



**VEGETABLE RESEARCH AND DEVELOPMENT  
STRATEGY 2023-2027**



**DEPARTMENT OF AGRICULTURE**  
**Ministry of Agriculture and Forests**  
**Royal Government of Bhutan**

**2022**

## **STRATEGY PREPARATION TEAM:**

1. Mr.Ganesh Bahadur Chhetri, Advisor (Former), Department of Agriculture, MoAF.
2. Mr.Kinley Tshering, Vegetable Focal (Former), Agriculture Production Division, Department of Agriculture, MoAF.
3. Ms.Laxmi Thapa, Dy. Chief Research Officer (National Vegetable Commodity Coordinator), National Centre of Organic Agriculture, Yusipang, Department of Agriculture, MoAF.
4. Ms.Tashi Gyalmo, Horticulture Officer (Vegetable), National Centre for Organic Agriculture, Yusipang, Department of Agriculture, MoAF.
5. Mr.Tshering Tobgay, Dy. Chief Agriculture Officer, Agriculture Research and Extension Division, Department of Agriculture, MoAF.
6. Ms.Pema Yuden, Program Officer, National Centre for Organic Agriculture, Yusipang, Department of Agriculture, MoAF.
7. Mr.Tirtha Bdr. Katwal, Program Director, National Centre for Organic Agriculture, Yusipang, Department of Agriculture, MoAF.

## **COORDINATION:**

1. Ms.Laxmi Thapa, Dy. Chief Research Officer (National Vegetable Commodity Coordinator), National Centre of Organic Agriculture, Yusipang, Department of Agriculture, MoAF.
2. Ms.Pema Yuden, Program Officer, National Centre for Organic Agriculture, Yusipang, Department of Agriculture, MoAF.

## **DESIGN AND LAYOUT:**

1. Ms.Laxmi Thapa, Dy Chief Research Officer, NCOA, Yusipang
2. Mr.Tshering Wangchuk, Research, and Communication Officer, NCOA, Yusipang

Copyright © Department of Agriculture

### **Published by:**

Department of Agriculture,

Ministry of Agriculture and Forests, Thimphu, Bhutan.

## FOREWORD

Over the past few years, nutrition and food safety have gained importance and visibility on the international development agendas in part through the efforts of the global panel on agriculture and food systems for nutrition. The year 2016 marked the beginning of the decade of action on nutrition. Sustainable Development Goal 2 (SDG 2) of the 2030 agenda for sustainable development recognizes agriculture and food systems as major contributors to food security and nutrition.

In Bhutan, agriculture, to a certain extent, is the mainstay of livelihood and economy and will continue to play a central role for years to come. Horticulture is one of the most important sub-sectors providing greater prospects to realize the vision and goals of the Ministry. Therefore, the Department of Agriculture continues to accord high priority to vegetable research and production. However, the research and development on vegetables continue to face several constraints and challenges, not least due to the complex production systems, diversity of crops, and marketing approaches. A lack of a proper research strategy and planning further adds to the loss of focus on high-impactful development activities and subsequently the achievement of the long-term visions and goals. With the objective to (i) contribute towards realizing the Ministry's long-term vision of National Food and Nutrition Security and (ii) achieve the goal of vegetable adequacy, accessibility, and affordability, the Department of Agriculture has developed this five-year Vegetable Research and Development Strategy 2023 - 2027.

The strategy, amongst others, strives to identify appropriate research needs, formulate a structured implementation mechanism and provide a platform for stronger collaboration and systematic implementation amongst the vegetable researchers and collaborating agencies. The strategy is a result of rigorous consultations with all the vegetable researchers of the ARDCs and the NCOA. With the adoption of the strategy, the researchers commit to implementing and realizing its objectives to help further sustain research for development.



Mr. Yonten Gyamtsho

**DIRECTOR**

## ABBREVIATION & ACRONYMS

Ac	:	Acres
APD	:	Agriculture Production Division
ARDC	:	Agriculture Research and Development Centre
ARED	:	Agriculture Research and Extension Division
AVDRC	:	Asian Vegetable Development Research Centre
DAMC	:	Department of Agriculture and Marketing Cooperatives
DoA	:	Department of Agriculture
FYP	:	Five Year Plan
GNH	:	Gross National Happiness
ICAR	:	Indian Council of Agriculture Research
IIVR	:	Indian Institution of Vegetable Research
Kgs	:	Kilograms
MoAF	:	Ministry of Agriculture and Forests
MT	:	Metric tones
NBC	:	National Bio-diversity Centre
NCOA	:	National Centre for Organic Agriculture
NSB	:	National Statistics Bureau
NSC	:	National Seed Centre
SAARC	:	South Asian Association Regional Cooperation
SAC	:	SAARC Agriculture Centre
WVC	:	World Vegetable Centre

