

Agricultural Research Vision 2030

Project Coordination Unit (PCU)
National Agricultural Technology Project (NATP): Phase-1
BARC, Farmgate, Dhaka.

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Vision Document-2030 for Agricultural Research in Bangladesh

Final Report

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Acronyms and Abbreviations

ACIAR	Australian Council for Industrial and Agricultural Research
AEC	Agriculture Extension Component
AEC	Atomic Energy Commission
AEZ	Agro Ecological Zone
App.	Approximately
ARI	Agricultural Research Institute
ASPS	Agriculture Sector Program Support
AWD	Alternate Wetting and Drying
B	Boron
B. Aman	Broadcasted Aman
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCSIR	Bangladesh Council for Scientific and Industrial Research
BFDC	Bangladesh Fisheries Development Corporation
BFRF	Bangladesh Fisheries Research Forum
BFRI	Bangladesh Fisheries Research Institute
BFRI	Bangladesh Forest Research Institute
BGM	Botrytis Gray Mold
BINA	Bangladesh Institute of Nuclear Agriculture
BJRI	Bangladesh Jute Research Institute
BLB	Bacterial Leaf Blight
BLRI	Bangladesh Livestock Research Institute
BLS	Bacterial Leaf Streak
BNF	Biological Nitrogen Fixation
BoB	Bay of Bengal
BPLB	Bipolaris Leaf Blight
BRRRI	Bangladesh Rice Research Institute
BSRI	Bangladesh Sugarcane Research Institute
BSTI	Bangladesh Standards and Testing Institute
BTRI	Bangladesh Tea Research Institute
CGIAR	Consultative Group of International Agricultural Research
CGP	Competitive Grants Program
CLS	Cercospora Leaf Spot
CNG	Compressed Natural Gas
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Organization
CU	Chittagong University
DAE	Department of Agricultural Extension
DLS	Department of Livestock Services
DoF	Department of Fisheries Electronic
DSR	Direct Seeded Rice

DTW	Deep Tubewells
EEZ	Exclusive Economic Zone
EPB	Export Promotion Bureau
FAO	Food and Agriculture Organization
FCR	Feed Conversion Ratio
FD	Forest Department
Fe	Ferrous
FFYP	Fifth Five Year Plan
FRI	Fisheries Research Institute
FSRD	Farming System Research and Development
FY	Financial Year
FYM	Farm Yard Manure
GDP	Gross Domestic Product
GIFT	Genetically Improved Farmed Tilapia
GIS	Geographical Information System
Gm	Gram
GM	Green Manure
GO	Government Organization
GoB	Government of Bangladesh
GPS	Geographical Positioning System
ha	Hectare
HACCP	Hazard Analysis at Critical Control Point
HRD	Human Resource Development
HVA	High Value Agriculture
HYV	High Yielding Variety
ICM	Integrated Crop Management
ICT	Information and Communication Technology
IDM	Integrated Diseases Management
IDRC	International Development Research Center
IMS	Institute of Marine Sciences
IPM	Integrated Pest Management
IPR	Intellectual Property Right
IT	Information Technology
IUCN	International Union for Conservation of Nature and Natural Resources
KCal	Kilo Calories
Kg	Kilogram
KGF	Krishi Gobeshona Foundation
Km	Kilometer
KU	Khulna University
LR	Leaf Rust
M & E	Monitoring and Evaluation
MDG	Millennium Development Goal
Mg	Magnesium
mha	Million hectare
MIS	Management Information System
MMD	Marine Markentile Department

mmt	Million Metric Ton
Mo	Molybdenum
MoA	Ministry of Agriculture
MoC	Ministry of Commerce
MoE	Ministry of Education
MoEF	Ministry of Environment and Forests
MoFL	Ministry of Fisheries and Livestock
MoL	Ministry of Law
MoI	Ministry of Industry
mn	Million Number
MOU	Memorandum of Understanding
MoWR	Ministry of Water Resources
MSY	Maximum Sustainable Yield
MV	Modern Variety
NACA	Network of Aquaculture Centers in Asia and Pacific
NAEP	New Agricultural Extension Policy
NARS	National Agricultural Research System
NATP	National Agricultural Technology Project
NCE	National Center of Excellence
NCFR	Non conventional Feed Resources
NFP	National Fisheries Policy
NFP	National Food Policy
NGO	Non-governmental Organization
NLDP	National Livestock Development Policy
NM	Nautical Mile
NMTPF	National Medium Term Priority Framework
PCR	Polymerize Chain Reaction
PCU	Project Coordination Unit
PG	Pituitary Gland
Ph.D	Doctor of Philosophy
PIU	Project Implementation Unit
PM	Poultry Manure
PO	Private Organization
POA	Plan of Action of the National Food Policy
PPP	Public Private Partnership
PRA	Participatory Rural Appraisal
PRSP	Poverty Reduction Strategy Paper
QPM	Quality Planting Material
QTL	Quantitative Trait Loci
R&D	Research and Development
RCT	Resource Conserving Technology
RFLDC	Regional Fisheries and Livestock Development Component
RRMAC	Rural Roads and Market Access Component
SAARC	South Asian Association for Regional Cooperation
SB	Sheath Blight
SEAFDEC	South East Asian Fisheries Development Center

SFYP	Sixth Five Year Plan
SIS	Small Indigenous Species
SME	Small and Medium Enterprise
SPS	Sanitary and Phyto-sanitary
SRDI	Soil Resources Development Institute
STW	Shallow Tubewells
T. Aus	Transplanted Aus
T. Aman	Transplanted Aman
TTMU	Technology Transfer and Monitoring Unit
UNDP	United Nations Development Program
WB	World Bank
WFC	World Fish Center
YMV	Yellow Mosaic Virus
Yr	Year
Zn	Zinc

1.0 Introduction

Agriculture is the most important sector of Bangladesh economy for its significant role in food security, employment generation and livelihood support. Eighty percent people of Bangladesh depends directly or indirectly on agriculture. The current share of agriculture to Gross Domestic Product (GDP) is 21% and employs about 48% of the working force. Again Crops dominate in Sub-sectoral contributions to GDP having 11.70% followed by that of Fisheries (4.64%), Livestock (2.90%), and Forestry (1.80%) (BBS & FAO, 2011). As regard sub-sectoral contribution to GDP in agriculture, Crops sub-sector contributes 56%, Fisheries 22%, Livestock 13%, and Forestry 9%. In order to achieve the GDP growth rate of 7% per year, agriculture must grow at least by 4-4.5% per year, which is possible through an increase in agricultural productivity based on appropriate agricultural technologies and a supply chain linking farmers with consumers in the domestic as well as overseas markets.

The present population of the country is about 149.69 million which will increase to 189.85 million by the year 2030 at a growth rate of 1.26%. The estimated food requirement, especially rice and wheat will be 43.6 million metric tons (mmt), fish requirement 5.80 mmt, meat, milk, and egg requirement will stand at 8.30, 17.50 mmt and 19750 million numbers, respectively. The projected demand of timber and fuel wood is 47.07 million cubic meters, while the demand of bamboo will be 1109.03 million culms. There will be a serious gap between demand and supply if the current rate of productivity and production continues. Therefore, the increase in productivity and production rate in all agricultural sub-sectors is of prime importance to meet future demand.

Bangladesh Agricultural Research Council (BARC) is the apex body of the National Agricultural Research System (NARS) and functions as a coordinating body to improve the overall activities of the NARS as well as to formulate and guide the research systems of the country. BARC prepared a Vision Document-2020 for agricultural research in the year 2000 that had significant contributions in inventing and adopting appropriate technologies by ARIs, agricultural universities, and private organizations.

The agriculture sector though plays the key role in food security and livelihood, it faces setbacks created by both human and nature. The agricultural arable land is shrinking with an alarming rate due to urbanization, roads, infra-structure, etc, while serious degradation of natural resources like soil, water, climate, etc. occur and frequent but devastating flood and drought appear on a regular basis and salinity increases in the coastal region. Further, the change of climate and its adverse effect on agriculture, in Bangladesh, is considered as the worst resulting in temperature rise, abnormal rainfalls, sea-level rise, cyclone and storm surges in high frequency and volume, encroachment of more areas by salinity, further aggravation of drought problem and reducing availability of surface and ground water, etc. In other words, Bangladesh agriculture is going to face serious natural problems that warrant special attention to this sector.

The present realization is that the agriculture sector as earlier stated is going to face critical issues emerging out of various problems and threats which will seriously affect food security and livelihood of the people, especially for poor and vulnerable groups. With this realization, BARC recently prepared 12 sub-sectoral documents on prioritized researchable areas in order to mitigate and overcome the foreseeable problems. The Project Coordination Unit (PCU) of National Agricultural Technology Project (Phase-1) appointed three specialists each on Crops, Fisheries and Livestock to prepare the Vision Document-2030 for Crops, Fisheries, and

Livestock Research in Bangladesh keeping in view the sectoral documents, national programs and policies, and emerging challenges. These three vision documents were prepared separately which have been compiled and edited for preparing Vision Document-2030 for Agricultural Research in Bangladesh. This Vision Document-2030 narrates the key challenges and approaches to identify the technologies to be required, research focus and support, and appropriate strategies in shaping up the overall research needs of the country.

2.0 Agricultural Scenario

Bangladesh has a total area of 148.4 million ha (mha), of which 67% is arable. The effective land area of the country is roughly 13.39 mha, about 0.98 mha is occupied by rivers and 2.14 mha are under forest (BBS, 2008). The country is predominantly flat with almost 80% of the land area occupied by floodplains and piedmont plains, about 8% by slightly uplifted fault blocks (terrace) and about 12% by hills. Based on topography, lands are classified as high (9%), medium high (35%), low (8%), medium low (12%), very low (1%) and 15% area covers urban, riverine and homestead.

During the last three decades the population grew rapidly, which has put intense pressure on the scarce land resource to produce more food for its vast population and infrastructure development. About 1% of the cultivable land is going out of agricultural use annually. The land-man ratio is decreasing at an alarming rate; the current estimated per capita arable land stands at 0.05 ha only. On the other hand, intensified agricultural land use accompanied by increased use of modern crop varieties has contributed to deterioration of soil health. The agricultural land use statistics is presented in Table 1.

Table 1. Agricultural Land use statistics of Bangladesh

Total area	14.845 million hectare
Forest	2.599 million hectare
Cultivable land	8.44 million hectare
Cultivable waste	0.268 million hectare
Current fallow	0.469 million hectare
Single cropped area	2.851 million hectare
Double cropped area	3.984 million hectare
Triple cropped area	0.974 million hectare
Net cropped area	7.809 million hectare
Total cropped area	13.742 million hectare
Cropping Intensity	180%

Source: BBS, 2010

There are about 18 million farm households in Bangladesh. Of them, 86.68% belongs to landless (0-0.49 acre), marginal (0.50-1.49 acre) and small (1.50-2.40 acre) farmers occupying 41.5% of land, 11.65% belongs to medium farmers (2.50-7.49 acre) occupying 42.4% of land and 1.67% belongs to large farmers (>7.50 acre) occupying 16.44% of land.

There is considerable extent of degradation of agricultural lands caused by soil erosion (1.70 mha), river erosion (1.70 mha), soil fertility decline (8.00 mha), depletion of soil organic matter (7.50 mha), water logging (0.70 mha), soil salinity (0.84 mha), pan formation (2.82 mha), acidification (0.06 mha) and deforestation (0.30 mha) (MOA & FAO, 2010). With regard to the quality of agricultural land, 2% belongs to very good type, 34% good, 39% moderate, 16% poor, and 9% very poor (MOA & FAO, 2010).

2.1 Scenario of Crops Sub-sector

The total cropped area of the country is 13.74 million hectares with 180% cropping intensity. However, the Table-2 shows the area, production and productivity of different crops for the year 2009-10

Table-2: Area, production and productivity of different crops (2009-10)

Crop	Area (Thousand ha)	% of total cropped area	Production (Th. mt)	Productivity (t/ha)
Rice	11358.70	76.71	31975.00	2.81
Wheat	376.42	2.94	901.49	2.39
Maize	152.22	2.85	887.00	5.83
Pulses	233.19	2.46	218.00	0.93
Oilseeds	365.58	2.47	786.00	2.15
Potato	434.81	2.19	7930.00	18.27
Vegetables	632.70	5.1	2189.00	3.46
Fruits	146.15	0.98	4023.00	27.55
Spices	285.82	3.1	1350.00	4.73
Sugarcane	117.40	1.11	4491.00	38.38
Jute	416.59	2.93	924.00	2.22
Tea	55.06	0.05	60.12	1.09

Source: BBS, 2010

Presently, rice alone constitutes about 95% of the total food grains produced and consumed annually in the country. It provides about 75% of the calorie and 55% of the protein in the average daily diet of the people. Rice alone contributes about 10% to GDP and the enterprise of rice production, processing and trade employs about 65% of the total labour forces of the country. The average yield of rice is 2.81 t/ha, while the average yield of modern varieties (mv) is 3.14 t/ha. The current yield gaps between demonstration and farmers' yield for Aus, T. Aman and Boro are 2.74, 4.89 and 4.08 tons per hectares respectively. The MV rice coverage is 74% during 2006-07, of which 96% is in Boro, 65% in T. Aman and 50% in T. Aus. The current production of wheat is about 0.90mmt against the national demand of 3.0mmt. Presently about 85% of wheat is grown after harvesting of T. Aman rice and about 60% of wheat is planted late. A vast area of about 0.8mha remains fallow in Southern and Sylhet regions where wheat can be successfully grown. In addition, the Barind area having about 70,000ha remains fallow due to moisture stress which can be utilized by growing wheat. Moreover, in Barind area, Boro rice may be replaced by wheat. The current productivity of maize is about 5.83t/ha, but the potential is around 10.0t/ha. However, by the year 2030, it is expected to raise the productivity to 8.5t/ha by increasing the area under hybrid with the targeted production of 3.90 mmt which is almost close to the requirement. The area and production of pulses are declining year after year. Since 1997 the area has been declined by 17.89% while the production has declined by 20.59%. In fact, at present, 30% of the country's requirement is met by local production and the rest is imported. Now the domestic production of edible oil can only meet about 20% of the country's annual demand and the rest is imported with a cost of huge foreign exchange. The decline in acreage and production of oilseed crops since 1997 was 32.84% and 38.85%, respectively. The area under different vegetables is about 632 thousand hectares (2009-10) covering 5.1% area of the total cropped area of the country, producing around 2.1 million tons. However, the area and production of vegetables have been increased in recent years. The total production of different fruits in the country is around 4023 thousand tons (2009-10). Of the fruits, banana occupies the highest

area (42.2%) followed by mango (19.6%), pineapple (12.8%) and jackfruit (7.0%). The area under potato in 2009-10 was 434.8 thousand hectares producing 7930 thousand tons with the productivity of 18.27 t/ha. The storage of potato is a serious problem. Spices production in the country is about 1.35 mmt from about 285.0 thousand hectares of land. The land area covered by spice crops is about 3.1% of the cropped area of the country. The present annual demand of spices is around 2.60 mmt. The shortage is met through import with the expense of foreign currency. About 0.60 million farm families are dependant on sugarcane cultivation and approximately 16000 persons are engaged in sugar industries of the country. Currently, on an average, sugarcane is grown in 117 thousand hectares of which 50% area is located in the mill-zone and the remainder in the non-mill zone. Presently, 15 sugar mills are in operation in the country with a production capacity of 0.21 mmt of sugar per year. Sugarcane in non-mill zones is generally used for production of jaggary and juice. Jute is grown on about 0.41 mha which is 2.9% of the total cropped area. Out of this, *C. capsularis* occupies 20% and *C. oltorius* occupies 80% area producing 0.96 million and 4.37 million bales, respectively, with a total production of 5.5 million bales. The productivity of jute is about 11.0 bales /ha. There are 163 tea estates in the country having about 55.0 thousand hectares of land under tea plantation producing about 56-60 million kilograms of made tea. Of the 163 tea gardens, 48 sick gardens give yield of only 274 kg per hectare against the national average yields of 1100 kg. About two-thirds of production is consumed locally and the rest is exported. Tea sector contributes 0.08% to GDP and about 0.30 million people are employed in this industry which is about 3.0% of country's total industrial employment.

Quality Seed Production Status

The seed requirement and supply of quality seeds of various crops for the year 2008-09 are shown in table-3.

Table-3 Seed requirement and supply of quality seeds (2008-09)

Crop	Total requirement (Ton)	Quantity supplied by different organizations (Ton)					
		BADC	DAE	ARIs	Private/NGO	Total	Percent (%)
Rice	309815	55754	65074	101	12338	133267	43.02
Wheat	70500	25000	12044	25	-	37069	52.58
Maize	5000	200	-	20	4000	4220	84.40
Jute	4000	1250	70	2	2500	3822	95.55
Pulses	21370	870	-	15	-	885	4.14
Oilseeds	15000	820	-	25	25	870	5.80
Vegetables	2600	81	-	0.7	750	831.7	31.99
Spices	137000	632	-	150	100	882	0.64
Potato	600000	18000	-	700	6000	24700	4.12
Total	1165285	102607	77188	1038.7	25713	206546.7	17.72

Source: MoA, 2010.

The supply of quality seeds of major crops varies from 0.64% for spices to 95.55% for jute. The supply of quality seed of rice, wheat, maize, pulses, oilseeds, potato and vegetables are 43.02, 52.58, 84.40, 4.14, 5.80, 4.12 and 31.99% respectively. As against the national need of 11.65 lakh tons of seeds, public sectors supply 1.8 lakh tons and private sectors supply 0.25

lakh tons of seeds. The remaining required seeds are the farmers' own seeds. It means the supply of quality seeds comes to about 18% while 82% seeds are qualitatively poor.

2.2 Scenario of Forestry Sub-sector

- The Forest crops of the country play an important role having contribution in many areas like environment determinant, fuel, wood supply, meeting house-hold materials, medicinal plants, etc.
- About 5000 plant species with 15% tree, 35% shrub and woody climbers, and 50% herb species exist in Bangladesh.
- There are 750 – 800 tree species in the country.
- There are over 300 fresh water wetland floral species in Bangladesh.
- The area of forest is declining at an alarming rate (3.3% annually).
- In 2007, the forest area was 2.53 million ha, of which the area of Hill Forest is 1.4 mha, Sal Forest 0.12 mha, Village Forest 0.27 mha and Mangrove Forest 0.74 mha.
- The present yield of forests managed by Forest Department is 2.0-2.5 m³/ha/yr while that of village forests is 5.0 m³/ha/yr.
- The import of wood is growing sharply having about 9.44 thousand tons/year.
- The productivity is low due to illicit felling, poor management practices, low initial survival, incompatible species composition, low soil efficiency, etc. The other problems for low productivity call for addressing appropriate management practices including improving the nursery techniques, selection of site specific species, using quality planting materials, controlling pests and diseases, applying appropriate silviculture practices, etc.

2.3 Scenario of Fisheries Sub-sector

Bangladesh water has wide aquatic diversity. In fresh water, 265 fish species belonging to 55 families and a total of 475 marine finfish species belonging to 133 families recorded so far of which about 50 species are of commercial interest. A total of 60 species of Palmononid and Penaeid prawn occurs in fresh water, estuarine and marine ecosystem of the country.

There are around 25 species of tortoise and turtles, 15 species of edible crabs and various species of algae and sea weed of economic importance have been identified in the marine environments of Bangladesh. In addition, there are 22 exotic species of fish widely used in the aquaculture and 93 aquarium species has been introduced as ornamental species (Akhtar and Rahman, 2007). The area and production of fish from different ecosystems are shown in Table 4.

Table 4. Area and total production of fish from various ecosystems (2009-10).

Production system	Total area (million ha)	Total production (million ton)
Inland capture	4.24	1.03
Inland culture	0.63	1.35
Marine	166.06	0.52
Total	170.93	2.90

Source: DoF, 2010

2.4 Scenario of Livestock Sub-sector

Livestock population in Bangladesh during 2009- 10 were Cows 23 million, Buffalo 1.35 million, Goats 23.28 million, Sheep 2.98 million, Chicken 228.0 million and Ducks 42.7 million. The per capita number of cattle was 0.16, goats 0.15, sheep 0.01, chicken 1.56 and ducks 0.29. The productivity of different livestock species is shown in Table-5

Table 5. Productivity of different livestock species in terms of milk, meat and eggs (2007- 08)

Milk	No. of cows (thousand)	Production (mmt)	Unit production
Cross bred	742	1. 5	2016kg/lactation
Indigenous	3380	0. 9 5	280kg lactation
Milch buffalo	227	0.180	793kg/ lactation
Milch goat	2587.2	0.027	10. 5kg/ lactation
Meat			
Indigenous cattle	3664	0.293	80kg/cattle
Imported cattle	139	0.252	150kg/cattle
Buffalo	139	0.018	130 kg/buffalo
Goat	8193	0.082	10kg/goat
Sheep	917	0.009	10 kg/sheep
Chicken	335703	0.336	1kg/chicken
Duck	49800	0.050	1kg/duck
Egg (mn)			
Large scale layer	7530	1731.8	230 eggs/year
Medium scale farm	13726	2745.1	200eggs/year
Indigenous chicken	21239	326.6	41 eggs/year
	Total	5653.2	

Source: DLS, 2009

3.0 Population and Food Requirements by the year 2030

3.1 Projected Population

The current population of the country is about 149.69 million. As projected, the population of country in the year 2030 will be 189.85 million at the growth rate of 1.26%. The following figure (Figure-1) shows the expected population during 2015, 2020, 2025 and 2030 (BBS, 2010).

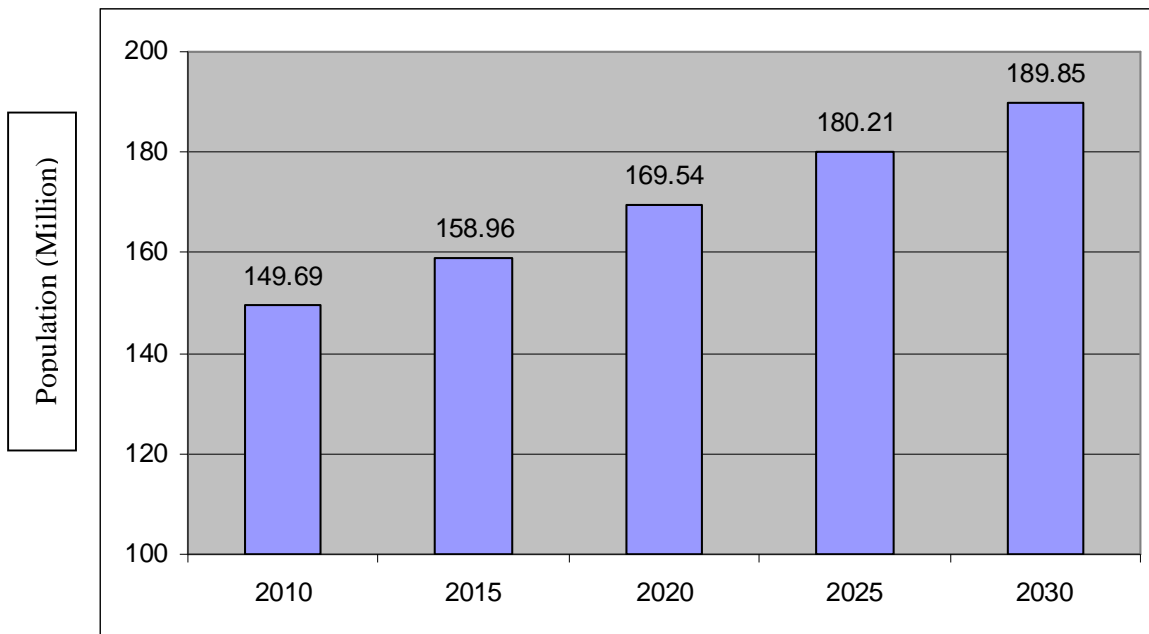


Figure-1: Projected population for the years 2015, 2020, 2025 and 2030

3.2 Projected Food Requirement (Crops)

The estimation of food crops requirement by the year 2030 is made by considering the population and minimum per head requirement. Except rice, the intake of all other food crops is far below the standard. However, the food crops requirement is prepared (Table-6) by taking into account the estimates prepared by expert groups of sub-sectoral studies (BARC, 2010).

