DEPARTMENT OF AGRICULTURE
Ministry of Agriculture and Forests

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ROYAL GOVERNMENT OF BHUTAN

Agriculture Research and Development Highlights 2017-2018

October 2018

Department of Agriculture
Ministry of Agriculture and Forests
Thimphu, Bhutan

FOREWORD

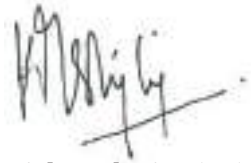
The Department of Agriculture is pleased to bring out its "Annual Research and Development Highlights" for the fiscal year 2017-18. This annual publication is a concise summary of all major achievements made in research and development by Agriculture Research and Development Centres (ARDCs), Central Programs, Commodity Programs and Support Services within the Department. It is an attempt to document the Department's progress highlight for the reporting year while also addressing the challenges in pursuit of crop research and production, service delivery, infrastructure establishment and capacity building.

We have put in effort to collect reports from all agencies within the Department of Agriculture, collate the information, analyse and synthesize them into an abridged version that succinctly presents the progress for the past one year. The highlights are aggregated into different groups of approved programs, and therefore relay the cumulative figure of all major achievements by agencies within the Department for the year.

Minor modification in the reporting format has been made to continuously improve on the presentation. This also allows for readers to browse through separate sections of interests to get a definitive overview of achievements thereof. However, readers are encouraged to refer to annual reports of individual agencies for an exhaustive coverage.

I commend the Agriculture Research & Extension Division (ARED) and the editor for their diligence in meticulously going through every single report to analyse and blend them into a single summary for the Department.

With best regards,



Kinlay Tshering (Ms)
DIRECTOR

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SUMMARY

- ✓ The production of major staple crops again saw an increase in 2017 as compared against 2016. Except for buckwheat and some legumes, production of oil seeds also saw an increase in the production as well as harvestable area in 2017.

- ✓ The Department continued its efforts in minimizing vegetable imports through its commercialization programs. Winter chili production program, for instance, was implemented in 56 geogs of 8 dzongkhags, on a staggered production system. The overall vegetables production in 2017 increased (in terms of area as well), with chilli production recorded at 13,606 MT - a commendable increase and almost the double of the production in 2015.

- ✓ Production of cole crops like cabbage and cauliflower were substantial and showed significant increase (above 55%) from the year before. Most fruit crops showed a significant increase in production with apple, mandarin, guava, litchi and passion fruit marking considerable increase in production compared to 2016.

- ✓ The Department introduced quinoa, a popular nutrient dense cereal and its production is picking up with 70 acres under cultivation and a production of 9 Tonne in 2017. A significant highlight is the release of four quinoa based on research results over the years. The four varieties endorsed for release are 1) Ashi Heychum-AM (Amarilla Marangani) 2) Ashi Heychum-AS (Amarilla Saccaca) 3) Ashi Heychum-123 (Ivory 123) and 4) Ashi Heychum- TW (DoA-1- PMB- 2015).

- ✓ As part of its continued effort into research and technology development, the Department of Agriculture released two high altitude rice varieties (Yusiray Kathramathra and YusirayKaap 3) recommended for high altitude areas above 1800 masl, and Samtenling Sokha Ray 1, a short duration rice variety for spring cultivation including a finger millet variety Samtenling Membja1.

- ✓ Building up on its efforts from previous years in putting in place an assurance system for local organic products, the Department launched eight local organic assurance system (LOAS) certified products to help organic growers attract premium value for their produce.

- ✓ The Department's School Agriculture Program (SAP) presently supports 315 schools, contributing 23% of fresh vegetables and over 50% of livestock produce to the school feeding program. In the academic year 2017 alone 280 member schools produced a total of 197 MT of fresh green vegetables and potatoes while 24 schools that ran poultry programs produced a total of 15, 00,000 eggs that not only contributed to the school feeding program but also generated substaintatial fund. 82 schools with piggery programe produced 77 MT of pork.

- ✓ Construction and maintenance of farm roads remain a priority and a total of 466.31 km of new farm roads have been constructed and 728.13 km of existing farm roads were maintained using the Department's farm machinery stationed at various locations across the country. The Department also supported the development and rehabilitation of 498 acres of terraced land.

- ✓ Unavailability of irrigation water is a recurring constraint for agricultural development. The Engineering Division, in addition to technical backstopping completed 14 new irrigation systems and rehabilitated 15 existing ones translating to around 180 kms of channels/pipeline covering 5,453 households.

