Vegetables–Fallow–T. Aman	17715	09	Vegetables–Vegetables–T. Aman	1850
10	Grasspea–Aus–T. Aman	16740	10	Tobacco-Fallow-T. Aman	1540
11	Boro-Aus-T. Aman	16070	11	Fallow-Aus-T. Aman	1320
12	Felon-Fallow-T. Aman	14630	12	Vegetables-Aus-Fallow	910
13	Chilli-Fallow-T. Aman	9450	13	Boro-Aus-Fallow	700
14	G. nut-Fallow- T. Aman	8630	14	Fallow-Vegeatbles-T.Aman	520
15	Vegetables-Vegetables-T. Aman	8505	15	Potato-Fallow-T. Aman	520

Barishal region			**Faridpur region**		
Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
01	Fallow–Fallow–T. Aman	105950	01	Boro–Fallow–Fallow	119750
02	Mungbean–Fallow–T. Aman	83770	02	Boro–B. Aman	34060
03	Boro–Fallow–T. Aman	80710	03	Wheat–Jute–T. Aman	33045
04	Grasspea–Fallow–T. Aman	66030	04	Onion–Jute–Fallow	25960
05	Grasspea–Aus–T. Aman	63140	05	Onion–Jute–T. Aman	24510
06	Mungbean–Aus–T. Aman	45640	06	Wheat–Jute–Fallow	23210
07	Fallow–Aus–T. Aman	43000	07	Boro–Fallow–T. Aman	17685
08	Boro–Fallow–Fallow	35100	08	Lentil–Jute–Fallow	15330
09	Chilli–Fallow–T. Aman	27700	09	Mustard–Jute–Fallow	13880
10	W.Melon–Fallow–T. Aman	22230	10	Lentil–Jute–T. Aman	13230
11	Felon–Fallow–T. Aman	16275	11	Grasspea–Jute–Fallow	12680
12	Vegetables–Fallow–T. Aman	15640	12	Mustard–Jute–T. Aman	10580
13	Groundnut–Fallow–T. Aman	14665	13	Vegetables–Vegetables–Vegetables	8420
14	S. Potato–Fallow–T. Aman	10250	14	Coriander–Jute–Fallow	6510
15	Boro–Aus–T. Aman	10230	15	Mustard–Boro–Fallow	6170

Annexure 2

Pictorial view: Participants from NARS, DAE, universities, NGOs, Private sector and Farmer group attending the regional workshops

Khulna workshop
(CSS Ava Centre; 13-06-2022)

Rajshahi Workshop
(Ashrai Centre; 19-06-2022)

Barishal Workshop
(BRAC Learning Centre; 31-07-2022)

Chattogram Workshop
(CVASU; 11-08-2022)






Rangpur Workshop
(RDRS; 04-09-2022)

Sylhet Workshop
(BRAC Learning Centre; 13-09-2022)

Annexure 3

Mymensingh Workshop
(BINA; 24-10-2022)

Dhaka Workshop
(NATA; 08-11-2022)

List of committee members responsible for Research Priority for Khulna division (not in order of seniority)