Table-6: Food requirement by the year 2030

Crop	Projected requirement (million ton)	Current production (million ton)	Additional requirement (million ton)
Rice	39.80	34.00	5.80
Wheat	3.85	0.84	3.01
Maize	4.00	1.50	2.50
Pulses	3.50	0.20	3.30
Oilseeds	1.70	0.66	1.04
Potato	5.25	5.26	-
Vegetables	13.98	2.90	11.08
Fruits	6.24	4.22	2.02

Source: BBS, 2009, Priority Setting Reports (BARC, 2010)

All food crops except potato will be seriously deficit as per projected requirements for the year 2030. However, horizontal expansion of crop area as well as vertical increase of crop productivity are to be explored and ensured through adoption of modern technologies. In addition, exploration of new areas especially in unfavorable ecosystems and technological interventions through reducing knowledge-gap of farmers are some of the important areas to overcome the problem.

3.3 Projected Demand and Supply of Forest Crop Products

- The estimated forest land will stand at 1.60 million ha in 2030.
- The estimated shortage of wood comes at 23.88 million m³ in 2030.
- It is also reported that the demand-supply gap of bamboo is projected as 497.24 million culms in 2030.
- The projected demand of timber and fuel wood is 47.07 million m³ in 2030 and the estimated supply will be 23.5 million m³.
- Thus the import of wood in 2030 comes to 0.454 million m³.
- The demand and supply of bamboo in 2030 is estimated as 1109.03 and 611.79 million culms respectively.
- Unless this tremendous demand-supply gap is narrowed down, 80% population living in the village will seriously suffer.

3.4 Projected fish demand and supply

Besides food item, other requirements of fish are as export item, industrial use, product development, and technical loss. Present amount of utilization of fish in these areas are very minimum. As a result, the targeted amount for 2030 requires a high growth in all the areas (Table 7).

Table: 7. Projected fish demand and supply in 2030

Year	Population (million)	Fish demand (mmt)					Total demand	Expected Production	Total gap
		Use as food	Export	Industrial use	Product development	Technical Loss			
2020	168.70	3.45	0.410	0.050	0.150	0.050 (1.5%)	4.00	3.856	0.144 (3.60%)
2025	180.89	3.70	0.543	0.080	0.250	0.030 (0.8%)	4.45	4.321	0.129 (2.89%)
2030	189.85	4.05	0.690	0.200	0.400	0.025 (0.5%)	5.38	5.300	0.08 (1.49%)

Thus the projected required amount of fish as food is 4.05 million metric tons (growth 1.3%), for export is 0.69 mmt (growth 10.5%), for fish and poultry feed industry is 0.20 mmt (growth 36.5%), for product development is 0.40 mmt (growth 34.5%) and technical loss is 0.025 mmt (growth -2.0%). Based on the demand estimation criteria and the projected requirement, the total demand of fish will be 5.38 million metric tons in 2030.

3.5 Projected Livestock Demand and Supply

The projected demand and supply of Livestock food products are shown in Table 8.

Table 8: Projected demand and supply of livestock food products to the year 2030

Product	2020			2025			2030		
	Demand	Target production	Deficit (%)	Demand	Target production	Deficit (%)	Demand	Target production	Deficit (%)
Milk (mmt)	15.5 (250ml /head/day)	4.8 (77.6ml /head/day)	69	16.4 (250ml /head/day)	8.67 (132ml /head/day)	47	17.5 (250ml /head/day)	15.6 (225ml /head/day)	11
Meat (mmt)	7.4 (120 gm /head /day)	2.5 (40 gm /head /day)	67	7.9 (120 gm /head /day)	4.24 (64.5 gm /head /day)	47	8.3 (120 gm /head /day)	7.2 (104 gm /head /day)	14
Egg (mn)	17628 (104/head /year)	13867 (82/head /year)	21	18740 (104/head /year)	18027 (112.5/head /year)	3.8	19750 (104/head /year)	19829 (104/head /year)	0

Source: BBS, 2010

To meet the estimated demand of food from livestock sources the production target of milk is 15.6 mmt at per capita availability of 225 ml/day, meat is 7.2 mmt at per capita availability of 104 gm/day, and egg is 19829 million no. at per capita of 104 nos/year for the year 2030. If the production estimate is achieved 100%, then there will be self-sufficiency in eggs and slightly below in case of milk and meat.

4.0 Major Challenges and Constraints

4.1 Crops Sub-sector

4.1.1 Challenges

The major challenges of crop agriculture are to raising productivity and profitability, retaining sustainability, increasing resource-use efficiency, conserving natural resources and increasing land and water productivity, improving product quality and developing marketable production, improving post harvest management, meeting demands for diversification and commercialization of agriculture.

The other emerging challenges include shrinking of agricultural land every year due to urbanization, infra-structure development, roads, etc. Due to climate change, sea level rise will cause inundation of about 16% of total cropped area, displace 10% population, ultimately causing loss of 2 million tons of crop harvest. Global warming will cause cyclones and storm surges in high frequency and volume. Due to river erosion and storm surges, moderate to severe erosion will occur in flood plains and char lands. Out of 2.85 million hectares, about 1.00 mha in the coast is affected by different degrees of salinity which will continue to increase due to climate change. About 2.32 mha and 1.2 mha of net cropped area are affected severely and moderately drought and the problem will further aggravate. About 1.32 mha and 5.05 mha of the net cropped area are severely and moderately flood-prone that seriously hamper crop production.

In addition, reduced availability of surface and ground water in dry season due to excessive extraction of ground water is coming up as a serious problem. Development of water saving technique in agriculture is a critical issue.

Facilities and programs for production and distribution of quality seeds of commodities to the farmers is the main reason for low productivity and there is wide yield gap between demonstration and farmers yield. The challenge is to reduce current yield gap. Farmers knowledge-gap in adopting modern agricultural technologies also leads to low productivity. Further, the yield ceiling of HYVs needs improving by developing super varieties.

Inadequate institutional development in the areas of creation of infra-structure, research fund and facilities and skilled manpower for the innovation of technologies to cope with the emerging challenges in the agricultural sector.

4.1.2 Constraints

The major constraints in research, research management, technology generation and dissemination are stated below:

- Inadequate budgetary allocation for agricultural research and irregular fund release.
- The existing incentive structure for scientists is poor resulting erosion of scientific skills.
- Lack adequate program for human resource development. Recently BARC has prepared one which needs to be implemented early.
- Inappropriate Policy issues in research system.
- Insufficient use of ICT in agriculture.
- Inadequate development of partnership with public-private and national-international organizations in research and technology transfer system.
- Declining and degrading land resources.

- Less awareness of mechanization and inadequate availability of appropriate machineries.
- Increasing natural hazards.
- Climate change vulnerability.
- Inadequate availability of varieties for stress conditions like flood, submergence, salinity, drought, pest and diseases, etc.
- Adulteration in fertilizer and imbalanced applications of fertilizers.
- Lower germplasm base and their proper utilization
- Slow progress in bio-technological research.
- Limited possibility of horizontal expansion of crops.
- High percentage of landless, marginal and small farmers (more than 85%).
- Farmers knowledge-gap and weak technology transfer system.
- Technological gap in pre and post harvest management system.
- Weak linkages between research-extension-farmer-market.
- Uncertainty of fair price of agricultural commodities due to underdeveloped marketing system.
- Lack of proper land use planning.
- Rapid perishable nature of agricultural commodities and excessive post-harvest losses.
- Limited access of farmers to agricultural credit.
- Inadequate technologies to meet export market requirements.
- Insufficient technologies for unfavorable ecosystems and environment.

4.2 Forestry Sub-sector

4.2.1 Challenges

- Encroachment of mangrove forests for shrimp culture,
- Clearing hill forests,
- Disease attack of sundari, sissoo and bamboo,
- Improper and insufficient post harvest technologies,
- Infra-structure development, urbanization, agricultural expansions, aqua culture, faulty water management interventions,
- Less aware of people for forests and environment,
- High demand of wood especially for fuel, natural calamities, etc.
- The import of wood is growing sharply having about 9.44 thousand ton/year.
- The yield of forest in Bangladesh is one of the lowest in the world.
- Scientific and planned cultivation of medicinal plants and development of proper preservation techniques.
- Protection and maintenance of enormous wild life species including wetland flora and fauna.
- Use of solid wood instead of composite wood when in case of composite wood the wood requirement is much lower.

4.2.2 Constraints

- Flash flood and siltation of river basin.
- Uneven forest distribution.
- Loss of bio-diversity.
- Inadequate availability of quality planting material.
- Scarcity of industrial raw materials.
- Climate change.
- Poor technology transfer.
- Colonial approach of the foresters and their wrong behavioural pattern.

- Linkage between research and extension is alarming poor.
- Shortage of qualified and effective scientists in Bangladesh Forest Research Institute.
- Both FD and BFRI suffer from inadequate funding and appropriate manpower.

4.3 Fisheries Sub-sector

4.3.1 Challenges

Unlike other sub sector of agriculture, fishery is still privileged and has opportunities to increase fish production through sustainable utilization of unutilized and underutilized fisheries resources which need to be backhanded by control flow of technological support and management approaches. In Bangladesh, gap between fish demand and supply will further increase by two reasons, like: (a) population growth and (b) possible reduction in potentialities in fisheries due to degradation of natural resource base and climate change and environment vulnerabilities. Climate change issues are mostly adaptable in nature. Therefore, pragmatic and demand driven research is needed to reduce the future production gap. To make pace with the future demand, the fisheries sub-sector has to face various adverse issues and challenges. The major challenges of the sub-sector are as follows:

- The sub-sector has to contribute at a rate higher than the rate of the initial phase of planning years to reduce the demand- supply gap followed by a steady rate of growth (app. 2.5%) up to 2030;
- The sub-sector has to play a vital role to establish food security and poverty reduction means for the extreme poor, poor and landless marginal farmers under increasing pressure of population growth and extreme situation of climate changes;
- Production has to be raised and managed in hazardous conditions in degraded physical, chemical and biological resources with high cost of inputs and land use policy;
- Global temperature and sea level rise due to climate changes are the issues to face with adoption of new technologies.

4.3.2 Constraints

1. Climate change vulnerability

It is apprehended that the vulnerability of fisheries and dependent communities, particularly open water and floodplain fisheries will be affected seriously if the climate becomes more extreme (BARC, 2010a). The extreme vulnerabilities will cause:

- Increase in frequency and intensity of occurrence of natural hazards like droughts, inundation, and flash flood;
- High degree variation in temperature and salinity intrusion;
- Changes in hydrological cycles and decrease in production of aquatic animals;
- Damage of grazing and nursing grounds, fry and fingerlings and culture fisheries.

Natural fish stock will be more affected due to climate change impacts which will endanger food security. In addition, the change will directly affects fish physiology and behaviour and alter growth and reproductive capacity, mortality and distribution.

2. Fish bio-diversity loss

Various natural and anthropogenic activities caused irreparable damage to fish bio-diversity. Anthropogenic activities are considered as the prime reason for the damage. Construction of flood control structures, development of irrigation systems, application of hazardous chemicals/pesticides in the wet land and floodplain crop fields without taking into account the interest of the fisheries are major causes of reduction of fish recruitment, breeding migration route blockage. Fishing pressure and indiscriminate killing of undersized and egg

bearing fish species causes heavy loss in the sector. According to the Red List of IUCN (1999), a total of 54 fresh water fish species have so far declared as critically endangered/ endangered, and threatened.

3. Environmental vulnerability

Because of its deltaic, low-lying topography, the country is very much vulnerable to floods, droughts, cyclones and storm surges. The delta is the natural drainage system for major rivers such as Ganges-Padma, Brahmanputra-Jamuna, and Meghna. Over 92% of the water passing through the delta originates outside Bangladesh. The sector is likely to face serious vulnerability in terms of global warming, shifting rain fall pattern. Various studies reveal a considerable loss on inland areas and severe coastal erosion will also affect coastal aquaculture, fishing effort, sustainable stock, and fish bio-diversity.

4. Water pollution

Chemical degradation of aquatic system makes it unsuitable for safe fish production accompanied by low productivity. The inland aquatic system receiving continuous untreated wastes from various sources, such as domestic, municipal/city sewages, agricultural wastes (including commercial poultry and livestock farming wastes, etc.), and various industrial sources.

Domestic wastes contain a variety of dissolve and suspended impurities and cause significant harm for aquatic animals.

Marine ecosystem is also receiving huge pollutants in the form of radioactive substances, heavy metals, oils etc. from land based and water based sources (Maruf, 2004). Bangladesh suffers seriously from heavy aquatic pollutions due to industries. Further pollution will increase with increase of human population; untreated sewage would cause the most serious aquatic pollution where contamination of water and food with heavy metals and hazardous chemicals are great threat.

5. Siltation of river beds

The natural sedimentation contributes to the development of many of the morphological features of rivers and floodplains. It is estimated that 2.197 million tons of sediments pass annually to the sea through Ganges-Brahmaputra river system. The Bangladesh Water Development Board estimated that 1.27 billion tons per year of suspended sediments discharged through six major rivers in Bangladesh. Siltation generally raises the river bed area and decreases water volume of the water ways. Silt deposits in river beds results in loss of breeding grounds and hinders breeding and feeding of migration of various open water species. Further siltation causes drainage problems and diminishes water refuge grounds for fish. Deposit of silt normally suffocates the spawning ground of the species.

6. Biological depression of farming species

Biological depression of culture fish species is one of the major constraints of aquaculture development in the country. Inbreeding and cross breeding activities in the fish hatcheries are the major causes of this hazard in the sector. Inbred and cross bred seeds are highly susceptible to diseases and mortality with poor growth. Among the cultured species, most affected fishes are Rohu, Catla, Mrigala, Thai Pangus, Thai Koi, Carpio, Silver carp, and Big head. Biologically depressed cultured seeds reduce the total production by more than 20.0% of any production system. More than 80.0% of the germplasm producing hatcheries of the country is now facing these corruption problems. Inadequate brood fish, knowledge gap of the hatchery operators about the negative effect of hatchery inbreeding/cross breeding

practices and lack of appropriate guidelines, monitoring, and supervision by the appropriate authorities are the major causes of this setback in the sector.

7. Quality and cost of farming inputs

Quality and cost of farming inputs in aquaculture are directly related with productivity and profitability of farming system. Rapid expansion of aquaculture practices from mid 90s in the country highly demanded for farming materials particularly seed and feed. The gap between requirement and supply tends to increase with time and invites various ill practices in feed, seed, and other materials like fertilizers and chemicals production and business. As a result, the aquaculture system failed to perform its output at the desired level.

4.4 Livestock Sub-sector

4.4.1 Challenges

Livestock subsector faces lot of challenges which need to be addressed effectively. Policy and institutional reform is a major challenge. The positive changes in part of livestock and poultry development are mainly due to some ad-hoc measures taken by the government such as waving of taxes and tariffs on imported food products, tax holiday, 20% rebate on electricity bill and land taxes at par with crop agriculture. These positive changes definitely warrant implementation of necessary policies enabling friendly environment for the sub-sector development.

Availability of quality feed and scarcity of efficient feeding system in the country is another challenge. This needs to be assured through technological innovation and integrating fodder production in cropping system. Moreover, establishment of Acts and legal bodies enforcement of laws and regulations, such as Feed Act, Quarantine Act, Quality Control Act for livestock products, drugs, vaccines and other inputs are other challenges. Formulation and implementation of all these Acts and Regulations will have positive impact on the development of this sub-sector.

Lower productivity of all the species in the country, technological innovation for the development of appropriate breed for different species of livestock, veterinary health coverage, disease diagnostics etc. are also in the fleet of challenges.

In the light of increasing demand of livestock food product (milk, meat, egg) due to rapid expansion of industries, urbanization and rising per capita income, and attaining these mountainous target is a great challenge.

Responses to these challenges will only be possible if the new advances in science and technologies, particularly molecular biology, genetic engineering and other bio technological tools are applied. Bio technology can play a cross-cutting and critical role in meeting the targets higher production, better resistance to diseases, and lower cost of production.

Development of new genotype/variety in the light of changing climate, socio-economic and agro-ecological conditions and location specific is the best alternative to sustainable higher livestock productivity. Resource conservation technology for improving livestock productivity, processing and product diversification, value addition and marketing would be the added advantages for achieving the required target. Preparedness to face the climate change effect, such as drought, flood, cyclone, earth quake with appropriate technology will endure stressed conditions.

For research and development, the key challenge is to develop promising / appropriate technologies for higher productivity, enabling environment for production, processing, conservation and marketing of value added products.

4.4.2 Constraints

- Development of the sub-sector is constrained by absence of appropriate breed for different livestock species including poultry;
- Indiscriminate breeding of genetically inferior livestock;
- Inadequate and poor quality feeds and fodder;
- Absence of appropriate technology for improving the feed efficiency of feed stuffs;
- Inadequate veterinary coverage and technologies for diseases diagnosis, treatment, and control;
- Poor/ lack of epidemiological information about major livestock and poultry diseases; shortage of quality vaccines for various infectious diseases;
- Poor/ lack of strategic disease control programs including absence of disease monitoring and information system;
- Poor / lack of appropriate quality control, bio-security and bio-safety issues;
- Absence of quarantine system in the ports; absences of livestock live market regulations;
- Poor / lack of preservation techniques for livestock products and by-products;
- Absence of systemic marketing net work for live livestock and their products and value addition.
- In addition to inadequacy of technological inputs livestock development is handicapped by the absence of a comprehensive development policy and national strategy;
- Absence of legal and regulatory framework for quality control of livestock products, drugs, vaccines, feeds and quarantine issues controlling trans boundary migration of diseases.

5.0 National Agricultural Policies and Programs

5.1 Poverty Reduction Strategy Papers (PRSP 2005)

According to the World Bank report, 53% of the rural population of Bangladesh are classified as poor and 85% of the total numbers of the poor live in rural areas and majority of them are still dependent for income and livelihood on agriculture.

According to PRSP, the poverty level to be reduced to half (26.5%) by 2015 for achieving the MDG. The government has identified agriculture and rural development as the topmost priority sector for rapid poverty reduction. With about 21.71% of GDP contributed by agriculture and another 36% by rural non-farm sector, the rural economy as a whole contributes more than 60% of the total GDP. Agriculture sector generates two-third of total employment, contributes 7.34% of total export earning and provides food security to the increasing population.

To achieve the PRSP goal, the agriculture growth rate will be required at least 4% and in non-farm sector 7% against the current growth rate (2007-2008) in agriculture is 3.61 and other services is 6.69.

Agriculture and the rural economy are recognized as the key driver of pro-poor growth strategy. The Govt. policy to support the strategy focuses on the following five issues:

- Increase productivity of major crops (i.e. cereals)
- Diversification of high value non-cereals crops (i.e. fruits, vegetables, cash crop)
- Development of non-crop agriculture (fishery, poultry, livestock, etc.)
- Promotion of rural non-farm activities (construction, transport, etc.)
- Development of agri-business services and market promotion

5.2 National Agriculture Policy (June 2009)

The National Agriculture Policy (NAP) aims at creating an enabling environment for sustainable growth of agriculture for reducing poverty and ensuring food security through increased crop production and employment opportunity as envisaged in PRSP, MDGs, and SDGs.

The specific objectives are to:

- (i) developing and harnessing improved technologies through Research & Training;
- (ii) increasing productivity and generating income and employment by transferring appropriate technologies and management inputs;
- (iii) promoting competitiveness through commercialization of agriculture;
- (iv) establish a self-reliant and sustainable agriculture adaptive to climate change and farmer's needs.

The research activities will focus on intensification, diversification, and whole farm activities in agriculture as outlined below:

- post production technologies, value addition, high value crops, agribusiness management, and trades;
- emerging Issues like biotechnology, hybrid, climate change, disaster and stress including flood, drought, cyclone, salinity, upland/hills, deep water crop management, organic farming, rainfed agriculture;

- cross cutting issues - sustainability of production system, poverty alleviation and livelihood improvement, household food security, off-farm income generation and rural development.

5.3 The National Food Policy (NFP) 2006

The NFP declares a comprehensive multi-sectoral approach to attain all aspects of food security as follows:

- technological security to ensure yield improvement coupled with production and safety;
- to achieve greater efficiency of domestic agriculture and enhanced availability of food for all;
- sustain increase incomes of the poor and the distressed to enhance their access to food;
- ecological security to provide the basic life support system upon which sustained agricultural improvement depends.

5.4 Agriculture Sector Review and Actionable Policy Brief

The sector review recommended to develop varieties and methods to:

- raise yield and increase production efficiency in both irrigated and rainfed areas;
- provide greater tolerance to stress conditions, such as prevailing and future diseases and insect pest, drought, flood, adverse soil condition;
- improve soil health and productivity;
- meet the challenges of climate change effect;
- introduce high yielding, stress tolerant alternative food crops for food security for special circumstances and regions.

5.5 National Land Use Policy 2001

The salient features of the National Land Use Policy are to:

- halt the present alarming rate of conversion of agricultural land to non-agricultural purposes;
- prepare guidelines for maximum land utilization based on agro-ecological characteristics;
- reduce environment pollution and degradation of land, water and air and promote environment friendly activities in agricultural development.

5.6 Agricultural Sector Programme Support (ASPS-II)

The main goal of ASPS (II) is to support the Government of Bangladesh implement the PRSP. The agriculture sector is an important tool to reach this goal as it directly reaches the poor in the rural areas providing both food and cash at the same time. The agricultural production should focus on a diversified and more effective production in the poor rural areas. The development objective of ASPS-II will focus on promotion of food production and diversification for improved living conditions of the poor, marginal and small farmer households through enhanced, integrated, and sustainable agricultural productivity. It will

provide supports through Agricultural Extension Component (AEC), Regional Fisheries and Livestock Development Component (RFLDC), Rural Roads and Market Access Component (RRMAC) and Strengthening Policy Planning.

5.7 New Agricultural Extension Policy

The MoA prepared the New Agricultural Extension Policy (NAEP) in 1996 in accordance with the agricultural policies and priorities set out in the 15-year perspective plan, 1995-2010. These policies and priorities include (i) attainment of self-sufficiency in food grain and increase production of other nutritional crops, (ii) ensuing sustainable agricultural growth through more efficient and balanced uses of land, water, and other resources, (iii) increasing foreign exchange earnings through agricultural seeds, (iv) introducing high value cash crops, (v) improving the quality and availability of seeds, (vi) reducing environmental degradation, (vii) increasing fish, livestock, and forestry production, and (viii) conserving and developing forest resources.

The main goal of NAEP is to encourage the various partners and agencies within the national agricultural extension system to provide efficient and effective services which complement and reinforce each other in an effort to increase the efficiency and productivity of agriculture in Bangladesh. The NAEP lists 11 policy measures called components. These components include extension support to all categories of farmers, efficient extension services, decentralization, demand-led extension, working with groups of all kinds, strengthened extension-research linkage, training of extension personnel, appropriate extension methodology, integrated extension activities, coordinated activities, and integrated environmental support.

5.8 National Forestry Policy (NFOP)

- The national forestry policy was prepared in 1994
- The major objectives of NFOP are as follows:
 - 20% of the total land area will be brought under afforestation programs;
 - bio-diversity of the existing degraded forests will be enriched by conserving remaining natural habitat of birds and animals;
 - agricultural sector will be strengthened by extending assistance to the sectors related with forest development, especially by conserving the land and water resources;
 - various international efforts and government ratified agreements relating to global warming, desertification, control of trade in wild birds and animals will be implemented;
 - illegal occupation of the forest lands, tree felling and haunting of wild animals will be prevented with the cooperation of local people.