## 1. Table of Contents

1. INTRODUCTION.....	5
2. SITUATIONAL ANALYSES .....	6
2.1. Area and Production .....	6
2.2. Vegetable Self-sufficiency Status.....	7
2.3. Status of Research and Development on Vegetables .....	8
2.4. Analysis of the Research Plan and Implementation .....	9
3. STRATEGIES FOR VEGETABLE RESEARCH AND DEVELOPMENT.....	11
3.1. Prioritization of high demand crops for vegetable research.....	12
3.1.1. Scaling up production of chilli, tomato, and onions.....	12
3.1.2. Production research of other vegetables .....	13
3.2. Prioritization of research agenda and areas.....	14
3.2.1. Breeding.....	14
3.2.2. Off-season vegetable production technology .....	15
3.3. Evaluation of germplasm and varietal improvement .....	17
3.3.1. Evaluation of climate, pest, and disease resilient varieties.....	17
3.3.2. Varietal improvement of traditional varieties.....	17
3.4. Development of production systems .....	18
3.4.1. Water management.....	18
3.4.2. Improved nursery raising techniques and management of prioritized crops .....	19
3.4.3. Management of crops under protected cultivation at different altitude .....	19
3.4.4. Soil fertility improvement.....	20
3.4.5. Plant protection .....	20
3.4.6. Weed management .....	21
3.4.7. Organic research and technologies .....	21
3.5. Use of hybrids .....	21
3.5.1. Fast-track evaluation of imported hybrid seeds.....	21
3.7. Realignment and coordination of vegetable research and development.....	22
3.7.1. National coordination .....	22
3.7.2. Regional coordination.....	23
3.7.3. Marketing and value-chain.....	24
3.8. POSTHARVEST AND VALUE ADDITION.....	24

3.9.	IMPROVING THE QUALITY OF SEED PRODUCTION.....	25
3.9.1.	Seed production, maintenance, and technologies.....	25
3.10.	HYDROPONIC RESEARCH .....	25
3.11.	CAPACITY DEVELOPMENT.....	25
3.12.	TECHNOLOGY DISSEMINATION .....	26
3.13.	INTERNATIONAL LINKAGES.....	26
4.	CONCLUSION.....	26

## 1. INTRODUCTION

The long-term vision of the Ministry of Agriculture and Forests (MoAF) is to ensure that “all people living in Bhutan at all times have physical, economic and social access to safe and adequate nutritious food for a healthy and active life contributing to the realization of Gross National Happiness” (Food and Nutrition Security Policy of the Kingdom of Bhutan, 2014). Vision 2020 envisaged that while the country’s economic future will be rooted in and driven by hydropower-based investments, the economy must be well-balanced and sufficiently diversified by thriving horticulture and organic-based high-value agricultural sector. The focus of the MoAF is to achieve food self-sufficiency and nutrition security. Among the agriculture sub-sectors, horticulture is one of the most important sub-sectors providing greater prospects to realize the vision and goals of the Ministry. Vegetables contribute and play a major role in increasing the household income, improving the nutritional standards, and employing many Bhutanese farmers, particularly women and youth, promoting their participation in the economy and society. The Ministry, therefore, has been prioritizing the vegetable program to realize the vision of food self-sufficiency/self-reliance. Taking advantage of the diverse agro-climatic conditions, Bhutanese farmers are growing a wide array of vegetables in different parts of the country.

The Government’s support towards commercial-scale cultivation of vegetables started in 2012. However, with the rising incomes, population, and urbanization in Bhutan influenced by the ever-rising COVID-19 pandemic situation the domestic demand for quality and quantity of vegetables have correspondingly increased. Therefore, vegetable production continues to be of priority to the Department of Agriculture. The vegetable program is expected to (i) contribute towards realizing the Ministry’s long-term vision of National Food and Nutrition Security and (ii) achieve the goal of food self-sufficiency. Consequently, appropriate approaches to planning, effective strategies, and implementation modalities/arrangements with adequate budgetary support are required.

In general, RNR Research is constrained by frequent organizational review, policy conflict, ad-hoc activities, lack of cascading plans and inadequate objective monitoring and evaluation. Research in Bhutan including vegetables has therefore faced several constraints and challenges over the years.

The drive on research on vegetables became diluted with the vegetable commercialization theme. Often the emphasis was given to increasing production and meeting the annual production target than on research and technology generation. The import ban on three commodities of vegetables (chilli, beans, and cauliflower) also diverted the focus from research-oriented works to import substitution and meet the demands of the domestic market. Although the research centers across the country continued to conduct various research trials on vegetables, the constant shift in mandate affected the vegetable research program. In view of inadequacy in technological generation and slow technological uptake and to enhance efficiency of agriculture production system, a definitive focus of aggressive innovation through strategic research and dissemination is necessary which will be crucial to achieve the goal of food self-reliance.

## **2. SITUATIONAL ANALYSES**

### **2.1.Area and Production**

The area under vegetable cultivation was 18,555 acres in 2019 (RSD, 2020). The total annual vegetable production increased from 42,872 Metric Tonnes (MT) in 2012 to 51,830 MT in 2016 and 57,727 MT in 2020. The data from the Statistical Year Book 2020 ([www.nsb.gov.bt](http://www.nsb.gov.bt)) shows an increase in vegetable production during 2019-2020 which may be attributed to the consequences of the COVID-19 pandemic. The major vegetables grown in the country are chilli, beans, radish, cabbage, green leaves, cauliflower, turnip, pumpkin, and other gourds. Among the vegetable crops grown by the farmers, chilli is the most important vegetable cultivated in an area of 4,686 acres with a production of 8,522 MT (average of 2014 - 2016) followed by beans and radish. The national average yield of chilli is 1.8 MT/acre (average of 2014 - 2016). Despite the expansion of vegetable production in the country, the import of vegetables has not decreased. Roughly, 13,963 MT of vegetables is imported annually (average of 5 years 2012 - 2016). Onion (3,312 MT), tomatoes (2,666 MT), leguminous vegetables (2,076 MT), chilies (1,612 MT), cabbage (1,481 MT), and cauliflower (1,071 MT) are imported in larger volumes, which is mainly due to the limited production in the country. Bhutan imported 3,308.13MT of onions and 2,590MT of tomato in 2019. In total Nu. 0.234 billion worth of vegetables were imported (BTS 2018).

