AGRICULTURE RESEARCH STRATEGY 2018-2028

DEPARTMENT OF AGRICULTURE
Ministry of Agriculture & Forests

April 2019

Strategy Preparation Team

Mr Mahesh Ghimiray	(Agriculture Research & Development Centre-Bajo)
Mr Tirtha Bdr Katwal	(Agriculture Research & Development Centre-Yusipang)
Mr Kezang Tshering	(Agriculture Research & Development Centre-Yusipang)
Dr Dorjee	(National Plant Protection Centre)
Mr Wangda Dukpa	(Agriculture Research & Extension Division)
Mr Lakey	(Agriculture Research & Extension Division)
Mr Loday Phuntsho	(Agriculture Research & Development Centre -Wengkhar
Mr Sangay Dendup	(Agriculture Production Division)
Ms Tashi Gyalmo	(Agriculture Research & Development Centre-Yusipang)
Mr Ngawang	(Agriculture Research & Extension Division)

Coordination & Lead

Mr Wangda Dukpa
Mr Lakey
Mr Nawang
Agriculture Research & Extension Division (ARED)

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FOREWORD

Agriculture sector and its contribution to economic growth worldwide are well-founded. Equally so is the recognition of the significance of research in agriculture as a strong driving force in meeting global food supply. Research-led agricultural development has been impactful in expanding agriculture production, enhancing rural household income, generating employment opportunities, and poverty reduction.

Although over the years the five year plan (FYP) outlay for agriculture sector has seen a significant decrease, Bhutan's agriculture sector still carries the overarching national mandate, amongst others, to increase food production for household food security, substitute or reduce imports through increased domestic production and generate marketable surplus. It is also striving to make farming attractive and stem rural urban migration.

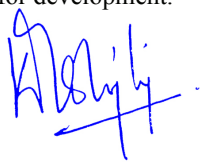
Greater emphasis on knowledge based and data driven agriculture production will be instrumental in achieving these objectives as well as in ensuring sustainable conservation of natural resources base, while also facing emerging challenges such as declining soil fertility and land degradation, increasing cost of inputs, human resources scarcity and vagaries of climate change.

Formal agriculture research in Bhutan began in 1982 with the establishment of the Centre for Agricultural Research and Development (CARD) at Bajo in Wangdue. Its contribution to agriculture and rural development thereafter has been tremendous with a number of technologies generated that include better performing crop varieties, improved farming methods, efficient pest and disease control measures, interventions into postharvest and water management, and progressive extension education and rapid services.

However, these far-reaching impacts did not preempt the series of structural changes over the years within the ministry and the department that not only affected the growth of agriculture research but also eroded its consistency and quality. A lack of a formal research strategy further compounded the situation in that the department increasingly found itself unable to contend the increasing focus on high-impact development activities with short-term tangible outcomes as against long-term visions and goals.

The Agriculture Research Strategy 2018-2028 strives to provide a strategic framework prioritizing identified research needs as well as formulate a structured implementation, monitoring and evaluation mechanism. The strategy also underpins the significance of stronger collaborative effort amongst agencies within, and in initiating or reinforcing enduring partnership with organizations outside for agricultural research. It also calls for building a critical mass of competent human capital while also underscoring the importance of platforms to encourage and retain researchers.

The strategy is a result of rigorous consultation and the Department of Agriculture commends the team for their efforts. With the adoption of the strategy the department calls on all agencies and stakeholders involved for their commitment in implementing and realizing its objectives. At the same time the department will continue to solicit support and endorsement at broader levels, and put in conscious efforts to help further and sustain agriculture research for development.



Kinlay Tshering (Ms)
DIRECTOR

ABBREVIATIONS & ACRONYMS

AED	Agriculture Engineering Division
AMC	Agriculture Machinery Centre
APD	Agriculture Production Division
ARDC	Agriculture Research & Development Centre
ARED	Agriculture Research & Extension Division
BAFRA	Bhutan Agriculture & Food Regulatory Authority
BJA	Bhutanese Journal of Agriculture
CARD	Centre for Agriculture Research & Development
CBD	Convention on Biological Diversity
CGIAR	Consortium of International Agricultural Research Centers
CMU	Centre Machinery Unit
CNR	College of Natural Resources
CoRRB	Council for RNR Research of Bhutan
CSO	Civil Society Organization
DoA	Department of Agriculture
EM	Effective Microorganism
FAO	Food and Agriculture Organization
FYP	Five year plan
GAP	Good agricultural practices
GHG	Greenhouse gas
GIS	Geographic information system
GLS	Gray Leaf Spot
Ha	hectares
IAS	Invasive alien species
ICT	Information technology
IPM	Integrated pest management
IPNM	Integrated pest & nutrient management
ISTA	International Seed Testing Association
Kgs	Kilograms
m	meters
MAS	Market assisted selection
NARS	National Agriculture Research System
NAP	National Action Plan
NoP	National Organic Programme
NBC	National Biodiversity Centre
NCHM	National Centre for Hydrology & Meteorology
NGO	Non-governmental organization
NPHC	National Postharvest Centre
NPPC	National Plant Protection Centre
NSB	National Seed Board
NSC	National Seed Center
NSSC	National Soil Services Centre
NUS	Neglected and underutilized species
OD	Organizational Development
PCR	Polymerase chain reaction
PD	Programme Director
RCSC	Royal Civil Service Commission
REID	Research Extension & Irrigation Division
RGoB	Royal Government of Bhutan
RMC	Research Management Committee
RNR RDC	Renewable Natural Resources Research and Development Centers
ROP	Research Outreach Programme
RSD	RNR Statistics Division
RSG	Registered Seed Growers
RUB	Royal University of Bhutan
SAC	SAARC Agriculture Centre
SDC	Swiss Agency for Development & Cooperation
SMAP	Spices, Medicinal & Aromatic Plants Program
TED	Technology Extrapolation Domains
TLB	Turcicum Leaf Blight
TRC	Technology Release Committee
TSS	Total Soluble Solids
VRC	Variety Release Committee

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1 Introduction

1.1 Background

Agriculture sector has the national mandate to increase food production to ensure household food security, alleviate poverty, substitute or reduce imports through increased domestic production, generate marketable surplus, enhance household income and employment opportunities. Agriculture sector strives to make farming attractive to youth and reduce rural urban migration. These objectives need to be accomplished while ensuring sustainable conservation of the natural resources base. Agriculture development is faced with emerging challenges such as depleting natural resources, scarcity of water, declining soil fertility and land degradation, increasing cost of inputs, scarcity of human resources for farming, and unpredictable weather patterns. In the face of these challenges, agriculture production is becoming increasingly knowledge-based and science-intensive. Historically, research for development in agriculture and extension services has been a strong driving force in meeting food supply around the world. It is further established that research plays an important role for agricultural development both in developed and developing countries where research-led agricultural productivity growth has had a positive impact on poverty reduction. Studies have clearly established the role of agriculture research for development and hence there is a clear need to redefine the strategic role of agriculture research for development in taking forward Bhutanese agriculture against the backdrop of a series of emerging challenges. The impacts of agricultural research for development are long-term and very diverse – positive, unexpected, sometimes negative. Therefore, there is the need to draw from positive lessons for long term sustainable research.

Formal agricultural research in Bhutan started in 1982 with the establishment of Centre for Agricultural Research and Development (CARD) at Bajo in Wangdue. Initially the research focus was on field crops - rice in particular – subsequently expanding to fruits and vegetables. Other research centres in Bhur, Khangma and Yusipang then followed, resulting in significant outputs and impacts. In rice, the Research and Development Centres have developed and released 23 improved varieties that are tolerant to biotic and abiotic stresses and yield at least 1t/ha more than the traditional varieties. Currently, more than 50% of the total rice area is grown with improved varieties. Average productivity has increased by over 104% from 2.05 t/ha in 1981 to 4.20 t/ha in 2017 as a result

of improved technologies. Five improved maize varieties have been released which are tolerant to important diseases like Turcicum Late Blight (TLB) and Gray Leaf Spot (GLS). More than 60% of the maize area is covered with improved varieties which contributed in attaining 100% self-sufficiency. Additionally, introduction of hybrid technology is giving way to commercialization of maize farming. In horticulture, average overall income of farmers from fruits and vegetable increased by 88% as evident in an impact assessment report in 2009. About 64% of the vegetable growers reported that vegetable production has increased in the last 5 years due to access to improved varieties of seeds, improved management practices, and marketing opportunities. Farmers' income from sale of vegetables has increased by 46% while the average productivity of apple has increased by 29%. Research system has released 5 potato varieties which in addition to their tolerance to prevailing diseases, are also nutrient dense (iron, zinc and other minerals). Similarly, MAPS programme has successfully domesticated and commercialized wild species such as Ruta *(Saussurea lappa*), Manu (*Inula racemosa*), chiraita (*Swertia chirata*) and Goned *(Carum carvi)*. In spite of these far-reaching impacts, several structural changes over the years within the ministry and the department have affected the consistency and growth of research. These were further compounded by the lack of a formal research strategy.

1.2 Current Agriculture Research System

The Organizational Development (OD) Exercise by the Royal Civil Services Commission (RCSC) in 2016 created the Agriculture Research and Extension Division (ARED) under the Department of Agriculture (DoA). The OD also called for the strengthening of the four Agriculture Research and Development Centres (ARDCs) with the department.

Presently, there are four ARDCs with mandates for agriculture research and development (Fig.1). In addition to these there are six central programmes: i) National Post Harvest Center (NPHC) ii) Agriculture Machinery Center (AMC) iii) National Seed Center (NSC) iv) National Soil Service Center (NSSC) v) National Plant Protection Center (NPPC) and vi) National Mushroom Center (NMC). These institutions undertake largely adaptive research to adapt and validate technologies in their respective disciplines. Since its formal institution in 1982, agriculture research system in Bhutan has, to date, introduced or developed and officially released 236 different crop varieties, and several

technologies. The National Biodiversity Centre (NBC) with the ministry also conducts research on agro-biodiversity that has implications on crop improvement. Beyond the MoAF, the College of Natural Resources (CNR) under the Royal University of Bhutan (RUB) also takes up some research in agriculture and related disciplines.