- ✓ Land development and management is an important initiative and the National Soil Service Centre (NSSC) successfully brought around 173 acres of land under several sustainable land management and stabilization interventions.

- ✓ Placing added emphasis on the primary importance of uniformity, safety, and validation, the Department finalized the Bhutan Organic Standards (BOS) and seedling standards for citrus including testing and development of standards for nine farm machineries.

- ✓ Several publications were brought out in the reporting period that include evaluation guidelines for field and horticultural crops, cultivation manual for select crops and inventory of released and de-notified crops in the country. The Department also launched the first issue of the Bhutan Journal of Agriculture (BJA) to help promote a vibrant culture of research and scientific communication amongst its employees as well as relay research findings to a larger audience.

1 CROP PRODUCTION HIGHLIGHTS

The production of major staple crops again saw an increase in 2017 as compared against 2016, which in turn also recorded an increase on the previous year (2015). Except for buckwheat and some legumes, the production of oil seeds saw an increase in the production as well as harvestable area in 2017 (See Figure 1 & Figure 2). Cardamom and ginger production decreased in 2017 in contrast to the drastic increase it showed in 2016 over the previous year (2015). The Department introduced quinoa, a popular nutrient dense cereal and its production is picking up with 70 acres under cultivation and a production of 9 MT in 2017.

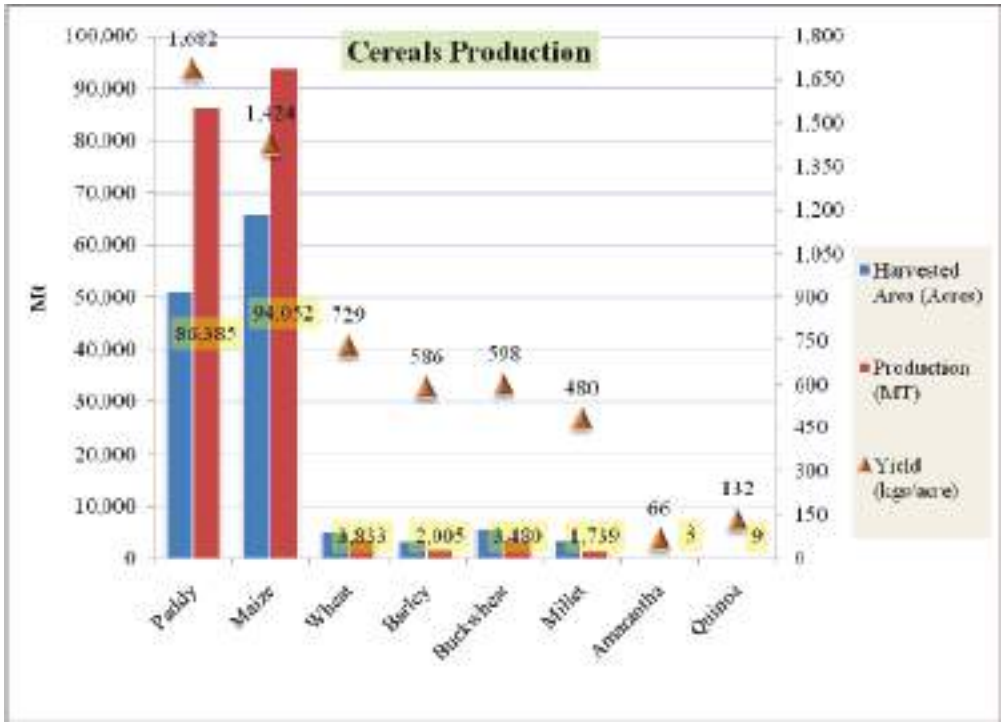

Figure 1. Harvested area and production of major cereals for 2017

The overall vegetables production also increased in terms of area and production, with chilli production recorded at 13,606 MT which is a commendable increase, and almost the double of the production in 2015. Production of cole crops like cabbage and cauliflower were substantial and showed significant increase (above 55%) the year before (See Figure 2). Asparagus, however, took a dip in production as well as in area under cultivation. Although it marked a huge increase in 2016, total potato production at 57,223 MT for 2017 recorded a slight slump (3%) as against 2016.