In terms of export, there has been a gradual increase. Between 2012 - 2016, 2,241 MT of vegetables worth Nu 37.75 million were exported in 2012 which increased to 8,242 MT worth Nu.189.65 million in 2016. The export volume, however, decreased to 5,091.66MT in 2019 and 3,160.92MT in 2020 mainly due to COVID-19 situation. The major vegetables exported are cabbages, carrots, radish, and peas and are mostly exported to India and some to Bangladesh. The need to increase vegetable production for both export and domestic market and reduce import dependency is greatly felt.

Based on the per-capita consumption of 200 grams/person/day, the self-sufficiency rate is estimated at 88% in 2020. This is a two percent increase over the 2014-2016 average domestic production, export, and imports of 86%, which in turn is a three percent increase over the 11th FYP baseline of 83%. The key objective of the Department of Agriculture is to achieve 100% vegetable self-sufficiency.

## **2.2. Vegetable Self-sufficiency Status**

Bhutan produces most vegetables during the summer-autumn (June – October) period while it largely depends on imports during the winter-spring (November – May) months. A study conducted by the Department indicates the shortages of winter vegetables in the market with acute shortages of tomato, onion, and small green chilli. The Ministry of Agriculture and Forests (MoAF) is focusing on seven southern Dzongkhags for winter vegetable production. Tomato, onion, and chilli are listed as mandatory crops to be grown by all Dzongkhags while other Dzongkhags have to produce identified signatory crops based on the production potential. The Dzongkhags are selected based on the suitable climatic conditions to grow 11 major vegetables: chilli, tomato, onion, beans, cauliflower, brinjal, broccoli, carrot, okra, bitter gourd, and garlic. There is a deficit of 1,124MT of chilli, 92MT of onion, 552MT of tomato, 78MT of okra, and 36 MT of bitter gourd. Additional 1,286 acres of land are needed to bridge the gap.

During the pandemic situation, it was found that : (i) production dominated by potato, cabbage, chilli, carrot & beans; (ii) there were critical shortages of onions and tomatoes; (iii) expected farm gate price was very high; (iv) presence of poor sorting; rudimentary packaging with higher post-harvest losses, poor traceability due to no tagging of the vegetables and producers;(vi) faced

challenges in swift aggregation and supply to the consumers; (vii) improper transportation (all mixed, overloaded) with post-harvest losses; (viii) consumers were seeking more diverse vegetables - small chilli, okra, gourds and (ix) there were huge losses of highly perishable items and lack of cool facility and rough handling. Bhutan still faces shortages of vegetables as vegetable production and demand remain out of sync.

### **2.3.Status of Research and Development on Vegetables**

There are four Agriculture Research and Development Centers (ARDCs) in the country. These are strategically located covering suitable agro-ecological zones and catering to the research and development needs on vegetables for the people living in these different zones. The ARDCs have conducted various trials and studies on vegetable research over the past couple of years. So far 84 vegetable varieties have been released for general cultivation during the past five year plans. Though the main thrust of research so far has not progressed from the simple adaptability trials, the research on vegetables is gradually gaining momentum. Some of the notable research studies being conducted so far include the study on the climatic suitability of major horticultural crops including chilli and tomatoes.

The change in the global scenario has also impacted the research system in the country. The move is on from performance evaluation trials to synthesizing the potentials of climate-smart agriculture, as evident from the research works on heat and cold tolerant varieties of vegetables.

A glimpse of the various research activities in the four research centers during the 12<sup>th</sup> FYP is presented below:

- **The main thrust on vegetable research and development of ARDC-Bajo included:** the release of off-season vegetable varieties, promotion of protected vegetable cultivation, evaluation of high-yielding varieties, the release of vegetable varieties, promotion of commercial vegetable production, evaluation of high-nutrient content vegetable varieties, and release of stress-tolerant varieties.

- **ARDC-Samtenling conducted:** promotion of protected cultivation of vegetables, the release of vegetable varieties, organic pest and diseases management in vegetables, initiation of breeding trial for vegetables, development of commercial production sites, evaluation, characterization, and screening group of local vegetable types and promotion of kitchen garden technologies.
- **ARDC-Wengkhar has planned the maximum activities that include:** generation of staggered vegetable production technology, promotion of protected vegetable production, the release of new varieties of vegetables and initiate a breeding program for vegetables, an extension of support to the vegetable seed growers in the region development of commercial production sites for vegetables, the establishment of protected cultivation for vegetable production, evaluation and maintenance of vegetable germplasm, study on the local vegetable diversity, demonstration through vegetable germplasm, the release of heat-tolerant vegetable varieties and promote micro-irrigation schemes for vegetables.
- **NCOA-Yusipang has included nine major activities for 12th FY that includes:** evaluation of off-season vegetable production, evaluation of vegetable varieties and release high-yielding vegetable varieties, the release of climate-resilient vegetable varieties, promotion of protected cultivation for vegetables, promotion of commercial vegetable production., promotion of winter vegetable production, production of basic seeds, collection and evaluation of indigenous vegetable varieties and studying climate-resilient vegetable management technology.