In 2009, the three ARDCs at Wengkhar, Bajo and Samtenling were realigned from the Council for RNR Research of Bhutan (CoRRB) to DoA. Thereafter, the research centers have been assigned the responsibility of both research and development changing its nomenclature from RNR RCs to ARDCs. The fourth ARDC, now the Agriculture Research and Development Center (ARDC)-Yusipang was realigned from the Department of Forest and Park Services (DoFPS) and merged with DoA in 2016. It is estimated that currently researchers at the ARDCs dedicate only 20-40% of their time for research while 60% - 80% of the time is spent on development activities.

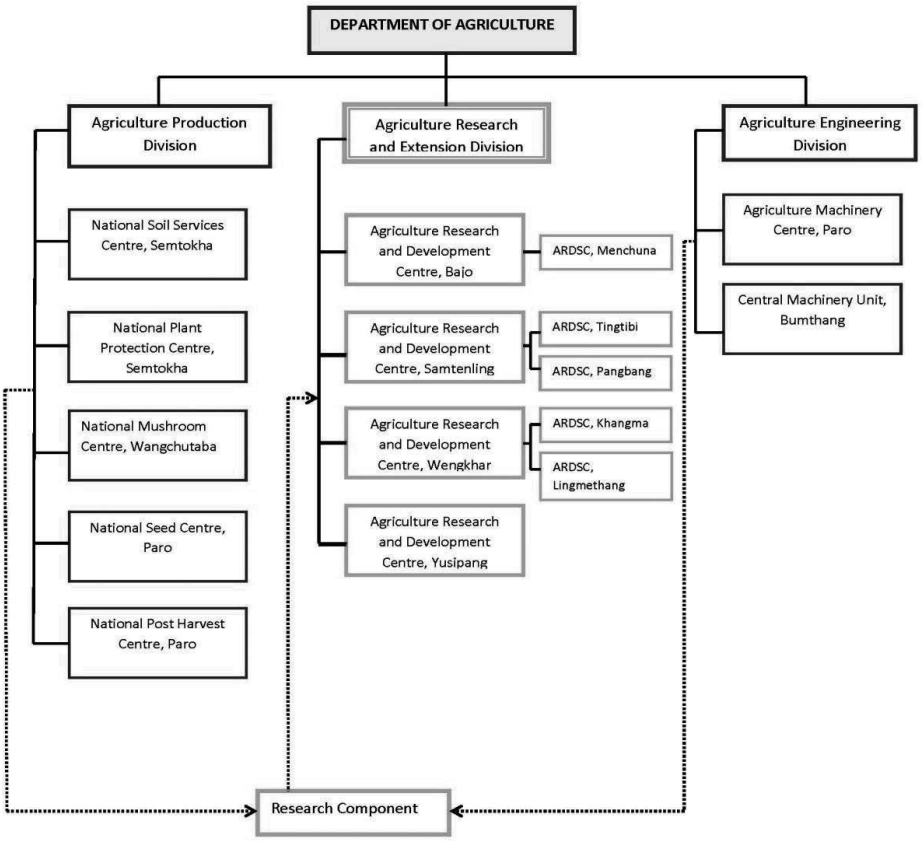

Figure 1 DOA's organogram vis-à-vis ARDCs & central programs linking research

Apart from the national research mandate, each ARDC is also assigned with regional mandates for development. ARDCs are identified with certain numbers of focal Dzongkhags in which they undertake different development programmes through Research Outreach Programmes (ROP) where successful and potential technologies are directly demonstrated by researchers. Over the years the regional mandate has seemingly weakened the national mandate of planning, coordinating and undertaking adaptive research.

Current Challenges in Research

Passive Linkage between DoA and ARDCs

Although ARDCs are directly with the DoA, interaction and engagement between the two entities vis-à-vis research is on the decline. After the realignment of ARDCs from CoRRB to the department, ARDCs did not have a focal point for research at the department. The institutional set-up did not adequately promote linkages and collaboration. Further, there were no national and regional forums to plan and prioritize research activities. After its creation, the ARED is mandated to coordinate and oversee research and extension programmes at the national level. It is now putting in place effective mechanisms to improve linkages between ARDCs and Central programmes. ARED will provide proper institutional framework, management and coordination for improving the planning, prioritization and implementation of research programmes.

Research Mandate

ARDCs tend to shift focus from their national research mandate to development. A very conservative estimate by researchers with the ARDCs indicates that they spend 60-80% of their time on development activities. Development activities that feature prominently in the ARDCs work plans are demonstrations and promotion of new varieties. The Research Outreach Programmes (ROP) of the ARDCs which were actually designed to fast-track promotion of released and in-pipeline technologies receive higher priority than technology generation. Consequently, in most ARDCs well planned, statistically designed trials are limited. To generate good quality information and data on any new technology researchers have to invest their time and skills on research. Diversion of researchers from their main functions compromises quality of research. The ARDCs management has to ensure that increasing number of development activities do not take precedence over planned research activities.

Emphasis has to be also placed on central programmes to focus and reinforce research in their respective components. Presently, the central programmes tend to concentrate resources and time only into development aspects, and do not initiate, lead or innovate research in their respective disciplines.

Lack of Dynamic and Professional Research Culture

In the past, research was seen as attractive option for young graduates joining the DoA. Currently most young professionals choose extension and project offices over research. Professionalism and the once vibrant research culture have now declined. It takes years and considerable effort to develop a good research culture in a research institution. Some of the elements of a good research culture comprise strong institutional reputation with credible research outputs, dynamic leadership that values research, facilitate research funding and provides an enabling environment for research. The current research system lacks mentoring and proper monitoring and evaluation mechanisms.

Inactive Research Forums

Although there were several well established research forums in the past, structural changes within the department resulted in their discontinuation and the subsequent poor collaboration among stakeholders. There is no uniform mechanism for proper planning and execution of research, thereby leading to poor quality of research outputs. Absence of standard research procedures, protocols and analytical tools lead to further decline in research quality. Hence, there is a need to put in place proper forums and processes for quality research.

Additional forums for presenting research output, findings and progress are required. Efforts are needed to reinforce or create platforms or set aside provisions at different levels in the department for serious scientific discourse so that a vibrant knowledge culture is promoted and sustained.

Poor Knowledge Management

Despite being a very small system sharing of knowledge and information among stakeholders is inadequate. Knowledge and information sharing across agencies and amongst members of the department at present is often limited to individual initiative and inter-personal relationships; often leading to duplication of work and waste of resources. There is a need to develop archival system and library resources for common access to knowledge and information. There is also very little or no access to industry standard statistical software and resources such as peer reviewed journals. Membership to international societies and technical forums needs to be instituted and supported.

Poor Accountability of Research Programmes

There is no mechanism to track research outputs. Annual reports of the ARDCs and central programmes are the only medium in place to report on research progress and outputs. The quality and frequency of publication of such annual reports are rather inferior (scientifically /technically) and irregular. The research communication units in the ARDCs need to be strengthened for proper documentation and regular publications. Scientific writing and research publications require added emphasis.

Lack of Socio-economic Research

Socio-economic research has weakened due to attrition of researchers and researchers switching into other attractive career avenues. Planning and policy decisions require the most current and up-to-date socio-economic data. Most often agronomist and breeders are required to fulfill the role of socio–economists, thereby not only compromising on their main responsibilities but also the quality of outputs.

1.3 Rationale for Research Strategy

In the 12th FYP, the government has recognized agriculture research as an important contributor to agriculture growth, and has identified research as one of the key programmes under the Ministry of Agriculture and Forests. Research forms an integral part of agricultural production system where technologies developed by either basic or applied research are trialed, tested or adapted to specific local conditions prior to their dissemination to farming communities or clients. However, over the years, certain process of integration, disintegration, realignment and reorganization in the Ministry have weakened the Department of Agriculture's research system, including the loss of some of its research base. Additionally, the increasing focus on short-term tangible outcomes in the form of high-impact development activities as against long-term visions and goals has also further weakened the research system.

Until 2016 the research programmes were integrated as the Renewable Natural Resources (RNR) research that comprised agriculture, livestock and forest sectors under the then Council of RNR Research of Bhutan (CoRRB). The Royal Civil Service Commission (RCSC)'s Organizational Development (OD) exercise created the Agriculture Research and Extension Division (ARED)

under the Department of Agriculture to align sectoral research with line departments. ARED is entrusted with the responsibility to provide strategic framework and guidance for agriculture research. Given this important role, the department felt the need to develop a holistic and a pragmatic strategy for Agriculture Research in the 12th FYP and beyond to help guide, coordinate and form a basis for long-term (5-10 years), medium-term (2-5 years) and short-term (1-2 years) research.

2 Strategic Objective

2.1 Vision and Mission of Agriculture Research

Vision

A dynamic, vibrant and functional research system for national food self-sufficiency, nutrition security and a self-reliant economy.

Mission

Generate knowledge, information and technologies that address emerging challenges of food self-sufficiency, nutrition security, rural income and economy.

2.2 Objectives

i. Strengthen the generation of knowledge, information and technology for agriculture development.
ii. Ensure that agriculture research programmes are demand-driven and responsive to emerging needs and challenges.
iii. Provide institutional framework and basis for formulation, operation and effective management of agriculture research system.
iv. Evaluate policy coherence of agricultural research and development in line with national goals.
v. Provide a framework for developing research capacity and funding for agriculture research and innovation.
vi. Stimulate a culture of learning, professionalism and knowledge management.
vii. Promote and strengthen research collaboration within and outside Bhutan.

2.3 Guiding Principles and Core Values

1. Interdisciplinary

To undertake agriculture research that encompasses all major disciplines that contributes to wholesome agriculture development.

2. Participatory

To include all stakeholders including client farmers in research at key stages of technology development.

3. Sustainability

To promote low external input sustainable agriculture (LEISA) to improve ecological and socio-economic sustainability.

4. Health and safety

To reinforce human nutrition, health and safety as primary intents and core operating principles.

5. Integrity and Trust

To ensure reliability and integrity at all levels of agriculture research to promote trust amongst all stakeholders.

6. Innovation

To support innovation and strive for cutting-edge technologies.

7. Complementary

To give recognition to the strengths and expertise of different stakeholders to complement rather than compete in research.

8. Accountability and Impact Orientation

To build accountability to ensure effective use of resources as well as quality research capacities to achieve strategic objectives.