Sl. No.	Thematic Area	Name & Designation
01.	Crop Improvement, Genetic Resources and Conservation	Md. Fazlul Haque, AD, DAE, Khulna
		Md. Eklas Uddin, AD, DAE, Jessore
		Dr. Md. Babul Akhter, SSO, BINA, Satkhira
		Md. Kamrul Islam, SSO, OFRD, BARI, Khulna
		Dr. Md. Amanat Ullah Razu, SO, BRRI, Satkhira
02.	Crop Production	GM Mostafizur Rahman, CSO, SRDI, Jeshore
		AKM Tahmidul Islam, Chief Engineer, BWDB, Khulna
		Md. Fazlul Haque, AD, DAE, Khulna
		Md. Eklas Uddin, AD, DAE, Jessore
		Omorendranath Biswas, PSO, SRDI, Khulna
		Md. Oli Ahmed Fakir, SSO, BARI, Satkhira
		Mahbubur Rahman Dewan, SSO, BRRI, Kushtia
		AKM Kamruzzaman, Joint Director, Jashore
		Md. Kamrul Islam, SSO, OFRD, BARI, Khulna
03.	Crop protection	Dr. Tahmid Hossain Ansary, CSO, BRRI, Satkhira
		Dr. Md. Sayeed Ali, PSO, RARS, BARI, Jashore
		Md. Motahar Hossain, DTO, Bagerhat
		Dr. Hayat Mahmud, DD, Kustia
		Shefaur Rahman, SSO, BINA, Magura
		Dr. Md. Jamal Uddin, SSO, BSRI, Chuadanga
		Mr. Robiul Islam, SSO, BMWRI, Jashore
		Sayed Nazrul islam, SSO, BJRI, Jashore
04.	Farm Mechanization, Post-harvest and Agro- Processing and value addition	Dr. Md. Ashraful Alam, PSO, RARS, BARI, Jashore
		Engineer Md. Harunur Rashid, DAE, Satkhira
		Md. Sujaul Haque, Agricultural Engineer, DAE, Jashore
		Md. Enamul Haque, Agricultural Engineer, DAE, Jhinaidoho
		Md. Masud Rana, SO, BRRI, Kustia
		Mr. Rokonuzzaman, SO, RARS, BARI, Jashore
		AKM Abul Kalam, DD, BADC, Khulna
05.	Technology Validation and Adoption	Dr. Md. Harun-ar-rashid, PSO, OFRD, BARI, Khulna
		AKM Tahmidul Islam, Chief Engineer, BWDB, Khulna
		Md. Nuruzzaman, DD, Jashore
		Mr. SM Khalid Saifullah, DTO, DAE, Satkhira
		Mr. Md. Moniruzzaman, SSO, BRRI, Kustia
		Dr. Jahan Al-mahmud, SSO, OFRD, BARI, Kustia
		Mr. Md. Mahbubur Rahman Khan, SSO, BRRI, Kustia
		Mr. Soyed Tanvir Abir, SO, BINA, Magura
		Dr. Md. Amanat Ullah Razu, SO, BRRI, Satkhira
		Mr. Md. Moshiur Rahman, SO, BINA, Satkhira

List of committee members responsible for Research Priority for Rajshahi Division

Sl no	Thematic Area	Name, designation and organization
1.	Crop Improvement, Genetic Resources and Conservation	Dr. Mohiuddin, Director, Pulse Research Station (Lead)
		Deputy Director, DAE, Rajshahi
		Dr. Md. Muklesur Rahman, CSO, BARI, Ishwardhi
		Dr. Md. Fazlul Islam, PSO, BRRI
		Dr Md. Ilias Hossain, Regional Station, Bangladesh Wheat and Maize Research Institute
		Dr. Md. Kamrul Islam, PSO, BARI, Chapai Nwabgong
		Dr. Md. Alim Uddin, PSO, BARI
2.	Crop Production	Additional Director, Rajshahi region, DAE
		Dr. Md. Fazlul Islam, PSO, BRRI
		Dr. Haridas Chandra, CSO, Spices Research Centre, Bogura
		Dr. Md. Muklesur Rahman, CSO, BARI
		Dr. Md. Alim Uddin, PSO, BARI
		Dr. Nilufer, SSO, SRDI
3.	Crop Protection	Dr. K.M. Khalequzzaman, PSO, SRS, BARI, Shibgonj
		Dr. Md. Altaf Hossain, CSO, Pulse Research Station, Ishurdi
		Deputy Director, DAE, Chapi Nawabgonj,
		Dr. Jagodish Chandara Barman, PSO, BARI
4.	Farm Mechanization, Post-harvest and Agro- Processing and value addition	Dr. Md. Masud Alam, SSO, SRS, BARI, Sibgonj, Bogura
		Deputy Director, DAE, Joypurhat
		Deputy Director, DAE, Natore
		GM Morshedul Alam, SSO, Chapai Nwabgonj, BARI
		Dr Md. Hasunuzaman, SSO, BINA, Rangpur
5.	Technology Validation and Adoption	Dr. Md. Sayedur Rahman, PSO, OFRD, BARI, Shampur
		Deputy Director, DAE, Noagoan
		Deputy Director, DAE, Pabna
		Dr. Md. Abdur Rouf, CSO, BARI, Ishwardi, Pabna
		Dr. Md. Shakhawat Hossain, SSO, OFRD, BARI, Barind, Rajshahi
		Dr. Samim Hossain Molla, SSO, OFRD, BARI, Pabna