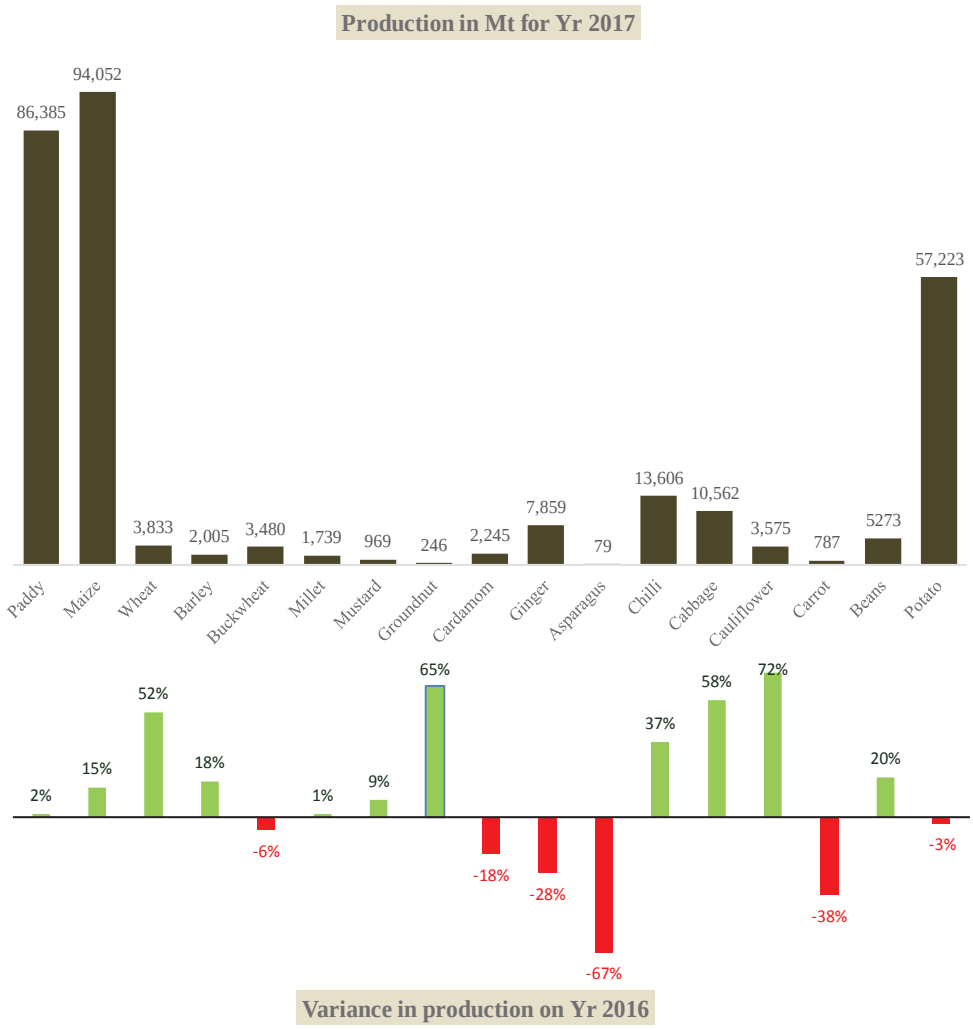

Figure 2 Variance in production of major crops in 2017 on that of 2016

Most fruit crops showed a significant increase in production (See Table 2 Fruit production **(2017)**. Apple, mandarin, guava, litchi and passion fruit (marked**) recorded considerable increase in production compared to 2016.

Table 1 Harvested area, production & yield of major vegetables in 2016 and 2017

Crop	Harvested Area (acres)		Production (MT)		Yield (Kg/acre)	
	2016	2017	2016	2017	2016	2017
Asparagus	417	201	239	79	574	392
Chilli	5,538	7,571	9907	13,606	1789	1,797
Cabbage	2,738	3,551	6685	10,562	2442	2,974
Cauliflower	1,512	1,604	2082	3,575	1377	2,229
Carrot	607	529	1276	787	2103	1,487
Radish	2,871	3,533	6490	6,307	2261	1,785
Turnip	1,603	1,804	10499	13,051	6651	7,236
Beans	3,385	3,739	4409	5,273	1302	1,410
Green Peas	795	1,003	1014	859	1275	856
Tomato	347	320	455	383	1310	1,198
Broccoli	725	1,056	1004	1,371	1385	1,298
Eggplant	408	751	585	643	1433	857
Green leaves	1,458	3,492	1937	4,153	1328	1,189
Onion Bulb	442	594	414	489	935	824
Garlic	1,409	1,441	1176	708	935	491
Potato	14,638	12,824	58820	57,223	4018	4462

Table 2 Fruit production (2017)