5.9 World Bank Priorities for Agriculture and Rural Development

Priority areas for the World Bank's support are:

- increasing agricultural productivity, diversification, and value addition through a dynamic and responsive agricultural research and extension to accelerate the transition from subsistence to commercial farming, export promotion, and bridging yield gap;
- enabling rural business environment for small and medium enterprise (SME) and agro-business development;
- improving factor markets, access to assets and natural resource management;

- strengthening rural Institutions and Livelihood Support by improving roads, electricity, communication, water, health and education and creating and strengthening local organization like farmers' association, womens' group, etc.

5.10 National Fisheries Policy

The Ministry of Fisheries and Livestock (MoFL) formulated the National Fishery Policy in 1998 with the overall objectives to:

- a) Enhance fisheries research and production;
- b) Alleviate the poverty through creating self-employment and improve the socio- economic conditions of the fisheries;
- c) Meet the demand for animal protein; and
- d) Achieve economic growth and earn foreign currency by exporting fish and fisheries products;
- e) Maintain ecological balance, conserve biodiversity and improve public health.

Besides the NFP, various other related policies have been developed and assessed their effect on fisheries development. Most of the policies emphasized on the sustainable use and conservation of large water bodies but paid little attention to address the needs of small scale fisheries. Existence of multiple goals in a single policy registered negative effects and makes the policy complicated for management of the resources. Few policies/plans related to fisheries indicate interests like:

- a) Few focuses on sustainable use of all natural resources;
- b) Emphasize on increased agricultural production through balanced use of water and land resources embracing aquaculture production as a part of this processes;
- c) Focuses on diverting benefit to genuine fishers through harvesting, adopting conservation measures and ensuring sustainability of resources;
- d) Focuses on equitable and participatory management of water resources, fisheries and wildlife;
- e) Emphasize on the need to harmonize national fishery policy, avoid conflict and facilitate agricultural and fisheries production.

5.11 National Livestock Development Policy 2007

Government of Bangladesh has formulated a very comprehensive National Livestock Development Policy (NLDP) 2007 to address key challenges and opportunities for the sustainable development of the livestock sub-sector with the main vision to provide the enabling environment , opening up opportunities, reducing vulnerability for harnessing the full potential of livestock sub-sector to accelerate economic growth for reduction of rural poverty in which the private sector will remain the main actor, while the public sector will play a facilitating and supportive role.

The specific objectives of the policy are to:

1. promote sustainable improvement in productivity of milk, meat, and egg production including processing and value addition;
2. promote sustained improvements in income, nutrition, and employment for the landless, small and marginal farmers; and
3. facilitate increase private sector participation and investments in livestock production, livestock services, market development and export of livestock product and by-products.

6.0 National Agricultural System

Agricultural system in the country has two major areas, namely Technology Generation and Technology Delivery Systems. Technology generation system is operated by different agricultural research institutes, universities, non-government organizations (NGO) and private organizations (PO), while technology delivery system is mainly handled by agricultural extension department, non-government organization and also by private organization. In both technology generation and delivery systems, the public institutions played the dominating role.

Technology Generation System: The National Agricultural Research System (NARS) with ten agricultural research institutes (ARIs) of the country plays the major role in developing new technologies for the improvement of agricultural sector. In addition, NGOs and POs are also involved in technology development. Bangladesh Agricultural Research Council (BARC), the apex body of NARS, is coordinating the overall agricultural research activities of the country. NARS includes Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI), Bangladesh Jute Research Institute (BJRI), Bangladesh Sugarcane Research Institute (BSRI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Forest Research Institute (BFRI), Bangladesh Tea Research Institute (BTRI), Bangladesh Fisheries Research Institute (BFRI), Bangladesh Livestock Research Institute (BLRI), and Soil Resource Development Institute (SRDI). BARC, BARI, BJRI, BSRI, BINA, and SRDI belong to the Ministry of Agriculture (MoA), BFRI and BLRI belong to the Ministry of Fisheries and Livestock (MoFL), BTRI belongs to the Ministry of Commerce (MoC) and BFRI belongs to the Ministry of Environment and Forests (MoEF). Out of total eleven Agencies, eight are autonomous and the remaining three are government organizations. NARS as a whole has 96 stations scattered throughout the country covering all agro-ecological zones having an area of about 3675.00 hectares of land. More than 2000 scientific personnel are involved in technology generation system. Over 1116 technologies have been released by these different ARIs, while 274 technologies by different universities and NGOs/POs during the last three decades. Through adoption of these technologies, a remarkable improvement has been achieved in productivity and production of crops, fisheries and livestock. However, emphasis has been given on research and technology development in support of increased productivity in varied eco-systems in the following areas: (a) for crops, varietal development (short maturing, HYVs, bio-technology), management practices (fertilizer, cropping patterns, cultural practices for char land, hill, and coastal areas), water and soil conservation; (b) for livestock, disease control (trans-boundary zoonotic diseases), poultry and dairy development and value added activities; (c) for fisheries, inland aquaculture development (breeding, feeding, cage culture, disease, etc.) and coastal aquaculture and marine fishery (shrimp and brackish water species). There is a need for strengthened human, physical and institutional capacities of key research players, including NARS institutes and universities.

Technology Delivery System: Department of Agricultural Extension (DAE), Directorate of Livestock Services (DLS), and Directorate of Fisheries (DoF) play the major role in dissemination of innovated technologies to the farmers. Demonstration of technologies, input supply, training of farmers, collection of field problems, etc. are some of the major activities of the extension departments. The extension services are regarded as main drivers of agricultural development of the country. Bangladesh Agricultural Development Corporation (BADC) is functioning to produce and supply quality seeds to the farmers. In addition, non-

government organizations and private organizations are also contributing in technology delivery system of the country.

The extension services have been revitalized and reoriented through the adoption of New Agricultural Extension Policy (NAEP) where emphasis has been given on sustainable and diversified agriculture through integrated research and extension. For this, a program like National Agricultural Technology Project (NATP) has been launched and is now under operation. The program includes the areas of technology adoption and community-based learning i.e. farmers' skill training, soil health improvement, diversification of agriculture, cultivation of quick growing fruits and vegetables, cropping patterns, farm mechanization, etc. and promotion of sustainable agriculture. In order for interventions to be successful, human and infrastructure capacities of relevant extension service delivery organizations like DAE, DLS, and DoF require strengthening.

7.0 Vision, Mission and Research Strategy

Vision

Ensure food and nutrition security, sustainable agricultural production and commercialization and improvement of livelihood through technological innovations.

Mission

To harness power of science and knowledge for higher and sustainable agricultural production to meet the demand of the country to the year 2030 and beyond.

Research Strategy

⇒ Improve efficiency of human and financial resources and effective utilization of infrastructure

- Formulate collaboration and target-oriented eco-region-wise research programmes for technology development cutting-across disciplines and institutions within and outside the NARS.
- Prioritize resource-based and demand-driven research programmes with focus on marginal and smallholders and emerging market opportunities.
- Promote sustainable management system for diversified ecologies
- Focus more on rainfed, backward, marginal, and fragile areas.
- Focus on ecosystem health and bio-security of fishes and animals.
- Promote efficient input management in the farm production system.
- Develop low irrigation water requiring crop production system.
- Stakeholders collaborations in developing improved technologies, systems and information.
- Public-Private partnership on agricultural research.

⇒ Facilitate accelerated dissemination of improved technologies, knowledge and information

- Develop efficient institutional mechanism and governance structure for linking technology generation and dissemination system.
- Develop effective delivery systems.
- Ensure standard scientific facilities in research laboratories.
- Evolve institutional models to link research and development system with farmers and other stakeholders in the value-chain for accelerated adoption, cost-effective post-harvest management.
- Value addition and processing and efficient marketing through information and communication technology and e.agriculture.

⇒ Enhance quality of human resource in agri-supply chain

- Regular manpower development planning in agricultural research and development system.
- Improve quality of higher agricultural education and enhance capacity of human resource in research through talent management to overcome new and complex, and emerging challenges in agriculture.
- Develop an accountable, professional, motivated and intellectual property rights-compatible work culture.

⇒ **Commercialization of technologies through organized intellectual property rights and benefit sharing system**

- A Compatible Intellectual Property Right (IPR) and technology for promoting science and benefiting farmers.
- Harmonization of IPR with other parallel laws in and outside the country.

⇒ **Promote effective, efficient, and decentralized governance by introducing best management practices in BARC**

- Institutionalize project-based budgeting, management information system, priority setting, monitoring and evaluation, multi-institutional participatory research.
- Multi-stakeholders, multi-disciplinary, multi-institutional participatory research
- Involvement of social science in research, technology development and dissemination.
- Research priority on unfavorable ecosystems like coastal, char, haor, hilly, barind, etc. and rainfed and marginal ecosystems, vulnerable groups.
- Provide gender-friendly technologies, machinery, and management options.
- Evolve an efficient administration by employing information and communication technology.
- Develop a performance-based work-culture with incentives and reward system.

8.0 Research Vision and Focus

8.1 Crops and Forestry Sub-sector

Productivity Pathway

Agriculture is multi-functional, it provides food, feed, fibre, fuel and other goods and plays a key role in efforts to achieve sustainable development. It plays an important role in providing employment, promote agribusiness and influence other essential ecosystems services and provide raw materials for agro-industries. Bangladesh agriculture faces great challenges today as it has to confront climate change, loss of biological diversity, loss of soil fertility, water shortages and loss of quality water, stagnating crop yield, and rapid population growth. Land, water and ecosystem are showing symptoms of degradation and fatigue and causing adverse effect on sustainability and future growth. The basic problems of food and nutrition security, poverty eradication and sustainability and management of natural resources are yet to be solved. To address these ground reality, new sources of productivity growth will have to be knowledge intensive. There is a pressing need to reorient agricultural research methods and approaches as research agenda became complex. In future both increased cropping intensity and productivity growth need to be explored. Use of new tools and techniques are needed to break the new grounds in productivity and application of new science has to be given greater attention. Breeding should address both quality and quantity. The focus will have to be on specific adaptation to harness yield potential. Input use efficiency particularly fertilizer and water should receive greater attention. Hybrid development should be given attention with pro-hybrid policy in crop improvement program. Emphasis on energy efficiency and alternate agriculture specially with low water requiring crops should receive our attention. Combined efforts of NARS and IARC would be the key to achieve future success. Research investment is key to innovation and prosperity in agriculture. Considering the above problem areas and to accomplish vision and mission of crops sub-sector, research focus should be given in the following key areas:

■ Food Security through Increased Production, Availability, Access and Utilization of Food crops.

Poor and vulnerable households are food insecure because of their inability to afford minimum food items through their own production, cash income, market purchases, and other resources necessary to acquire safe and nutritious food. Enhancing food security can be achieved through increasing productivity of crops, agricultural diversification, and increase of non-farm activities. Access to food for the poor could be achieved through creation of pro-poor employment in farm and non-farm activities as well as supply chain development for income enhancement, post harvest loss reduction and price gap reduction, woman participation in agriculture and entrepreneurship development. Food security should follow the guidance of the National Food Policy Plan of Action, structured along the three main dimensions of food availability, access and utilization.

■ Ensure Intake of Safe Nutritious Food through Diversified Food Use

General dietary habit of people of Bangladesh is dominated by cereal food intake, especially rice. There is a slow decreasing trend in cereal food intake, while vegetables, fruits, pulses, oils, etc. are increasing, which is far below the nutritional requirements. Agricultural production system need to be diversified to improve the dietary diversity of consumers and for balanced human diet. Crop production, pre and post harvest processing, storage, availability and access of non-cereal crops in diet are some the areas required to meet the nutritional requirements. These aspects should be considered in preparing the research agenda.

■ **Improve Crop Productivity/Production**

Varieties with diverse genetic make-ups create an opportunity to withstand adverse condition and enhance productivity. Exploration and use of genomes that could contribute yield increase and to cope with adverse environmental condition should be given emphasis in varietal development program. The country should take advantage of these innovations and simultaneously devote to continue the efforts.

There exists high yield gap among potential, demonstration and farmers' yield. This is because of farmers knowledge gap in modern technologies, inadequate supply of quality seeds and non-adoption of recommended crop management practices. To reduce the gap it requires participatory on-farm research in different AEZ to fine tune the research innovation at farm level. The available technological intervention can improve the productivity and production of crops.

■ **Enhancing Genetic Resources**

The world is gifted with enormous genetic resources. The scientists have already utilized part of the inherent characteristics of these genetic resources in enhancing productivity of crops. But still many of the traits remain unexplored which can positively contribute in further improvement. Globalization and Commercialization of economy may hasten process of mono cropping and spread of improved varieties of a few major food and cash crops and animal species resulting in the replacement of traditional indigenous germplasm. This may lead to faster erosion of bio-diversity and loss of traditional knowledge. Therefore a national action plan is required to collect, evaluate, characterize, conserve and utilize plant, insect, animal, fish and microorganism genetic resources of indigenous and exotic origin. Efforts should be made on bio-prospecting of wild species for bio-modules and genes for commercialization. To address future needs, research on genetic resources should receive greater attention on sustainable use of available genetic resources through characterization, genetic enhancement and pre-breeding, functional genomics, proteomics, phenomics, gene mining, molecular breeding through tools like marker-aided selection and gene stacking and customized genetic engineering. DNA fingerprinting is needed to establish ownership of indigenous materials and IPR issues will have to receive priority.

■ **Breeding Options for Crop Improvement**

Climate change coupled with population growth will produce unprecedented stress on production system. Abiotic stress such as drought and salinity may reduce yield. Increasing demand can only be met by improving plant productivity. Traits that are the focus of abiotic stress resistance include optimized adaptation of temperature-dependant enzymes (to higher or lower temperature), altering day-length, regulation of flower and fruit development, optimization of photosynthesis including circumventing inherent limitations in C₃ and C₄ pathways in plants. Modern, conventional and participatory plant breeding approaches play a significant role in the development of new crop varieties. There is a need for new varieties of crops with high productivity in current and emerging marginal and unfavorable environments, resource limited farming system, intensive land and resource use systems. Plant breeding is facilitating the creation of new genotypes with higher yield potentials in a greater range of environment mainly through recruiting genes from within gene pool of interbreeding plants and also through bio-technology assisted hybridization and tissue regeneration. Breeding augment by molecular screening may yield rapid advances in existing varieties. Whole genome analysis coupled with molecular techniques can accelerate the breeding process. Further development of approaches using molecular markers through MAS will accelerate identification of individuals with the desired combination of genes because they can be

rapidly identified among hundreds of progeny as well as improve backcross efficiencies. Heterosis breeding and radiation breeding should also be employed to develop hybrid and varieties. Critical to improved plant breeding is ensuring the continuity of specialist knowledge in plant breeding. Approaches that encourage research in the field and continuity of career structure for specialist are key to the continuation of classical and plant breeding knowledge.

■ **New and under-utilized crops**

Crops diversity in Bangladesh is enormous, but traditionally major emphasis has been given on limited crops like rice, wheat, potato, a few vegetables, oil seeds, pulses and fruits. Rice alone occupies more than 75% of the total cropped area. A large number of important crops remained under-utilized. These crops have potential both for domestic use and for export market. Again the production costs of these crops are minimal and land suitability are wide. Thus these crops have great potential for cultivation under adverse conditions specially under foreseeable climate change. Genetic enhancement will play a very important role in crop improvement, and will serve as a prerequisite in development of new crops or new products from under-utilized and new crops and in bringing new traits not present in cultivated crops. Research emphasis is necessary for the improvement of such crops to develop varieties, improved production technologies and value addition research to compete in the market place. Moreover, there are several crops like strawberry, dragon fruits, capsicum, mushroom, grape, sugar beet, etc. are new crops with high potential for growing in this country. Proper attention is necessary for these valued crops in the area of varietal development, adaptation, management practices and industrial use.

■ **Hill Agriculture and Unfavorable Agri-Ecosystems**

A large area of agricultural land is still remaining unutilized/under-utilized specially in the unfavorable agri-ecosystems like coastal, hill, hoar, char, barind, peat, etc. Special attention should be given to develop crop varieties and management practices. Emphasis need to be given to improve production and productivity in these areas. Development of salt tolerant varieties, water shed management, water conservation and utilization, development of farming system, hill slope management, agro forestry should receive priority attention.

■ **Efficient Management of Natural Resources**

The agriculture is highly dependent on the natural resources, but unfortunately there is continuous degradation of natural resources like soil, water, climate, etc. There is vast scope to improve the productivity of rainfed agriculture provided natural resources like soil and water are scientifically and efficiently managed. Potential of conservation agriculture, zero tillage, precision agriculture and micro-irrigation need to be properly addressed for different agro-eco-regions. Efficient farming systems, composite farming, integrated crop management, integrated nutrient management, integrated pest management, water saving efficiency technology, water management, storage and processing should be given due importance to improve productivity and natural resource management. Enhanced participation of stakeholders and increased agro-ecological literacy would be given due priority in managing natural resources. Improved long-range weather prediction technology would be required to take advantage of precision operations for crops and resource applications, particularly nutrients and water.

■ **Mechanization in Agricultural Production and Processing**

The increase of population results in increased food requirement in one hand and the other is migration of rural labour force to urban areas make the crop production activities more

difficult, hampers timely operations, increase cost and ultimately suffers agricultural production. The agricultural machinery sector provides an opportunity to overcome the problem. Limited mechanization in the areas of land preparation, irrigation, weeding, spraying and threshing of crops has been achieved, but it needs to make more efficient. Other labour intensive agricultural activities such as sowing of seeds and seedling, fertilizer application, drying, design of water saving technology and water management, cool chain management, storing and processing, livestock housing and management, small scale feed meal design are equally demanding areas of mechanization. The limited application of farm machinery has gained popularity among farmers for its multi-dimensional benefits such as reduction of operational cost and human drudgery, timelines of operation, increased labour productivity and efficiency.

■ **Post-Harvest Management and Value Addition**

An inefficient and unorganized marketing system is prevailing in the country and as a result high percentage of losses occur in the supply chain from production to consumption. Low-cost improved technologies, improve market efficiency and appropriate sanitary and phytosanitary measures are to be addressed.

To improve market access and to remain competitive in domestic, regional and international market, continuous improvement of post production technology becomes imperative to reduce post harvest loss, cost of production and for increasing quality of marketable fresh and processed agricultural produce. To address the post production management, it is necessary to identify what has to be grown for linking up to processing and in that primary processing should receive priority. Post production technology with emphasis on on-farm handling and storage system for different commodities, covering sanitary and phytosanitary measures, packaging, transport, marketing, value addition, both for domestic and export market are considered important. Utilization of crop residue and by-products for food and feed need to be strengthened.

These activities require multi-disciplinary and multi-stakeholders research for agri-commodities, especially post-harvest engineering, horticulture, plant protection, etc.

■ **Potential of Bio-technology**

Agricultural biotechnology has a great potential to address the future challenges in the agricultural sectors like crops, livestock, fisheries, post-harvest processing and value addition. ARIs should take advantage of this science especially to speed-up breeding processes, increasing yields, minimizing production risk, sustaining environment and for meeting consumer taste and preferences. The transgenic research should continue and further strengthened. Application of bio-technology to evolve new genetically engineered varieties of plants, animals and fishes, and plants of high nutritional quality, tolerant to pest and diseases, soil salinity, environmental stresses like heat, cold, drought, flood, foggy weather and environmental friendly farm practices need to be developed. While doing so proper testing of transgenic and bio-safety will have to be addressed effectively. Research efforts are also needed for increasing shelf-life and converting food stuff into more palatable, nutritious and stable form. Also public awareness relating to benefit of bio-technology and IPR issues will be necessary to harness the benefit of bio-technology.

■ **Climate Change and Bio-Risk Management**

Bangladesh is one of the worst victim of climate change. Again bio-risk is increasing in agriculture owing to trans-boundary insect-pests and diseases. It is adding cost, reducing food

production and is adversely affecting farm income. To overcome problem of bio-risk, efforts would be made to develop effective and integrated risk and disaster management production systems and institutional mechanisms. Bio-risk intelligent system such as early warning, drought indicators, migratory movements of bio-risk agent, etc would be developed and addressed.

Climate change, which is taking place at a time of increasing demand for food, feed, fibre and fuel, has the potential to irreversibly damage the natural resource base on which agriculture depends. Climate change adversely affects agriculture. Some negative impacts are visible in many regions of the country, additional warming will have increasingly negative impacts in all regions. Water scarcity and timing of water availability will increasingly constrain production. Climate change will require a new look at water storage to cope with the impacts of more extreme precipitation, higher intra and inter-seasonal variations and increased rate of evapotranspiration in all types of ecosystem. Climate change is affecting the distribution of plants, invasive species, pest and disease vectors and the geographic range, and incidence of many human, animal, fish and plant diseases is likely to increase. Extreme climate events are expected to increase in floods, droughts, heat waves, tropical cyclones and other extreme events with significant consequences on food and forestry production. Climate change is expected to threaten livestock holders in numerous ways, animals are very sensitive to heat stress. Climate change is expected to alter marine and fresh water ecosystem and habitats. Rising sea levels will alter coastal habitats and their future productivity, threatening some of the most productive fishing areas. Climate simulation model is to be developed and appropriately utilized.

To address climate change it is necessary to increase the adaptive capacity by adjusting and changing institutional role and policies and investment in new technology innovation system to enable effective adaptation activities. These include: a) changing varieties/species to fit appropriately to the changing temperature and hydrological condition, b) changing timing of irrigation and adjusting nutrient management, c) developing water conserving technologies along with its judicious use and promoting agro-biodiversity for increased resilience of agricultural system, d) addressing research on altering timing or location of cropping activities and diversification of agriculture, e) improving the soil carbon retention by promoting biodiversity as tool for climate mitigation and adaptation and enhance the management of residue, using zero or reduced tillage including legumes in crop rotation, f) developing technologies for rainfed agriculture, g) developing integrated nutrient management practices to lower nitrous oxide emission and optimizing nitrogen up-take efficiently by controlling the application rates, methods and timing, h) increasing the efficiency of livestock production, improving animal diets, increasing feed efficiency, aerating manures before composting and recycling agriculture and forestry residues.

■ **Agricultural Diversification**

Changing consumption and demand patterns and new agro-business opportunities have opened up the opportunities towards greater commercialization and diversification of farming system through greater emphasis on horticulture, animal husbandry, milk, poultry and fish and other non food crops such as fibre, mushroom, spices, condiments, medicinal and aromatic plants. These enterprises are to be implemented considering land use planning and resource optimization.

The high value commodities are gaining importance among the farmers due to high profit margin, increasing urbanization and opening of export-market. Thus research focus is

required for efficient and competitive production of such commodities through development of improved genotypes and management practices for different agro-eco-regions and consumer-preference. The focus should be on the entire value-chain management, from production and post-harvest to value-addition, processing and marketing, enhancing shelf-life and improving demand-driven commodity traits like colour, size and aroma of those commodities.

■ **Management of Energy and Agricultural Waste**

Efficient management of energy in agriculture for various operations is the key research and development challenge. High dependence on oil and non-renewable sources of energy may make agriculture more risk-prone and less profitable. To efficiently manage energy, new sources of renewable energy need to be explored. Research would be targeted to develop bio-fuels without compromising on food security and by effectively utilizing huge agri-waste, wastes from crude oil after refinement and solar energy. A strategy to explore new biological sources of ethanol, specially from non-food stocks, explore management practices and opportunities to grow bio-fuel stocks in low productive areas and process high quality animal feeds from crop residues and waste from food processing industries need to be explored and adapted. New forms of machinery and equipment would also be developed for efficient use of renewable sources of energy.

■ **Improving Forest Resources**

The country has bright prospect to increase forest resources through intensive practice of social/participatory forestry, scientific coverage of agro-forestry, by large scale growing of medicinal plants and bamboos, and by using quality seeds. In addition, use of composite wood instead of solid wood is also another area of bright prospect. Efforts are to be made to address the above issues.