List of committee members responsible for Research Priority for Barishal Division (not in order of seniority)

Sl no.	Thematic Area	Name & Designation
1|	Crop Improvement, Genetic Resources and Conservation	Dr. Md. Alamgir Hossain, CSO, BARI, Barishal
		Dr. Md. Ekhlasur Rahman, PSO, RARS, Barishal
		Dr. Md. Jahedul Islam, SSO, RARS, Gopalgonj
		Mr. Md. Shahidul Islam, SSO, RARS, Barishal
		Mr. Rhidoyessor Dutt, AD, DAE, Barishal
		Mr. Md. Monirul Islam, DD, DAE, Jhalokakhi
2|	Crop Production	Dr. Md. Alimur Rahman, PSO, RARS, Barishal
		Dr. Md. Rofiqul Islam, PSO, RARS, BARI, Barishal
		Dr. Mohammad Idris Ali Hawlader, PSO, RARS, BARI, Patuakhali
		Mr. Md. Mahbubur Rahman, SO, RARS, BARI, Barishal
		AKM Mohiuddin, DD, DAE, Patuakhali
		Dr. Mohammad Nazrul Islam, DD, DAE, Pirojpur
		Israt Ahmed Eva, CDO, CDB, Borguna
		Ashik Elahi, SSO, SRDI, Bhola
		Dr. Md. Mozibor Rahman, SSO, BJRI, Foridpur
3|	Crop protection	Dr. Md. Mostafizur Rahman Talukder, PD, RARS, BARI, Barishal
		Dr. Md. Salehuddin, CSO, RARS, BARI, Madaripur
		Dr. Md. Golam Kibria, PSO, RARS, BARI, Barishal
		Mr. Md. Mahbubur Rahman, SO, RARS, BARI, Barishal
		Md. Harun-or-rashid, DD, DAE, Barishal
		Md. Hasan Wasiul Kabir, DD, DAE, Bhola
		Abu Sayed Md. Jobaydul Alam, DD, DAE, Borguna
4|	Farm Mechanization, Post-harvest and Agro- Processing and value addition	Md. Aminur Rahman, SO, RARS, BARI, Barishal
		Shapan Kumar Khan, AD, DAE, Faridpur
		Dr. Md. Hazrat Ali, DD, DAE, Faridpur
		Dr. Md. Moazzem Hossain, DD, DAE, Madaripur
		Md. Shohid Nur Akbar, DD, DAE, Rajbari
5|	Technology Validation and Adoption	Mostaq Ahmed, SSO, RARS, BARI, Barishal
		Dr. M. M. Kamruzzaman, CSO, BARI, Gopalgonj
		Dr. Selim Ahmed, PSO, OFRD, BARI, Foridpur
		Dr. Md. Shohidul Islam Khan, PSO, OFRD, BARI, Potuakhali
		Gazi Nazmul Hasan, SSO, OFRD, BARI, Bhola

List of committee members responsible for Research Priority for Rangpur Division (not in order of seniority)