#### **2.4. Analysis of the Research Plan and Implementation**

- The drive on vegetable research is diluted and lacks methodical arrangements of focused and need-based research.
- Target setting for commercial production in the research programs leading to loss of research focuses on technology generation.
- The main thrust of research so far has not progressed from the simpler adaptability trials.
- Basic research such as breeding is still dormant.

- Few production technology generation activities have taken up (mostly in the form of variety release and adaptation).
- Well planned, consolidated, and coordinated statistically designed trials are limited.
- Seed production and maintenance systems are limited.
- The term vegetables encompassed many crops (16 species of vegetables are listed as important). Currently, there is one Coordinator for this vast range of crops and crop-related works which has led to various issues
- Poor adoption of technology and poor technology dissemination

### **3. STRATEGIES FOR VEGETABLE RESEARCH AND DEVELOPMENT**

In obeisance to (1) the long-term vision of the MoAF which is to ensure that “all people living in Bhutan at all times have physical, economic and social access to safe and adequate nutritious food for a healthy and active life contributing to the realization of Gross National Happiness” and (2) the key objective of the DoA to achieve 100% vegetable self-sufficiency, the need for a clear strategy to contribute to the realization of the vision and objective of adequacy, accessibility and affordability have been greatly felt. In view of the slow technological uptake and inadequacy of technological innovation to enhance efficiency of agriculture production system in general, a definitive focus of aggressive innovation through research and dissemination is crucial. The strategy for vegetable research and development aims to generate appropriate knowledge, information, and technologies that address emerging challenges in vegetable production for self-sufficiency, nutrition security, rural income, and economy.

#### **The specific objectives of the strategy are:**

- 1 Streamline and strengthen the current research and development strategy on vegetable research and development.
- 2 Strengthen and fast track generation of technology, knowledge, and information for current needs and issues.
- 3 Provide a basis for the formulation of the research agenda and onwards planning that addresses emerging needs.
- 4 Promote and strengthen vegetable research collaboration with Research Centers, other relevant agencies, and outside Bhutan.
- 5 Ensure the research programs are demand-driven and responsive to emerging needs and challenges.
- 6 Ensure appropriate and timely information and technology dissemination.

#### **The following interrelated strategies on vegetable research and development shall be adopted:**

- Prioritization of high-demand crops for vegetable research.
- Prioritization of research agenda and areas.

- Undertake to breed
- Development of off-season vegetable production technologies.
- Evaluation of germplasm and varietal improvement
- Development of production systems and crops that provide resilience to changing climate and economic conditions.
- Undertake organic research and technologies.
- Expedite consolidated technology dissemination.
- Develop and apply information technology (IT/digitization) of vegetable research and development.
- Undertake realignment and coordination.

### **3.1.Prioritization of high demand crops for vegetable research**

#### **3.1.1. Scaling up production of chilli, tomato, and onions**

Very high year-round demand for chilli, tomato, and onions is established. Corresponding deficits of 1,124MT of chilli, 552MT of tomato, and 92MT of onion, which until recently were met through imports, are also established.

The MoAF, in cognizance of the above demand and supply situation, and to ensure adequacy, accessibility, and affordability, has accorded high priority to the production of chilli, tomatoes, and onions. The scaling up of the production shall be accompanied by year-round vegetable production technology generation, climate-smart and tested production technologies, and crop varieties.

Therefore, the four ARDCs shall:

- i. Conduct research and generate off-season production technology for year-round vegetable supply, climate-smart production technologies,
- ii. Carry out varietal improvement,
- iii. Collaborate with the relevant departments to address each stage in the value chain, and
- iv. Package the technologies and in collaboration with the extension carry out rigorous dissemination to the farmers.

### 3.1.2. Production research of other vegetables

The MoAF in ensuring that all people living in Bhutan have adequate nutritious food for a healthy and active life has listed 13 vegetables that are important to Bhutan. Production research on the import of banned vegetables such as chilli, cauliflower & beans will be emphasized. The focus will also be given to the export potential of vegetables such as asparagus, cabbage, carrot, and peas.

These 13 important vegetables have been grouped under eight categories, viz: 1) Leafy greens (spinach, lettuce, silverbeet, Mustard Greens, etc.); 2) Crucifers (cabbage, cauliflower, broccoli, brussels sprouts); 3) Cucurbits (pumpkins, cucumber, summer squash, gourds); 4) Roots (radish, carrot, potato, sweet potato, yam); 5) Allium (onion, garlic, shallot, chives); 6) Fruits (tomato, chilli, brinjal, lady’s finger); 7) Legumes (peas, beans) and 8) Edible plant stems celery, asparagus).

This grouping has been done to ensure systematic evaluation of the crops and production systems. Each ARDC, in addition to the three national priority crops, shall be mandated to coordinate and lead in conducting Research and Development in two groups of vegetables from the listed groups. ARDC can also conduct research in other vegetable groups with guidance from the lead or coordinating centers (Table 1).