9. Gender and Cultural Sensitivity

To ensure technology development incorporates and addresses gender concerns and cultural sensitivities.

10. Relevance

To ensure that targeted research is focused and guided by emerging needs.

3 Key Strategic and Thrust Areas

3.1 Field Crops Research

Field crops comprise all staple cereals, grain legumes and oilseeds. Historically, the concept of Dru-na-gu (or nine food crops) that includes rice, maize, wheat, barley, buckwheat, millets, pulses, oilseeds and amaranths is well established. The share of dietary energy supply from cereals, oilseeds and pulses is estimated to be about 87%. Bhutanese farming system and food habit is dominated by nine major staple food crops. Bhutan is only 50% self- sufficient in cereals and the gap is met through import. For the development of these crops the DoA has been pursuing a commodity approach where the major commodity like rice and maize receive special attention. The major challenges in field crops are declining productivity, increasing shortage of water, shortage of farm labour, increasing pest and diseases and crop predation by wildlife. In light of these challenges, a prudent and pragmatic field crops research programme should be in place to ensure and sustain critical level of self-sufficiency in cereals consistent with food security and national security, and at the same time transform field crop production into a node of economic growth, commercialization and increased cash income for rural areas.

The field crops research programme shall:

i. Generate and disseminate suitable technologies, information and knowledge to achieve and sustain critical levels of food self-sufficiency in cereals, grain legumes and oilseeds at the household and national levels.
ii. Conduct research and generate results that lead to improved practices and crop management to increase efficiency in production
iii. Collaborate with relevant agencies to initiate research in post-production technology, packaging, handling, marketing, and value-addition of cereals, oilseeds and grain legumes.

iv. Make major sustainable breakthroughs in a number of specific strategic segments of field crops namely: climate resilient and high-yielding, cold-tolerant, blast-resistant rice varieties; improve rice and maize yields in the low and mid-altitude areas.
v. Initiate research in collaboration with other agencies to minimize post-harvest losses; improve maize and oilseeds crop yields and processing; and integrate grain legumes in farming systems.
vi. Undertake basic and in-depth research through technical collaboration to explore, identify and exploit unique gene pool using modern plant breeding technologies in field crops for development of climate resilient germplasm adapted to marginal mountain farming environments.
vii. Establish a functional national plant breeding systems including introduction and or development of hybrid varieties to enhance crop productivity.
viii. Mainstream participatory plant breeding and participatory varietal selection methods in the formal plant breeding systems to exploit farmer's local knowledge to enhances and ensure adoption of new varieties.

3.2 Horticulture Research

Horticultural crops encompass a major share of the country's export basket. Over the last couple of years, both area and production have substantially increased.

3.2.1 Fruits and Nuts Research

In keeping with current needs, future prospects and prevailing challenges, the broad research areas of immediate focus for fruits and nut crops can be outlined as follows:

i. Genetic improvement through introduction and local selection for priority crops and initiate basic research into fruits and nuts breeding.
ii. Early flower induction for early season production.
iii. Documentation and characterization of cultivated and wild species of select crops
iv. Improve plant propagation (including tissue culture), crop production and canopy management techniques.
v. Improve crop nutrient and water management.

vi. Lead or initiate research in collaboration with concerned agencies in the following areas of importance: IPM research for areca nut bud rot, walnut dieback and stem borer management, banana pseudo-stem weevil, etc; Post-harvest research into processing for export quality products, Market research for potential crops such as walnut, pear and persimmon consisting variety choice, quantity, price, product specifications and standards, economic analyses, market forecasting, etc.

vii. Maintain a "National Scion Bank" of released fruits and nuts cultivars and provide support to NSC and private nursery growers as source of genetic materials.

viii. Research to diversify fruits and nuts to include potential crops like macadamia nut, durian, star fruit, blueberry, etc.

ix. Emphasize clean production technology for citrus through propagation methods, disease diagnostics, improvement through local germplasm, and breeding for cold tolerance.

3.2.2 Vegetable Research

The Ministry's vegetable commercialization drive in some measure affected vegetable research programme. Efforts in increasing production and the emphasis on meeting annual production targets as well as domestic demand in the wake of ban on selected vegetables somehow diverted focus and resources away from research.

To date the primary focus in vegetable research has not progressed beyond basic adaptability trials. However, of late, certain climate smart agriculture interventions are being researched into in response to climate change impacts, therefore indicating transition.

Priority areas for research in vegetable programme shall include the following:

i. Strengthening research in breeding and variety development

Enhance varietal improvement through breeding and selection with focus on higher yield, quality, tolerance to pests and diseases and environmental stresses.

ii. *Climate resilient crops and technologies for different production systems*
Strengthen research on climate resilient crops and climate smart technologies including studies into crop production variability and crop failure risks using modeling approaches.

iii. *IPM practices for enhanced and sustainable crop production*
Emphasize research efforts into developing effective and sustainable IPM technologies for major pests and diseases in vegetables (club rot in cole crops, Fusarium wilt in tomato and blights in chili).

iv. *Develop innovative production systems*
Strengthen research on protected cultivation, hydroponics, efficient irrigation technologies and production systems like staggered production, organic vegetable production, farm mechanization, IPNM and weed control.

3.2.3 Medicinal and Aromatic Plants & Spices Research

Aptly referred to as "*Lho Jong Men Jong*", the Southern Land of Medicinal Herbs, Bhutan's vast topography and unique geographical setting harbours around 6000 different species of plants, of which 600 have been identified with medicinal properties, and amongst which over 300 are used in traditional medicine. Drawing from its rich medicinal resources, Bhutanese have been practicing the age-old medical institution, the *gSo-ba-Rig-pa,* from as far back as the 8th century. The introduction of a small traditional medicine dispensary in Dechencholing in 1968 officially incorporated *gSo-ba-Rig-pa* in the national health system.

The popularity of traditional medicine and the strong foothold it has in the country coupled with the scope of commercialization has resulted in a pressing demand for medicinal plant resources. Conservation of medicinal plants with emphasis on sustainable collection regimes and formulation of management strategies have been accorded significant priority. Conversely, domestication of potential wild species as well as expansion of production of important cash-generating spice crops like large cardamom, ginger, turmeric and black pepper to name a few for enhancing livelihood of Bhutanese farmers are areas that can derive rich dividends from research efforts. More still, as is evident, there is huge opportunity in reaping economic benefits from the country's rich

biological resources, and hence, research emphasis should also include bioprospecting

Research in MAPS shall:

i. Initiate domestication and cultivation of potential market-driven medicinal plant species to improve rural livelihood and provide alternate source of self-employment.
ii. Liaise with relevant agencies and help develop sustainable management and utilization plans of medicinal plants species in the wild to ensure conservation.
iii. Plan and implement research into potential MAPS species and varieties through introduction and evaluation.
iv. Collect and maintain indigenous medicinal plants at research stations or designated in-situ conservation sites and initiate exploration of its sustainable utilization.
v. Develop standard protocols for domestication/research trials as well as comprehensive package of practices for selective MAPS having scope of commercialization.
vi. Establish research infrastructures for medicinal plants with emphasis on good agricultural practice (GAP).
vii. Implement studies on aspects of medicinal plant agronomy designed towards meeting the requirements of traditional pharmacopoeia and conforming to emerging pharmacological findings and modern herbal healthcare standards as well.
viii. Collaborate with relevant agencies in developing and standardizing economically feasible post-harvest handling practices or methods, as well as initiate studies on processing and value-addition including small-scale aromatic and essential oil extraction.
ix. Carry out research into extraction of bio-materials from medicinal plants and explore bio-prospecting potential in collaboration with the National Biodiversity Center.
x. Initiate market identification and intelligence for promising medicinal plant raw materials and their bio-extracts vis-à-vis world/regional markets.

3.2.4 Mushroom Research

The department's mushroom program has received little or no emphasis on research. This is partly due to the overwhelming demand on services by growers resulting in added focus on development activities. However, in keeping with emerging needs and future prospects as well as in responding to challenges, both present and imminent, it is imperative that concerted efforts in identifying, planning and implementing research on priority aspects of mushroom is made and outlined clearly.

Some of the broad areas of focus in mushroom research are:

Mushroom Production

i. Assess different cultivation methods and explore opportunities in improving existing cultivation techniques.
ii. Study, develop and improve mushroom propagation techniques including tissue and spore culture methods.
iii. Start basic mushroom breeding research through introduction and local selection of priority mushroom species/cultivars for genetic improvement.
iv. Initiate collaborative studies to minimize post-harvest losses and add value in mushrooms as well as in developing affordable mushroom production machinery/equipment.
v. Research and develop standards, guidelines and protocols for mushroom spawn production and initiate seed quality assessment.

Wild Mushroom Collection & Domestication

i. Characterization and documentation of wild mushroom species including setting up of a mushroom herbarium.
ii. Initiate studies into domestication of potential wild and demand-driven specialty mushroom species with medicinal properties.

Pest & Disease Management

i. Study pests and contaminants physiology in various mushroom cultivation media/substrate (sawdust, logs, straw, etc) as well as in spawn production laboratories.
ii. Study and develop effective and sustainable IPM technologies for major pests and diseases in mushroom spawn labs and farms.

iii. Conduct collaborative pest risk assessment of new, emerging and existing pests including their spatial and temporal distribution.

3.3 Organic Research

The RGOB has a long-term vision to make Bhutanese agriculture fully organic and has accorded high priority towards the development of organic agriculture. There is a strong advocacy and enabling policy support for organic sector development. The DoA has designated and mandated ARDC Yusipang to lead and coordinate the National Organic Programme. The MoAFs proposal on "Flagship Programme on Organic Sector Development for Sustainable Food Security and Livelihood" has also outlined "Organic research and development programme in all the sectors" and emphasizes the need to ground organic research and focus on organic technology development, packaging and promotion. There is a need to realign on-going research and initiate organic research including establishment of permanent demonstration plots in ARDCs.