Sl no.	Title of Article	Name & Designation
1.	Crop germplasm conservation, characterization and improvement	Dr. Md. Abu Jaman Sarker, Director, BMWRI, Dinajpur
		Dr. Md. Rofiqul Islam, SSO, BRRI, Rangpur
		Dr. Mohammad Ali, SSO, BINA, Rangpur
		Dr. Md. Al-amin Hossain Talukder, PSO, OFRD, BARI, Rangpur
		Anowara Akhter, SSO, BRRI, Rangpur
		Md. Anowarul Haque, DD, DAM, Rangpur
		Nirmol Kumar Das, DD (Veg.), BADC, Rangpur
		Md. Shah Alam, DD, AD Office, DAE, Dinajpur
2.	Crop Production	Prodip Kumar Guho, AD, DAE, Dinajpur
		Dr. Sarkar MohammadAbu Hena Mostafa Kamal, PSO, OFRD, BARI, Rangpur
		Dr. Md. Abul fazal Molla, PSO, BJRI, Rangpur
		Partho Kumar Kundu, SRDI, Gaibandha
		Md. Mahbubur Rahman, DD, DAE, Rangpur Region
		Md. Moshiur Rahman, SSO, SRDI, Lalmonirhat
		Md. Khalid Hasan Tareq, SO, BARI, Rangpur
		Dr. Md. Shariful Islam, SSO, SRDI, Thakurgaon
		Khandker taheratul Hosna, SSo, SRDI, Rangpur
		Dr. Ranojit Chandra Kobiraj, PSO, BSRI, Gaibandga
		Md. Abu Elias Mia, DD, CDB, Rangpur
3.	Crop protection	Dr. Ashis Kumar saha, CSO, BARI, Rangpur
		Md. Anwar Jahid, PSO, BARI, Rangpur
		Dr. AKM Khorsheduzzaman, BARI, Thakurgaon
		Md. Obaydur Rahman Mondal, DD, DAE, Rangpur
		Dr. Md. Harunur Rashid, SSO, RARS, Rangpur
		Dr. Md. Mostafizur Rahman Shah, SSO, Entomology Division, BMWRI, Dinajpur
		Tapan Kumar Roy, SO, BRRI, Rangpur
		Dr. Md. Muzahid-e-rahman, SSO, RARS, Rangpur
		Md. Aminul Islam Anu, DD, BMWRI, Dinajpur
4.	Farm Mechanization, Post-harvest and Agro- Processing and value addition	Md. Assaduzzaman Khan, DD, BADC, Rangpur
		Dr. Md. Jannatul Ferdaus, SSO, OFRD, BARI, Rangpur
		Md. Shamsuddin Mia, DD (Incharge), DAE, Kurigram
		Mosa. Baby Naznin, SSO, SRDI, Dinajpur
		Md. Aminul Islam Anu, DD, BMWRI, Dinajpur
		Md. Shahin Ahmed, Soil Fertility & Water Specialist, CDB, Rangpur
		Md. Robiul Islam, Assistand Engineer, BADC, Rangpur
		Md. Shariful Islam, SO, BMWRI, Dinajpur
5.	Technology Validation and Adoption	Md. Shah Alam, DD, DAE, Rangpur
		Dr. Abdullah Al-mahmud, PSO, OFRD, BARI, Gaibandha
		Dr. Md. Sajjad Hossain, CSO, BARI, Debigonj
		Md. Shamsuddin Mia, DD (Incharge), DAE, Kurigram
		Dr. Md. Shamsul Huda, SSO, BARI, Dinajpur
		Md. Abu Bokkor Siddique, DD, DAE, Nilphamary
		Md. Nuruzzaman, DD, DAE, Dinajpur
		Md. Jahangir Alam, SSO, SRDI, Thakurgaon
		Md. Belal Uddin, DAE, Gaibandha

List of committee members responsible for Research Priority for Sylhet Division (not in order of seniority)