Commodities	Total Trees (Nos)	Bearing Trees (Nos)	Production (MT)	Yield (kg/bearing tree)
Apple	321,928	258,215	8,039**	31
Mandarin	1,539,076	864,608	28,017**	32
Areca nut	1,678,321	895,579	9,342	10
Mango	38,311	17,273	530	31
Pear	35,141	24,423	1,510**	62
Peach	32,472	25,865	1,124**	43
Plum	11,735	9,571	482	50
Walnut	16,042	10,646	239	22
Jackfruit	4,297	3,088	528	171
Guava	44,694	36,189	1,084**	30
Papaya	9,949	7,853	278	35
Pomegranate	6,019	4,500	74	16
Litchi	44,076	10,456	313**	30
Persimmon	5,632	4,305	152	35
Banana	458,651	161,000	3,113	19
Date Plum (Gendum)	1,177	1,128	23	20
Avocado	4,219	1,455	43	30
Apricot	1,502	360	8	23
Passion Fruit			94**	
Pine Apple			72	
Total			**54,656**	

2 RESEARCH HIGHLIGHTS

2.1 Field Crops

2.1.1 Rice

High altitude rice

Six varieties of high altitude rice were evaluated for yield, blast and cold tolerance at Tsento geog (Paro) on a 2.84 acre leased land (2600 masl) where the research site was relocated to following the Ministry's directives to hand over the green area development site to Farm Machinery Corporation Limited. Research on these high altitude Japanese rice varieties also include advanced evaluation trial and maintenance breeding of released and pipeline varieties.

Two high altitude rice varieties were proposed and endorsed for release by the 20th Varietal Release Committee (VRC). PP4-38-4 was released as Yusiray Kathramathra and YPS-7 or China-7 as Yusiray Kaap 3. Both varieties are recommended for high altitude areas above 1800 masl of Paro, Thimphu, Chukha, Punakha, Wangdi, Trongsa, Dagana, Tsirang, Lhunetse, Trashigang and Trashiyangtse dzongkhags.

Spring Rice

Evaluation of short duration rice varieties under spring condition is an ongoing activity both in the south and in the east. This has culminated in the release of BRRI28 from Bangladesh as Samtenling Sokha Ray1. A low altitude paddy variety IR20913 (ARDSC Lingmethang) has also been found to be very promising with a yield of 3.30 MT/acre. These two varieties were the most preferred in terms of their ease in threshing, grain fill, short plant height and early maturity.

Phenotypic characterization of traditional rice varieties

192 accessions of local rice varieties from the National Gene Bank were phenotypically characterized on station (at ARDSC Tsirang) in collaboration with National Biodiversity Centre (NBC) on station.

Different agronomic traits were collected as per international protocols and submitted to the NBC for analysis. These include leaf blade pubescence, leaf sheath colour, flag leaf angle, ligule colour, ligule type, culm habit, plant height, days to maturity, panicle length and number of grains per panicle.

On-farm evaluation of new advanced rice lines (production evaluation trial)?

As wider adaptability is often important for new varieties to succeed, on-farm evaluation was organized in two sites in Tsirang - Sunkosh (600 masl) and Zomlingzor (750 masl) to evaluate four advanced four lines (CB08514, IR09A220, IR05A235 and SAHABAGI) for yield potential, maturity, and other desirable agronomic traits.

The lines were entirely raised under farmers' agronomic management conditions from nursery till maturity. Field day was organized at harvest to jointly assess yield potential of the new lines and gather farmers' feedback (See Table 3).

Table 3 Performance of rice lines in different sites

	Sunkosh		Zomlingzor	
Variety	Plant height (cm)	Yield (t/ha)	Plant height (cm)	Yield (t/ha)
CB08514	89	3	90	2.45
IR-05A235	86	2.9	85	2.30
Shabagi	87	2.6	87	3.60
IR09A220	85	2.5	90	3.79
Locals Attey	110	2.4	160	3.10

Research into Rice Farming & Labour

Direct seeding as an alternative to mitigating farm labour constraint is being assessed and drum seeding has shown a significantly low requirement of labour as against conventional methods. No significant yield differences were observed. Rehabilitation and conservation of six popular high-altitude rice varieties have also been initiated in collaboration with NBC through the custodian farmer approach.

Initial Evaluation of Elite Lines under Rain-fed Conditions

Genotypic differences in elite rice lines under rain-fed or limited water conditions were studied in on-station in Tsirang. A total of 5 lines including a standard check were evaluated in 2017-2018 season where nursery raising, transplanting and other crop management practices followed standard packages recommended for the location. None of the lines suffered from any pests' incidence. Crop cut at maturity indicated the potential of two new lines compared to others (Table 4). The selected lines will be further evaluated for performance.