■ **Use of ICT and informatics**

With the advancement of science, agricultural production efficiency can be largely improved with the application of increasingly powerful computers, sophisticated softwares and advance sensors. This will also contribute in better understanding of global warming and climate change and their drivers. The frontier sciences and techniques like nano technology, Information and Communication Technology (ICT), Remote Sensing (RS), Geographic Information System (GIS) and Global Positioning System (GPS) could be well integrated in the on-going and future agricultural research for improving research efficiency, better targeting of technologies and also identifying production and marketing environments. The frontier science can also enhance progress in the application of precision and site specific agriculture. Site specific research activities includes AEZ based nutrient management, crop suitability and integrated crop management technology development. RS technique play important role in crop identification, crop area inventory, crop yield forecasting, crop damage detection, soil and water resources inventory and assessment of flood, drought and other environmental damage. Nano technology can improve agriculture and resource management particularly soil fertility, pest management, product safety and quality and farm waste management. Adopting these technologies in phases should be given due importance to improve the research quality and for judicious use of resources.

The importance of ICT is increasing in importance for agricultural research and development. Thus information technology needs to be exploited to add value in research investment. The issue is how to strengthen NARS information capacities and how to make towards a knowledge system that effectively links up to the emerging global knowledge

system. Priority for greater investment in information technology infrastructure and for its appropriate HRD program having dedicated manpower will have to be developed. Electronic networking will be able to serve cause of research as well as generation and dissemination of technology. Information modules on personnel information system, financial information system, library information system and technology information system should be fully developed and made operational. Linking up with global science and technology information system and instant processing of information will contribute efficiency and relevance of research system. For easy access to information, libraries in various NARS institutions should be digitized. E-governance of NARS institutions should get due attention in the research management. ICT should be used to strengthen research-extension linkages in order to speed up the technology flow from research to extension.

■ **Governance in NARS Institutions**

Several factors like diversified food demand, climate change, participation of private sector in agri-research, agri-business, industrial requirement of agricultural commodities, changes in the regional and international trade regime, IPR issues in agriculture, etc. calls for revised policy design, developing new institutional mechanism, evolving decision-making process, mobilizing partnership and political support, etc. All these require innovative institutional models, pro-agricultural policies and regulatory mechanisms are to be evolved and addressed.

a) Improving Research Management, Impact Assessment and Evaluation

In improving research management, impact assessment and evaluation, special attention should be paid to upgrading the management skill of NARS institutional managers and senior scientists for effective demand-led research and financial management. This requires attention to stronger institution, efficient management, new facilities, higher scientific skills, collective efforts, highly focused research and more investment. Information managers should also be trained to strengthen research-extension-farmers linkages and management of generated technology. As a result research projects and activities will be suitably identified and prioritized, funding support/grants for research will be obtained and made available, and institutional program will be managed efficiently and effectively. There is also a need to develop a monitoring system on regular basis to assess the performance of various research activities and to evaluate the output and outcome of research findings. There should be periodic internal and external reviews of NARS to ensure that they remain responsive to stakeholders' needs corresponding to emerging challenges in research and development activities. Creation of endowment fund may help BARC to support long term research program of NARS institutions.

b) Strengthening Research-Extension Linkages

Some factors responsible for technology transfer gaps are inadequacy of demand-led technology, lack of suitable technology assessment mechanism, weak research extension farmer linkages. Technology assessment and refinement in future form more knowledge demanding, diverse, location specific and farm management system based. The agriculture is becoming more commercial and capital intensive. Thus precise and time advice on input use, management practices, output handling in marketing will play an important role in overall farm productivity and profitability. This requires close interaction of farmers at all levels between the research and extension managers, researchers, farmers and extension workers.

c) Partnership and Networking

The partnership and networking is a key mechanism for facilitating research by linking national and international institutions and organizations and universities. The technical and financial capacity of BARC to establish or strengthen these linkages will have an impact on the overall management of the research programs.

International support to NARS institutions is critical in areas such as information technology, bio-technology, IPR, GIS and remote sensing applications, crop and system modeling, global climate change and agro-meteorology, value addition and export related research issues. It is also important to recognize the changing balance between public and private research, upcoming participatory research model, the increasing role of information in technology transfer to farmers with stronger research/agri-business/extension/farmer links. These areas require substantial institutional strengthening and capacity building. BARC has a pivotal role to play in coordinating these emerging needs of NARS and in facilitating technical and organizational support from IARC, FAO, GFAR, APARI, IFAD, WB, ADP, UNDP, JICA, DFID, USAID and other bilateral donors. The partnership will be helpful in three ways: (a) promoting interactions with NARS leaders and scientists, (b) setting up of research agenda and (c) facilitating joint collaborative programs. BARC should strengthen proactive role in establishing partnership and networking.

d) Human Resource Development

Qualified and trained manpower is the pre-requisite for planning and implementing research programs for developing appropriate technologies. To cope with global advancement of science and technology and competitiveness, development of quality human resource and their proper utilization in agricultural research should be considered as a priority area. A long term program for HRD with identification of human resource gaps in ARIs has been developed and current brain-drain is to be converted to brain-gain through formulation and adoption of appropriate policy by the Government. The HRD plan already prepared by BARC need to be implemented. Fund for the implementation of HRD plan should be made available for both in country and abroad higher study program.

e) Institutional Issues

BARC is functioning as an apex body of National Agricultural Research System. As yet BARC could not establish a good governance with ARIs because of several inherent problems of ARIs and BARC. However, recently an Act has been passed in the Parliament to redefine the functions and activities of BARC and its roles and relationship with ARIs. It is now necessary to implement the provisions of the Act and function accordingly. This will help ARIs to work closely and confidently with BARC. Some issues like adoption of Agricultural Research Service for NARS, creation of an Endowment Fund at BARC to support agricultural research in the country, provision of Open Posts of senior posts of BARC, introducing Self-Performance Assessment System in NARS, Unified Service Rule for ARIs, Institutional Infra-structure development and sustainable fund flow to ARIs to be addressed.

f) Management Issues

A serious problem is prevailing in the management issues at BARC and ARIs. There is lack of good governance in all sectors. The issues may be resolved by introducing Personal Management System in BARC and ARIs where delegation of authority down the line, institutionalizing Management Information System across the NARS, framing uniform Monitoring and Evaluation System, building managing partnership, framing uniform financial management system, creating technology data base, strengthening research-extension-farmer linkage, etc.

8.2 Fisheries Sub-sector

The research system would strive to harness the knowledge of fisheries science in increasing productivity, input efficiency, reducing cost and technical losses, minimizing risks and improving quality of product. The system would also attempt to understand the interest of the different stakeholders involved in the total supply chain. Therefore, the focus would be to accomplish vision and mission of the fisheries sub-sector and to shift present system of national fisheries research into an innovative system where the concentration would be given to the following key areas:

■ Reclaim degraded fisheries, enhance production from natural resources and conservation of fish bio-diversity;

There is a wide scale concern that the fisheries natural resource base is gradually dwindling and quality is deteriorating. Fisheries activities are highly dependent on natural resources. Physical, chemical, and biological degradation of fisheries resources made the achievements for increased production from the resource more challenging. Degradation and shrinkage of fisheries habitats, water and soil quality and pollution, siltation and biological depression are major causes of resources degradation. Present research in these areas is very limited with slow progress but have huge potentials if managed scientifically and efficiently. Collaborative research with the incorporation of advance sciences would be necessary to address these issues to make pace with vision target.

■ Enhance fish production from culture based fisheries

Fishing level from inland open water and marine resources of the country already reached the Maximum Sustainable Yield (MSY) level or even crossed the limit. Closed and semi closed water bodies under aquaculture practices are the major culture based resources with increasing contribution but with low rate of production. Improved quality of inputs and their cost and efficiency of culture technologies and bridging knowledge of fisheries between research and farmers would be preferred. Improvement of existing culture technologies, protein rich quality feed, inbred free quality fish seed of cultures species, improvement of culture and health management of fish and shrimp, affordable cost of fertilizers chemicals, medicines and inputs, AEZ based water budgeting in aquaculture, pond designing, polyculture and farming system research and integrated fish farming would be given due priorities to ensure increased output.

■ Sustainable harvest and management of marine fisheries resources

Marine fisheries resources of Bangladesh are well diversified, but now under the threats of bio-diversity loss and ecosystem health hazards. Artisanal fisheries are overexploited with a trend of reduction in CPUE. Lack of information on standing stock, habitats, and potential fishing grounds, fishing efforts are the constraints towards development of marine fishing and management protocol. Energy efficient technology for appropriate vessels and gears for offshore fishing is also lacking. Post harvest loss, lack of data base, absent of mariculture practices, pollution, adaption technologies for breeding and culture of fish due to sea level and temperature rise would be major areas of research.

■ Foster fish genetic resources

Development of management and conservation action plan for fish genetic resources is essential for bio diversity conservation. Protection of fish habitats and hatchery practices for cross and inbred seeds production need special attention. Human interventions are considered as major causes of this degradation. Research on development of breeding and culture

technologies for the threatened fish species, overcoming of genetic and breeding depression of cultures species, cataloguing and developing genetic chart for important fish and shell fish species, cryo preservation and biotechnology research for fish disease control will be the priority areas. Research on policies and regulatory issues for conservation of aquatic biodiversity is also equally important to conserve open water genetic resources.

■ **Food safety and quality control, value chain efficiency and diversification of products**

Quality control of products needs attention both for local and international markets and quantitative loss reduction. In the marine sector, as high as 20% and in other areas (inland capture and culture), 5% losses occur in the entire food supply chain from production to consumption. Markets for value added and processed fisheries commodities are consistently increasing with increasing demands in local and international markets necessitates low cost improved technologies to unleash potentials and improve market efficiency and to remain competitive. New opportunities have emerged with the opening of the trade and advancement of communication. Therefore, issues related to sanitary and phyto-sanitary measures would need to be appropriately addressed.

Technology for diversified product, development of e-traceability for mitigating the quality and marketing issues will be the areas of priority research. In the case of export of shrimp or fish, SPS and packaging qualities are developed by private sectors. Formal research is also needed in these areas.

For establishing an efficient value chain market, the research on improvement of efficiencies and to address market risks through improved market intelligence, improved market access to ensure quality and reduce technical losses and establish equity of shares need immediate attention.

■ **Fish feed for aquaculture**

The gap between demand and supply of fish feed invites various ill practices in aquaculture. The most important is the quality of the feed followed by high cost which ultimately results low output from the culture based fisheries. Increased production of fish in the coming decades will depend mostly on success of aquaculture practices. Under that consideration, research on formulation of low cost nutrient efficient high digestible feed, identification and use of local ingredients, packaging and preservation, live feed production for shrimp and fish hatcheries and energy efficient feed mill model development for use at farm level will be given priority.

■ **Fish and shrimp health management**

Lack of appropriate and adequate fish and shrimp health management efforts are depriving the nation from a bulk production particularly from cultured based fisheries. Regular occurrence of viral diseases and presence of hazardous chemicals in coastal shrimp have become a threat for shrimp production and export. Inland culture system is affected mostly with bacteria, fungus pathogens, and parasitic problems in hatcheries, carp, catfish, and climbing perch aquaculture. Loss due to disease in shrimp and fish is huge. To overcome this problem, research is needed particularly on improvement of aquaculture and water quality management, genetic and biotechnology research on disease resistant variety development, disease diagnosis and control, improve diagnosis technique and drug/chemicals or herbal medicines of health standards, fish quarantine and export risks analysis.

■ **Improve harvest and post harvest efficiency**

Harvest and post harvest losses are major drawbacks of the sector which claimed heavy loss in almost every year particularly from marine and coastal sectors. Inefficient crafts and gears, inadequate transportation and preservation facilities, processing problems and marketing structures all together claimed an amount of about 3.0% of total fish production annually. Therefore, research should be concentrated on the development of safe and energy efficient gears and equipments for fishing, fish preservation and processing, eco-friendly fishing technology development, energy efficient fishing vessel and gear, technology for effective utilization of marine bi-catch and fishing wastes, diversification and value added product development and improve quality of traditional fish products.

■ **Development of pro-poor technologies**

Gradual increases in landlessness of marginal agriculture farmers and the involvement of asset less poor people in aquaculture and capture fishing activities are continuously increasing. Poor and marginal fishers are mostly dependent on capture fisheries for their livelihoods that demands development of a number of pro-poor fisheries technologies with new opportunities for small scale operation and good economic return suitable for playing a vital role for food security and rural employment. Poor or vulnerable group will derive benefits of technologies that will adjust to the availability of their resources. Some mentionable pro poor technologies are Carp seed nursing; Seed production of aquarium ornamental fish; Rice-fish integrated culture; Integrated poultry-fish farming; Tilapia culture; Rajpunti culture; Seasonal culture of short cycle fishes; PG extract and preservation; Fry/fingerling transportation; Crab fattening etc;

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

■ **Breeding and culture of fish and aquaculture diversification**

As the demand of high valued commodities is continuously increasing because of increasing income, rapid urbanization, globalization, and changing in socio-cultural trends, research focus would be further strengthened to augment the production of these commodities more efficiently and competitively. Parallel to development of improved fish genotypes and improved management practices for enhancing productivity from different ecosystems, diversification of aquaculture by including some more potential aquatic species will bring more opportunities for contribution and improvement. Among the worthiest, mentionable ones are the species of clams and snails, kuchia, edible oyster, pearl oyster(marine), sea grass and weeds, rock lobster, soft shell turtle(fresh water) and marine turtle, green crabs and marine fin fishes, snake heads, etc. Salinity range and temperature is suitable for culture, commercially important high valued exotic sea weed, *Gracilaria* sp. in Bangladesh waters. Breeding and marketing of a number of indigenous and exotic ornamental species for aquarium can be a good venture for economic activities and employment. The non-conventional species can be used as local food, and as export item and source of raw materials for production of gelatins, ornaments, cosmetics, decoration materials, and valuable ingredients for medicines and food items, such as soup, nodules etc. Research for

development of technologies for breeding and culture, product development and marketing chain would be the better options for increasing food production, employment, and women involvement in the sector.

■ **Strengthening institutional capacity**

Institutional capacity in terms of laboratory facilities, standards and human resources capacity of the research system is weak to generate and evolve continuous output at desired level. Development of quality of human resources is a pre requisite for implementing and upgrading the present research system, developing technologies, evolving institutional arrangements to face challenge and harness opportunities. This is also important to maintain global standards and enhance competitiveness in technology development of the sector. Therefore, effort is needed to enhance faculty competence for improving higher education in the sector. In this regard, BFRI- HRD planning and development need to be matched with the following priority areas:

- Biological management of commodities for ensuring higher productivity;
- Resource management for ensuring optimum productivity, sustainability of production and conservation of resources;
- Market management for ensuring economic returns.

The HRD plan developed by BARC for NARS scientists (2010-2025) for various reasons has limitations. As the current vision document is rather wider, and institutional alignment with new emerging issues is considered with emphasis, therefore, the scientific staff of BFRI need to be revised, increased and equipped with knowledge, skill and tools to address the issues of food and nutrition security, environmental degradations, man-water productivity increase, poverty and hunger eliminations under various adverse situations. Under that consideration, in addition to the existing scientific and technical posts, an estimated number of another 206 posts of scientists and technicians will be required to strengthen the system.

■ **Access right and livelihoods of fishers**

Information on socio-economic aspects of fishers and impact of various fisheries activities on fishing community are not adequate. Revenue oriented management of open water fisheries by neglecting biological management, depriving access right of fishers and benefit sharing from marketing system and absence of institutional mechanism for empowering poor fishers for improved livelihoods and rights are the major causes that invited dominancy of middle groups in the chain. Research focus is to be given to address the issues to establish access rights of fishers, benefit sharing, and improved livelihoods.

■ **Preparedness for adaptation with climate change**

Evolving of technologies and management mechanisms to adapt to the climate change vulnerabilities also require special attention. Global temperature rise, sea level rise, erratic rainfall, and drought will affect fish physiology and behaviour, spawning irregularities, pathogen susceptibility, and natural distribution of fish and socio-economy of fishers. Advance research to evolve adaption technologies and genetic research to develop resistance against pathogen susceptibility and disease in fish will be the priority areas of research. Livelihoods and socio-economics of fishing-dependent groups and information on climate change impact are also important to develop anticipatory research plan.

To ensure the benefits of fish production through increasing efficiency of the system will require obtaining parameters and simulation of the complex system with the application of advance tools and techniques of frontier sciences. Improved long-term prediction of changes

will provide advantage of various precision operations which will also give better understanding of possible climate changes and anticipatory research plan development.

■ Synergies of frontier sciences in fisheries research

Incorporation of frontier sciences in fisheries research with MIS, ICT, GIS, GPS based programming are basic requirements for harmonizing the research activities with global context and to achieve the vision target. Proper data base of fisheries resources and generation of information are basically important for the development of technology and management action plans for resources. Quick and effective communication from lab to land and back from land to lab will also be emphasized. In order to be equipped with up-to-date information about fast growing new technologies and sciences, it is necessary to have various ICT and electronic resources available in the research institute, which is lacking at present. Further support of various frontier sciences in the areas will specifically contribute to the following priority areas of research:

- Shrimp zoning and mapping of shrimp culture areas for intensification of shrimp farming activities;
- Oceanographic studies and marine resource identification;
- Marine fish stock assessment and identification of new fisheries resources;
- Continuous observation and monitoring of river morphology, hydrology;
- Technology transfer and e-traceability and market information flow; and
- Development of fisheries data base for inland capture and culture, coastal and marine ecosystem and GIS/GPS based mapping for R&D.

Frontier sciences and technologies will be well integrated in the ongoing and future fisheries research for improving research efficiency, better targeting of technologies and identifying production and marketing environment.

■ Transfer of knowledge on fisheries science and technology

Continued development and delivery mechanism of improved technologies will greatly help in bridging the wide gap between the potential and the realized productivity. At present, there exist a number of causes and constraints in the sub-sector, which are responsible for weak linkages in technology generation and dissemination process, viz:

- Lack of true institutional mechanism for downstream linkage and feed back;
- Absence of inbuilt linkage of research and extension projects;
- Suspension of project based institutionalized linkage activities after project completion (like FSRD);
- Absence of a separate unit for technology testing, transfer, dissemination, and socio-economic study in the research institute;

Strengthening of the system is essential. The process will consider the followings:

- (a) Coordination and monitoring of technology transfer activities of BARC for better linkage and output, strengthening and revamping of its TTMU;
- (b) A separate unit of BFRI for coordinating technology transfer activities with GO/NGO's and socio-economic research;
- (c) Early involvement of research in extension planning for strengthening of linkages; and
- (d) Establishment of institutional linkage among BFRI, DoF and other GO, NGO, extension agents and farmers society/cooperatives or individuals for knowledge generation and dissemination.

■ **Foster linkages and collaboration with national and international organizations**

To achieve vision target, the present research system has to be supported and strengthened further in the areas of national and international collaboration, linkages with global system, realignment, and policy issues. Strengthening linkages of NARS with regional and international fisheries research centers could be a better option for deriving benefit particularly for advance technical supports from the global research system for strengthening national research activities and addressing emerging issues of global concern through development of MoU and bilateral agreements.

Linking with the global research system is also important and highly prioritizes to fulfill the national obligation of the sub-sector. The research system needs to be modernized as an advance research organization and National Center of Excellence (NCE). Linking of the fisheries research system with the mainstream as per the model mechanism designed in the NARS Vision for Agricultural Research-2020 in Bangladesh under the leadership of BARC will further strengthen functional relationship with CGIAR and other international research centers.

BARC as the apex organization of NARS, generally establish national research priorities coordinate research and foster inter institute collaboration, monitor and review the research program of the system. As a whole, it is obligated to serve society at large as well as the producers and processors within the agricultural sector. To fulfill its obligation, the NARS must transfer scientific principals into useful production and processing technologies.

The system will have to extend its role by maintaining linkage with the regional and international fisheries bodies like NACA, SEAFDEC, SAARC, WFC, IDRC (Canada), ACIAR (Australia), CSIRO and selected leading universities more closely for coordinated and collaborative research on issues of common regional and global interest.

At the national level, CGP of KGF may widen the scope. Universities represent a major pool of scientific expertise that must be better mobilized to contribute to progress in fisheries research. Therefore, competitive grants for research projects could be an effective mechanism for putting scientists and expertise into mainline research programs. Collaboration with private fisheries entrepreneurs will pave the way to create new avenues by taking issue based research. BFRI with the collaboration and support from various other organizations can act as a common platform for all those engaged in fishery education, research, extension and policy advocacy to interact and share their experiences and views towards promoting fishery sector development, especially poor focus on rural livelihood improvement and resource management.

■ **Address policy requirements**

Rising demand of fish, increasing risks and uncertainties in the sub-sector and involvements of private sectors call for designing policies, developing institutional mechanisms and decision making processes and improving governance of service providers in the value chain. Therefore, formulation of a more comprehensive and cohesive strategies for R&D will require policy changes.

The emerging of new challenges and issues for fisheries research, will cover in the policy matters related to:

- Provision for extending opportunity by facilitating process of R&D through more NGO/Donor/ GoB projects;

- Linkages between science and farmers in a consistent way, while disregarding overlapping and lack of coherence between existing policies and constraints;
- Provision for harmonization of policies in the areas of land, water, fisheries, agriculture and environment to ensure sustainable utilization and productivity of natural resources;
- Provision for management of market value chain with defined role of stakeholders;
- The emergence of the Intellectual Property Rights (IPR) regime that needs to be established as an opportunity; and
- Bilateral water sharing, pollution issues and shared ecosystem and stock management need special attention in respective policy guidelines.

All these issues require effective and need based institutions to accelerate innovations and link farmers with different stakeholders to harness growing opportunities.

The NFP also emphasized the enhancement of fish production through culture based fish farming, which is largely dependent on availability of quality seeds, fish feeds, and farming inputs. Absence of appropriate regulations and controlling measures in the sector appears as a major constraint towards achieving the objective of the NFP. Hatchery Regulations and Fish Feed and Livestock Feed Regulations need prompt administrative approval of the government to overcome the situation.

8.3 Livestock Sub-sector

■ **Enhanced productivity of the livestock and poultry products through improvement in the genetic capacity and breeding process combined with bio technology**

Much of the gains in the productivity of the livestock product have been attributed to the genetic up gradation through crossbreeding of local cows with high yielding Jersey, Holstein, Sahiwal, and Sindhi. A study from BLRI showed that F₁ generation only proved to be suitable for cross-breeding program.

Yield of livestock product in the country is much lower than that in the rest of the world demanding the urgent need to strengthen adaptive research and technology generation, assessment, refinement, and transfer capabilities so that the existing wide technology transfer gap is bridged.

There is ample scope to increase the productivity of the livestock products to satisfy the huge production target set for the year 2030 through the ingenious use of modern genetic tools in the development of technology. The tools, such as characterization, genetic enhancement, functional genomics, proteomics, phanomics, etc., gene mining, molecular breeding through tools like marker aided selection and gene stacking etc. will help develop appropriate technology.

■ **Enhance productivity through improving efficiency of feed and feeding system**

Feed scarcity in terms of both quality and quantity is one of the serious constraints to livestock production in the country. Any stress due to serious malnutrition and under-nutrition during the early life of growth starting from last part of pregnancy to growing period

will certainly affect the full expression of the genic capability of the animal causing a great economic loss to the farmer. So it is urgently needed to develop and improve the feed situation in the country. Research and development focus will be on increasing the prospect of using agro-industrial by-products and low quality roughages as complete feed using modern frontier science tools.

Development of data base on animal feed resources for different agro-climatic zones of the country is a prime need for designing research and development programs. Area specific mineral mixture for different agro-ecological zones needs to be developed.

High demand for protein and animal food products demands drive to develop new technologies that improve efficiency and safe food production at low cost. These will involve development of feeding systems, bioengineered foods, delivery of vaccines for disease prevention and growth enhancement.

Research and development strategies should be taken enough to meet the challenges faced by small, marginal, and landless farmers for different species of livestock and poultry in meeting the feed requirements.