Sl no.	Thematic Area	Name, designation and organization
1.	Crop Improvement	Dr. Partho Sarothi Biswas, CSO, BRRI, Hobigonj
		Dr. Md. Abu Sayeed, SSO, Regional Office, BRRI, Hobigonj
		Dr. Md. Sarwar Alam, SSO, RARS, BARI, Moulovibazar
		Bimal Chandra Som, DD, DAE, Sunamgonj
		Mostafa Iqbal Azad, DTO, DAE, Sunamgonj
		Md. Hasan-ud-doula, UAO, DAE, Sunamgonj
		Dr. Shah Md. Lutfor Rahman, PSO, Citrus Research Centre, Jointapur
		Md. Mahbubur Rahman, SO, BINA, Sunamgonj
2.	Crop Production	Dr. Mahmudul Islam Nazrul, PSO, OFRD, BARI, Sylhet
		Afsar Ali, PSO, SRDI, Sylhet
		Md. Nur-e-alam Siddique, DD, DAE, Hobigonj
		Md. Ashek Parvez, DTO, DAE, Hobigonj
		Shirin Akhter, UAO, DAE, Sylhet
		Dr. Md. Mojammel Haque, SSO, BRRI, Hobigonj
		Dr. Md. Jamal Hossain, PSO, RARS, BARI, Moulovibazar
		Nilufar Yesmin Monalisa Sweety, UAO, DAE, Moulovibazar
		Dr. MHM Borhan Uddin Bhuiyan, SO, Citrus Research Centre
3.	Crop protection	Shamsuddin Ahmed, DD, DAE, Moulovibazar
		Dr. Md. Haider Hossain, CSO, RARS, BARI, Moulovibazar
		Dr. Md. Jamal Hossain, PSO, RARS, BARI, Moulovibazar
		Mohammad Kazi Mozibor Rahman, DD, DAE, Sylhet Region, Sylhet
		Dr. Shah Md. Lutfor Rahman, PSO, Citrus Research Centre, Jointapur
		Md. Moshkor Ali, ADD, DAE, Moulovibazar
		Ovijit Biswas, SO, BINA, Sunamgonj
		Abdur Rakib, SO, BINA, Sunamgonj
4.	Farm Mechanization, Post-harvest and Agro- Processing and value addition	Mohammad Khayer Uddin Molla, DD, DAE, Sylhet
		Dr. Md. Shahinuzzaman, SSO, RARS, BARI, Moulovibazar
		Md. Moazzem Hossain, Agricultural Engineer, DAE, Hobigonj
		Taposh Kumar Talukder, Agriculture Engineer, DAE, Sunamgonj
		Md. Ikhlas Ashraf, Agriculture Engineer, DAE, Sylhet
5.	Technology Validation and Adoption	Md. Mosharraf Hossain Khan, AD, DAE, Sylhet
		Dr. Md. Jamal Hossain, PSO, RARS, BARI, Akborpur
		Dr. Mahmudul Islam Nazrul, PSO, OFRD, BARI, Sylhet
		Monfiq Ahmed Chowdhury, CSO, SRDI, Sylhet
		Mohammad Kazi Mozibor Rahman, DD, DAE, Sylhet Region, Sylhet
		Md. Faroque Hossain, AD (Crop), DAE, Sylhet
		Dr. Md. Enayet Ullah, PSO, SRDI, Sylhet
		Mosa. Mahmuda Khatun, SO, BRRI, Hobigonj

List of committee members responsible for Research Priority for Mymensingh Division (not in order of seniority)

Sl no.	Thematic Area	Name & Designation
1.	Crop Improvement, Genetic Resources and Conservation	Dr. Md. Abdul Maleque, Director (Res.), BINA, Mymensingh
		Dr. Md. Iftekharuddola, CSO & Head, Plant Breeding Division, BRRI
		Dr. Shamsunahar, Dept. Head, Plant Breeding Division, BINA, Mymensingh
		Dr. Md. Golam Mostafa, CSO & Head, Breeding Division, BJRI, Dhaka
		Dr. Md. Monjurul Kadir, CSO, BARI, Jamalpur Region
		Dr. ABM Arif Hasan Khan, Prof. Genetics & plant breeding dept. BAU,
		Dr. Md. Alamgir Hossain, PSO, BJRI, Jamalpur
		Mosa. Jakia Sultana, Deputy Director Office, DAE, Jamalpur
2.	Crop Production	Dr. Md. Alimur Rahman, PSO, BARI, Barishal
		Dr. Md. Rofiqul Islam, PSO, BARI, Barishal
		Dr. Mohammed Idris Ali Haolader, Physiology Division, BINA, Mymensingh
		Dr. Md. Alamgir Hossain, PSO, BARI, Jamalpur
		Dr. Md. Rajob Ali, PSO, BARI, Jamalpur
		Mohammed Reza Ahmed Khan, DD Office DAM, Mymensingh
		Dr. Md. Shohidul Islam, PSO & Head, Agronomy Division, BINA, Mymensingh
		Dr. Hafizur Rahman, SSO, BARI, Jamalpur
		Dr. Md. Johirul Islam, PSO & Head, Soil science Division, BINA, Mymensingh
		Dr. Md. Anisur Rahman, PSO, SRDI, Mymensingh
		Dr. Md. Rafiqul Islam, PSO, Horticulture Division, BINA, Mymensingh
		Md. Motiuzzaman, Deputy Director, DD Office Mymensingh
		A K M Murshedur Rahaman, PSO, SRDI, Jamalpur
		Dr. Md. Showkotuzzaman, PSO, SRDI, Mymensingh
		Nilima Akhter Kohinur, PSO, SRDI, Netrokona
		Md. Ayubullah, DD Office, (Seed marketing), BADC, Mymensingh
3.	Crop protection	Dr. Khondokar Shohidul Islam, Professor, Entomology Department, BAU, Mymensingh
		Dr. Md. Abdul Latif, CSO & head, PPD, BRRI
		Dr. Shaikh Samiul Haque, CSO & Head, Entomology Division, BRRI
		Dr. Md. Lutfor Rahman Molla, PSO, Entomology Division, BINA
		Dr. Md. Ibrahim Khalil, PSO, PPD, BINA
		Dr. Md. Abdul Halim Khan, PSO, BARI, Jamalpur
		Dr. Mahbuba Kaniz Hasna, PSO & Head, PPD, BINA
		Dr. Md. Rashidul Islam, Professor, PPD, BAU
		Dr. Sukolpo Das, DD, Sherpur
		Dr. Md. Abdul Mannan, PSO, BARI, Jamalpur