Table 4 Agronomic traits of new rice lines

Line	Plant height (cm)	Leaf blade (cm)	Panicle length (cm)	Days to maturity	Grain Yield (Mt/ha)
Shahagi	75	41	25	157	3.07
IR05A235	72	42	19	170	3.05
IR09A220	40	39	21	150	3.70
CB08514	73	40	25	150	3.20
Attay (check)	110	37	25	180	3.10

2.1.2 Maize

Evaluation of Heat Tolerant Maize for Asia (HTMA) lines

A total of 153 maize lines are being evaluated under Bhutanese condition to prepare against possible heat stress on maize crop in the future. This research is part of the Heat Tolerant Maize for Asia (HTMA) project of which Bhutan became a member 5 years ago. As a result of these multi-location trials carried out across the country, 30 promising climate resilient lines are under evaluation at ARDSC Lingmethang from which five best lines will be identified for further seed production for distribution as climate resilient hybrid lines within the country.

Crop Intensification through Hybrid Maize Promotion

The spring maize program was first initiated in 2015 as a part of cropping system intensification. The program focused especially in rice-fallow system, which brought immense benefits to farmers and owing to the higher productivity of hybrid maize; farmers have shown increased interest in hybrid technology over the years. However, the supply of free seeds every year raises the issue of sustainability and thus from 2016 season the seeds were supplied on 50:50 cost sharing. A total of 1000 acre was covered with supply of 15 MT hybrid maize seed through National Maize Program. The seeds were supplied to six dzongkhgs of Sarpang, Mongar, Dagana, Trashigang, Tashiyangtse and Zhemgang benefiting over 1671 households.

2.1.3 Quinoa

Quinoa cultivation is slowly picking up amongst Bhutanese farmers. The DoA aims to upscale quinoa cultivation to enhance household food and nutritional security as well as diversify farmers' cropping systems to adapt this versatile climate resilient crop. The consolidated total 12th FYP target for quinoa is 630 acres with an expected production of 310.50 MT.

Production Observation Trial

12 Quinoa varieties were evaluated in a replicated trial. Observation trials were established at Paro and Yusipang to assess quinoa cultivation after potato crop in high altitude areas. The crop was successfully harvested although at lower yields as compared to spring crop. More of such trials will be conducted to establish the feasibility of growing quinoa after potato harvest in high altitude areas.

Table 5 Agronomic performance of Quinoa varieties on-station

Sl No	Variety	% germination	Plant height (cm)	Grain yield kg/acre	Days to maturity
1.	Amarilla Marangani	100 %	103.60	300	110
2.	Blanca de Junin	100 %	102.00	375	115
3.	INIA 415 Pasankalla	100 %	97.20	850	105

4.	INIA 427 Amarilla Sacaca	100 %	130.00	675	114
5.	Huancayo	100 %	107.80	650	118
6.	Hualhuas	100 %	117.00	500	115
7.	Salcedo INIA	100 %	97.40	500	119
8.	INIA 420 Negra Collana	100 %	74.00	400	115
9.	DoA-1-PMB-2015	100 %	105.00	875	105
10.	Quinoa Ivory 123	100 %	87.00	425	105

A significant highlight on quinoa research for the past year include the release of four varieties through the Variety Release Committee of the Department of Agriculture based on the results of multi-location trials over the years in Paro, Yusipang, Gasa, Wangdue, Dagana and Tsirang. The four varieties endorsed for release are 1) Ashi Heychum-AM (Amarilla Marangani) 2) Ashi Heychum-AS (Amarilla Saccaca) 3) Ashi Heychum-123 (Ivory 123) and 4) AshiHeychum- TW (DoA-1- PMB- 2015).

2.1.4 Oilseeds

The Department of Agriculture aims to increase oilseeds production from 1332 MT to 2000 MT by the end of the plan period. The current total production stands at 1536 MT and there are numerous challenges. Some of the highlights in oil seeds research include:

a) Nationally coordinated trial on the evaluation of new mustard varieties at ARDCs Bajo and Samtenling, and ARDSCs Khangma and Tsirang. Results under Samtenling conditions show Bari Sharisha 14 and 15 varieties have higher yield and healthy crop stand followed by Pragatti.

b) Staggered sowing trial at Dawakha to determine precise sowing time of improved varieties.

c) Maintenance breeding of the released varieties of mustard and HYV of sunflower.