■ **Animal health protection, prevention and production of drugs vaccines pharmaceuticals for increased production**

Livestock farming is always a bio-risk enterprise because of the prevalence of some highly infectious diseases, such as Anthrax, Haemorrhagic septicaemia, Black Quarter, and Foot and Mouth diseases causing heavy economic loss to farmers. The losses due to some highly morbid diseases like parasitism and deficiency diseases are also significant. Protozoal diseases like anaplasmosis, Babesiosis and theileriosis cause heavy losses. PPR and Goat Pox in goats cause heavy loss. Ranikhet, some bursal diseases like Avian influenza, fowl cholera etc. cause heavy loss to the poultry industries. To treat and prevent these diseases is a great challenge. Research and development should aim to develop diagnostic and immunoprophylactics for various diseases using bio-tech and nano-tech tools, recombinant DNA vaccines.

Immediate transmission of recurring and newly emerging diseases due to trans boundary and other management faults is having a driving demand for more preventive products, such as vaccines, rapid detection diagnostics, etc. that help avert diseases and infestations. These will be made possible by advances in genetic engineering and by preventing chemical, biological products that carry organisms before infestations.

■ **Enhancing the capacity of small holding, marginal and landless farmers through technology innovations**

Small holding livestock dominates the country's animal agriculture; about 89% of the rural households rears, on an average, 7 livestock units. But the productivity per unit livestock is one of the lowest in the world, which demands innovations of appropriate technology that will increase productivity. As the small holding livestock owners are heterogeneously spread over the country it has become very difficult to get the benefit of the advanced technologies. Small sized farms, marginal and landless farmers face serious constraints in adopting modern technology, in marketing their produces, and in getting other input readily. These constraints can be obviated, to some extent, by forming common interest groups (CIG), community based groups or formation of co-operative societies. Research and

development programs should be designed to develop appropriate low cost technology catering to the needs of the pro-poor farming communities.

■ **Bio safety and climate change vulnerability**

Animal species are getting more vulnerable to infectious diseases, sometimes in epidemic form many of which are trans boundary in nature.

New strains of existing and emerging micro organisms due to adverse change in the climate are likely to create regional and global out breaks. Innovative surveillance methods, the effective forecasting systems like (IT, ICT, etc.), ways of preventing and controlling infectious agents, and effective communications systems between the producers and authorities; and management of emerging zoonoses are pertinent requirement to address.

Adjustment to climate change will require development of suitable varieties of different livestock species coping with the new cropping sequences, new feed, and feeding management system. All these demand additional investment for researches.

■ **Livestock diversification and control of environmental pollution**

To meet the increasing demand of high value livestock and poultry products due to rapid increase in their per capita income, growing urbanization and industrialization research focus should be further strengthened to augment their production more efficiently ensuring the quality and safe food. Research and development efforts should also involve entire value-chain from production to value addition processing and marketing; and these will require multi disciplinary and multi stakeholder participation.

For a sustained soil fertility, there is no other alternative to the use of bio-fertilizer. Livestock sub-sector is unfolding opportunities to produce bio-fertilizer using animal wastes suitable for different types of crops and horticulture plantations.

Use of livestock by-products as feedstock for bio-fuel production is another opportunity as well as help in the control of environment pollution, and also prove to be potential alternative source for mitigating energy crisis.

■ **Production of improved quality, safe and low cost food**

Growing consumer preferences for organic animal products that are hormone and antibiotic free will in turn drive the inclusion of probiotics, nutraceuticals and other functional foods into animal feeds.

Growing demand for safe and low cost animal protein, change of antibiotics as growth promoters by new pharmaceuticals demand drives to design research and development programs addressing changed issues involving bio-technological tools.

■ **Strengthening institutional capacity, policy reform and implementation**

Issues like low yield potentialities of livestock species, scarcity of quality feeds and efficient feeding system, poor livestock health coverage, rising demand for livestock food products and value added products, climate change vulnerability, quality control of feeds, drugs and the other inputs called for designing policies, formulation of Acts, Laws, and Regulations which will have positive impact in enhancing the productivity of livestock products through better use of resources.

Institutional capacity building involving necessary infrastructure development, increasing lab facilities capable of addressing the new emerging issues in various disciplines of livestock sub-sector, standard reference lab capable of maintaining global standards and enhancing competitiveness in technology development are essentially needed to establish.

■ **Human resource development to harness the growing opportunities**

For implementing research programs, developing technologies, evolving institutional arrangements to face challenges and harness opportunities, it is very essential to enhance quality of human resources. Educational institute should design the curricula and courses catering to the needs of the farmers in the face of new emerging issues and to maintain the global standards with competitiveness.

■ **Foster linkages and collaboration with public, private organizations at national and international levels**

Technology adoption of improved technology and effective dissemination at farmers' level will have significant impact on its expression of potentialities. Absence or weak Research- Extension- Farmer linkage coupled with illiteracy of the farmers affect adversely the full utilization of the potentiality of technology. Lack of proper marketing system is another constraint. There is need to increase public and private sector participation in marketing and dissemination of technology, too.

Collaborative research programs and MoU with national and international research and funding organizations will improve the efficiency of the researchers and strengthen institutional activities.

BARC as the apex organization of NARS, generally formulate national research priorities, coordinate research programs and foster inter institute collaboration, monitor and review the research program of the system.

9.0 Strategic Framework

9.1 Crops and Forestry Sub-sector

Goal	Issues/Problems	Research areas/ Actions needed	Implementing Agency
1. Ensure Food Security	<ul style="list-style-type: none"> • Shortage of food crops • Low crop productivity • Non-availability of food to poor • Unstable price of food crops • Inefficient market channel • High dependence on rice as food crop • Low intake of other crops as food 	<ul style="list-style-type: none"> • Higher food crop production by adopting modern technologies • Increase of productivity • Introduction of food crops in unfavorable agri-ecosystems • Agricultural diversification • Market intervention for sustainable supply • Increase income through employment in farm and non-farm activities • Stabilization of price of commodities from production to consumers level • Increase food access through proper storage, transport and distribution system • Inclusion of vegetables, fruits, tubers, root crops, etc. as food crop 	MoA, DAE, DAM, BARC, ARIs,
2. Ensure Intake of Safe Nutritious Food	<ul style="list-style-type: none"> • Intake of unbalanced food • High intake of cereal foods • Excessive pressure on rice • Less consumption of vegetables, fruits, pulses, oils, etc. • High crop competition specially land scarcity for growing crops other than rice • Farmers negative attitude to release rice lands • Absence of crop zoning 	<ul style="list-style-type: none"> • Crop zoning with due emphasis for growing crops other than rice • Increase productivity and production of vegetable, fruits, pulses and oil seeds • Survey and formulation of dietary habits including safe nutritious food • Increase intake of vitamin-mineral-rich food • Develop awareness to take balance food 	MoA, DAE, BARC, ARIs

Goal	Issues/Problems	Research areas/ Actions needed	Implementing Agency
3. Improve Crop Productivity and Production	<ul style="list-style-type: none"> • Low productivity and production of crops • High yield-gap between potential, demonstration and farmers yield • Farmers knowledge-gap on improved technologies • Inadequate availability of quality seeds • Non-judicial uses of fertilizers, pesticides and water • Lower cropping intensity in unfavorable agri-ecosystems 	<ul style="list-style-type: none"> • Emphasis on basic research prior to applied and adaptive research • Development of HYV, hybrid, super hybrid and tolerant to stress conditions • Development of appropriate technologies and their proper adoption for enhancing productivity and production • Reducing yield gap by appropriate adoption of technologies • Minimizing knowledge-gap through training of farmers • Production and supply of quality seeds • Agricultural research stations located at urban areas may be utilized as centers for training demonstration and quality seed production and distribution to the users • Improvement of storage, transport and distribution systems • Introduction of crops in unfavorable agri-ecosystem • Development of appropriate technologies and their adoption in unfavorable agri-ecosystems 	BARC, ARIs, DAE, BADC, NGOs, POs
4. Enhance Genetic Resources	<ul style="list-style-type: none"> • Low genetic base for commodities and their utilization in crop improvement • Lack of molecular characterization of germplasm, crop varieties and plant pathogens 	<ul style="list-style-type: none"> • Collection, conservation, characterization and preservation of genetic materials of all commodities from home and abroad • The utilization of germplasm for variety development • Genetic enhancement through inter-specific crosses, nutrition and tissue culture • Molecular characterization of germplasm and varieties including desired use of them through conventional and 	BARC, ARIs

Goal	Issues/Problems	Research areas/ Actions needed	Implementing Agency
		molecular techniques <ul style="list-style-type: none"> • Molecular characterization of plant pathogens 	
5. Potential of Bio-Technology	<ul style="list-style-type: none"> • Limited bio-technological research • Limited use of tissue culture technique • Inadequate funds and facilities 	<ul style="list-style-type: none"> • Development of well equipped laboratories and trained manpower • Appropriate programs in the areas of crop improvement through speedy breeding, post harvest processing, production of disease free planting materials with rapid multiplication 	BARC, ARIs
6. Advancement of breeding options for crop improvement	<ul style="list-style-type: none"> • New problems arise due to climate change • Domination of conventional breeding • Initial stage of participatory plant breeding approach • Inadequate basic research • Lack of proper facilities to use molecular technique in crop improvement 	<ul style="list-style-type: none"> • Necessary development of laboratory facilities for advanced studies • Undertaking basic researches as priority areas • Emphasis on conventional and participatory breeding, bio-technology assisted hybridization and molecular technique for crop improvement 	ARIs, BARC
7. Enhance Capacity on Knowledge Generation and Management	<ul style="list-style-type: none"> • Lack of use of modern sophisticated tools in agricultural research and dissemination • Inadequate infrastructure, trained manpower and relevant programs 	<ul style="list-style-type: none"> • Modeling of crop cultivation system • Computer vision to identify insect-pest, soil health, precise use of fertilizer, water and other inputs • Databases related to research management, monitoring and evaluation and financial management • Improvement of data collection and preparation of statistical information of commodities and related areas by adopting modern tools and recognized produces 	BARC, ARIs, MoA, MoEF

Goal	Issues/Problems	Research areas/ Actions needed	Implementing Agency
		<ul style="list-style-type: none"> • Updating AEZ database • GIS-based information system for agricultural development • Use of remote sensing and GIS for assessment of climate change impact on agriculture • Web-based agro-market intelligence system • Early warning system for abiotic and biotic hazards like flood, drought, rainfall, pests, diseases, etc. 	
8. Innovate Technologies for Unfavorable Agri-Ecosystem	<ul style="list-style-type: none"> • Limited agricultural technologies for unfavorable agri-ecosystems like coastal, hill, haor, char, barind, peat, etc. • Weak dissemination of available technologies for those areas • Inappropriate adoption of recommended technologies • Low priority on agricultural development in those areas 	<ul style="list-style-type: none"> • Emphasis on the development of appropriate technologies for unfavorable agri-ecosystem areas • Introduction of pilot projects based on available technologies for improvement of crop productivity and production • Conducting large scale on-farm demonstrations of proven technologies in those areas • Adopt measures to increase cropping intensity • Efforts to introduce major crops like rice, wheat, maize, pulses, oil seeds, roots and tubers, vegetables, fruits, spices, etc. in those areas 	BARC, ARIs, DAE
9. Efficient Management of Natural Resources	<ul style="list-style-type: none"> • Continuous degradation of natural resources like soil, water and climate • Depletion of organic matter and soil fertility • Enhanced nutrient deficiency, soil salinity, soil 	<ul style="list-style-type: none"> • Soil organic matter improvement through organic amendments • Conservation agriculture • Improve nutrient use efficiency through integrated nutrient management practices • Fertilizer need assessment for major crops and cropping patterns 	DAE, BARC, ARIs

Goal	Issues/Problems	Research areas/ Actions needed	Implementing Agency
	<ul style="list-style-type: none"> erosion and drought Extensive extraction of groundwater in dry season 	<ul style="list-style-type: none"> Assessment of surface and ground water resources Use of water saving technique Modeling of crop-soil-water-weather system 	
10. Improve Bio-risk Management	<ul style="list-style-type: none"> Increase of natural hazards like floods, droughts, salinity, cyclone, global warming, sea-level rise, climate change, pests and diseases occurrence 	<ul style="list-style-type: none"> Address climate risks in agriculture Innovation and adoption of technologies for changed environment Development of salt, drought, sub-mergent/water logging, pests and diseases resistant cultivars Policy and institutional arrangement to address climate change, disaster relief and bio-security 	MoA, MoEF, BARC, ARIs
11. Agricultural Diversification	<ul style="list-style-type: none"> Lack of technologies for safe, demand-driven, value added commodities Proper storage and processing Problem of adulteration Model for linking production, value-addition and marketing 	<ul style="list-style-type: none"> Innovation of improved technologies for safe, demand-driven, value-added commodities, Improved efficiencies of storage, processing, marketing, Control of adulteration in food, fertilizer, pesticides, etc. Commercialization of technologies and intellectual property management 	ARIs, BARC, DAE, MoA
12. Strengthening Farm Mechanization	<ul style="list-style-type: none"> Lack of machinery for crop production, irrigation, agro-processing, oil extrication, juice extraction, gur processing, rice drying, parboiling, etc. Limited use of available machineries 	<ul style="list-style-type: none"> Development of appropriate machineries related to crop production like tiller, seeder, planter, weeder, fertilizer applicator, harvester, etc. Machineries for threshing, sorting, cleaning, storage, drying, rice parboiling, milling, oil extraction, juice extraction, gur processing, etc. Design and manufacture of irrigation equipment 	ARIs, BARC, MoA

Goal	Issues/Problems	Research areas/ Actions needed	Implementing Agency
	<ul style="list-style-type: none"> • Policy issues about quality and standardization of agricultural machineries 	<ul style="list-style-type: none"> • Prospect and process for using renewable energy like solar, wind, bio-fuel, bio-gas, etc. in farm machineries • Impact study of mechanization in rural livelihood and environment 	
13. Post Harvest Management	<ul style="list-style-type: none"> • High percentages of losses occur in supply chain from production to consumption • Inefficient and unorganized marketing system • Lack of low-cost improve technologies 	<ul style="list-style-type: none"> • Assessment of post harvest losses of different commodities • Development of technique to minimize losses through pre and post harvest treatments • Development of safe technique for ripening of fruits and extending shelf-life • Standardize maturity indices for major fruits • Standardize post harvest handling, packaging, transportation and storage techniques for different commodities 	ARIs, BARC, NGOs
14. Management of Energy and Agricultural Waste	<ul style="list-style-type: none"> • Crisis of energy in agricultural operation • Absence of program for exploring renewable energy • Under-utilization of agricultural waste 	<ul style="list-style-type: none"> • Searching sources of renewable energy • Development of bio-fuel without hampering food security • Explore biological source of Ethanol • Effective use of huge agri-waste • Conversion to bio-fuel from wastes leftover after refinement of crude oil for edible oil • Development machinery and equipment for efficient use of renewable source of energy 	BARC, ARIs, MoA, POs, NGOs
15. Improving Forest Resources	<ul style="list-style-type: none"> • Low forest productivity • Scarcity of bamboo • Uneven forest distribution • Loss of 	<ul style="list-style-type: none"> • Improvement of forest productivity • Development of appropriate social forestry technique for forest land • Development of agro forestry 	ARIs, BARC, MoEF, NGOs

Goal	Issues/Problems	Research areas/ Actions needed	Implementing Agency
	biodiversity <ul style="list-style-type: none"> • Post harvest loss • Lack of medicinal plants • Inadequate availability of quality seeds/seedlings 	models for forest <ul style="list-style-type: none"> • Development of conservation technique of soil and soil fertilization in hilly areas • Increase production of forest resources through intensive practice of social forestry/participatory forestry • Strengthening of quality seed production • Scientific and planned cultivation of medicinal plants • Protection and maintenance of wild-life species and wet land flora and fauna • development of high yielding clones of bamboo • Management of bamboo orchards • Development of disease resistant and water-logging tolerant species • Use of composite wood instead of solid wood 	
16. Linkages and Collaborations with Public-Private and National-International Organizations	<ul style="list-style-type: none"> • Lack of proper coordination, cooperation and research partnership within disciplines of Institutes, • Limited inter-institutional cooperation • Inadequate public-private collaboration • Inadequate linkage with international institutions 	<ul style="list-style-type: none"> • Development of strong coordination • Establish participatory research programs, • Exchange of research materials, germplasm, • Participation in national and international conference, seminar, symposium, etc. 	MoA, BARC, ARIs

Goal	Issues/Problems	Research areas/ Actions needed	Implementing Agency
17. Human Resource Development	<ul style="list-style-type: none"> • Inadequate quantitative and qualitative manpower in agri-research and production process and also to address emerging challenges 	<ul style="list-style-type: none"> • Assess and estimate adequate human resources • Develop and implement human resource development plan • Incase of higher studies, a sandwich program involving in-country and foreign universities • Capacity building of in-country universities • Higher studies, short and long term training program • Utilization of trained manpower in appropriate field 	MoA, BARC, ARIs
18. Technology Transfer System	<ul style="list-style-type: none"> • Weak linkage between research-extension-farmer-market • Wide yield gap between potential, demonstration and farmers yield • Unstable pricing of commodities due to imperfect marketing system • Lack of market-led research • Absence of information and communication technology in agricultural system 	<ul style="list-style-type: none"> • Assessment and policy direction in research-extension-farmer-market linkages • Production and business model development on crops • Agricultural education and training impacting research and extension performance • Managing risk factors in agriculture • Web-based agro-market intelligence system 	DAE, DAM, BARC, MoA, ARIs
19. Governance in NARS Institution	<ul style="list-style-type: none"> • Old and ineffective institutional policy • Inefficient service policy • Weak institutional linkage and coordination 	<ul style="list-style-type: none"> • Framing of efficient workable and up-dated service policy for NARS having incentives and built in reward system, in-situ promotion, up-grading of retiring age. • In act an Agricultural Research Service for NARS • Creation of an Endowment Fund at BARC to support agricultural research in the 	MoA, BARC, ARIs

Goal	Issues/Problems	Research areas/ Actions needed	Implementing Agency
		<ul style="list-style-type: none"> country • Provision of 10% reserve post of total sanctioned posts in each ARI and BARC for scientists • Establish accountability of scientists and supervisors by introducing a modern Self-Performance Assessment System in NARS • Unified service rules for ARIs • Strong coordination within NARS • Foster linkage, monitoring and evaluation by BARC • Introduction of institutional M&E Framework 	

Note: Detail prioritized researchable areas are shown in Annexure 1 and 2.

9.2 Fisheries Sub-sector

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
1. Reclaiming degraded fisheries resources and biodiversity conservation	<ul style="list-style-type: none"> ○ Decline in areas of most capture based fisheries; ○ Restriction of breeding-migratory routes; ○ Loss of biodiversities; ○ Illegal encroachment; ○ Increased pollution, siltation, diversion of river courses; ○ Unregulated water extraction for irrigation; ○ Indiscriminate fishing; ○ Use of harmful gears; 	<ul style="list-style-type: none"> • Development of design of sanctuaries, determination of principal and impact of sanctuaries on fish biodiversity conservation in open water system; • Bio-monitoring and pollution study and impact analysis; • Research on Hilsa fisheries management; • Management and conservation of dwindling, threatened and endangered open water and floodplain fish species; • Dvelopment and pilot scale testing of appropriate management models for improving fisheries in 	BFRI, DoF, Universities, Community organizations, NGOs

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
	<ul style="list-style-type: none"> ○ Ownership conflict; ○ Loss of dry season habitat; ○ Encroachment in refuge waters and loss of fish habitats; ○ Loss of spawning and nursing habitats, siltation of river beds and wet lands; ○ Disorganized management; ○ Violation of management policies/regulations. 	<p>reservoirs, lakes and floodplain wet lands;</p> <ul style="list-style-type: none"> ● Community approach in aquaculture in large water bodies like floodplain, beel etc; ● Impact of river linkage and distribution network and hydrological parameters on fish stock, aquatic biodiversity and estimates environmental flows in river system to sustain ecosystem properties and productivity; ● Development of long term data base on ecosystem ecology, fish biology and behavior and physiology to extreme climate changes in open water; ● Application of GIS –remote sensing technology for mapping of inland fishery resource(using data on production, dominant catch trends, species composition and ecological status); ● Population dynamics of major riverine species; ● Development of management guidelines for SIS conservation; ● Effective technology for rice-fish culture in floodplain and wetland areas; ● Assessment and management action plan development for Kaptai lake fishery management; ● Environmental impact assessment and bio-remedies of stressed aquatic ecosystem; ● Impact of agro pesticide on fish biodiversity of coastal floodplain and wet land waters; ● Flood ranching and growth 	

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
		repopulation study; • Management of endangered and threatened species and establish gene banking; • Propagation and breeding of fish in extreme climate conditions; • Development of open water fishing protocol; • Genetically improved strains through selective breeding.	
2. Enhance fish production from culture based fisheries	<ul style="list-style-type: none"> ○ Lack of proper engineering farm design; ○ Low quality of fingerlings; ○ High inputs cost; ○ Inconsistency in market price; ○ Breeding depression in private hatcheries; ○ Ownership right and conflict in pond use; ○ Disease infestations; ○ Mangrove destruction and illegal expansion of farming area; ○ Large area shrimp ghers without proper design; ○ Conflicts in user rights and social unrest; ○ Poor quality of hatchery shrimp seeds; ○ Lack of soil, water, silt and effluent management; ○ Knowledge gap; 	<ul style="list-style-type: none"> • Improved farming system management for maximizing production with minimum inputs; • Diversification of aquaculture by bringing more potential fish/shell fish species in farming; • Breeding and culture of high value fin/shell fish; • Technology for good aquaculture practices and organic aqua farming at profit level; • Water budgeting in inland aquaculture; • Development aquaculture in water re-circulating units; • Mass scale quality seed production of prawn, mono-sex tilapia, cat fish, climbing perch and snake heads; • Development GIS data base and resource mapping of fresh water ecosystem; • Farming system research and integrated aquaculture based farming; • Pond dynamics and productivity management; • Development of eco-region specific aquaculture practices; • Refinement of pen and cage culture technologies for reservoir, irrigation canals 	BFRI, DoF, Universities, NGOs, Public-Private partnership, fish/shrimp hatchery owners association

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
		and wet lands; <ul style="list-style-type: none"> • Development of technologies to control seepage in ponds under aquaculture; • Development of technologies for fish farm construction in porous and loose soils; • Remodeling large ponds (tank/canals) towards surface water based fish farming in drought prone areas; • Natural feed based farming of drought tolerant short cycle fishes in ponds by extreme poor farmers; • Water quality management and efficient hatchery model for mass seed production; • Diversification of brackish water aquaculture farming; • Development of integrated and rotational farming of shrimp-fish-rice; • Development of low cost efficient technology for shrimp PL production, nursing and transportation; • Development of breeding, propagation and culture and mariculture technologies of commercial important marine/brackish water fin and shell fish, algae/weed etc; • Ornamental fish breeding and farming; • Development of GIS based mapping for shrimp zoning and Intensification shrimp farming for production enhancement; • Technology for marine floating cage culture in Sunder bans mangrove forest sheltered channels; 	
3. Sustainable harvest and management of marine fisheries	○Over fishing in inshore waters causing	<ul style="list-style-type: none"> • Production enhancement through aquatic biomass production; 	BFRI, DoF, IMS-CU, KU, Exporters

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
resources	biodiversity threats; ○ Unregulated access; ○ Marine pollution and ecosystem health threats; ○ Global climate change; ○ Indiscriminate killing of larvae and post larvae; ○ Lack of information about marine fish stock; ○ Post harvest handling and processing loss; ○ Loss of non-target industrial bi-catch; ○ Lack of marine data base; ○ Lack of preservation and quality control efforts; ○ No conservation guidelines; ○ No effective MCS measures; ○ No effort to address trans boundary issues;	<ul style="list-style-type: none"> ● Marine stock assessment and development of protocols for marine fishing; ● Development of species wise biological data base of commercial marine fish stock and estimate of existing fish yield; ● Marine and estuarine bio diversity data base formulating conservation and management action plane on GIS plat form; ● Generating long term data base on ecosystem ecology, response to fish behavior including physiology to extreme climate changes in marine environment; ● To minimize negative impact and exploit new opportunities, development of a climate change action plan; ● Identification of new potential marine fishing grounds through GIS based remote sensing technique ; ● Marine pollution assessment, impact on marine resources and mitigation ; ● Management of shared marine living resources and habitats and trans- boundary diagnostic analysis ; ● Development of landing data based fishery chart; ● Development of conservation guidelines for threatened marine species; ● Development of satellite technology for effective monitoring, surveillance and controlling of marine resources; 	Association, Private Enterprises
4. Foster fish genetic resources	○ Inbreeding and cross bred seed production in the	● Genetic assessment and development of breeding protocol, improved strains	BFRI, DoF, Universities