4.	Farm Mechanization, Post-harvest and Agro- Processing and value addition	Dr. Md. Monjurul Alam, Professor, Farm Power & Machineries Department, BAU
		Dr. Md. Abdul Mojid, Professor, Irrigation Water Management Department, BAU
		Dr. Md. Hossain Ali, CSO & Head, Agricultural Engineering Division, BINA
		Dr. Md. Abdul Alim, Professor, Food Technology Department, BAU
		Mohammad Reza Ahmed Khan, DD, DAM, Mymensing
		Engineer Muhammad Bodrul Alam, Superintend Engineer, BADC, Mymensing
		Md. Moshiur Rahman, SO, BARI, Jamalpur
		Shaikh Forid, Senior Agriculture Engineer
		Mohammad Nuruzzaman, DD, Netrokona
		Professor Choyon Kumar Saha, Farm Power & Machineries Department, BAU
		Professor Dr. M. G. Mostafa Amin, Irrigation Water Management Department, BAU
		Professor Poly Karmokar, Food Technology Department, BAU
5.	Technology Validation and Adoption	Dr. M. Julfikar Rahman, Professor, Agricultural Extension Department, BAU
		Md. Ashraf Uddin, Additional Director, DAE, Mymensing
		Salma Akhter, DD, AD Office, Mymensing
		Dr. Md. Monjurul Alam Mondal, CSO & Head Applied Research & Extension Division, BINA
		Dr. Shamima Begum, PSO, Applied Research & Extension Division, BINA
		Md. Motiuzzaman, DD, Mymensing
		Dr. Md. Moniruzzaman, PSO, OFRD, BARI, Mymensing
		Dr. Nargis Sultana, SSO, OFRD, BARI

List of committee members responsible for Research Priority for Dhaka Division (not in order of seniority