At present research on organic agriculture is weak and there is a pressing need for development and packaging of organic agriculture technologies. There is also a need to realign conventional research and focus on organic technology development. The research thrusts under organic agriculture are:

i. Identify technology gaps and priority research issues and need in organic agriculture.
ii. Introduce, adapt, identify, and package suitable organic crop production technologies to enhance production.
iii. Plan, design and implement immediate, short and long-term organic trials on horticulture and cereal crops.
iv. Design and establish long-term permanent research plots integrating different research disciplines both on-station and on-farm to obtain time series data for showcasing technologies, and for training farmers and extension.
v. Designing research methodologies, protocols and evaluation procedures for organic agriculture
vi. Evaluate and identify pest and disease tolerant and climate resilient crop varieties.
vii. Improve quality of farm yard manure, green manure crops and biomass production for composting.

viii. Evaluate and adapt alternative technologies and inputs for plant protection covering pest and disease, weed management and storage pest.
ix. Evaluate and adapt suitable technologies such as bio-fertilizers, organic fertilizers and inputs for sustainable soil fertility management for organic crop production.
x. Evaluate suitable water management technologies for organic crop production.
xi. Evaluate and optimize cultural practices for organic crop production.
xii. Adapt suitable crop rotations, intercropping and crop combinations for organic farming system for different agro-ecosystem.
xiii. Validate, refine and package traditional knowledge supporting organic crop production
xiv. Adapt and package technologies for production of organic seed.
xv. Develop post–harvest, processing and value addition technologies to support organic value chain development.

3.4 Indigenous Food Crops Research

Subsistence Bhutanese farmers continue to depend on large numbers of indigenous cereals, root and tubers, and traditional vegetables for household food and nutritional security. These traditional crops are best adapted to their cropping and agro-ecosystems and occupy special niches in the local production and consumption systems. However, such crops are often stigmatized as Neglected and Under-utilized Species (NUS) or minor crops by mainstream research and development programmes. NUS are also marginalized and mostly left to the farmers for their selection and development.

There is a need to exploit crop genetic diversity to avoid dependence on a few food crops. Under-utilized crops may have lesser importance in terms of production and market value, but they continue to play an important role in assuring household food security, especially in remote areas. These crops also ensure systems resilience in the face of climate change. Hardly any research and development activities on minor crops are undertaken in the country despite their potential for useful gene source, dietary diversification and the provision of micronutrients such as vitamins and minerals. Their potential value is underestimated and underexploited, risking permanent displacement and extinction from farmers' cropping systems.

Given the importance of such NUS for household food and nutritional security, increasing demand from consumers and their increasing use as health food, research and development of these crops must be streamlined and up-scaled in collaboration with relevant agencies. The research focus areas for NUS are:

i. Evaluate, identify and promote promising NUS landraces and neglected crop varieties following the standard germplasm screening procedures
ii. Initiate the genetic enhancement of valued landraces of NUS through seed selection, seed rehabilitation and purification methods
iii. Analyze and document the nutrient status of NUS native to the country to establish their nutritional value.
iv. Initiate research on post-harvest, processing, value addition and product development of NUS crops.
v. Identify and promote special traditional varieties of NUS in niche areas based on market demand.
vi. Undertake basic research in NUS crops with modern breeding tools to identify and exploit unique gene pool that could be used for development of climate resilient germplasm adapted to Marginal Mountain farming environments.
vii. Develop package of practices for NUS.

3.5 Climate Change Adaptation Research

Agriculture is highly vulnerable to the impacts of climate change like variation in temperature, rainfall frequency, intensity and time. Average temperature in Bhutan is observed to have increased by 0.5^{o}C. However, rainfall trend has largely remained erratic, and without any noticeable patterns. Temperature is projected to increase with greater change in the western part of the country. Overall rainfall is also projected to increase. Bhutan has been experiencing untimely and/or increased frequency of dry spells, floods, frost, hailstorms, windstorms, landslides, outbreak of new pest and diseases, and increasing scarcity of water for crop production.

There is limited climate-proof interventions identified for smaller holder farmers to adapt to climate change. Smallholder farmers need to become more resilient to deal with the additional stresses caused by climate change. On the contrary, agriculture sector is also one of the major contributors to Greenhouse Gas (GHG) emission. The RNR sector accounts for 35% of the total GHG emission while agriculture alone contributes about 5.4% of the total GHG

emission, thereby necessitating the adoption of climate smart agriculture practices as well.

Currently formal research in the agriculture sector does not consider climate parameters while evaluating technologies. Development and promotion of adaptation interventions should be backed up by adequate scientific information and knowledge.

Potential areas of intervention therefore include:

i. Reviewing and realigning agriculture research and taking on board climate change challenges in the research agenda.
ii. Identifying key climate change challenges that impact Bhutanese agriculture.
iii. Identify, adapt and adopt suitable research methodologies to evaluate climate smart technologies and mainstream into the ongoing research system.
iv. Identify tests sites using climate data to evaluate climate smart technologies.

The following should comprise a comprehensive broad area of climate change research:

i. Generate local climate scenarios from climate data and integrate the use of agro meteorology in agriculture research.
ii. Identify climate analogue sites.
iii. Determine the length of cropping season with climatic details.
iv. Introduce and evaluate crop germplasm for drought, heat, cold and pest and disease tolerances, including evaluation of planting time and seasons.
v. Study critical periods of abiotic stress in different agro-ecologies, and initiate crop modeling for different stresses.
vi. Initiate cropping intensity study to address food security through intensification of subsistence agriculture.
vii. Capacity development on climate science research.
viii. Potential pest and diseases of agriculture crops that could reach epidemic scale due temperature increase; for instance, army worm outbreak in 2013.

ix. Current land uses and adaption mechanism for future climate change scenarios.
x. Changes in soil fertility/soil erosion/degradation due to climate change including investigating nitrous oxide releases from fertilizer application.
xi. Climate impact on agriculture biodiversity including research on conservation agriculture – technology adaptation such as mulching, intercropping, relay cropping, etc.
xii. Systematic engagement of local communities in evaluating climate smart technologies.

3.6 Water Management Research

Water management is an important aspect of agriculture. Untimely and erratic rainfall patterns lead to poor crop yields or cause crop failures. An assured means of water supply to irrigate crops during drought and periods of erratic rainfall should be put in place. Since the access to reliable water source is mostly seasonal, efficient technologies related to water use should be explored and introduced.

There is urgent need to produce more crop per drop of water especially in view of water shortage. Improvements in efficient handling of water resources must be adopted through integrated soil-water-plant-nutrient management and use of smart technology.

Research focus includes:

i. Optimization of irrigation scheduling.
ii. Identification of efficient irrigation systems including irrigation and smart irrigation.
iii. Investigate/study crops' water needs or crop water budget.
iv. Assess soil moisture conservation technologies for water use efficiency.
v. Evaluate water-use efficient crops and varieties for different soil moisture regimes.
vi. Assess and design appropriate water-harvesting technologies to help enhance farmer response and resilience to climate extremes.
vii. Study operation and management systems in irrigation and water resource use.

3.7 Soil and Nutrient Management Research

Of the several causes identified for land degradation in Bhutan unsustainable agriculture practices and poor irrigation management system are directly relevant to the agriculture sector. The National Action Plan (NAP) 2014 identifies development and promotion of sustainable agricultural practices as one of its specific objectives, in addition to setting Research and Knowledge Management as one thematic area to address land degradation, thereby outlining the priorities for sustainable management of agriculture lands and integrated soil fertility management.

Additionally, the RGOB has prioritized the development of organic sector in the 12th FYP. This policy decision requires the National Soil Services Centre (NSSC) to develop information and technologies to address nutrient management for organic crop production. Presently, research on soil nutrient management is insignificant where soil related activities concentrate on soil erosion control and land development. There is a need to study soil nutrient status in farmers' fields at the national level and come up with an appropriate recommendation for soil fertility improvement in all the geogs and dzongkhags. Soil research should hence, focus on developing integrated approaches on sustainable nutrient management, conservation agriculture, conservation tillage including residue management, crop rotations, nutrient and soil organic matter management.

Some of the important research strategies for combating land degradation and soil fertility management include:

i. Generate appropriate knowledge and information to address land degradation and soil fertility issues.
ii. Undertake long-term soil nutrient management studies for agro-ecological zone-specific soil and nutrient management technologies.
iii. Undertake research to evaluate and recommend suitable nutrient application rates to different crops to maximize the returns.
iv. Evaluate different green manure crops, legumes and cropping systems as alternative.
v. Evaluate and adapt suitable technologies and alternative inputs for sustainable soil fertility management for organic crop production.
vi. Undertake studies to enhance the quality of organic fertilizers including composting technologies.

vii. Assess, evaluate and make recommendations on bio-fertilizers and organic fertilizers.
viii. Plan and undertake collaborative research on soil organic carbon and nitrogen status in different soil types to understand the effect of agricultural land management.

3.8 Agricultural Landscape Research

A landscape is a social-ecological system that consists of a mosaic of natural and/or human-modified ecosystems, often with a characteristic configuration of topography, vegetation, land use, and settlements that is influenced by the ecological, historical, economic and cultural processes and activities of the area. There are four distinct agriculture landscapes in the Bhutanese agriculture context. In Bhutan agriculture landscapes are categorized into four groups namely wetland (0.83%), dryland (1.78%), orchards (0.19%) and plantations (0.12%). The wetland or Chhuzing production refers to rice terraces where rice is the main crop and other crops are grown in rotation with rice. The dryland or Kamzhing landscape which is the most dominant refers to un-terraced sloppy farmland where irrigation is normally not applied, and featuring potato and maize as most dominant crop. The orchard refers to the area under horticulture crops, mainly apple and citrus while plantation refers to areas under cardamom and areca nut. Of the four categories wetland and dryland are very important and are spread in all agro-ecological zones.

Due to the limited technical capacity and human resource, studies on agriculture landscape have received very low attention. Considering the shift in research paradigm, there is an increasing need to consider agriculture landscapes for research and development. Governments elsewhere recognize the importance of integrated landscape management for long-term economic, social and ecological sustainability. Therefore, research on integrated management of different agriculture landscapes needs to be initiated.

Some of the important research strategies that could be focused are:

i. Undertake studies to document in detail geo-physical, crops and cropping systems, livelihood, economic and social characteristics of typical mountain agriculture landscapes.
ii. Undertake agro-ecological and farming systems analysis to understand and assess current status of land degradation, productivity, management,

agro-biodiversity and nutrient re-cycling process in each agriculture landscape.

iii. Undertake in-depth research to understand soil nutrient re-cycling and crop production under different cropping systems.

iv. Analyze potential vulnerability of different agriculture landscapes to climate change impacts and suggest adaptation measures to enhance resilience.

v. Use GIS and remote sensing tools to classify diverse micro-environments to develop location specific agriculture technologies.

vi. Document and compare existing agro-forestry, multiple cropping practices and combination of enterprises in different agro-ecological zones.