**Table 1 Crop prioritization and groups assigned to ARDCs**

ARDCs	Priority crops	Assigned other group of vegetables
ARDC Bajo	Chilli	Brinjal, Lady finger Leguminous (peas, beans).
ARDC Samtelling	Winter Chilli	Cucurbits (Gourds-bitter gourd, bottle gourd, wild gourds) Pumpkins, Cucumber, Summer Squash, Squash) Leafy Greens (spinach, lettuce, silver beet, mustard greens etc
ARDC Wengkhar	Onion	Root type (Carrot, Radish, Sweet potato, Yam Tapioca, Beets, Turnip, etc.); Allium species; (Onion, Garlic, Shallot, Chives)
NCOA, Yusipang	Tomato	Cruciferous group (Cabbage, Cauliflower, Broccoli, Brussels sprouts) Edible stem plants (celery, asparagus, etc.)

## **3.2.Prioritization of research agenda and areas**

### **3.2.1. Breeding**

Although vegetable production has increased no deliberate effort of initiating a vegetable breeding program has been developed. Our dependency on the import of hybrids seeds has increased by many folds in recent years. The National Seed Centre imports more than 1,000 kgs of hybrid seed worth Nu.17-20 million annually. Varietal improvement through breeding and selection focusing on higher yields, quality, pests and diseases resistance/tolerance, and environmental stresses shall be initiated at the ARDCS. Given the limitation on technical human capacity and facilities in the country, the breeding program will focus on the mandatory crops comprising tomato, chilli, and onion for five years from 2023 to 2027. Each crop will be led by an ARDC with the suitable climatic condition for the crops.

The ARDCs, by the mandates, shall source parent materials for both local and improved open-pollinated materials that have good yield potential and other desirable characteristics. To shorten the long process of breeding, researchers shall take direct crossing and hybridization of pure lines.

Breeding of vegetables carried out in all the Research Centers, to start with tomato and chilli breeding should be initiated.

- **Sourcing of germplasm shall be made in the following ways:**

NCOA, Yusipang will coordinate the variety development and initiate breeding on tomatoes. Each ARDC shall share existing germplasm and available information on the tomato to NCOA Yusipang.

ARDC Wengkhar will coordinate onion variety development and breeding. ARDC Bajo will coordinate and facilitate a variety of development programs and breeding on chilli. ARDC Samtelling will lead on chilli breeding program for cold and heat, disease, and pest resistance traits.

**Table 1 Breeding responsibility**

<b>ARDCs</b>	<b>Major breeding agenda</b>
<b>ARDC Bajo</b>	Breeding (chilli- <i>capsicum annum</i> ) and variety development Maintenance of germplasm and gene poles of mandated crops for future breeding programs.
<b>ARDC Samtelling</b>	Breeding heat and cold tolerant, disease resistant (small chilli), and variety development Climate-resilient technology development Maintenance of germplasm and gene poles of mandated crops for future breeding programs
<b>ARDC Wengkhar</b>	Breeding (Onion) and variety development of onions Climate resilient technology development Maintenance of germplasm and gene poles of mandated crops for future breeding programs
<b>NCOA, Yusipang</b>	Breeding in Tomato and variety development of tomato Maintenance of germplasm and gene poles of mandated crops for future breeding programs

### 3.2.2. Off-season vegetable production technology

Off-season vegetable cultivation refers to the production of fresh vegetables outside of their typical cropping cycle, i.e., when supply is low, and prices are high. Focusing on off-season production technology shall be a major intervention to promote a year-round vegetable supply. The concept of off-season vegetable growing is new to our farmers and advocacy and training and knowledge dissemination shall be made.

Despite the varying agro-ecological zones and potential, people living in Bhutan at all times do not have adequate access to nutritious vegetables. The off-season production of fresh vegetables is therefore strategic in ensuring that all people living in Bhutan always have access to fresh vegetables.

It is, therefore, paramount to re-imagine the focus on the production of crop varieties and production technologies for (1) winter months such as cold-tolerant varieties, early varieties or late varieties, staggered cultivation, and protected cultivation technologies. (2) heat resistant varieties for summer hot climatic zones. In chilli, simple technology such as the practice to raise nurseries

by farmers in the high-altitude areas for cultivation in low-altitude farms is currently under evaluation. Technologies on off-season production need to be packed and disseminated.

Off-season vegetable technology, amongst others, include:

**1. Taking advantage of the prevailing, diverse agro-climatic conditions in Bhutan:** Bhutan is gifted with diverse agro-climatic conditions. In these varying agro-climatic conditions, the 13 vegetables can be cultivated and produced marketed during the on-and off-seasons. In southern Bhutan, it is feasible to cultivate almost all kinds of vegetables. These can be marketed to other areas in the west and temperate region, e.g., vegetables produced in Samtse, Chhukha could meet the demand in e.g., Thimphu, Paro Haa, northern Chhukha, Bumthang, Trongsa, during the winter months when there is scarce production in these locations.

A feasibility study on tapping the potentials of these different agro-ecological zones for vegetable production needs to be conducted. Mapping of these zones and production planning should be made. Yields from the production area should have a forecast system in place. Each ARDC with feasible crops and mandated crops should come up with the proposal. The activity can be conducted in collaboration with DAMC and FCBL.