2.1.5 Legumes & Other cereals

Finger Millet Research

Comparative studies on two promising finger millet varieties in Samtenling showed variety GPU48 providing a yield of 1950kg /ha as against 1900kg/ha by variety of HR911. On farm trials on these will follow next year. GPU48, a variety from India has been under evaluation for the last six years and was endorsed for release by the Department this year as Samtenling Memja1.

Characterization of Other Cereal Germplasm

Germplasm collection and characterization of 5 locally available other cereals (Mudhey- amaranthus, Yungkaar- mustard, Raan- foxtail millet, Kongpo- finger millet, Brathma- bitter buckwheat) were carried out at ARDSC Panbang. The evaluation assessed their performance in yield, resistance to pests and disease, and other agronomic traits. These cereals showed impressive performance with almost no pest and disease incidence except for mild appearance of aphids. Seeds are being maintained at the sub-centre.

2.2 Horticultural Crops

2.2.1 Vegetables

Evaluation of Heat Tolerant Varieties

Cabbage and cauliflower varieties grown in the country today are conventional ones that prefer cool season, and do not tolerate high temperature. There is a need to research into heat tolerant varieties in response to rising temperature and demand for year-round consumption. Evaluation of heat tolerant varieties is one of the adaptation strategies. Hence, production evaluation of heat tolerant varieties of cabbage (2 varieties) and cauliflower (2 varieties) during peak summer are being undertaken in ARDC-Wengkhar.

Evaluation of Cold tolerant Chilli Varieties

Chilli is a very important vegetable that make up an integral part of Bhutanese cuisine. Chilli in general is a warm season crop, usually coming into the market between April and October. However, the demand for chilli is year-round, with a spike in demand in the lean season months of December to March. Huge quantities are imported from India at this time of the year. In order to look into potential varieties that can thrive during winter season 14 chilli varieties are being evaluated.

Evaluation of Short Duration Radish Varieties

Radish is an important crop and a good source of income for farmers. It is less perishable, easy to grow and can be produced in large quantities. It is a cold season crop that takes at least two months to mature. There is huge market potential to export to India when prevailing weather conditions are too hot for radish. Therefore, there is a demand for short duration varieties that can be grown under warm season. ARDC-Wengkhar evaluated two radish varieties - Hybrid 35 and OP 45 – during both cool and warm season and found that both the varieties can be produced during warm season. Cool season production failed due to bolting at very early stage.

Germplasm Maintenance of Indigenous Vegetables

34 varieties of indigenous vegetables have been collected and are being maintained at the research centre in Yusipang.

1. Radish: RatoMula
2. Pumpkin: RangthangKakur
3. Pumpkin: Lawshar(Green Small)
4. Pumpkin: Pheykakur
5. Pumpkin: Sherpa Anjam
6. Brinjal: Dolom (L/K/T/10)
7. Brinjal: Dolom (L/M/T/34)
8. Dolom: L/K/P/16
9. Radish: CharoKarpola
10. Radish: Nyontsho
11. Radish: L/K/P/15
12. Sag: YungmangMarpo
13. Sag: NgontshoKarpo
14. Cucumber: AAAgom
15. Cucumber: DorjiLingpa
16. Cucumber: Angkong
17. Cucumber: Sherpa Gagun
18. Cucumber Kawan
19. Beans: BrokpalingShepai
20. Beans: MukaShepai
21. Beans: Black Orae
22. Beans: KaloBori
23. Beans: ChakharpaShayben
24. Beans: Brokpolaorae
25. Beans: PatangOrae
26. Beans: Danganey
27. Beans: GewBori
28. Beans: KengkharpaShepai
29. Beans: White local
30. Chilli: Yangtsepa Round
31. Chilli: Khasadrapchu local
32. Chilli: Orong Solo
33. Chilli: DukpaEma
34. Coriander: Yesee local

Some of them are being used for seed production and some indigenous varieties were sown as fall crop for performance evaluating.

Fast Track Evaluation of new Hybrid Vegetables

As required ARDC-Yusipang carried out fast track evaluation of six hybrid vegetables received from Japan.

a) Hybrid Radish: T1-092
b) Hybrid Carrot: Vermillion
c) Hybrid Turnip: Purple Prince
d) Hybrid Tomato: Cosmic
e) Hybrid Onion: Red star
f) Hybrid Cauliflower: KSB-12196

All the varieties performed exceptionally well in terms of yield except for cauliflower which produced small and non-compact heads. Curds were of non self-blanching type, and therefore not preferable.