3.9 Plant Protection Research

Small holder farmers operate under diverse farming environment and are confronted with multiple problems of pests, diseases, weeds and wild animal depredation of crops. The Agriculture Statistics 2017 ranks crop damage by wild animals, and pest and diseases as number 2 and 4 among the 14 types of farming constraints faced by farmers in Bhutan. These directly impact farmers' crops and livelihood. Hence, there is a need to take up integrated approaches to address such complex issues and help make farming more productive and sustainable.

Crop protection measure needs to be diversified other than electric fencing and options like development/introduction of tolerant/resistant varieties and forecasting of pests and diseases need to be studied.

Key research in plant protection includes:

i. Assess spatial and temporal distribution of emerging and major pests/diseases/weeds.

ii. Conduct pest risk analysis and weed risk assessment of new, emerging and existing pest.

iii. Assess economic importance of pests.

iv. Study integrated pest management options including bio-pesticides.

v. Research on pest incidence dynamics in relation to climate change.

vi. Study human wildlife conflict and assess intervention options.

3.10 Biosecurity Research on Introduced Species

Despite the increasing volume of trade and informal movement of commodities along the open porous border with India, Bhutan does not have an effective mechanism to prevent or minimise the entry of invasive alien species (IAS) such as pests, diseases and weeds. Consequently, the risk of introducing or dispersing IAS that cause loss of agricultural production and biodiversity is high. Preventing introductions of IAS is widely recognised as the first line of defense and the most-cost effective option. However, there is no research on either preventing or managing them in our biosecurity continuum. The main research strategy on IAS will:

i. Initiate research on plant biosecurity to minimise the risk of entry, establishment, or spread of exotic and emerging pests.
ii. Develop a knowledge base for assessing and managing the risks of new or existing pests, diseases and weeds including their introduction or dispersal pathways under the influence of changing climate and global environment.
iii. Develop a standard pre-border risk assessment tools and post-border risk management system for the country.
iv. Build capacity to prepare for, and respond to, pest, disease or weed incursions.
v. Create a nationally integrated surveillance and diagnostic networks for pests, diseases and weeds in collaboration with other agencies such as BAFRA, DoL and DoFPS.

3.11 Farm Mechanization Research

Shortage of farm labour is the number one farming constraint as per Agriculture Statistics 2016. Thus, the focus of the farm mechanization research programme shall be to strengthen farm mechanization to address labour shortage. Farm labour shortage has remained a perennial challenge in agriculture and in general farming is labour intensive. Moreover, there is limited scope for mechanization due to the steep terrain.

The department will be pursuing organic agriculture on a priority basis through the organic flagship programme. Compared to conventional agriculture, organic farming is more labour intensive as it does not permit the use of agro-chemicals.

Unless there are suitable mechanisms to address the shortage of farm labour the success of organic farming will be difficult.

To address labour issue farm mechanization research should focus on:

i. Map out landscape/terrain to evaluate appropriate interventions on farm mechanization.
ii. Identify, introduce and adapt farm mechanization options for mountain farming.
iii. Adapt and promote farm machineries to enhance labour efficiency in agriculture.
iv. Design, modify and promote efficient and gender-friendly agriculture tools and implements.
v. Identify and adapt farm mechanization options for post-production operations to enhance value addition.

3.12 Seed Science Research

Since its establishment in 1982, the agriculture research system in Bhutan has introduced or developed and officially released 236 different varieties of field and horticultural crops with superior agronomic traits. Seeds and planting materials of these released varieties are being produced and supplied by government and private seed agencies at affordable cost. However, seed replacement ratio for both horticultural and field crops still remain low due to a weak national seed system.

Seed and planting materials production system need to be improved at various stages and at different agency levels. Seed is broadly categorized into three stages: breeder seed, foundation seed and certified seed.

Breeder Seed are seed or vegetative propagation material directly controlled by the originating or in certain cases the sponsoring plant breeder or institution, providing the source for the initial increase of foundation seed. ARDCs and releasing agencies are responsible for its maintenance, production and supply to NSC at regular intervals.

Foundation Seed refers to the progeny of breeder seed stocks that are so handled as to maintain specific genetic identity and purity, and are designated or distributed by government or private seed companies. The NSC produces and maintains foundation seeds from breeder seed on its farms.

Certified Seed refers to the progeny of foundation seed with genetic purity and identity standards handled and maintained at levels acceptable to the certifying agency, the Bhutan Agriculture and Food Regulatory Authority (BAFRA). NSC supplies the foundation seed to Registered Seed Growers (RSGs) who produce the certified seed for further supply to farmers. Besides the released varieties, there are many indigenous and traditional crop varieties that are still preferred and cultivated by farmers. Seeds of these traditional crops have degenerated over the years and thus access to quality seeds by farmers is limited.

For a robust and sustainable national seed system, clear responsibilities for relevant agencies have to be defined and accountability entrusted, while putting in place necessary guidelines, protocols and strategies of seed production system. It is crucial to develop guidelines for maintenance breeding of seeds at different stages to be adopted by relevant agencies. Farmers are interested to continue cultivating popular traditional crops but lack pure seeds due to seed degeneration. Thus, it is essential to develop seed purification guidelines or protocols for different crops.

Seed quality parameters such as physical purity, germination and moisture content are being tested following the International Seed Testing Association (ISTA) standards by NSC to ensure seed quality. Seed health, an important quality parameter, is not tested or systematic research is not conducted. The following are hence, necessary.

i. Put in place necessary guidelines, protocols and strategies for seed production system.
ii. Assess and standardize current breeder and foundation seed production mechanisms.
iii. Develop a robust maintenance breeding systems in ARDCs and NSC.
iv. Develop seed production schemes for priority commodities outlining seed flow mechanism.

v. Initiate and build capacity for seed health research in ARDCs, NSC and NPPC to improve seed quality and information generated to help develop policy guidelines.
vi. Initiate seed quality assessment research in important crops.
vii. Evaluate and identify appropriate propagation techniques in horticulture crops.
viii. Promote private seed and nursery entrepreneurs.
ix. Put in place mechanism to further link the National Seed Centre with other private seed companies.

3.13 Agro-meteorology Research

Bhutan's predominantly rain-fed farming system is highly sensitive to climate variability and extreme weather events that are becoming more prominent due to climate change. Changing rainfall patterns and climate related hazards pose high risks to livelihoods of farming communities. Farmers frequently report losses to their crops due to wind storms, hail storms, disease outbreaks and erratic monsoon.

As the vagaries of weather and climate intensify in the face of climate change, it is important to capitalize on favorable spells as well as prevent and mitigate weather and climate-induced crop losses through effective agro-meteorology services. Prior knowledge and skills in using such information to convert weather and climate spells into valuable resources can lower costs and help bring about environmental sustainability.

Generating and maintaining climatic data are critical for agricultural research and innovation in the face of changing climate. The available raw weather and climate data at the National Centre for Hydrology and Meteorology (NCHM) needs to be appropriately analyzed and stored to be used for generation of climate resilient agricultural technologies

Efforts are therefore, required to:

i. Describe and understand changing technologies with change in climate and society.
ii. Change and variation on major agronomical traits of crop with changing climate.

iii. Efficiencies in the use and management of resources, including the whole production environment: climate, water, light, nutrients, space (above and below the soil surface), germplasm, biomass.
iv. Research on agro-meteorological aspects of management in agriculture at different scales for different purposes.
v. Validation and application of models (for example, phenology, morphological predictions, yields), limitations of models, models for specific users.
vi. Research methods and approaches at the eco-regional level, including the assessment of socio-economic effects of weather/climate variability on food production.
vii. Research on reducing the impact of natural disasters (including pests and diseases and anthropogenic hazards).
viii. Consideration of ways to ensure that results of research are adopted by farmers, are holistic, interdisciplinary, and of sufficient duration and of operational scale.
ix. Leverage ICT for systematic integration of location specific agricultural information with available weather/climate data and render climate-smart agriculture a practical reality.
x. Conduct research on developing and adapting climate resilient technologies including modeling for Technology Extrapolation Domains (TED) for intensification and expansion of agriculture in locations with greatest potential for impact.

3.14 Biotechnology Research

Agriculture research systems of developing countries generally consider agriculture biotechnology as a hi-tech tool relevant only to industrialized nations. However, biotechnology offers great potential to contribute to sustainable agricultural growth, food security and poverty alleviation in developing countries. The Convention on Biological Diversity (CBD) defines biotechnology as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use."

According to the Food and Agriculture Organization (FAO), a wide range of crop biotechnology tools are available, and some are increasingly used in developing countries, especially tissue culture-based techniques (micro-

propagation), mutagenesis, interspecific or inter-generic hybridization, genetic modification, marker-assisted selection (MAS), disease diagnostics and bio-protection, and bio-fertilization. Biotechnology also offers important tools for the diagnosis of plant diseases of both viral and bacterial origin, and immuno-diagnostic techniques. Additionally, biotechnologies such as cryopreservation, artificial seed production, somatic embryogenesis, and other forms of in vitro cell or tissue culture are also extensively used for the conservation of genetic resources for food and agriculture.

Due to the increasing popularity of biotechnology in enhancing crop productivity agriculture research system should make a start by building on the existing biotechnology facilities available at some institutions.

i. Develop proposals to seek resources to make biotechnology a part of agricultural research programmes in relevant disciplines.
ii. Identify research disciplines where use of biotechnology can make significant contributions.
iii. Prioritize capacity development for biotechnology research, especially for utilizing existing facilities such as PCR (polymerase chain reaction).
iv. Promote collaborative researches that focus on the application of biotechnology such as tissue culture, micro-propagation, EM, bio-inputs, molecular markers and diagnostic tools such as PCR.
v. Initiate genetic characterization of traditional and wild crop genetic resources.