Sl. No.	Thematic Area	Name. designation and organization
1	Crop Improvement, Genetic Resources and Conservation	Dr. Nargis Akhter, Director, BJRI, Dhaka
		Dr. Shahanaz Sultana, PSO, BRRI, Gazipur
		Dr. Md. Saidur Rahman, DD, Narsindi
		Dr. Khondokar Mohammad iftekharuddowla, PSO & Head, PBD, BRRI, Gazipur
		Dr. Mir Shorof Uddin Ahmed, PSO & Head, Genetic Research and Seed Division, BRRI, Gazipur
		Dr. Md. Golam Mostafa, CSO & Head, Breeding, Division, BJRI, Dhaka
		Krishibid Jafor Ali, DD, Head Quarter, CDB, Dhaka
		Dr. Reshma Sultana, CSO, PBD, BARI, Gazipur
		Dr. Surojit Saha Roy, DD, Dhaka
		Mr. Md. Ibrahim Hossain, HDD, BADC, Dhaka
2	Crop Production	Mr. Md. Joynal Abedin, AD, DAE, Dhaka
		Mr. Md. Sabbir Hossain, CSO, SRDI, Dhaka
		Dr. Md. Shohidul Islam, CSO & Head, Agronomy Division, Dhaka
		Mr. Md. Mojammel Haque, BADC, Dhaka
		Dr. Md. Abdul Alim, CSO, BJRI, Dhaka
		Mr. Md. Abdul Motin Sarkar, Additional Chief Engineer, BWDB, Dhaka
		Dr. Habib Mohammad Naser, CSO, BARI, Gazipur
		Dr. Md. Khairul Alam, PSO, NRM Division, BARC
		Sultanan Nasira, Assistant Director, DAM, Dhaka.
		Dr. Delwar Ahmed Chowdhury, CSO, BARI, Gazipur
		ABM Mahmud Hasan, Senior Seed Production Officer, CDB, Dhaka
		Dr. Shah Mohammad Monir Hossain, CSO, Crops Division, BARC, Dhaka
		Abu Mohammad Anayet Ullah, DD, DAE, Manikgonj
		Md. Jahidul Islam, Assistant Director, DAM, Dhaka.
3	Crop protection	Dr. Md. Motiur Rahman, CSO, PPD, BARI, Gazipur
		Dr. Md. Abdul Latif, CSO, PPD, BRRI, Gazipur
		Dr. Shaikh Samiul Haque, CSO & Head, Agronomy Division, BRRI, Gazipur
		Dr. Nirmal Kumar Datta, CSO, Entomology Division, BARI, Gazipur
		Krishibid Dr. Md. Nazrul Islam, CSO, BJRI, Dhaka
		Dr. Md. Mominul Islam, SSO, CDB, Dhaka
		Mr. Utpal Kumar, PSO, SRDI, Tangail
		Dr. Md. Nazmul Islam, Joint Director, BADC, Dhaka
		Mosa. Israt Jahan, Assistant Director, DAM, Dhaka
		Md. Saiful Islam, DD, DAE, Gazipur
4	Farm Mechanization, irrigation and water management, Post-harvest and Agro-	Dr. Md. Nazmun Nahar Karim, Member Director, Livestock Division, BARC, Dhaka
		Dhirendra Chandra Debnath, Member Director, BADC, Dhaka
		Md. Shofiqul Islam Sheikh, DPD, Farm Machanization Project, DAE, Dhaka
		Dr. Md. Moniruzzaman, PSO & Head, Irrigation & Water Management Division, BRRI, Gazipur
		Dr. Md. Ayub Hossain, CSO, FMPED, BARI, Gazipur
		Dr. Md. Eunus Ali, SSO, FQI Division, BJRI

Sl. No.	Thematic Area	Name. designation and organization
	Processing and value addition	Dr. Md. Nazrul Islam, CSO, Post Harvest Technology Wing, HRC, BARI, Gazipur, Dhaka
		Dr. Md. Durrul Hura, CSO & Head, Farm Machineries & Post Harvest Technology Division, BRRI, Gazipur
		Md. Moslem Uddin, Director (Technical Wing), BJRI, Dhaka
		Md. Abdul Wahab, Cotton Agronomist, CDB, Dhaka
		Engineer Khaled Saifullah, SSO, BJRI, Dhaka
		Md. Khurshid Alam, DD, DAE, Munshigonj
5	Technology Validation and Adoption	Dr. Md. Majharul Anwar, CSO, OFRD, BARI, Gazipur
		Dr. Md. Robiul Alam, PSO, OFRD, BARI, Gazipur
		SM Sohorab Uddin, Additional Director, Dhaka Region, DAE, Dhaka
		Dr. Md. Nasir Uddin, CSO, Jute Farming System Division, BJRI, Dhaka
		Dr. Humayun Kabir, CSO & Head, Applied Research Division, BARI, Gazipur
		Dr. Md. Ibrahim, PSO & Head, RFS Division, BARI, Gazipur
		Dr. Md. Gazi Golam Mortuza, PD, CDB, Dhaka
		Amir Mohammad Zahid, PSO, SRDI, Dhaka
		Md. Mamunur Rahman, PSO, SRDI, Dhaka
		Shahana Khatun, M&E Officer, DAE, Dhaka
		Md. Ferdousur Rahman,Chief (Planning), BADC, Dhaka
		Touhid Mohammad Rashed Khan, AD, DAM, Dhaka
		Dr. Md. Abdul Majid, DD, DAE, Narayangonj

ISBN : 978-984-35-4708-8

Towards Building Advanced Intelligent System for Agriculture

Project Implementation Unit (PIU)
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
Farmgate, Dhaka-1215
Bangladesh