Poly-house Use Survey

A survey was conducted in Thimphu and Paro to find out how effectively poly-houses were being utilized by the farmers. In total, 121 households were interviewed, and 133 green houses were inspected. Some of the findings are as follow:

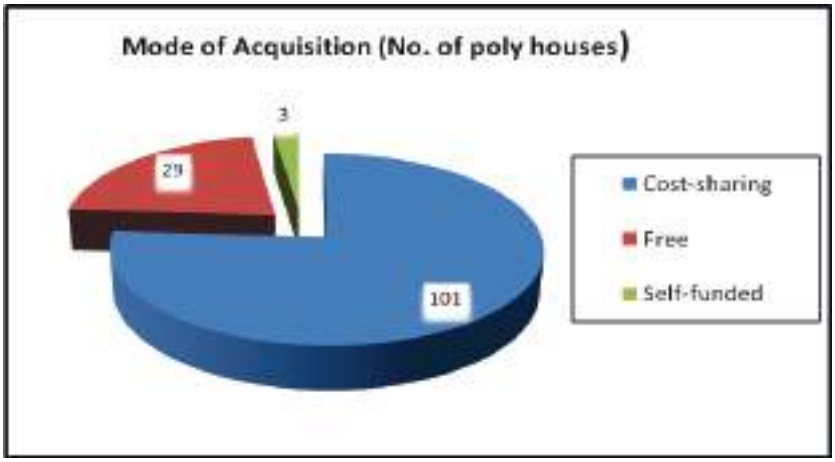

Figure 3 Mode of acquisition of poly houses

Out of the 133 poly houses surveyed, 33 were large size (5mx20m) and 100 were medium size (5mx10m). In terms of mode of acquisition, 101 nos. were acquired through cost-sharing basis, 29 nos. were acquired on free of cost and 3 nos. were acquired through self funding.

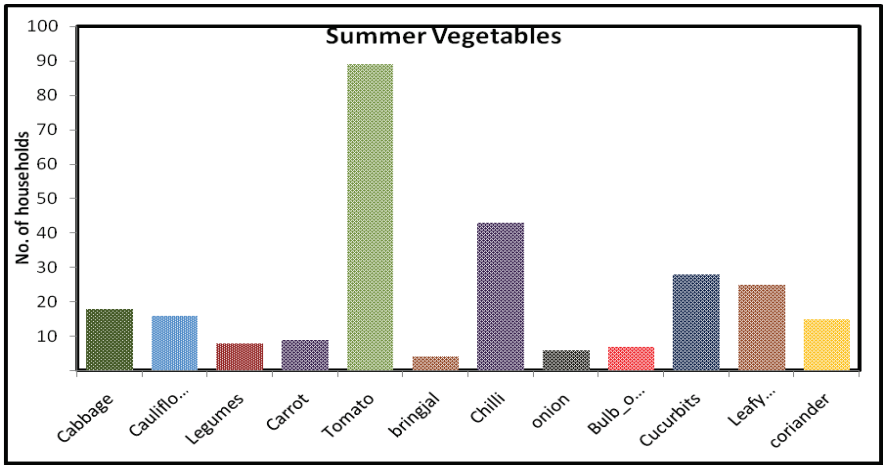

Figure 4 Summer vegetables in poly houses

Around 12 types of assorted vegetables are grown in the poly houses in summer. Although households grew different vegetables in winter, poly houses were mostly used for leafy vegetables, coriander and for raising cole crops seedlings (Figure 5).