3.15 Value chain and Post-harvest Research

Agriculture research should ensure food and nutritional security. Most agricultural research and development programmes are aimed at increasing production. However, a substantial portion of food is wasted due to post-harvest losses. The FAO estimates that in developing countries 40% of the food losses occur during post-harvest and processing, with most food lost during the production-to-processing stages. The national post-harvest loss for cereals is about 20%. Post-harvest losses in Bhutanese subsistence farming are mainly attributed to crude harvesting techniques, poor packaging, storage and cooling facilities and rudimentary marketing systems. If adequately addressed, it will help contribute to 15-20% increase in crop production.

Focus on post-harvest research is limited. The National Post Harvest Center (NPHC) has to be strengthened and its coverage increased in collaboration with ARDCs to identify and adapt better post-harvest technologies.

Three broad strategic areas of research in post-harvest can include:

i. Post-harvest physiological research comprising postharvest handling losses, response of fresh produce to different storage conditions and nutritional status of fresh produce under different agro-climatic conditions.
ii. Food product development research consisting better product development and value addition technology, determining nutritional content and product stability, response to storage conditions, and determining suitable packaging materials.
iii. Postproduction technology research focusing on need based, cost-effective, efficient and maintenance easy post-harvest technologies, tools and equipment, processing and storage methods, structures, and packaging materials.

3.16 Policy and Socio-economic Research

Policy and socio-economic discipline is of paramount importance in research. It transverses various disciplines like agriculture, environment, infrastructure, health, education, economy, labor dynamics, and resource use and optimization. It guides agricultural scientists prioritize resource investment and help understand socio-economic structure of the farmers and thereby informs on technology transfer strategies.

Currently, there is no involvement of socio-economic scientists in research due to human resource shortage. Social and behavioral constraints to change are not fully understood, and hence farmers' willingness and preference to adopt technologies are not considered. Impact assessment of technologies is also rarely carried out as researchers often tend to give less importance to the policy and socio-economic discipline.

Research strategies for policy and socio-economic discipline can comprise

i. Mainstreaming socio-economic disciplines in agricultural research system and enhance capacity of agricultural scientists in socio-economic

disciplines such as cost-benefit analysis, basic qualitative and quantitative socio-economic analyses.

ii. Evaluating the implications of globalization and trade on Bhutanese farming and agri-business community to effect policy change.

iii. Assessing trends in demographics, change in land use, urbanization, shift in economic activities, consumer preference and change in dietary habit to effect policy change.

iv. Undertaking studies on food balance sheet and dietary energy.

v. Monitoring and assessing trends in food self-sufficiency.

3.17 Information Communication Technology for Research

The use of advanced tools like ICT based research tool including crop models, GIS, smart technologies, and others will be vital in producing and disseminating research outputs. The use of these tools requires specialized training and capacity building.

Strategic areas of interventions are:

i. Mainstream ICT for enhancing efficiency in research and technology transfer.

ii. Exploit ICT-based tools like models, GIS, etc., for generating user-friendly research outputs.

iii. Build capacity of researcher in the use of advanced ICT based tools and make them available for technology dissemination.

iv. Promote e-agriculture using ICT platforms.

3.18 Technology Transfer

The ultimate goal of agriculture research is to create impact in food production and income generation through the adoption of the improved technologies. Availability of technology is not enough. Sustainable dissemination and adoption of agricultural technologies and innovations by farmers are critical. As ARDCs and Central programmes are mandated with development functions, there is a need to have a suitable technology transfer mechanism.

Research Outreach Programmes (ROP) has been designed and tested by ARDCs to fast-track the promotion and adoption of new technologies. Due to its success, ROPs shall remain as one of the key mechanism for ARDCs in fast-tracking technology promotion. ROPs will invariably be implemented within

the broad and overriding concept of testing technologies in pipeline and demonstration of released technologies to create awareness. They will be designed and implemented by ARDCs and Central programmes in areas that have the best potential in terms of human and agro- ecological capacities, and making use of the success in these areas as a model to promote technologies elsewhere. ROP will include on-farm participatory trials, demonstrations and hands-on trainings, and will be implemented in consultation and collaboration with relevant stakeholders focusing on newly released or technologies in pipeline.

ROPs will be adopted as an integral medium of technology transfer for agriculture research:

i. All ARDCs and central programmes will design and implement ROPs as one of their programmes.
ii. ROPs will be pursued as part of the research methodology and address immediate technology needs of dzongkhags and farmers.
iii. ROPs will entail some elements of on-farm participatory research and should be packaged holistically to encompass cross-cutting disciplines.
iv. ROPs should be designed and developed in consultation with stakeholders with specific objectives and purposes, and with clearly defined time-frame.
v. ROPs can be location and needs-specific and should be designed to address either poverty alleviation or commercialization of technologies with best chance of success.
vi. Ownership of ROPs will be transferred to the beneficiaries' over time.
vii. In ARDCs the Technical Support Services Programme (TSSP) shall take the lead role in the coordination of ROPs.

3.19 Human Capital

3.19.1 Professionalism and Leadership in Agriculture Research

Professionalism and leadership are seen as the cornerstone of a research institution. Some define "research leadership" as the influence of one or more people on research-related behavior, attitudes or intellectual capacity of others. It considers three specific features of professional research leadership which influence and enhance people's capacity to make appropriate choices, achieve requisite standards, and effect processes, within research activity. The

department should therefore accord highest significance to professionalism and leadership in research programmes.

Young professionals joining the department then, considered agriculture research centers as the most relevant institution for professional development. The trend now is reversing as most new entrants choose extension and programmes over research centers. The once vibrant and dynamic agriculture research culture has declined.

Good research system and culture take years to develop and nurture. Some of the elements of good research culture are credible institutional reputation with good research productivity, a professional and dynamic leadership with a passion for research and emphasis on the value of research. ARDCs lack mentoring and capacity development schemes and support to mentor young researchers. There is also no system of tracking research productivity and recognition of research outputs.

To ensure professionalism and leadership in the research institutions it is important to:

i. Ensure and promote enabling environment for a more innovative and a professional research culture.
ii. Ensure right professional and dynamic leadership in all research programmes to steer and enhance agriculture research system.
iii. Promote professional development of research scientists.
iv. Ensure long-term sustainability of research institutions.
v. Establish clear strategic research vision, mission, goals and objectives for research programmes and institutions to enable professionalism in research.
vi. Initiate need-based and purpose driven research by initiating proposal based research on emerging issues.
vii. Ensure access to standard research tools, technologies and facilities.
viii. Promote research publications to showcase research outputs.
ix. Promote accountability, ethics and integrity in research system.

3.19.2 Critical Mass of Research Professionals

Agriculture as a primary sector provides livelihood to 58% of the population. Developing this sector requires generating information, knowledge and technologies through research. Even if all staff working across the department's

research centres, central programs and divisions at the head office is accounted for, it only constitutes a meagre 0.19 % of Bhutan's rural population. The current ratio of agriculture researchers to farmers – assuming that even central programs' staff engages in full-time research – is 0.02: 1 or one researcher for every 500 farmers.

Research processes are knowledge intensive and requires skills and experiences. Building a research institution entails substantial time and investment. Human capital is the primary asset for a strong research institution. Developing and accruing a critical mass of human resource for research is a protracted and investment intensive process. Despite the efforts, the current strength of available research professionals is quite bleak (Table 1). It is therefore imperative to develop and maintain a critical mass of qualified and motivated researchers in the system by putting in place a vibrant human resources policy that provides enabling environment and accords high priority for professional development.

Table 1 Existing staff strength with the Department of Agriculture

Division/Agency	P.hd	M.Sc	Bachelors	Diploma, Certificates & others	Total
ARED & ARDCs	2	28	35	138	203
APD & Central Programs	5	24	28	126	183
AED, AMC &CMU	0	5	9	125	139
Dzongkhags	0	2	16	259	277
Total	**7**	**59**	**88**	**648**	**802**

The department should therefore put in efforts to:

i. Strive to develop and build a pool of competent researchers in different disciplines.
ii. Put in place a mechanism to prevent research professionals leaving the system resulting in brain drain.

iii. Institutionalize clear career path and incentives including proper nomenclature for research professionals within the scope of civil service rules in force.
iv. Institute sound mentorship programme to develop skills and capacity of researchers.
v. Encourage and ensure the placement of professional in the right institution based on their academic background and relevance.
vi. Institute a mechanism to recognize and reward outstanding research outputs through meritorious promotion and participation in relevant regional and international forums.
vii. Develop collaborative research networks and exchange programmes with international institutions for professional development.

3.20 Knowledge Management

As in any organization knowledge management is an important and an indispensable aspect of research. Research involves creation of information as well as use of information. Therefore, knowledge management as an essential process of capturing, storing, preserving and effectively distributing information in research system should be provided strong emphasis.

3.20.1 Inventory and Database

Proper storage of records in all forms for retention and easy retrieval as well as effective dissemination should form an integral part of a good research practice. Records and information archival serve multiple purposes including prevention of data loss as well as in fulfillment of legal or institutional requirements. Management of information or data is also important in that most funding bodies also encourage it for information storage, sharing and reuse. Proper archival and management of records in several formats or devices is hence a crucial element in enhancing science.

Key actions for enhanced information management are:

i. Respective ARDCs shall maintain regional data and the national level data shall be maintained by the ARED (DoA). Data maintained by ARDCs and ARED will comprise data beyond that of production.
ii. The RNR Statistics Division (RSD) shall have access to all data maintained by respective ARDCs and the ARED (DoA).

iii. Emphasis should be made to continue maintenance of library at regional and national levels.
iv. Online forums for professional discourse should be set up and maintained.
v. E-archiving, as recommended, to be instituted with access at both regional and national level.

3.20.2 Publications

Publications in various forms serve as an effective and reliable source of information. These can be used for furthering research as well as for proper planning and sound decision making at all levels.

The department should therefore reinforce a series of publications to enhance knowledge management for a conducive research culture.

I. **Journals**

The department has recently launched the Bhutanese Journal of Agriculture (BJA). BJA is published yearly to help Bhutanese researchers in agriculture showcase their work as well as to sustain a vibrant research culture.

In the similar vein, efforts need to put in to:

- Promote quality research through publications in reputed international journals to present progress in research as well as attest the capacity, credibility and acceptance of researchers amongst their peers.
- Provide access to reputed and relevant journals through membership and subscription support.