**2. Choosing improved varieties:** The use of hybrids which produce early, medium, and late during the year is widely used in commercial off-season farming. The use of these varieties can supply vegetables year-round. Choosing the right variety for evaluation for off-season production should be undertaken by all the ARDCs.

**3. Adjusting planting time:** Vegetables can be transplanted or sown about two months early for early production than the normal season. Technology on planting time should be produced. A calendar of the practices should be prepared and disseminated.

**4. Making plastic tunnels, poly houses, and permanent glasshouses to provide a controlled environment:** The use of controlled conditions can produce crops early or late. Research on the technology shall be conducted and production practices shall be packaged and disseminated.

### **3.3.Evaluation of germplasm and varietal improvement**

#### **3.3.1. Evaluation of climate, pest, and disease resilient varieties**

Development of climate-resilient varieties such as cold and heat tolerant, pest and disease resistance need to be focused on.

The ARDCs will focus on germplasm collection and evaluation of climate-resilient tomato, chilli, and onion varieties.

- Procure/introduce seeds and a package of practices of composites from AVRDC gene banks and other seed companies/agencies.
- Perform evaluation trials of the composite seeds for 2-3 years.
- If found to be promising in the Research Centers, recommend the release of the seeds.
- Multiply a sufficient quantity of breeder's seeds for further multiplication by the NSC as well as maintenance of breeder's seeds at the Research Centers by the releasing Research Center.

#### **3.3.2. Varietal improvement of traditional varieties**

With the introduction of improved varieties and hybrids, vegetable production in the country has substantially increased over time. However, it is felt that the wealth of landraces/traditional varieties are gradually disappearing despite possessing rich crop genetic resources, both wild and domestic, in diverse ecosystems and agro-ecological zones of the country that has significance at regional and global levels. Traditional varieties or landraces are more genetically diverse than modern varieties and will serve as the sources of development of resilient crop varieties to cope with the negative impacts of climate change. Capitalizing on the available crop genetic resources, utilizing farmers' indigenous knowledge on these traditional varieties or landraces and backed up by modern scientific technologies can serve as natural insurance against the impending impacts of global climate change on agriculture and food security.

- Identification of potential indigenous vegetables.
- Collection of seeds of indigenous vegetables.

- Purification and selection of the best seeds of the cross-pollinated crops.
- Conduct research/explore stress-tolerant climate-resilient vegetables.
- Evaluation trial and propose for release if found potential.
- Proper documentation of the seeds of indigenous varieties.
- Maintenance of breeder's seeds (annually)
- Establishment of Seed Repository.
- Promotion of the selected seeds through appropriate management practices (follow organic practices).

### **3.4. Development of production systems**

Bhutan has been experiencing the impact of climate change with extreme weather patterns such as droughts, floods, rise in temperature, and precipitation affecting the production of vegetables.

Adaptation to the impacts of climate change through the development of climate-resilient crops and crop varieties and climate-smart technologies need to be undertaken. Research must assess the adaptation, yield, and quality of existing or new vegetable cultivars and allied crops identified as having market potential. Investigate future production variability and risk of crop failure using modeling approaches. Development of production systems and crops that provide resilience to changing climate and economic conditions are crucial.

The four ARDCs, when conducting research and development on the three national priority crops and the other crops listed in each of the eight categories, shall ensure to factor in the influences of climate change and develop climate-resilient technologies.

The emphasis, amongst others, shall be on the development of production systems that address the following areas:

#### **3.4.1. Water management**

Improved water use efficiency through precision farming methods, digitization, water conservation, and excess water harvesting shall be the key criteria. The ARDCs shall explore vegetable production technologies on efficient water management technologies, such as drip,

sprinklers, or other effective methods; develop improved crop and water management practices, like mulching with crop residues, plastic mulches, and explore potentials for excess water harvesting. Every research activity on the three national priority crops and/or the other crops in the eight categories shall include water management as one of the research areas.

**3.4.2. Improved nursery raising techniques and management of prioritized crops**

Initiate or refine and document research on the improved nursery raising techniques using different types of locally available media like leaf mold, organic manures and soil amendments, sand, and soil in different proportions. Best nursery production practices shall be studied, and practices shall be developed. Dissemination of the technology shall be made available to the end-users in the fastest possible time. Adaptive research and innovation on mechanized nursery raising and transplanting techniques will be explored for major vegetable species such as chilli, and onion initially.

**3.4.3. Management of crops under protected cultivation at different altitude**

Conduct research on the suitability of different protective structures like greenhouses, net houses, hothouses, shade houses, lath houses, etc. at different altitudes focusing on off-season production. ARDCs shall also explore and research low-cost poly houses, polytunnels, and rain shelters using locally available materials for local adaptation. ARDCs will also refine the existing production technologies on protected cultivation, develop a package of practice to farm situations. The management of smart irrigation technologies and temperature inside the protected cultivation structures are crucial.