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
	hatcheries; ○ Hatchery guidelines and fish breeding regulations absent; ○ Genetic charts and cataloguing of fish/shell fish are absent; ○ Temperature rise and higher disease susceptibility of fish; ○ Research facilities are limited.	resistance to heat and cool stress and diseases; ● Management of endangered and threatened species and establish gene banking; ● Propagation and breeding of fish in extreme climate conditions; ● Genetic cataloguing of fish and shellfish, pathogens/microbes; ● Development of biodiversity repository through cataloguing fish germ plasma resources; ● Development of genetic fish standards and certification norm for primary fish produce and products; ● Genetically improved strains through family selection; ● Development of Quantitative Trait Loci Specific (QTL's) molecular marker and marker assisted selection for all major cultivated species.	
5. Food safety and quality control, value chain efficiency and diversification of product	○ Inadequate measure for fish safety and quality; ○ Awareness and knowledge gap of primary producers and traders; ○ Supervision over the use of use of harmful chemicals in aquaculture absent; ○ Environmental aspects related to quality and safety are neglected; ○ Use of antibiotics, drugs and preservatives in fish and shrimp	● Quality improvement of local fish medicines, drugs and hormones following aquatic animal health standard guidelines; ● Techniques for determination of toxin chemical residues in fish, fish-products, by-products and feeds and their investigation; ● Safety potency, efficacy of locally produced and imported medicines for fish health and water quality management; ● Evaluation of hazardous chemicals and toxic compounds for their harmful effect on fish health and development of mitigation measures;	BFRI, Universities, EPB, BFDC, Private Investors, BSTI, AEC

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
	preservation and processing.	<ul style="list-style-type: none"> • Address market risks through improved market intelligence and improved efficiencies and market access; • Development of bio-secure effective aquaculture system; • Quality control of different fish medicines, biologics and diagnostics available in the country; • Development of diversified affordable value added fish products; • Quality improvement and value addition in traditional fisheries products like, dried, smoked, salted and fermented products etc. • Development of hygienic and safe processing and preservation techniques of fish and fishery products ,bi-products and feeds; • Product development and adhere to Sanitary and Phyto-Sanitary (SPS) issues and quality control; • Development of National Residue Plan and Guidelines for aquaculture product certification; • Baseline survey on value status in aquaculture; • Development of e-traceability technique for shrimp quality control. 	
6.Fish feed for aquaculture	<ul style="list-style-type: none"> ○ Knowledge gap; ○ Inputs scarcity; ○ High cost and inter- sectoral competition of inputs; ○ Use of hazardous chemicals in commercial pellet feed; ○ Unavailability of 	<ul style="list-style-type: none"> • Chemical composition and nutrition level of locally available fish feed ingredients and development of affordable nutrition rich quality fish feeds by using non conventional feed resources; • Health hazards of commercial fish feed ; • Environmental implications 	BFRI, Universities, BCSIR

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
	<p>live feed for hatcheries;</p> <ul style="list-style-type: none"> ○ Violation in fish feed standards by the producers; ○ Nutritional requirements are not well known. 	<p>of commercial fish feed and fertilizers on pond ecology and water quality;</p> <ul style="list-style-type: none"> ● Nutritional requirements of farming fishes and feeding optimization; ● Nutrition efficient high digestible low cost feed development; ● Development of live feed production technology; ● Alternative feeding schedule for cultivable species to minimize feed cost in aquaculture; ● Development of efficient method for enhancing shelf life and storage period of fish feed ; ● Energy efficient low cost fish feed mill model development to reduce feed cost in aquaculture. 	
7.Fish and shrimp health management	<ul style="list-style-type: none"> ○ Poor management of pond, water and soil; ○ knowledge gap; ○ Non availability of inputs and drugs/vaccines; ○ Improper management in culture systems; ○ Shortage of laboratory facilities and field services; ○ Quarantine risks. 	<ul style="list-style-type: none"> ● Development of PCR based molecular technique and biotechnical tools for rapid and effective diagnosis of infectious diseases in fish and shrimp; ● Development of genetically engineered vaccines for protecting devastating pathogens; ● Cloning of genes of economic traits from fish and production of transgenic fish for enhanced growth and diseases resistance; ● Diagnosis, control and prevention of shrimp/ fish diseases; ● Identification of herbal extracts and formulation of herbal medicines for fish/shrimp disease control; ● Fish health management, immuno-prophylaxis and 	BFRI, Universities, DoF

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
		therapeutics against common diseases; • Exotics and quarantine, export risks analysis and disease diagnosis.	
8.Improving harvesting and post harvesting efficiency	<ul style="list-style-type: none"> ○ Poor harvesting methods and high energy cost; ○ Quality loss due to mishandling during harvesting; ○ Weak facilities in carrying and transportation; ○ Absence of adequate preservation facilities; ○ High cost of processing; ○ Less product development efforts; ○ Inadequate mesh and gear regulation; ○ No formal research on product packaging and shelf life. 	<ul style="list-style-type: none"> • Development of energy efficient safe and suitable gears and equipments (on board and on shore) applicable for fishing, fish preservation and processing ; • Bio-informatics and IT based solutions to fishery harvest and post harvest issues; • Improved production, processing, transportation and handling and energy conservation ; • Development of eco-friendly fishing techniques for harnessing sustainable fishing from rivers and reservoirs; • Designing fuel/energy efficient new generation fishing vessels and gears; • Processing, value addition, packaging and marketing of fishery products; • Minimize post harvest handling and processing losses and effective utilization of fishing wastes and bi catch; • Identification and extraction of bio-active substances of pharmacological importance. 	BFRI, Universities, EPB, BFDC, Private Investors, MMD
9.Development of pro-poor technologies	<ul style="list-style-type: none"> ○ Limited technologies are available; ○ Respective stakeholders are not well acquainted with the available technologies; ○ Knowledge gap; 	<ul style="list-style-type: none"> • Refinement and practice of new sustainable technologies on: <ul style="list-style-type: none"> - Seasonal short cycle fish farming; - Breeding and seed production; - GIFT and Rajpunti culture; - Rice-fish/Rice-poultry 	BFRI, Universities, DoF, NGOs, Private Sectors Investors

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
	<ul style="list-style-type: none"> ○ Credit facility. 	farming; <ul style="list-style-type: none"> - Crab fattening; - Prawn seed production using backyard hatchery model; - Small scale mariculture; - Drying, salting, smoking and fermented product preparation; - Fishing net, carrier baskets making and trading; <ul style="list-style-type: none"> ● Create awareness; ● Training of stakeholders. 	
10. Breeding and culture of fish and aquaculture diversification	<ul style="list-style-type: none"> ○ Present aquaculture practice is limited with few selected species and techniques; ○ Less effort for breeding and culture of other species; ○ Less attention for non fish aquatic species; ○ Less preference of sea food. 	<ul style="list-style-type: none"> ● Refinement of existing fish breeding and culture technologies; ● Breeding and propagation of marine and brackish water species of food and commercial interests, like: Snail, Oyster, Clam, Sea weeds/grasses, Mud crab, Rock lobster, Turtle and fresh water species like, Kuchia, Soft shell turtle, snake heads etc; ● Development of culture technologies for non-conventional aquatic species; ● Diversification of aquaculture and product development through newly introduced species. 	BFRI, Universities, NGOs
11. Strengthening institutional capacity	<ul style="list-style-type: none"> ○ Inadequate laboratory facilities in the ARI; ○ Qualitative and quantitative shortage of human resources; ○ Development facilities are limited and most users are scientists of 	<ul style="list-style-type: none"> ● Upgrading of research laboratories to international standards; ● HRD planning and implementation as per demand; ● Ensure HRD facility for universities and NGO scientists; ● Increase in scientific and technical man power in the ARI; ● Short and long term training. 	BFRI, BARC, MoFL, NGOs, DoF

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
	institutes; ○ No extra funding support at institute level; ○ BARC has limited role to play; ○ Research system suffers.		
12. Access rights and livelihoods of fishers	○ Scanty information on socio-cultural strata of fishers; ○ Inadequate rules, regulations and acts; ○ Institutional, non-institutional credit; ○ Long marketing channels; ○ Limited scopes for alternative income source; ○ Scanty information on socio economic of fishers and livelihoods; ○ Revenue oriented management of Jalmahals; ○ Limited access of poor, true fishers; ○ No institutional approach.	<ul style="list-style-type: none"> ● Policy research on land-water use; ● Equity, sharing and justice of community based fishery activities; ● Socio-economic impact of shrimp-crop farming; ● Analysis of fish/shrimp market value/supply chain and marketing risks; ● Institutional model development for empowering coastal fisheries; ● Rural financing and credit market for fishery enterprises; ● Impact assessment of technology interventions on poverty reduction, gender issues and livelihoods of the poor's; ● Analysis of opportunities for value addition to fish and understanding structural and competitive forces; ● Local institutions and conflict regulation for shrimp gher management; ● Development of efficient value chain marketing for fish/shrimp and small marine products; ● Socio-economics of fisher folks and fisherman; ● Pro-poor research on socio-economic aspects of fishery, equity and gender focus. 	BFRI, Universities, DoF

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
13. Preparedness for adaptations with climate change	<ul style="list-style-type: none"> ○ Vulnerable adaptive capacity; ○ Fishing pressure and Loss of genetic diversity; ○ Habitat destruction; ○ Introduce invasive species of pathogens; ○ Fish maturation, behavior and breeding hamper; ○ Anticipatory actions are absent; ○ Irregular rainfall, draught and flash flood; ○ Salinity intrusion; ○ Impact on livelihoods. 	<ul style="list-style-type: none"> ● Modeling study on aquaculture (coastal and marine) in extreme conditions; ● Climate change impact of fish migration, breeding and growth; ● Development technology for breeding and culture of new potential species in coastal floods under climate change regime; ● Anticipatory research on fish habits and habitats with climate aberrations; ● Temperature rise and its effect on fish maturation, reproductive performance, biology and behavior; ● Species diversification, breeding and culture technologies for changes adaption and livelihood approaches in the southern coastal and northern drought prone region; ● Hydrology and biometrics of the Sundarbans ecosystem under the face of climate changes; ● Management protocol for seasonal and perennial waters under the face of climate changes. 	BFRI, Universities, DoF, NGOs, Fisheries Community, Financial Institutions, WFC, MoFL
14. Synergies of frontier sciences in fisheries research	<ul style="list-style-type: none"> ○ Limited facilities at institute level; ○ No data base on fisheries resources; ○ No functional unit in the research system; ○ Less collaboration with international organizations. 	<ul style="list-style-type: none"> ● Incorporating knowledge and facilities of frontier/advance sciences in fisheries research; ● Setting up functional unit at ARI; ● Develop linkages with supportive organizations like SPARSO; ● Strengthen M&E and BARC support; ● Training of personnel's. 	BFRI, BARC, SPARSO, MoFL, MoE

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
15. Transfer of knowledge on fisheries science and technology	<ul style="list-style-type: none"> ○ Lack of an true institutional mechanism for downstream linkage and feed back; ○ Absence of inbuilt linkage of research and extension projects; ○ Suspension of project based institutionalized linkage activities after project completion (like FSRD); ○ Absent of a separate unit for technology testing, transfer, dissemination, and socio-economic study in the ARI. 	<p>Strengthening of the present system required effective mechanism which should have the following considerations like:</p> <ul style="list-style-type: none"> (a) For coordination and monitoring of technology and knowledge transfer activities of ARI's, strengthening and revamping of TTMU of BARC is needed; (b) BFRI should have a separate unit for coordinating technology transfer activities with GO/NGO's and socio-economic research; (c) Early involvement of research in extension planning may further strengthen linkages; and finally (d) Institutional linkages among BFRI, DoF and other GO,NGO, extension agents and farmers society/cooperatives or individuals should brought under an effective system of knowledge generation and dissemination. 	BFRI, BARC, DoF, NGOs, WFC, BFRF
16. Foster linkage and cooperation with national and international organizations	<ul style="list-style-type: none"> ○ Weak linkages with the international centers; ○ Depriving of benefits of global fisheries research; ○ Lack of initiatives by the appropriate agencies; ○ No active role of BARC. 	<ul style="list-style-type: none"> ● Development of MoU, bilateral agreement with the international research centers; ● Involvement through collaborative research; ● Technical assistance and training; ● Scientists exchange visits under sandwich programs; ● Involvement in research prioritization exercises; ● Strengthening BARC's role as CGIAR member; ● Increased collaborative 	BFRI, BARC, WFC, MoFL, DoF

Goal	Issues/Problems	Research areas/Actions needed	Implementing Agency
		research with other institutes under CGP and KGF funds as a common platform.	
17. Address policy requirements	<ul style="list-style-type: none"> ○ Rising demands of fish, increasing risks and uncertainties, and increasing involvements of private sectors call for designing policies, developing institutional mechanisms and decision making processes and improving governance of service providers in the value chain. Therefore, formulation of a more comprehensive and cohesive strategies for R&D would require policy changes. 	<ul style="list-style-type: none"> ● Provision for extending opportunity by facilitating process of R&D through more NGO/donor/ GoB projects; ● Linkages between science and farmers in a consistent way, while disregarding overlapping and lack of coherence between existing policies and constraints; ● Provision for harmonization of policies in the areas of land, water, fisheries, agriculture and environment to ensure sustainable utilization and productivity of natural resources; ● Provision for management of market value chain with defined role of stakeholders; ● Bilateral water sharing, pollution issues and shared ecosystem and stock management need special attention in respective policy guidelines; ● The emergence of the Intellectual Property Rights (IPR) regime that needs to be established as an opportunity; 	BFRI, DoF, MoFL, MoL, MoI, MoA, MoFE, MoWR, BARC

Note: Detail prioritized researchable areas are shown in Annexure 3.

9.3 Livestock Sub-sector

Goals	Issues/Problems	Research areas/Actions needed	Implementing Agency
<p>1. Enhanced productivity of livestock products through Genetic improvement</p>	<ul style="list-style-type: none"> • Low yielding varieties of different livestock species • Absence of data base on genetic characterizations • Absence of National Animal Breed Registration Authority • Lack of conservation and improvement of livestock and poultry resources • Absence of gene mapping • Lack of animal breeding recording 	<ul style="list-style-type: none"> • Develop an integrated database on genetic characterization of animal genetic resources • Describe local breeds of livestock and poultry through systematic surveys in their native tracts • Establish National Animal Breed Registration Authority (NABRA) • Develop methodologies and technologies for in-situ and ex-situ conservation of livestock and poultry resources • Develop information system on Animal Genetic Resources of the country, including exotic. • Establish gene repository of breeds of different species of livestock and poultry. • Develop livestock and poultry varieties/lines for low input management system • Develop livestock and poultry varieties/lines for harsh environment like cyclone, drought, flood etc. • Develop assorted breeds for dairy cattle/beef/buffalo/Sheep/Goat/poultry/duck • Conserve and improve the local and Hill livestock species. • Studies on the genetic variability for resistance to infectious diseases of livestock species and identification of genes related to diseases • Detection and treatment of hereditary diseases and genetic disorders in breeding animals • Studies on the hormone profile in the cyclic and pregnant indigenous cross bred cows in relation to fertility • In-vitro culture and fertilization of embryos in livestock species • Standardize embryo transfer technology for livestock in Bangladesh • Production of seed stock for economically 	<p>Agricultural Universities, BLRI and Other relevant Institutes</p>

Goals	Issues/Problems	Research areas/Actions needed	Implementing Agency
		<p>important livestock species</p> <ul style="list-style-type: none"> • Genomics of major livestock species. • Embryonic losses and improvement in reproductive efficiency • Improve strains of sheep for fine wool, carpet wool and mutton 	
<p>2.Enhanced productivity through improved feeding system</p>	<ul style="list-style-type: none"> • Feed scarcity in terms quality and quantity • Under nutrition and mal nutrition in livestock and poultry species • Lack of appropriate technology on the utilization of low quality roughages and NCFR • Lack of data base on feed resources • Absence of area specific mineral mixture • Absence of appropriate feeding system • Inadequate availability of suitable fodder species • Lack of conservation fodder germ plasm 	<ul style="list-style-type: none"> • Develop database on animal feed resources for different agro-climatic zones of the country • Develop cost effective detoxification technologies for oil cakes and other unconventional feed stuffs. • Develop area- specific mineral mixture for different agro-ecological zones of the country • Studies on the bio-availability of micro-nutrients from different feed sources • Conservation of germ plasm for fodder and forages • Feed information, feeding standard and feeding system development of cattle/buffalo/sheep/goat/poultry/duck • Development of salt, drought and submergences tolerant forage/fodder varieties. • Development of improved and appropriate feeds and feeding system for different species of hills and coastal areas. • Commercial prebiotic and probiotic development for calves, growing, lactating and beef cattle/ buffalo. • Development of cost-effective complete feed block for cattle, buffalo, sheep, goat and poultry for different productive function using low quality roughages and unconventional sources of feed stuffs • Develop biochemical markers to asses micronutrient status of animals • Develop suitable fodder/ forage crops in the forest lands, tree plantations, fruit plantations, sugar cane areas, haors and boars, roadsides and bund areas. • Develop appropriate technology for the 	<p>Agricultural Universities, BLRI and Other relevant Institutes</p>

Goals	Issues/Problems	Research areas/Actions needed	Implementing Agency
		<p>utilization of NCFR such as algae, duckweed, water hyacinth, silkworm pupae, tree levels, herbs and shrubs.</p> <ul style="list-style-type: none"> • Commercial milk replacer and calf starters. • Tissue culture technique for forage crop seed production and distribution. 	
3. Animal health protection and prevention	<ul style="list-style-type: none"> • Prevalence of highly infectious and contagious diseases • Parasitism, deficiency diseases and protozoal diseases also cause significant economic loss • PPR and goat pox cause serious loss to goat species • Prevention of Ranikhet, Fowl Pox, Avian Influenza, Fowl Cholera is a great challenge • Control of trans boundary diseases is also a problem • Absence of sero surveillance studies • Absence of IT system for disease monitoring 	<ul style="list-style-type: none"> • Develop effective technology for the eradication of PPR, Avian influenza, Ranikhet in collaboration with the neighbouring countries. • Development of vaccine against mycoplasmosis. • Development of antiserum against different types of FMD virus. • Development of new vaccine seed viruses against emerging diseases. • Development of recombinant DNA vaccine for important viral and bacterial diseases. • Epidemiology, surveillance and characterization of PPR, Goat pox, contagious Ecthyma. • Epidemiology, surveillance and characterization of foot and mouth diseases, Tuberculosis (TB), Brucellosis, Anthrax and HS etc. • Sero-surveillance of important diseases of public health significance in collaboration with animal and human health. • Epidemiology, surveillance and characterization of new castle diseases, Avian influenza, Infectious Bursal Diseases, Marek's diseases, avian leucosis, egg drop syndrome etc. • Studies on repeat breeding and retention of placenta in cattle and buffalo and development of mitigation measures. • Development of binary ethylene mine inactivated polyvalent foot and mouth disease vaccine. • Isolation, identification and molecular characterization of FMD, Rota, PPR, Goat Pox and emerging viruses of poultry. 	Agricultural Universities, BLRI and Other relevant Institutes

Goals	Issues/Problems	Research areas/Actions needed	Implementing Agency
		<ul style="list-style-type: none"> • Surveillance studies on reproductive diseases. • Cell culture technique for diagnosis and vaccine production. • Development of recombinant vaccine for important viral and bacterial diseases. • Development of appropriate cost-effective zoo-sanitary and bio-security measures for farm animals and poultry. • Development of appropriate herd health management system. • Development of health management system (Hormone assay, AI service quality and efficiency, ovulation synchronization, tools for predicting bull fertility, application of ultrasonography, color dopler etc.) • Molecular and immunological events in host-pathogen interaction. • Epidemiology studies on protozoal and gastro-intentional parasitic diseases. • Prevention and control of gastro-intestinal parasitic and protozoal infestations. • Development of new vaccine seed viruses against immerging diseases. • Identification of causes of high calf mortality specially in cross bred cattle and buffalo and their mitigation measures. • Assessment of climate change effects on health and diseases problems of farm animals. • Surveillance and development of disease control system of livestock in hill areas. 	
4.Enhancing capacity of small holding	<ul style="list-style-type: none"> • Low per unit productivity of livestock species of landless, marginal and small holding farmers • Absence of 	<ul style="list-style-type: none"> • Develop appropriate low cost technology suitable for the smallholding, marginal, landless and pro-poor farming communities. • Develop institutional mechanisms for imparting education and training to the farmers on the innovated technologies for effective utilization. • Constitute multi-stakeholders societies to 	Agricultural Universities, BLRI and Other relevant Institutes

Goals	Issues/Problems	Research areas/Actions needed	Implementing Agency
	proper system in the availability of inputs and marketing of produces	get the benefit of the developed advanced technologies.	
5.Safe and low cost food Production, Value addition	<ul style="list-style-type: none"> • Lack of quality, antibiotic and hormone free foods • Lack of pathogen free safe foods • Low cost and absence of organic animal foods 	<ul style="list-style-type: none"> • Develop organic foods with the inclusion of probiotics, nutraceuticals and other functional foods into animal feeds. • Develop technologies for producing low cost, hormone and antibiotic free foods with the inclusion of probiotics, nutraceuticals and other functional foods as animal feed. 	Agricultural Universities, BLRI and Other relevant Institutes
6.Livestock diversification and control of environmental pollution	<ul style="list-style-type: none"> • Lack of high quality and value added food products • Lack of utilization of animal wastes as bio- fertilizer and bio- fuel 	<ul style="list-style-type: none"> • Research program should be taken to develop technology involving entire value-chain from production, value addition, processing to marketing in participation with multi-stakeholders • Develop various poultry meat products from spent hen, chicken nuggets, patties kababs and dairy food products. • Develop research and technology programs for the production of bio- fertilizers suitable for different crops and horticulture plants using animal waste. • Develop appropriate technology using animal waste as seed stock for bio-fuel production. • Address market risk through improved market intelligence and market access. 	Agricultural Universities, BLRI and Other relevant Institutes
7.Bio safety and climate change	<ul style="list-style-type: none"> • Absence of innovative methods and effective forecasting systems for the prevention and control of newly emerging diseases due to 	<ul style="list-style-type: none"> • Develop technologies and management practices for drought, flood, cyclone including other climate change effects. • Develop new strains of existing and emerging micro organisms due to adverse change in the climate • Develop suitable varieties of different livestock species coping up with the new cropping sequence, new feed and feeding 	Agricultural Universities, BLRI and Other relevant Institutes

Goals	Issues/Problems	Research areas/Actions needed	Implementing Agency
	<p>adverse changes in climate</p> <ul style="list-style-type: none"> • Absence of suitable varieties of livestock s and fodder species adjusted to climate change effects 	<p>management systems</p> <ul style="list-style-type: none"> • Develop approaches for green house gas reduction. 	
8. Human resources development	<ul style="list-style-type: none"> • Inadequacy of qualitative and quantitative manpower in research systems • Inadequate research fund; • Lack of effective monitoring and evaluation system. . 	<ul style="list-style-type: none"> • Modernize education system incorporating problem solving approaches in curricula: increase experimental learning. • Capacity strengthening through training at the international level. • Develop HRD planning and development as per national demand • Introduce long and short term training program in country and abroad. • Introduce incentive packages for the scientists. • Strengthen monitoring and evaluation system • LRI and CDIL of DLS needs to be upgraded to undertake research programs. 	Agricultural Universities, BLRI and Other relevant Institutes
9. Foster linkages and collaboration	<ul style="list-style-type: none"> • Weak linkages with G.O. NGO and other organizations • Limited collaboration with national and international organizations 	<ul style="list-style-type: none"> • Develop HRD planning as per demand • Introduce short and long term training programs in country and abroad. • Introduce incentive packages for the scientists. • Strengthen monitoring and evaluation system • Develop collaborative research programs involving national and international organizations. 	Agricultural Universities, BLRI and Other relevant Institutes
10. Institutional capacity and policy reform	<ul style="list-style-type: none"> • Weak institutional capacity • Absence of required policy formation • Weak 	<ul style="list-style-type: none"> • Develop infrastructures capable of addressing new emerging issues like climate change vulnerability, quality control of feeds, foods, drugs, drug residues, vaccines and other inputs. • Implement policies for commercialization of technologies developed for the 	Agricultural Universities, BLRI and Other relevant Institutes

Goals	Issues/Problems	Research areas/Actions needed	Implementing Agency
	implementation of existing policy	production of safe and quality foods ensuring the intellectual property rights <ul style="list-style-type: none"> • Formulate policies for commercialization of technologies and food processing • Implement Feed Act, Slaughter Act, Quarantine Act etc. 	