II. **Annual Highlights**

The annual highlights published by the department provides a summary of physical progress in an abridged form that represent a cumulative synthesis of reports from all ARDCs, central programmes, and support services. ARDCs and other agencies within the department are mandated to submit annual highlights in standard formats.

III. **Annual Reports**

Detailed technical report shall include all completed and on-going programmes/activities including financial details. ARDCS, central and support services shall publish annual reports in prescribed formats.

IV. **Technical Series**

All programmes and agencies undertaking research shall be encouraged to publish technical series to package and disseminate accurate and timely technical information on different disciplines.

Technical series is a scientific publication that describes the process, progress and results of scientific research or the state of a technical problem. Technical series may include posters, pamphlets, occasional papers, package of practices and booklets. Technical series can be produced by individual programmes based on need and availability of information.

V. **Technical Seminars**

Technical forums like seminars, talks and topical discussions are very important for interactions among professionals for technical discourse. ARED, ARDCS and central programmes shall put in place technical forums to further research in their assigned mandates.

4 Governance and Institutional Arrangement

The Agriculture Research and Extension Division (ARED) shall endeavour to achieve the Ministry's vision of enhancing socio-economic wellbeing of the Bhutanese people through agricultural research. However, governance structures and their processes will determine the effective implementation of research strategies and improvement of agriculture research outputs in the country. A good research governance consists of the following parameters:

- participatory;
- accountable;
- transparent;
- responsive;
- effective and efficient;

- equitable and inclusive; and
- in accordance with existing rule of law.

Weak institutional linkages and ineffective governance in the current research system are supposedly responsible for the decline in research outputs and gaps in generating appropriate technologies that address farmers' needs. This is because the current institutional set-up does not promote linking and mainstreaming of national research priorities and issues among different agencies (e.g. NPPC and NSSC reporting to Agriculture Production Division). In the absence of a proper governance mechanism and an assigned lead coordinating agency for research programmes, development activities will continue to overshadow the core research mandates of ARDCs and central agencies. Thus, ARED is assigned to serve as the primary focal point for all ARDCs/central agencies. The following governance, strategic processes and linkages are instituted to provide a proper institutional framework for management and coordination of all ARDCs/central agencies towards improving planning, prioritization and the implementation of research programmes in the country.

4.1 Research Management and Coordination

4.1.1 Research Management Committee (Department Level)

A Research Management Committee (RMC) is proposed at DoA to ensure proper management and coordination of research programmes, improve quality of research outputs, avoid duplication and provide technical and policy guidance.

The Research Management Committee (RMC) shall:

i. Oversee management and coordination issues in the Department of Agriculture and other agencies relating to agriculture research plans and programmes in the country.
ii. Ensure that any agriculture research proposals proposed by different agencies within and outside the department are in-line with the national plans and priorities.
iii. Review research proposals including ethical issues and endorse research proposals and work plans.
iv. Invite research proposals and project proposals

v. Provide guidance and directions for adequate knowledge management.

The Committee shall consist of the following members:

1. Head of the department (Chairperson)
2. Agriculture Specialist (Advisor)
3. Chief of the ARED (Member Secretary)
4. Chief of the APD (Member)
5. Chief of the AED (Member
6. Programme Director (one PD from any ARDCs)
7. Programme Director (one from central agencies)

The RMC shall convene annually. However, it may call for unscheduled sitting depending on the earnestness of the proposal.

4.1.2 Research Management Committee (Programme Level)

A Research Management Committee at ARDCs and central programmes shall be instituted consisting of Programme Directors, Specialists and Sector Heads to plan/approve research proposals emanating from different sectors on respective research mandates. The committee shall ensure the quality of the proposed research in terms of design and methodologies. Proposals that require approval at the department level shall be submitted for review and endorsement by the RMC at the department level. Copies of annual work plans should be submitted to the RMC at the department level through the Member Secretary.

4.1.3 Variety Release Committee

As provisioned in the Seeds Act of Bhutan, 2000, the Variety Release Committee (VRC) comprising relevant technical representatives evaluates crop variety release proposals based on tests and research by ARDCs and other entities including private seed companies and makes necessary recommendation to the National Seed Board. Additionally, VRC shall recommend the notification (official communication for multiplication and distribution of a variety) or de-notification (of obsolete, poor performing or varieties susceptible to pests and diseases) of varieties to the NSB.

The Member-Secretary shall invite proposals within a time frame for release as per the prescribed format. VRC convenes annually.

4.1.4 Technology Release Committee

ARDCs and central agencies are mandated to innovate better and efficient technologies for sustainable agriculture development in the country. These innovations cover a wide range of topics from agriculture production system to agriculture engineering and food and environmental safety. However, weak interaction and dialogue between research and extension could lead to development of irrelevant technologies that do not address farmers' concerns. Therefore, the erstwhile Technology Release Committee (TRC) with the then CoRRB will be reinstituted to screen technologies other than crop varieties for release. TRC shall establish guidelines to assess the suitability of innovative agricultural production technologies proposed for introduction by private, public or government entities.

TRC shall comprise the following members:

1. Director, DoA – Chairperson
2. Specialist, DoA (Adviser)
3. Relevant subject matter specialist
4. Chief Agriculture Officer, APD
5. Chief Postproduction Officer, NPHC, DoA
6. Chief Engineer, Engineering Division, DoA
7. Programme Director ARDC (one PD will represent the ARDC)
8. Programme Directors (one PD representative of Central programmes)
9. Chief Agriculture Officer, ARED as Member Secretary

The frequency of meeting shall be as and when required. Special meetings could be called on need-basis.

4.1.5 National Seed Board

The Seeds Act of Bhutan 2000 also provisions the establishment of the National Seed Board with the Ministry of Agriculture and Forests as an apex body to approve the release/notification/de-notification of crop varieties. Its core mandates include approval of release of recommended varieties or other proposals like fee structure for seed testing and other costs.

The NSB is also empowered with other pertinent functions that are complementary and consequential to its roles as conferred by the Seeds Act of Bhutan, 2000. Additionally, it will ensure maintenance of and accessibility to

proper records of all released, registered and notified/de-notified varieties/kinds of seeds/planting materials. The board shall also ensure the introduction of crop germplasm is in compliance with the provisions of the NSB.

4.1.6 Annual Regional Agriculture Review and Planning Workshop

Annual Review and Planning Workshop was first conducted by the Department of Agriculture (erstwhile Research, Extension and Irrigation Division-REID) in Lingmethang in 1995 with the primary aim of decentralizing planning process on research and extension activities at regional and dzongkhag levels. Thematic workshops on agriculture, horticulture, livestock and forestry were held annually, and depending on their given mandate, RNRRCs organized the workshops with support from CoRRB.

The workshop reviewed preceding year's progress and drew collaborative activities, introduced field activities in plans and programmes of different stakeholders which provided greater ownership of the programmes. It was also an important mechanism to strengthen research and extension linkage and provided a forum for presenting and disseminating technologies.

ARDCs shall coordinate the Annual Regional Agriculture Review and Planning Workshop in consultation with the department in their respective regions. The workshop will comprise all DAOs in the region, the national commodity focal officers, representatives from the central programmes and DoA. The workshop shall:

i. Review progress of research – central programme – extension collaborative activities.
ii. Set research priorities based on issues and needs of stakeholders.
iii. Harmonize, plan and agree annual collaborative work plans.
iv. Plan, discuss and finalize research outreach programmes.
v. Present and showcase new research technologies and findings
vi. Present success stories from extension.
vii. Ensure compilation and publication of proceedings.

4.1.7 Agriculture Research Coordination Meeting

Similar to the Annual Regional Agriculture Review and Planning Workshop, programme specific research coordination workshops were put in place and served as technical forum for planning, reviewing and endorsing annual research activities. The Annual Research Review and Planning Workshop has

been re-instituted in 2017 as Agriculture Research Coordination Meeting (ARCM) in view of its importance in efficient coordination of research programmes. This forum will provide a suitable and effective platform for coordination, critical peer review, planning and development of annual plans endorsed by the different stakeholders. The scope and objective of this forum should also be developed and endorsed by the RMC to ensure its credibility and legitimacy.

The Agriculture Research Coordination Meeting shall be continued with the following functions:

i. Plan, review and harmonize annual agriculture research work plans.
ii. Identify emerging research needs and priorities.
iii. Finalize nationally coordinated trials and collaborative work plans.
iv. Assess quality of research and research methodologies adopted.
v. Review research proposals that are new and outside the annual work plan for endorsement.
vi. Provide platform to present completed research results to highlight significant findings for endorsement, knowledge sharing, visibility, and for publication in peer reviewed journals.
vii. Ensure compilation and publication of proceedings and put up critical issues to the Research Management Committee.

4.2 Mandates and Responsibilities

For an efficient, vibrant and a sustainable research system, the Department of Agriculture needs to spell out and delineate clear mandates and responsibilities amongst its ARDCs and central programs. These set mandates and responsibilities of respective agencies within the department will help support the governance structure and associated process vis-à-vis effective implementation of research strategies, and subsequently in strengthening agriculture research system in the country.

4.2.1 ARED (DoA)

The Agriculture Research and Extension Division (ARED) with the department in its endeavour to achieve the ministry's vision of enhancing socio-economic wellbeing of the Bhutanese people through agricultural research shall:

i. Coordinate and facilitate implementation of research programmes for agriculture development.
ii. Coordinate and facilitate technology dissemination for agriculture development.
iii. Lead the formulation and review of research and extension policies and strategies.
iv. Lead the monitoring, evaluation and supervision of the implementation of the planned research and extension programmes including technology impact and needs assessments.
v. Lead the coordination of agriculture research coordination meeting and support annual and regional agriculture research review and planning workshops.
vi. Serve as the secretariat for Journal Editorial Board, Variety Release Committee, Research Management Committee, National Seed Board, and Technology Release Committee of the department/ministry.
vii. Facilitate and foster a wide range of arrangements for research collaboration and funding with national, regional and international bodies and centers of excellence.