**Table 2 Example of research areas**

SN	Activities	ARDCs
1	Comparative studies of different protected structure for tomato production	NCOA, Yusipang
2	Development of package of practice for tomato production under protected cultivation systems	NCOA, Yusipang

3	Off season (year-round vegetable) production under protected structure	ARDC Samtenling, Wengkhar and Yusipang	Bajo, and	ARDC ARDC NCOA
5	Development of package of practice for chilli production under protected cultivation systems	ARDC Samtenling	Bajo and	ARDC
6	Study of onion nursery production in protected structure and mechanization for commercial onion production	ARDC Wengkhar		

#### **3.4.4. Soil fertility improvement**

Explore research options on improved soil fertility management for various farming systems-integrated, conventional and organic for chilli, tomato, and onions. Production practices, crop rotation, and integrated farming with the use of legumes need to be explored. Package best option of crop rotation and soil fertility management for these crops.

#### **3.4.5. Plant protection**

Conduct research on the bio-pesticides and bio-control agents and other cultural practices and their efficacy for major pests and diseases of key crops in different cropping systems.

#### **Suggested research topics**

- Evaluation of blight resistant varieties of solanaceous crops (chilli and tomato).
- Evaluation of bio-fungicides for tomato and chilli blight control.
- Clubroot management of brassica.
- Improved nursery management technology on disease control

The major pests & diseases that have threatened vegetable development are clubroot for Cole crops, Fusarium wilt for tomato & chilli, Phytophthora blight in chilli, and fruit borer in Solanaceous vegetables. Therefore, major research efforts are needed to develop productive and sustainable IPM techniques for the aforementioned major pests and diseases. More research focus

is to be given in developing pest and disease resistant/tolerant varieties and the development of new biological control measures.

#### **3.4.6. Weed management**

Research on organic mulching techniques using the locally available mulch materials and their effectiveness should be adopted. In addition to mulching, the development of mechanical weeders should be given a priority to reduce labour, costs and to minimize the usage of weedicides.

#### **3.4.7. Organic research and technologies**

Organic agriculture provides a global promise of a future for which food and other farm products are produced in locally ecologically sound sustainable and fair manners. It provides an enabling agriculture system that provides resilience to climate and is the preferred land-use system in rural farming communities. Research on organic vegetable production should focus on the conservation of our landraces and their utilization and breeding for organic conditions. Each ARDC shall lead in variety development of indigenous and traditional varieties through collection, evaluation and selection process. Other priority areas include closing yield gaps through improved soil fertility management and plant protection while improving the resilience and stability of farms in organic farming.

### **3.5. Use of hybrids**

The National Seed Centre, Paro produces open-pollinated seeds of vegetables. These include vegetable seeds of peas, beans, beetroot, radish, mustard greens, lettuces, tomatoes, brinjal, chilli, cucumber, pumpkin, etc. However, the quantity produced doesn't meet the internal demand which is met through the imports of hybrid seeds.

#### **3.5.1. Fast-track evaluation of imported hybrid seeds**

Hybrid seeds being proven and bred for superior traits don't have to go through the usual and time-consuming process of varietal evaluation. This will only mean wasting our time on testing something which is already proven to be performing well. However, rapid testing for a season or two if necessary is recommended for hybrids for their adaptive ability and suitability in a particular

agro-ecology before recommending them to any grower. The procedure for fast-track evaluation is as follows:

- Any importing agency including the NSC should provide seed samples to the Research Center for initial evaluation. NCOA will facilitate the permit and distribute seeds for evaluation as per the mandate of the centers.
- The Research Center shall evaluate the hybrid seeds for one season or two to verify their suitability and potential, if necessary.
- Based on the performance of the seed, or if found suitable and potential, then the particular hybrid shall be recommended for release.

### **3.6. Development of hybrids**

Bhutan imports a substantial number and quantities of hybrids of various vegetable species. However as of now, there is not a single one that has been bred in country. Besides promoting our local varieties, it is equally important to develop a few high yielding and disease resistant hybrids of our own for species such as for tomato, chilli and onion. The respective mandated centres should initiate breeding studies and development of hybrids and target to develop at least one of each in the next five years.

### **3.7. Realignment and coordination of vegetable research and development**

#### **3.7.1. National coordination**

NCOA-Yusipang shall be responsible for the overall coordination and planning of research activities of the ARDCs about the national requirements. The National Vegetable Coordinator based at the NCOA, Yusipang shall be responsible to coordinate consultations with the Chiefs of the Department of Agriculture, DAOs, and the Program Directors of the ARDCs. This shall be executed during the Agriculture Research Coordination Meetings. Based on the outcome of the consultations, activities shall be planned and allotted to the ARDCS and Central agencies by ARED focal for vegetables

### **3.7.2. Regional coordination**

ARDCs shall be streamlined and realigned to conduct research on focused crops for strengthening research systems in the country by the organization of vegetable research.

#### **The objectives of streamlining are:**

- Streamline research on vegetables with existing human resources and improve on the collective efforts to enhance vegetable production and productivity thereby contributing to the emerging needs.
- Build up teamwork to bring the vegetable industry to the forefront of food security.
- Bring common understanding and formalization so that at the end of the day, Research Centers can focus and generate appropriate technologies.
- To set regional research coordination and agenda, keeping in the crops' priority for vegetable R&D given to the respective ARDCs in collaboration with their respective vegetable researchers and through RRPW and ARCM. Each ARDC has the mandate to coordinate and lead in conducting Research and Development in two groups of vegetables from the listed groups considering the agro-ecological suitability.