Note: Detail prioritized researchable areas are shown in Annexure 4.

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11.0 Annexure

Annexure-1: Prioritized Researchable Areas on Crops

The overall approaches on crop researches are based on commodity and non-commodity areas. Commodity areas include crop improvement, crop production, crop protection and value addition, while the non-commodity areas include land and soil management, water management, climate change, farm mechanization, agricultural economics, food technology and ICT. For convenience of research areas prioritization, the foreseeable research areas are grouped under thematic, sub-thematic and prioritized research areas which are presented in tabular form below:

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
1. Crop Improvement	1.1 Variety development	<p>1. Rice</p> <ul style="list-style-type: none"> • High Yielding Variety (HYV) (Equal or higher Yields than the existing popular varieties) • Hybrid (20% higher yield than HYV) • Super HYV (30% higher yield) • Short duration (10-15 days shorter) • Salt tolerant (10-12 ds/m) • Submergence tolerant (10-15 days) • Drought, cold and arsenic tolerant • Varieties resistant to Brown Plant Hopper, Stem Borer, etc. • Varieties resistant to BLB, BLS, Blast, Tungro, SB, etc. • Fine grain aromatic rice varieties • Rice varieties with high Fe, Zn and Vitamin A <p>2. Wheat</p> <ul style="list-style-type: none"> • HYV (Equal or higher yielder) • Early maturing • Late planting • Tolerant to heat, drought, salinity and disease resistant to LR, BPLB, etc. <p>3. Maize</p> <ul style="list-style-type: none"> • Hybrid • Dwarf • Pop corn and Sweet corn hybrid • Tolerant to salinity, water-logging and disease resistant to leaf blight, downy mildew, etc. • Mg, B, Mo, Zn efficient inbred and hybrid <p>4. Lentil</p> <ul style="list-style-type: none"> • HYV • Short duration • Disease resistant (Stemphylium blight,

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<p>rust , foot rot)</p> <p>5. Chickpea</p> <ul style="list-style-type: none"> • HYV • Disease resistant (wilt, BGM) <p>6. Mungbean</p> <ul style="list-style-type: none"> • HYV • Disease resistant (YMV, CLS) <p>7. Blackgram</p> <ul style="list-style-type: none"> • HYV • Short duration • Disease resistant (powdery mildew, sclerotinia) <p>8. Cowpea</p> <ul style="list-style-type: none"> • HYV • Disease resistant (YMV, CLS) <p>9. Mustard</p> <ul style="list-style-type: none"> • HYV • Short duration • Disease resistant (Blight) <p>10. Groundnut</p> <ul style="list-style-type: none"> • HYV • Short duration • Disease resistant (Tikka, rust, stem rot) <p>11. Sesame</p> <ul style="list-style-type: none"> • HYV • Water-logging resistant • Disease resistant (stem rot, wilt) <p>12. Soybean</p> <ul style="list-style-type: none"> • HYV • Disease resistant (YMV) <p>13. Sunflower</p> <ul style="list-style-type: none"> • Hybrid • Dwarf <p>14. Vegetables</p> <ul style="list-style-type: none"> • HYV • Hybrids • Summer vegetables like radish, tomato, brinjal, cabbage, cauliflower, etc. • Suitable variety for hills, saline and haor areas • Disease resistant (YMV, Wilt, Foot rot) <p>15. Fruits</p> <ul style="list-style-type: none"> • High yielding, good quality, regular bearing varieties of mango, jackfruit, litchi, guava, etc. • Early, medium and late varieties for

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<p>major fruits.</p> <ul style="list-style-type: none"> • Disease resistant (virus, Anthracnose, wilt, powdery mildew, rot, blight, etc.) • Suitable variety of fruits for export <p>16. Potato</p> <ul style="list-style-type: none"> • HYV • Suitable variety for export, starch, flakes, chips etc. • Disease resistant (late blight, virus) <p>17. Root crops</p> <ul style="list-style-type: none"> • High yielding (sweet potato, yam, aroids) • Disease resistant (leaf blight) <p>18. Spices</p> <ul style="list-style-type: none"> • HYV • Hybrids • Disease resistant (purple blotch, powdery mildew, rot, etc.) <p>19. Sugarcane</p> <ul style="list-style-type: none"> • High yield, high sugar • Disease resistant (Red rot) • Tolerant to submergence, salinity and drought <p>20. Jute</p> <ul style="list-style-type: none"> • HYV • Disease resistant (Anthracnose, stem rot, blackband, etc) <p>21. Tea</p> <ul style="list-style-type: none"> • HYV • Drought resistant <p>22. Flowers</p> <ul style="list-style-type: none"> • Hybrids • Dwarf • Suitable variety for export • Diseases resistant (corm rot, leaf spot, etc.)
	1.2 Genetic Resource Enhancement	<ul style="list-style-type: none"> • Collection, evaluation, characterization and conservation of germplasm/genetic materials of all crops and their utilization in variety development and other relevant purposes. • Genetic enhancement through inter-

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		specific crosses, mutation and tissue culture.
	1.3 Bio-technology and Modern Tools	<ul style="list-style-type: none"> • Molecular characterization of germplasm of different crops and identification of potential donors for crop improvement • Identification and isolation of genes tolerance to biotic, abiotic stresses of different crops and genes controlling micro nutrient condensation • Transfer of useful QTLs through Marker Assisted Selection • Development and evaluation of transgenic rice having tolerance to biotic and abiotic stresses as well as improved nutritional quality • Improvement of <i>in-vitro</i> propagation techniques and rapid multiplication of different crops • Develop tissue culture technique for rapid multiplication
2. Crop Production	2.1 Crop Management Practices	<p>1. Rice</p> <ul style="list-style-type: none"> • Integrated crop management (ICM) practices for higher rice productivity in different rice ecosystems • More productive rice – based cropping system with best management practices for different rice ecosystems • Yield gap minimization in rice and rice based cropping system using management practices through participatory on - farm research • Intensification and diversification of rice- based cropping system under different rice ecosystems. • Management practices for DSR (direct seeded rice)-Dry/Wet • Quality rice seed production and strategies for quick dissemination <p>2. Wheat</p> <ul style="list-style-type: none"> • Yield gap minimization of wheat-through farmer’s participatory research. • Resource Conserving Technologies (RCT) to maintain soil moisture and fertility

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<ul style="list-style-type: none"> • Introduction of wheat in unfavorable areas • Refine improved management package for high yield goal through farmer's participatory research • Water resource management and promotion of water saving technology, especially in the drought prone areas like Barind Tract by replacing Boro rice by wheat. • Wheat residue management for soil improvement <p>3. Maize</p> <ul style="list-style-type: none"> • Develop maize based cropping pattern to sustain and improve soil fertility • Introduction of maize after T. Aman rice in new areas, especially in the southern Bangladesh • Develop and refine improved management packages for high yield goal on regional basis • Determination of optimum planting time for maximum seed setting of inbreds and F1s • Seed quality research, seed health, vigour, seed abnormality etc. in storage. <p>4. Pulses</p> <ul style="list-style-type: none"> • Introduction of short duration pulse varieties (lentil, mungben) in appropriate cropping system, specially mungbean in <i>Kharif-1</i> season in new areas • Validation of economic advantage of pulses over Boro through participatory adaptive research • Design new cropping patterns including short duration pulses like lentil, pea, grasspea (as fodder) in between T.Aman and Boro rice • Relay cropping of lentil, chickpea, field pea and backgram in suitable areas • Introduction of biofertilizer in pulse, especially in non-traditional areas • Introduction of pulses in new areas • Yield maximization of pulses through optimum management practices

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<p>5. Oilseeds</p> <ul style="list-style-type: none"> • Intensification of short duration mustard cultivation in between T.Aman and Boro rice • Introduction of improved groundnut varieties in char land and traditional areas • Standardize fertilizer package especially micronutrients, for different oil crops in deficient areas • Adaptive trials on yield maximization of oil crops to minimize yield gap • Develop seed storage technique in groundnut, soybeans and sunflower • Up-scaling of seed production of new varieties through block demonstration <p>6. Vegetables</p> <ul style="list-style-type: none"> • Refine production technologies especially for micronutrients for commercial vegetables • Up-scaling of HYVs and hybrids of vegetables in the southern regions and hilly regions • Develop organic culture and protective culture, hydroponics for high value vegetables (Tomato, lettuce, capsicum, etc.) • Development of pot culture techniques and potting medium for selected vegetables like tomato, capsicum, chili for roof gardening • Study on irrigation requirement, mulching techniques, weed control for vegetable crops <p>7. Fruits</p> <ul style="list-style-type: none"> • Standardize management packages for major fruits and coconut • Land management of orchards • Develop trailing, pruning, fruit thinning practices for important fruit crops • Use of growth regulators for flower induction, fruit set and fruit retention in mango, pineapple. etc. • Introduction of grafting technique of jackfruit • Introduction of improved fruit species in hills and saline coastal areas

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<ul style="list-style-type: none"> • Development of vegetative propagation techniques for fruits difficult for propagation • Improvement of <i>in-vitro</i> propagation techniques and rapid multiplication of selected fruit crops <p>8. Tubers and Root Crops</p> <ul style="list-style-type: none"> • Standardize cultivation practices for higher yield of potato, mukhikachu and panikachu • Standardize zero tillage potato cultivation with mulching, especially for southern region • Introduce high yielding yam, olkachu, mankachu varieties in the homestead through out the country • YMV free seed tuber production of potato through tissue culture and enhance breeder's seed production <p>9. Spices</p> <ul style="list-style-type: none"> • Standardize production packages (including micronutrients) for different spice crops • Introduction of ginger in the homestead area • Preservation technique for seed storage at farmer's level • Introduction of spices varieties in the non-traditional areas like southern belt <p>10. Sugarcane</p> <ul style="list-style-type: none"> • Farmer's participatory adaptive research on multiple cropping with sugarcane, intercropping with high value winter crops, ratoon management and yield maximization with appropriate nutrient management packages • Biological Nitrogen Fixation (BNF) in sugarcane • Stress management research against flood, drought, water logging, etc. • Crop management research for enhancing yield and sugar content <p>11. Jute</p> <ul style="list-style-type: none"> • Nutrient management including micronutrients for maximizing yield

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<ul style="list-style-type: none"> • Development of jute based profitable cropping patterns for sustained soil fertility • On farm participatory research for maximizing jute yields and reduce yield gap • Up-scaling of seed production of new varieties <p>12. Tea</p> <ul style="list-style-type: none"> • Raising organic matter status of degraded tea soils • Biotechnology to improve soil fertility • Drainage, irrigation and drought management • Crop diversification/intercropping • Management of high soil acidity • Energy source utilization • Effect of spray of different fertilizer mixtures on the growth of tea cuttings. • Nursery raising and its management • Development of cultural practices with proper maintenance of sick and low yielding tea gardens • Soil organic matter on productivity <p>13. Flower and Ornamentals</p> <ul style="list-style-type: none"> • Standardize cultivation practices for commercial cultivation of major flowers (from seedling to harvest) • Develop tissue culture technique for rapid multiplication • Standardize seedling raising techniques • Standardize pot culture technique, pot size, potting media using commercially available compost and mix fertilizers
3. Crop Protection	3.1 Management of Insect pests, Diseases and Weeds	<p>1. Rice</p> <ul style="list-style-type: none"> • Appropriate management practice for major diseases, insects and weeds in rice and rice based cropping system • IPM in rice and rice based cropping system <p>2. Wheat</p> <ul style="list-style-type: none"> • Cultural, chemical and integrated control of major diseases <p>3. Maize</p> <ul style="list-style-type: none"> • Cultural, chemical and integrated

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<p>control of major disease and insect pests</p> <p>4. Pulses</p> <ul style="list-style-type: none"> • On-farm chemical and cultural control of major diseases of pulses like stemphylium and rust of lentil, BGM in chickpea, YMV in mungbean and black gram, powdery mildew in field pea, blackgram and mungbean • Biological control of soil borne fungal disease of pulses like wilt and food rot in chickpea and lentil • On farm chemical control of major insect pests of pulses like pod-borer complex of mungbean, chickpea, cowpea, aphids in lentil and lathyrus, thrips, mites, apion in mungbean etc. • Development of IPM against major pests of pulses <p>5. Oilseed Crops</p> <ul style="list-style-type: none"> • Development of chemical and cultural control measures of major diseases of oil crops (like Alternaria in mustard, stem rot and wilt in sesame, foot rot, leaf spot and wilt of groundnut, leaf disease of sunflower) • Development of control measures against major insect pests of oil crops (aphid, hairy caterpillar, hawk moth in sesame, thrips in soybean, termite and white grub in groundnut, etc.) • Biological control of major pests of oil crops <p>6. Vegetables</p> <ul style="list-style-type: none"> • Management of fungal/bacterial/nemic/ viral diseases of different vegetables through chemical, cultural and biological means • Control of foot rot, stem rot, die-back of betel leaf • Control of seedling diseases of vegetables, especially winter vegetables • Integrated disease management of major vegetables • Chemical, biological and integrated pest management of major vegetables (brinjal, country bean, cabbage, cauliflower, tomato etc.)

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<p>7. Fruits</p> <ul style="list-style-type: none"> • Development of control measures for major diseases of mango, jackfruit, guava, banana, citrus, watermelon, etc. • Control of Powdery mildew in BAU and Apel kul • Management of mites in coconut, chilli, watermelon, etc. • Management fruit borer in mango, jackfruit, BAU and Apel kul • Integrated pest management (IPM) for major insect pests of fruits <p>8. Tuber and Root Crops</p> <ul style="list-style-type: none"> • Update control measures against late blight, viral and other major diseases of potato and other root crops with newly available fungicides/cultural/vector control <p>9. Spices</p> <ul style="list-style-type: none"> • Control measure development of major diseases like rhizome rot of ginger, leaf blight of turmeric, Alternaria leaf blight of onion and garlic, etc. • Validation and Up-scaling of controlling alternaria blight of onion and garlic • Development of control measures of major insect pests of spices crops • Validation and Up-scaling of controlling thrips of onion and garlic <p>10. Sugarcane</p> <ul style="list-style-type: none"> • Search for resistant sources against major diseases and pests of sugarcane • Integrated disease management of major diseases of sugarcane • Integrated control of major insect pests like borers, root borers, scale insect and pyrilla • Control of major insect pests using bio-agents <p>11. Jute</p> <ul style="list-style-type: none"> • Biological control of soil borne fungal pathogens and other major diseases • Identification of sources of resistance against apion, mites, spiral borer and mealy bug • IPM of major insect pests of Jute and

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<p>Allied Fibres</p> <p>12. Tea</p> <ul style="list-style-type: none"> • IPM with emphasis on biological control • Integrated management of diseases, pests and weeds <p>13. Flower and Ornamental</p> <ul style="list-style-type: none"> • Standardize control measures for important diseases of commercial flowers of the country (corn rot of gladiolus, leaf spot of rose, etc) • Develop control measures for major insect pests of commercial as well as pot plants of flowers and ornamentals
	3.2 Basic studies on Insect pests and Plant pathogens	<ul style="list-style-type: none"> • Survey and identification of diseases and insect pests of different crops • Studies on yield losses of crops due to diseases and insect pests • Study the etiology of major diseases of crops • Surveillance of new diseases and insect pest of crops due to climate change • Identification of races and biotypes of major disease and insect pest of rice; mapping of R-genes and genes pyramiding • Pest risk assessment of all crops • Study of quarantine pests and diseases of different crops • Study on storage diseases and insect pests • Studies on natural enemies of harmful insect pests
	3.3 Molecular Characterization	<ul style="list-style-type: none"> • Molecular characterization of major pathogens of different crops • Identification of races using molecular technique
4. Value Addition	4.1 Processing, Supply Chain and Marketing	<ul style="list-style-type: none"> • Rice milling for higher recovery • Diversified utilization of rice byproducts (bran, husk, straw) • Develop appropriate packaging, transportation system for local and export market • Contract farming and marketing

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<ul style="list-style-type: none"> channel development for vegetables • Value addition and supply chain development for selected vegetables, fruits, etc. • Development of preservation technique for increasing shelf life of vegetables • Processing of different spices for powder and paste products development and design suitable packing materials (packets, cans, etc.) • Determine the quality of different packed spices (especially causes of rancids) • Survey the quality of available processed spices in the market and suggest improvement • Marketing and sales promotion • Diversification of tea products and value added items • Development of fungal inoculum packages for acceleration of jute retting • Improvement and Scaling-up of ribbon retting technology • Using micro organisms for quality up-gradation of fiber • Manufacture fancy jute products using jute blended yarns with other textile fiber • Improvement of jute fiber using chemicals and blended with other natural and synthetic fiber for diverse use in textile sectors • Bio-pulping of Jute by using enzymes instead of chemicals • Empirical mapping of supply chain analysis for high value added commodities • Development of market chain for farmers' participation in all types of markets (local and city markets) • International trade (Export-Import) analysis quality and safety issues for different agricultural commodities
	4.2 Post Harvest Management	<ul style="list-style-type: none"> • Standardize maturity indices for major fruits and other crops • Standardize, post harvest handling,

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<p>packaging, transportation and storage techniques for fruits, vegetables, etc.</p> <ul style="list-style-type: none"> • Study on post harvest loss of different crops and develop techniques to minimize the losses through pre and post harvest treatments • Development of safe technique for ripening of fruits and extending shelf life
5. Land and Soil Management	5.1. Soil Organic Matter Management	<ul style="list-style-type: none"> • Conservation agriculture with minimum tillage, mulch, cover crops, etc. for upland crops under light textured soil • Organic amendments with FYM/PM/Bio-slurry/GM, crop residue/compost etc. for intensive cropping systems • Carbon sequestration in soils under single, double and triple cropping systems
	5.2 Soil Fertility and Fertilizer Management	<ul style="list-style-type: none"> • Fertilizer need assessment for major crops and cropping patterns • Integrated nutrient management for major crops and cropping patterns • Nutrient use efficiency for major crops and cropping patterns • Micronutrient management for major crops and cropping patterns • Nutrient dynamics in soil-crop-water system • Fertilizer need assessment model for major crops and cropping patterns • Delineation of and nutrients status in soils in 5-year intervals and GIS mapping
	5.3 Ecologically Unfavorable Land and Soil Management	<ul style="list-style-type: none"> • Adaptation of crops with soil and water management in coastal saline environment • Adaptation of crops with land/soil and water shed management in hilly areas • Sedimentation, nutrient accretion, crop adaptation and soil –crop management in char lands • Adaptation of crops with soil amendment, nutrient and water management in different agro-

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<p>ecosystems like peat and piedmont areas, char lands, hills, terraces, etc.</p> <ul style="list-style-type: none"> • Soil organic matter and water management for major crops and cropping patterns in Barind areas • Conservation of soil and soil fertility in hilly areas
	5.4 Bio-Fertilizers	<ul style="list-style-type: none"> • Microbial inoculants for N and P in legume/rice/wheat/ sugarcane • Mycorrhizal inoculants for vegetables/fruits/forest crops. • Bio-activators for rapid composting/decomposition of crop residues and methane bacteria for bio-gas production
	5.5 Soil and Water Pollution	<ul style="list-style-type: none"> • Heavy metal /Arsenic contamination and its management in water, soils and crops in arsenic contaminated areas • Pesticide residues in soils and crops specially in vegetables and fruits
6. Water Management	6.1 Water Resources for Crop Production	<ul style="list-style-type: none"> • Quantitative and qualitative assessment of surface and groundwater resources for agriculture • Watershed management for hilly areas • Rainwater harvesting and use for agriculture • Decline in groundwater resources and associated pollution
	6.2 On Farm Water Management	<ul style="list-style-type: none"> • Increasing water productivity through water saving techniques(increasing irrigation water use efficiency/alternate wetting and drying technology) for major crops and cropping patterns • Cost effective and high efficiency irrigation system for upland crops (including high value crops) and wetland rice • Development of water management techniques for major cropping patterns as a way towards adaptation to climate change

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<ul style="list-style-type: none"> • Use of alternative energy (CNG and Solar energy) for pumping • Water management for coastal saline soil; methods of reducing water logging in cultivable land; technology for conversion of sweet water from saline water • Modeling of crop-soil-water-weather system
7. Climate Change	7.1 Climate change effect on biotic and abiotic stresses	<ul style="list-style-type: none"> • Climate change effects on soil and water salinity/ drought/ inundation regimes and crop production practices in coastal, drought and flood prone areas • Estimation of CH₄ and N₂O emission from rice field • Impact of climate change on pest, disease and environment
8. Farm Mechanization	8.1 Pre-Harvest Farm Machinery	<ul style="list-style-type: none"> • Appropriate machinery/equipments for upland crops and wetland rice culture (tiller/seeder/planter/weeder/fertilizer applicator/harvester/irrigation device) including their marketing • Development of different tillage and weed control equipment and techniques (power operated weeder/furrower for maize, wheat, potato, pulses and sugarcane; laser leveler) • Hydraulic design and manufacture of irrigation equipment • Investigation of appropriate pump zoning and tube-well spacing.
	8.2 Post-Harvest Farm Machinery	<ul style="list-style-type: none"> • Small and medium scale machinery/equipment for crop (threshing/sorting/cleaning/storage device/drying/rice parboiling and milling) • Appropriate machinery and equipment for agro-processing (Crops/Livestock/Fisheries/Forestry) • Improved oil extraction technology from rice bran, mustard and palm, improved juice extraction for sugarcane

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		and gur processing
	8.3 Utilization of Renewable Energy	Renewable energy (solar, wind, bio-fuel, bio-gas etc.) use in farm machinery/equipment and application (rice drying and parboiling and irrigation of selected crops)
	8.4 Survey and Policy Research	<ul style="list-style-type: none"> • Survey on current status of mechanization; impact study of mechanization on rural livelihood and environment • Utilization of vast fallow land through mechanization in specific areas • Policy issues about quality and standardization of agricultural machinery
9. Agricultural Economics	9.1 Policy and Planning	<ul style="list-style-type: none"> • Policy impact on farm productivity, output and resource management • Policy investigation on price of inputs and outputs towards productivity and profitability • Production and business model development on crops (seed and high value crops), livestock and fisheries • Impact of research innovations on return to investment including factors affecting their adoption • Impact of research and development programs/projects on productivity, profitability and environment • Assessment and policy direction in “Research -Extension-Farmers linkage” contributing to productivity and income • Agricultural subsidy, insurance and credit and their impact on small, medium and commercial enterprises • The quality of agricultural education impacting research and extension performance • Assessing effectivity of demo and block demo in relation to farm productivity and income • Effectiveness of training of researchers, extension personnel and farmers on