4.2.2 ARDCs

Agriculture Research and Development Centres (ARDCs) are established to conduct basic, applied, adaptive and policy research for sustainable agriculture development. ARDCs supported by Research Sub-Centres are located at different regions to carry out agriculture research and development activities (Table 2). Research is the foundation stone of any developmental activities. Therefore, to ensure greater emphasis on research, every scientist should devote 70% of the time on research and the rest 30% on developmental activities. ARDC will have national and regional mandates as outlined below:

i. National mandate will constitute planning, coordination and monitoring of commodity research programmes at national level.
ii. Regional mandate will include planning, coordination and ensuring timely implementation of research and development programmes including collaborative activities specific to respective regions on Field Crops, Potato, Horticulture, Organic Agriculture and MAPS.

Table 2 ARDCs and their mandates

ARDCs	Coordinating Centre	National Mandate	Client Dzongkhags
Bajo	Field Crop Research	Citrus, rice, other cereals	Dagana, Gasa, Punakha, Tsirang and Wangdue
Samtelling	Sub-tropical agriculture research	Cardamom, ginger, mango, areca nut, banana, litchi, passion fruit, legumes, betel leaf and spices	Samdrup Jongkhar, Samtse, Sarpang, Trongsa and Zhemgang
Wengkhar	Horticulture research	Fruits and nuts, maize and oilseeds	Bumthang, Lhuentse, Mongar Pemagatshel, Trashigang and Trashiyangtse
Yusipang	Organic agriculture	Apple, quinoa, potato, medicinal & aromatic plants, high altitude rice, vegetables	Chukha, Haa, Paro and Thimphu

Responsibilities

For smooth implementation of aforementioned mandates, ARDCs are entrusted with the following responsibilities.

i. Identify and prioritize research needs.
ii. Develop research guidelines.
iii. Conduct research and generate new technologies.
iv. Maintain database (regional dzongkhag profiles and administrative data).
v. Maintain repositories (breeder seeds, mother block).
vi. Establish and strengthen linkages with regional and international centres.
vii. Serve as a forum for knowledge sharing (seminars).
viii. Disseminate technologies and provide technical backstopping.

ix. Strengthen research facilities.

x. Serve as knowledge hub for technology and capacity building.

xi. Build and maintain linkages with central programmes and extension services.

xii. Conduct regional review and planning workshops.

4.2.3 Central Programmes

The Department of Agriculture has six discipline-specific programmes on farm mechanization, mushroom, plant protection, post-harvest, seeds, soil and nutrient management which are called as central programmes. These central programmes include Agriculture Machinery Centre, National Mushroom Centre, National Plant Protection Centre, National Postharvest Centre, National Seed Centre and National Soil Services Centre. They are assigned specific mandates of national importance as per their field of discipline or expertise. They will provide similar services in their discipline to any sectors or agencies outside the department and the ministry. Since the central programmes have to cater to both research and development functions of the country, they will devote a minimum of 40 % of their time on research and the rest 60% on developmental activities.

The broad national research mandates of these centres are (but not limited to):

i. Identify and assess research needs and priorities of different stakeholders in their discipline.
ii. Lead any research plans and programmes in their respective discipline at local, regional and national levels.
iii. Support and provide technical expertise to commodity research programmes.
iv. Develop capacity of farmers/stakeholders in the use of improved technologies and sustainable or climate-smart farming practices.
v. Strengthen research capacity and facilities on assigned programmes at regional centres.
vi. Foster regional and international research coordination and implementation of collaborative activities.

4.3 Monitoring and Evaluation

There is need for a separate Monitoring and Evaluation unit under the Department of Agriculture to ensure regular monitoring of implementation and completion of the planned research activities under different regions. Monitoring and Evaluation (M & E) are integral tools for managing and assessing the efficiency and effectiveness of investments in agricultural research systems. However, monitoring and evaluation of research results and impact is a huge challenge. Regular monitoring will not only ensure quality outcomes but also help in focusing research and investments in priority sectors.

4.3.1 Monitoring

Process Monitoring

Process monitoring in research is the assessment of the implementation of activities against planned targets and objectives. It focuses on how a programme works to attain specific goals and objectives, implementation status, and barriers to implementation. It also helps identify implementation problems early in the delivery cycle. Thus, a process monitoring shall be instituted to track the process of setting research priorities, identification of research issues, and planning and implementation of research activities.

ARDCs and the central programmes shall design tools and mechanisms such as monthly, quarterly and annual meetings for effective process monitoring in real time. At the national level, the proceedings of the Annual Regional Agriculture Review and Planning Workshop and Agriculture Research Coordination Meeting, annual progress reports, and highlights will serve as mechanism for process monitoring.

Technology Monitoring

One of the primary responsibilities of ARDCs and central programmes is to generate appropriate technologies for the farmers. Of the different technologies generated, a number of crop varieties have been developed or introduced and released since the establishment of agriculture research. Since 1988, the agriculture research system has released 236 improved varieties of field and horticulture crops, offering a range of technology to the food growers. Although number of technologies other than crop varieties is generated by different agencies, information on these including their adoption by farmers are not

maintained and monitored. Technology monitoring, therefore, shall be used to monitor the number of technologies developed and disseminated. It will be carried out on an annual basis by the respective programmes.

4.3.2 Evaluation

Technology Impact Assessment

Agriculture research system is expected to address a wide range of farming, socio-economic environmental and other emerging issues. Substantial resources are invested in generating technologies. Research outputs and impacts for different programmes require assessment. Currently, apart from annual auditing which focuses on the financial aspects, there is no mechanism for assessing research outputs and impacts, thereby, leading to lack of accountability of research programmes.

Technology impact assessment:

i. Will make research programmes accountable and efficient.
ii. Will generate socio-economic data for planning and policy interventions.
iii. Shall be conducted to assess the outputs and impacts of a research programme.
iv. Shall evaluate the turnover of technologies, quality of research, success and adoption rate of technologies developed and released.
v. Shall help economic valuation of technologies, determination of cost of production, cost-
benefit, net benefit ratio, and return analysis.
vi. Shall be conducted once in a plan period and will be initiated by the concerned programmes.

4.4 Collaboration and Partnership

Collaboration and net-working with the institutes at different levels is increasingly a critical component of efficient national research and innovation systems. It is useful to examine and adopt the experiences and the technologies of developed countries to better understand research systems, collaborate and work together to enhance our research systems. Such linkage should be institution-based rather than on individual level.

A strong network with international centers will help enrich the research capacity, quality and enhance the institutional status of ARDCs. Each ARDC

should put in efforts to link and network with the most relevant centers of excellence through potential partnership programmes like networking with the universities, international research stations like NARS, CGIARs and academic institutions at the international level. At the regional level, ARDCs should establish collaboration and linkages with the institutes like the SAC to obtain supports both in terms of funding and technical supports to improve our research system. At the national level, linkages with NBC, CNR, CSOs, NGOs and other private research institutes should be maintained.

5 Fund/Resource Mobilization

5.1 Regular RGoB Financing

The Government shall, through the annual budgets, provide adequate fund for agriculture research.

The budget for agriculture research shall be based on annual work plan and drawn from the annual budget allocation to the MoAF. The Ministry of Finance allocates the agriculture research budget amongst the various research institutions under MoAF based on priority needs and research work plans (five year and annual) scrutinized and endorsed by the ARED.

Allocate RGoB budget codes and sub-codes to research in general and agriculture research in particular in order to ensure focused funding on research, to highlight its importance, to increase the accountability of researchers, to raise the public profile and support for research, and to enable cost-benefit analysis of research.

5.2 Research Endowment Fund

The need to institute a Research Endowment Fund (REF) to support agriculture research and research institutions is increasingly being felt. An Endowment Fund for Agriculture Research can help guarantee a steady flow of research funding for institutions and individuals working on agriculture research themes of immediate as well as long-term implications.

The Department of Agriculture, with the support of the Ministry of Agriculture and Forests shall put in concerted efforts to establish an Endowment Fund for

Agriculture Research. Subsequent to its approval by the government, the MoAF will, in accordance with the Revised Operational Guidelines for Endowment Funds 2017, institute a governing board to manage the fund.

5.3 Research Fund Mobilization

Following the completion of the Swiss Agency for Development Cooperation (SDC Helvetas) funded RNR Research System Support there has been no single project supporting the agriculture research system in the country. The ARDCs mostly sustain on core RGOB funds. Most ARDCs have often relied on area development projects for support as a result of which ARDCs tend to get overwhelmed with development function. To ensure continuity of quality research for technology and information generation it is essential to ensure the availability of financial resources.

The ARED with support of the DoA shall initiate the following:

i. Explore and approach potential donors to support national agriculture research.
ii. Negotiate with and convince donors of ADPs to allocate funds (a minimum of 5% to ARDCs for research).
iii. Facilitate and foster a wide range of arrangements for research collaboration and funding with international and regional centers of excellence.
iv. Encourage and support researchers to develop proposals for sourcing fund for research.
v. Ensure the allocation of budget for research under the commodity programmes.
vi. Encourage international or national agencies or individuals, including the private sector to sponsor research endeavours by Bhutanese researchers or research institutions.
vii. Encourage and facilitate Public Private Partnership (PPP) model for investment in research to help adequately support research and innovation in agriculture.
viii. Explore and put in place a competitive research grant programme for ARDCs.

6 Legal and Policy Framework

A strong legal and policy framework are necessary for the successful implementation of agriculture research strategies. The research strategy shall be implemented in line with existing government policies and legal frameworks which will create the enabling environment for the successful implementation of strategies designed for improving agricultural research systems in the country. Acts, rules and regulations and other policy documents will be used as a guiding principle for improving research governance through effective implementation of the research strategy at different levels under the Department of Agriculture.

While planning any research activity, it is important to ensure that research activities are planned within the scope of the existing national policies and acts, and that they remain guided by these.

Some of the examples are:

i. RNR Research Policy of Bhutan 2011
ii. Food and Nutrition Security Policy of Bhutan 2012
iii. Biosafety Act of Bhutan 2015
iv. Biosecurity Policy of the Kingdom of Bhutan 2010
v. Seeds Act of Bhutan 2000
vi. National Food Security Reserve
vii. RNR Marketing Policy of Bhutan 2017
viii. Plant Quarantine Act 1993
ix. Pesticides Act of Bhutan 2000
x. Biodiversity Act of Bhutan 2003
xi. National Biodiversity Strategy and Action Plan 2014
xii. Bhutan Civil Service Rules & Regulations 2018

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Department of Agriculture
Ministry of Agriculture & Forests
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