#### **The objectives for realigning coordination are:**

- To enhance the whole research process and inculcate a sense of ownership among each RDCs and researchers.
- Broaden researchers' expertise on specific crops thereby enabling professionalism in their career path.
- Build a team of professionals covering a wide range of vegetables in the long run.
- Ownership of the gene poles of the allocated vegetables.
- Terms of Reference of ARDCs for regional coordination mandates
- Overall authority over their designated vegetable groups in terms of research strategies, planning, and research coordination at the national level.
- Coordinate research and development among the RDCs for the assigned crop species following any farming systems.
- Maintain research and extension information in relation to their mandated crops.

- Establish and maintain regional and international linkages on their mandates.

### **3.7.3. Marketing and value-chain**

The Research and Development needs for marketing and value chain-based research will be proposed by the respective Departments through the Program Directors and Program Coordinators or through ARCM.

Based on the recommendations of the COVID lessons learned, some of the research needs that should be taken up for enhancing the marketing of vegetable produce are:

- Identification of proper markets for vegetable produce through market research and intelligence, relay market demand to producers, and establish a link between the market and growers.
- Initiate market-based programs on the mandatory crops with the community (Based on-demand information from the market) supported by ARDCs.
- These activities need to be taken up with the assistance of the DAMC

### **3.8.POSTHARVEST AND VALUE ADDITION**

Poor post-harvest and marketing practices (lack of grading, improper packing, in appropriate packaging materials, improper stacking) are common issues. The Research and Development needs for postharvest and value addition shall be proposed by the respective Departments through the Program Directors and Program Coordinators through ARCM. ARDCs will collaborate. Some suggested topics are;

- a. Explore crop harvesting technologies,
- b. Improve grading, packaging, transportation, and marketing,
- c. Enhance the role of vendors, youth, and farmer groups in marketing,
- d. Introduce low-cost cool chambers in different locations for storage,
- e. Enhance value addition through inter alia up-scaling of preservation, drying, and pickling techniques and processing (NPHC),

- f. Explore and research post-harvest handling, processing, value addition, and packaging,
- g. Conduct market research on availability, pricing, and marketing mechanisms for the domestic market.

### **3.9.IMPROVING THE QUALITY OF SEED PRODUCTION**

The issue of poor quality of seeds and their unavailability on time has been a major constraint faced by the farmers. Therefore, there is a need to carry out extensive research and development on seed production.

#### **3.9.1. Seed production, maintenance, and technologies**

The National Seed Centre shall develop guidelines/packages of practices on seed production of vegetables. NSC will also focus on dissemination of technologies on seed production to the farmers, registered seed growers, and other NGOs or private entrepreneurs while the ARDCs will maintain breeders seed of the released varieties (categorized by name of the crops).

In addition, review of all germplasm with ARDCs shall be made. Prioritized and put them under systematic evaluation systems if necessary.

#### **3.10. HYDROPONIC RESEARCH**

In order to come up with various options to make farming attractive and efficient particularly for the youth and urban dwellers, farming methods such as hydroponics need to be studied and adapted to suit our own needs. NCOA, Yusipang shall lead and coordinate overall research on hydroponics in close collaboration with other centers. The prioritized tomato and chilli crops will be tried under hydroponics by all ARDCs and come up with appropriate production technologies for adoption by farmers. The national Hydroponics research strategy will need to be referred to while working on production under hydroponics

#### **3.11. CAPACITY DEVELOPMENT**

Research capacity development is felt to be of utmost importance. Researchers shall be oriented to build research capacity and shall focus on:

- Research methodologies, field experiments, data collection standards and methods, analysis and interpretation, software usage, report and paper writings and proposals, and protocols preparations.
- Capacity development of researchers on technology development such as breeding and variety development and production technology shall be given priority.

### **3.12. TECHNOLOGY DISSEMINATION**

The research and development front has often been criticized for poor technology availability and adoption when it comes to the farmer's field. ARDCs shall initiate a process of vegetable production technology dissemination through field demonstrations and information technology (IT/digitization). Each ARDC shall be responsible to develop information and package of practices on their mandated crops.

### **3.13. INTERNATIONAL LINKAGES**

The coordinating center, NCOA will explore international linkages with allied international research centers for future research and collaborations. World Vegetable Centre (WVC), Asian Vegetable Research and Development Centre (AVRDC), SAARC SAC, and ICAR-Indian Institution of Vegetable Research and another allied research institute. The coordinating center will further deliberate to other ARDCs with the mandated crops for further collaboration.

## **4. CONCLUSION**

With this strategy in place, it is expected that the research and development on vegetables in Bhutan will be streamlined. Crop development and promotion through focused research and intervention outcomes to benefit our farming community is achieved. Vegetable farming is gender-friendly and is expected to benefit women farmers while increasing household income. It is expected to boost commercial farming in our drive and contribution to vegetable self-sufficiency. It is also expected to attract farming to the youth and address unemployment. The technology development and adaptation against the impacts of climate change on farming will benefit the rural community ensuring food security, nutrition, and income in the long run

**Published by:**

**Department of Agriculture  
Ministry of Agriculture & Forests**

**Thimphu: Bhutan**

**Tel# 02-322228/331316/336462/336186(F)**

**[www.doa.gov.bt](http://www.doa.gov.bt)**