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		productivity and profitability
	9.2 Production and Farm Productivity	<ul style="list-style-type: none"> • Managing risk factors in agriculture with appropriate coping mechanism • Combination of profitable enterprises for elevating productivity and farm income
10. Food Technology	10.1 Food Production, Consumption and Human Nutrition	<ul style="list-style-type: none"> • Re-orientation of agricultural extension approach focusing on both production and consumption of nutritious foods for balanced nutrition • Integrated farming of crops, livestock, fisheries and agro-forestry for improved nutrition and livelihood • Food based approaches in alleviating nutritional problems and sustainable improvement nutritional status • Diversification and intensification of agriculture production system emphasizing on protein- and micronutrient-rich foods through bio-fortification • In-depth national survey to determine nutritional status and factors associated with malnutrition in order to take necessary remedial measures • Formulation of low cost balanced, nutritious and safe diet including street food with multiple options for the vulnerable section of the population • Comprehensive analysis of different food items for determining their nutritional values including flatulent and anti-nutritional factors of existing and newly developed varieties • Formulation of nutritious foods like corn flakes, bakery items, etc. blended with non-conventional food items e.g. cassava and maize powder/flour • Screening for Quality Planting Materials (QPM) with high carotene and minerals for human consumption • Determination of nutrients loss of different food items in cooking, marketing, transportation and handing processes and develop measures for

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		their retention
	10.2 Food Safety and Quality, Hazards and Risk	<ul style="list-style-type: none"> • Development and adoption of appropriate standards on various food and additives • Study on contaminants (arsenic/heavy metals), adulterants and additives and their implications on human health • Sanitary and phytosanitary measures for protection of food borne diseases • Identification of phyto-toxin and myco-toxin in food items and feeds and develop mitigation measures
11. ICT in Agricultural Research	11.1 Precision Farming	<ul style="list-style-type: none"> • Computer vision/model to identify insect-pest, soil health; application of crop image for identifying precise amount of fertilizer, water and other inputs; modeling of rice cultivation system; modeling of rice milling system
	11.2 MIS for Research Management	<ul style="list-style-type: none"> • MIS of NARS Institutes • Database of equipments/laboratory of NARS Institutes • Databases related to research management on completed and on-going projects of NARS • Database on monitoring and evaluation • Database on financial management
	11.3 Databases on NRM and Socio-economics	<ul style="list-style-type: none"> • Updating of AEZ database with land, soil, climate, hydrological parameter • Development of variety/agricultural technology database • Development of socio-economic database
	11.4 GIS and Remote Sensing	<ul style="list-style-type: none"> • GIS based information system on surface and groundwater resources • GIS based pest and disease information system • GIS based information system for agro-ecologically constraint areas • GIS based information system on Plant/Animal Genetic Resources • Assessment of climate change impact on Agriculture/forests using remote sensing and GIS

Thematic Areas	Sub-thematic Areas	Researchable Areas/ Issues
		<ul style="list-style-type: none"> • Development of Remote sensing and GIS based applications for crop/fisheries/forest resources • Development of Remote sensing and GIS based applications for crop agriculture • Assessment of AEZ based suitability of major crops • Crop zoning for land use planning
	11.5 Web-enabled databases	<ul style="list-style-type: none"> • Web-based agro-market intelligence systems • Web-based information systems for natural resources • Development of virtual knowledge centre
	11.6 Biometry/ Applied Statistical Tools for Agricultural Research	<ul style="list-style-type: none"> • Data bank of agricultural research • Existing/traditional analytical tool • Need base or demand oriented statistical analysis • Modern/latest statistical packages for agricultural research to develop technologies
	11.7 Disaster Management	<ul style="list-style-type: none"> • Early warning systems for abiotic and biotic hazards (flood, drought, rainfall, pests, diseases, etc.) • Expert Systems/Decision Support Systems for food security and disaster management • Farmer information system /disaster management

Annexure-2: Prioritized Researchable Areas on Forestry

The researchable areas of forest crops are grouped under six thematic areas and are presented below:

Thematic Areas	Researchable Areas/ Issues
1. Forests and Biodiversity Conservation	1.1 Study the drivers of deforestation and develop appropriate participatory approaches for forests and biodiversity conservation
	1.2 Study the biodiversity resources (flora and fauna including soil microbes) of different forest types including home gardens
	1.3 Inventory and assessment of wildlife species and their keystone species in different forests (and wetland areas) of Bangladesh.
	1.4 Assessment of ecological impacts of different exotic species including rattan in forests
	1.5 Ecosystems analysis of mangrove forests and developing measures for preservation under varied climatic situations and risks
2. Production Management	2.1 Identification of best provenances/ clones of commercial species of trees and establishment of their breeder seed orchards
	2.2 Establishment of a seed bank for sustained supply of quality planting stock
	2.3 Collection and testing of seeds collected from plus trees and mother trees, and develop storage techniques in seed bank
	2.4 Development of high yielding clones of bamboo and cane (rattans)
	2.5 Establishment of germplasm centre of endangered indigenous species in different ecological regions
	2.6 Identification/standardization of control measures for major insect pests and diseases of important tree species in the forests and homestead areas
	2.7 Development and screening of diseases and pests resistant tree species and their expansion.
	2.8 Coordinated regional program for controlling common diseases and pests of forest tree species

Thematic Areas	Researchable Areas/ Issues
	2.9 Development of nursery practices of endangered indigenous species
	2.10 Identification of pests and diseases of nurseries and their control
	2.11 Assessment of wood production trends and consumption pattern in non-forest or poorly forested areas
	2.12 Development of conservation techniques of soil and soil fertility in hilly areas
	2.13 Identification and economic analysis of existing (traditional, introduced, farmer-innovated) agroforestry practices in and development of improved agroforestry practices
	2.14 Development of agroforestry models for forest and newly accreted land
	2.15 Development of improved shifting cultivation in the hilly areas
	2.16 Development improved management technique for degraded forest land
3. Adverse effect of climate change	3.1 Development of appropriate social forestry techniques for forest land
	3.2 Mitigation of impact of climate change on food security of forest dependent people
	3.3 Assessment of carbon stock in different forest land
	3.4 Assessment of climate change impact on forests using remote sensing and GIS
	3.5 Investigating possible impacts of climate change and sea level rise on different forest types with particular emphasis on the mangrove forests
4. Livelihood improvement	4.1 Exploring forest resources and livelihood linkages in different forest regions with socioeconomic, quantitative and qualitative data
	4.2 Development of IGA for improving livelihood of forest dependent people
	4.3 Development of community based eco-tourism in forest areas for forest conservation <i>inter alia</i> poverty alleviation, women empowerment and creating environmental awareness
5. Production of Non-timber forest products including medicinal plants	5.1 Selection of appropriate varieties of commercially important medicinal plants for their best medical efficacy and higher yield
	5.2 Development of mass propagation techniques including tissue culture of commercially important medicinal plants/trees/bamboo/cane

Thematic Areas	Researchable Areas/ Issues
	5.3 Development of end-use specific silvicultural/ agronomic management packages for commercial production of important medicinal plants
	5.4 Development of appropriate technologies (processes, equipment) for processing of commercially important medicinal plants
	5.5 Screening of effective bio-pesticides for medicinal plants and other crops
6. Value Addition and Technology transfer	6.1 Packaging mature technologies for dissemination to the clientele through training, advisory services and information supply
	6.2 Development of marketable products from waste woods and wood and bamboo products

Annexure-3: Prioritized Researchable Areas on Fisheries

Under Fisheries sub-sector, there are ten thematic areas and under each thematic area, a number of researchable areas are identified which are presented below:

Thematic areas	Researchable Areas/Issues
1. Fish breeding and propagation	1.1 Development of improved brood fish and breeding protocols for threatened and endangered fish species; 1.2 Breeding and seed production of high value fin/shell fish; 1.3 Propagation and breeding of non conventional aquatic species like clam, oyster, crab. Sea grass/sea weed, turtle/tortoise of food and economic interest; 1.4 Up scaling mass scale quality seed production of prawn, mono-sex tilapia, cat fish, climbing perch and snake heads; 1.5 Ornamental fish breeding, seed production and farming;
2. Protection, conservation and management of fisheries and fish genetic resources	2.1 Principles and designing of sanctuaries and its impact on fish production and biodiversity; 2.2 Source and type of pollution and effect on fish health, habitat and productivity and its management in open and marine ecosystem; 2.3 Sustainable management of Hilsa fisheries; 2.4 Community approach in floodplain aquaculture and management; 2.5 Genetic improvement of depressed cultured fish species through family selection/selective breeding; 2.6 Generating long term database on ecosystem ecology, response to fish behavior and physiology to extreme climate change in marine environment; 2.7 Development conservation guidelines for threatened marine and open water fish species; 2.8 Development of management guidelines for SIS conservation; 2.9 Development of improved strains resistance to heat and cool stress and diseases; 2.10 Management of endangered and threatened fish species and establish gene banking; 2.11 Development of biodiversity repository through cataloguing fish germ plasm resources; 2.12 Genetic cataloguing of shell and finfish, pathogens/microbes; 2.13 Marine and estuarine biodiversity database for formulating conservation and management action plan on GIS platform; 2.14 Development of Quantitative Trait Loci (QTL) specific molecular marker and marker assisted selection for all major cultivated species; 2.15 Conservation of dwindling and endangered indigenous open water and floodplain fish species; 2.16 Development and pilot scale testing of appropriate management models for improving fisheries in reservoirs, lakes and floodplain wet lands; 2.17 Impact of river linkage and distribution network and hydrological parameters on fish stock, aquatic biodiversity and estimates environmental flows in river system to sustain ecosystem properties and productivity; 2.18 Environmental impact assessment and bio-remedies of stressed aquatic

Thematic areas	Researchable Areas/Issues
	ecosystem; 2.19 Application of GIS –remote sensing technology for mapping of inland fishery resource (using data on production, dominant catch trends, species composition and ecological status); 2.20 Population dynamics of major riverine species; 2.21 Impact of agro pesticide on fish biodiversity of coastal, floodplain wet land waters; 2.22 Development of genetic fish standards and certification norms for primary fish produce and products;
3.Fish production and productivity	3.1 Productivity enhancement; 3.2 Intensification of zoning of fish/shrimp culture practices in different agro-ecological zones for Effect of antibiotics, growth promoters, inducing agents and hazardous chemicals uses in aquaculture and its impact on human health; 3.3 Bio-physical characteristics of brackish water to intensify shrimp culture; 3.4 Enhance aquatic biomass production; 3.5 Development of culture and management practices for marine important commercial fisheries resources; 3.6 Biotechnology and genetic engineering of fishes for development of high yielding varieties(HYV); 3.7 Development of technologies for lake creek aquaculture; 3.8 Development and pilot scale testing of appropriate management models for improving fisheries in reservoirs, lakes and floodplain wet lands; 3.9 Diversification of aquaculture by bringing more potential fish/shell fish and marine weed species in farming; 3.10 Technology for good aquaculture practices and organic aqua farming at profit level; 3.11 Improving farming system research and integrated/rotational aquaculture based farming; 3.12 Development of eco-region specific aquaculture practices; 3.13 Improvement of pen and cage culture technology in reservoir, irrigation canals and wet lands; 3.14 Natural feed based farming of drought tolerant short cycle fishes in ponds by extreme poor farmers; 3.15 Development of bio-secured effective aquaculture system; 3.16 Development of pro-poor technologies for income generation and increased women participation;
4. Water and soil management	4.1 Water budgeting in inland aquaculture; 4.2 Development of technologies for fish farm construction in porous and loose soils and control seepage in aquaculture ponds; 4.3 Development of aquaculture in water re-circulating units; 4.4 Pond dynamics and productivity management; 4.5 Productivity and management of water and soil of shrimp ghers;

Thematic areas	Researchable Areas/Issues
	<p>4.6 Remodeling large ponds(tank/canals) towards surface water based fish farming in drought prone areas;</p> <p>4.7 Water quality management and efficient hatchery model for mass seed production;</p>
5. Fish feed and nutrition	<p>5.1 Nutrition efficient high digestible low cost feed for diverse aquaculture practices;</p> <p>5.2 Standardization of principles of feeding and fertilization in aquaculture for sustainable environment;</p> <p>5.3 Chemical composition and nutrition level of locally available fish feed ingredients and development of affordable nutrition rich quality fish feeds by using non conventional feed resources;</p> <p>5.4 Health hazards of commercial fish feed ;</p> <p>5.5 Environmental implications of commercial fish feed and fertilizers on pond ecology and water quality;</p> <p>5.6 Nutritional requirements of firming fishes and feeding optimization;</p> <p>5.7 Development of live feed production technology;</p> <p>5.8 Alternative feeding schedule to minimize feed cost in aquaculture;</p> <p>5.9 Development of efficient method for enhancing shelf life and storage period of fish feed ;</p> <p>5.10 Energy efficient low cost fish feed mill model development to reduce feed cost in aquaculture;</p>
6. Harvesting and post harvesting	<p>6.1 Development of energy efficient safe and suitable gears and equipments (on board and on shore applicable) for fishing, fish preservation and processing ;</p> <p>6.2 Bio-informatics and IT based solutions to fishery harvest and post harvest issues;</p> <p>6.3 Improved production, processing, transportation and handling and energy conservation ;</p> <p>6.4 Development of eco-friendly fishing techniques for harnessing sustainable fishing from rivers and reservoirs;</p> <p>6.5 Designing fuel/energy efficient new generation fishing vessels and gears;</p> <p>6.6 Processing, value addition, packaging and marketing of fishery products;</p> <p>6.7 Minimize post harvest handling and processing losses and effective utilization of fishing wastes and bi catch;</p> <p>6.8 Identification and extraction of bio-active substances of pharmacological importance;</p> <p>6.9 Development of diversified affordable value added fish products;</p> <p>6.10 Development of hygienic and safe processing and preservation techniques of fish and fishery products(including fish drying, smoking, salting, fermentation, canning etc) and bi-products;</p> <p>6.11 Marine stock assessment and development of protocols for marine fishing;</p> <p>6.12 Identification of new potential marine fishing grounds through GIS based remote sensing technique;</p>

Thematic areas	Researchable Areas/Issues
7. Fish health management	<p>7.1 Fish disease diagnosis, treatment and development of fish health management protocol;</p> <p>7.2 Identification, characterization and treatment of shrimp disease and health management;</p> <p>7.3 Development of PCR based molecular technique for rapid and effective diagnosis of infectious diseases;</p> <p>7.4 Development of genetically engineered vaccines for protecting devastating pathogens;</p> <p>7.5 Cloning of genes of economic traits from fish and production of transgenic fish for enhanced growth and diseases resistance;</p> <p>7.6 Identification of herbal extracts and formulation of herbal medicines for disease control;</p> <p>7.7 Fish health management, immuno-prophylaxis and therapeutics against common diseases;</p> <p>7.8 Exotics and quarantine , export risks analysis and disease diagnosis;</p> <p>7.9 Development breeding protocol, improved strains resistance to heat and cool stress and diseases;</p> <p>7.10 Quality improvement of local fish medicines, drugs and hormones following aquatic animal health standard guidelines;</p> <p>7.11 Safety potency, efficacy of locally produced and imported medicines for fish health and water quality management;</p> <p>7.12 Quality control of different fish medicines, biologics and diagnostics available in the country;</p> <p>7.13 Development and adoption of biotechnological tools including PCR,RT PCR, PCR ELISA etc for diagnosis of different fish and shrimp diseases;</p>
8. Fish safety and Quality	<p>8.1 Quality improvement of local fish medicines, drugs and hormones following aquatic animal health standard guidelines;</p> <p>8.2 Techniques for determination of toxin chemical residues in fish, fish-products, by-products and feeds and their investigation;</p> <p>8.3 Safety potency, efficacy of locally produced and imported medicines for fish health and</p> <p>8.4 water quality management;</p> <p>8.5 Evaluation of hazardous chemicals and toxic compounds for their harmful effect on fish health and development of mitigation measures;</p> <p>8.6 Development of bio-secure effective aquaculture system;</p> <p>8.7 Development hygienic and safe processing and preservation techniques of fish and fishery products ,bi-products and feeds;</p> <p>8.8 Protocols for sanitary and phyto- sanitary (SPS) issues and quality control;</p> <p>8.9 Development of National Residue Plan and Guidelines for aquaculture product certification;</p> <p>8.10 Development of e-traceability technique for shrimp quality control;</p>

Thematic areas	Researchable Areas/Issues
9. Socio economics and marketing	9.1 Impact of shrimp farming in coastal zones; 9.2 Social and economic implications of transferred technologies and impact on productivity; 9.3 Policy research on land-water use; 9.4 Equity, sharing and justice of community based fishery activities; 9.5 Socio-economic impact of shrimp-crop farming; 9.6 Analysis of fish/shrimp market value chain and supply chain; 9.7 Institutional model development for empowering coastal fisheries; 9.8 Rural financing and credit market for fishery enterprises; 9.9 Fisheries technology development and impact on socioeconomic and gender issues ; 9.10 Impact assessment of technology interventions on poverty reduction and livelihoods of the poor's; 9.11 Analysis of opportunities for value addition to fish/shrimp and understanding structural and competitive forces; 9.12 Local institutions and conflict regulation for shrimp gher management; 9.13 Development of efficient value chain marketing for fish/shrimp and small marine products; 9.14 Socio-economics of fisher folks and fisherman; 9.15 Pro-poor research on socio-economic aspects of fishery, equity and gender focus; 9.16 Development of National Residue Plan and Guidelines for aquaculture product certification;
10. Climate change adaption	10.1 Impact of climate factors on fish migration, breeding, growth and productivity; 10.2 Fish breeding and propagation in extreme and diverse climate conditions; 10.3 Modeling study on aquaculture(coastal and marine) in extreme conditions; 10.4 Climate change impact of fish migration, breeding and growth; 10.5 Development technology for breeding and culture of new potential species in coastal floods under climate change regime; 10.6 Anticipatory research on fish habits and habitats with climate aberrations; 10.7 Temperature rise and its effect on fish maturation, reproductive performance, biology and behavior; 10.8 Species diversification, breeding and culture technologies for changes adaption and livelihood approaches in the southern coastal and northern draught prone region; 10.9 Hydrology and biometrics of the Sundarbans ecosystem under the face of climate changes; 10.10 Management protocol for seasonal and perennial waters under the face of climate changes;

Annexure-4: Prioritized Researchable Areas on Livestock

Based on the report of Research Prioritization in Livestock sub-sector, the followings are the prioritized researchable areas under 5 thematic areas:

Thematic Areas	Research Areas/ Issues
1. Livestock production	1.1 Baseline survey on the productive performances of cattle and buffalo at all stage of productive life in Bangladesh
	1.2 Characterization, conservation and improvement of local /native animal/poultry genetic resources for increasing meat, milk and egg production.
	1.3 Studies on the genetic variability for diseases and parasites in livestock and identification of genes related to diseases.
	1.4 Studies on the hormone profile on the cyclic and pregnant indigenous and cross-bred cows in relation to fertility.
	1.5 Fine wool yielding sheep development for commercial wool production .
	1.6 Conserve and improve the hill livestock species.
	1.7 Standardization of embryo transfer technology for livestock.
	1.8 Evaluation of existing AI (Artificial insemination) service and factors affecting infertility in cattle buffalo
	1.9 Screening the breeding males for breeding soundness, infectious and genetic diseases.
	1.10 Development of a biotic stress tolerant breed of livestock/ poultry for low input management system
	1.11 Assorted dairy cattle/ beef cattle/ buffalo breed development and production
2 Feed and Nutrition	2.1 Feed information, feeding standard and feeding system development of cattle/buffalo/sheep/goat/poultry/duck
	2.2 Development of salt, drought and submergences tolerant forage / fodder varieties.
	2.3 Development of improved and appropriate feeds and feeding system for the hill species.
	2.4 Commercial prebiotic and probiotic development for calves, growing, lactating and beef cattle/ buffalo.
	2.5 Development of cost-effective complete feed formulation for cattle, buffalo, sheep, goat and poultry for different productive function.
	2.6 Develop suitable fodder/ forage crops in the forest lands, tree plantations, fruit plantations, sugar cane areas, haors and boars, roadsides and bund areas.
	2.7 Develop appropriate technology for the utilization of NCFR such as algae, duckweed, water hyacinth, silkworm pupae, tree levels, herbs and shrubs.
	2.8 Commercial milk replacer and calf starters.
	2.9 Tissue culture technique for forage crop seed production and distribution.
3. Livestock protection	3.1 Development of vaccine against mycoplasmosis.
	3.2 Development of antiserum against different types of FMD virus.
	3.3 Development of new vaccine speed viruses against immerging diseases.
	3.4 Development of recombinant DNA vaccine for important viral and bacterial diseases.
	3.5 Epidemiology, surveillance and characterization of PPR, Goat pox,

Thematic Areas	Research Areas/ Issues
	<p>contagious Ecthyma.</p> <p>3.6 Epidemiology, surveillance and characterization of foot and mouth diseases, Tuberculosis(TB),Brucellosis, Anthrax and HS etc.</p> <p>3.7 Sero-surveillance of important disease of public health significance.</p> <p>3.8 Epidemiology, surveillance and characterization of new castle diseases, Avian influenza, Infectious Bursal Diseases, Marek's diseases, avian leucosis, egg drop syndrome etc.</p> <p>3.9 Studies on repeat breeding and retention of placenta in cattle and buffalo and development of mitigation measures.</p> <p>3.10 Development of binary ethylene mine inactivated polyvalent foot and mouth disease vaccine.</p> <p>3.11 Isolation, identification and molecular characterization of FMD, Rota, PPR, Goat Pox and immerging viruses of poultry .</p> <p>3.12 Surveillance studies on reproductive diseases.</p> <p>3.13 Cell culture technique for diagnosis and vaccine production.</p> <p>3.14</p> <p>3.15 Development of recombinant vaccine for important viral and bacterial diseases.</p> <p>3.16 Development of appropriate cost-effective zoo-sanitary and bio-security measures for farm animals and poultry.</p> <p>3.17 Development of appropriate heard health management system.</p> <p>3.18 Development of appropriate herd health management system (Hormone assay, AI service quality and efficiency, ovulation synchronization, tools for predicting bull fertility, application of ultrasonography, color dopler etc.)</p> <p>3.19 Molecular and immunological events in host-pathogen interaction.</p> <p>3.20 Epidemiology studies on protozoal and gastro-intentional parasitic diseases.</p> <p>3.21 Prevention and control of gastro-intestinal parasitic and protozoal infestations.</p> <p>3.22 Development of new vaccine seed viruses against immerging diseases.</p> <p>3.23 Identification of causes of high calf mortality specially in cross bred cattle and buffalo and their mitigation measures.</p> <p>3.24 Assessment of climate change effects on health and diseases problems of farm animals.</p> <p>3.25 Surveillance and development of disease control system of livestock in hill areas.</p>
4. Safe food, Quality Control, bio security	<p>4.1 Quality improvement of local vaccine and drugs following OIE standard guidelines.</p> <p>4.2 Tools and techniques of drug residues and toxin in livestock products, by-products and feeds.</p> <p>4.3 Investigation of drugs (antibiotic, steroid, hormones etc.) residues and toxins in livestock feeds.</p> <p>4.4 Safety, potency, efficacy of locally produced and imported vaccine.</p> <p>4.5 Feed preservation and processing and quality management system development.</p> <p>4.6 Evaluation and development of mitigation measure of the effect of hazardous toxic chemicals on animal health.</p> <p>4.7 Development of effective bio-secure / housing system for rural poultry.</p>

Thematic Areas	Research Areas/ Issues
	4.8 Quality control of different vaccines, drugs, biologics and diagnostics available in Bangladesh.
	4.9 Quality control of livestock products and by –products, seed materials , feed and fodder
	4.10 Development of hygienic and safe processing and preservation techniques of livestock products and by-products
	4.11 Development of cost-effective and rapid diagnosis system against different diseases
	4.12 Development of effective and hygienic slaughter house management system
	4.13 development or adoption of biotechnological tools including PCR, RT-PCR, RFLP, PCR-ELISA, etc. for diagnosis of different diseases
	4.14 Development of techniques to identify dead livestock meat
5. Socio-economic	5.1 Development of an effective milk marketing system with special emphasis on small and Medium dairy farms
	5.2 Development of suitable bio-fertilizer mixture using livestock and poultry manure appropriate for different crops
	5.3 Socio-economic and environmental impact analysis of livestock and poultry farming