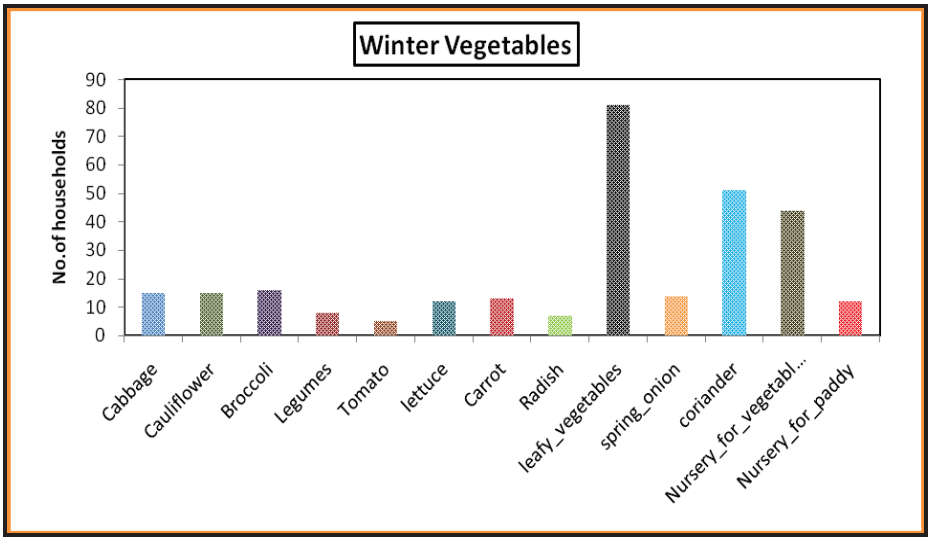

Figure 5 Winter vegetables in poly houses

Despite all the positive benefits, respondents also expressed certain constraints in using poly houses like requirement for frequent irrigation, lack of knowledge on use and management of poly houses, water shortage and farm labour, and extreme heat in summer.

2.2.2 Potato

Evaluation of New Clones

In continuation with its earlier initiatives the National Potato program evaluated new climate resilient CIP potato varieties (clones) in different agro-ecological zones in Yusipang, Khangma, Phobjikha and Bumthang. Presently, there are 20 new clones in under greenhouse being multiplied from micro-tubers in addition to 45 new clones/ varieties on evaluation trials in various agro climatic zones.

Table 6 Micro-tubers in greenhouse (Yusipang) planted out from tissue culture

S/L	CIN (Clone Identification No)	S/L	CIN (Clone Identification No)
1	Clone No:309103.85	11	Clone No: 398180.292
2	Clone No:309028.56	12	Clone No: 309074.129
3	Clone No: 309017.101	13	Clone No: 398180.289
4	Clone No: 309003.11	14	Clone No: 309077.116
5	Clone no: 398098.203	15	Clone No: 309036.2
6	Clone no: 398208.219	16	Clone No: 309041.1
7	Clone No: 398190.605	17	Clone No: 398192.592

8	Clone No: 309087.23	18	Clone No: 304079.1O
9	Clone No: 398192.213	19	Clone No: 302535.3
10	Clone No: 309121.6	20	Clone No: 598192.553

New Released Potato Varieties

The National Potato Program, in keeping with the decisions of the annual review and planning meeting established demonstration-cum-trials in 22 locations covering the entire potato growing regions in the country. The plots, established in collaboration with respective dzongkhag agriculture sectors, aimed to assess farmer preference, seed quality, and yield potential, and also to disseminate emerging technologies in order to help increase production.

Amongst the three varieties, the demonstration trial observed that Desiree yielded the least due to late blight attack and deterioration in seed quality. Yusi Maap was the most preferred by farmers due to its red skin, higher yield, and moderate resistance to late blight. Nesaphey Kaawa Kaap is found highly resistant to late blight. These results indicate the importance and the potential measures required to sustain farmers' livelihood through higher yields and better income generation.

Table 7 Seeds distributed for demonstrations-cum-trials & seed multiplications (2017-18)

Sl	dzongkhags	Geog	Quantity (kg)		
			Yusimaap	NKK	
1	22 locations	13 dzongkhags	1100	1100	Demonstration & Trials
2	NSC Phobjikha	Phobjikha	1000	400	Seed Multiplication
3	NSC Nesaphey farm	Bumthang	1000	200	
4	RDC Yusipang (Demonstration)		200	100	
5	NPP, Potato Farm	Bumthang	1000	300	
6	Potato Farm	Phobjikha	63	20	
7	Chhukha	Chapcha Farmers group	300	50	
8	Thimphu	Hongtsho	300	100	
9	RDC Khangma	kanglung	600	0	
10	Paro	Nagu	400	0	
The total seed distributed			**5963**	**2270**	

2.2.3 Fruits and Nuts

Pear Varieties Released

Two new Asian pear varieties (Nitaka and Hakuri) were released based on their performance against local check varieties (Hosui, Shinko and Chojuro) in trials established under the farmers' field management conditions in Dawakha (Paro**).**

Evaluation of Passion Fruit Varieties

Two passion fruit types are grown in the country. The popular Purple type is cultivated between elevation range of 900 and 2000 masl while the Yellow type, which is bigger

in size and high in acidity, is found below 1000 masl. Passion fruit is one of the easiest fruit crops to cultivate with huge potential both in terms of consumption as fresh fruits and for processing. However, there are no commercial varieties in the country.

Two new potential varieties were introduced into the country and tested for performance. They are larger than the local cultivar, very attractive in colour, have significantly higher TSS and pulp weight which are essential quality for processing. These two varieties can be used for both table and processing purposes.

Evaluation of Apple Varieties

Adaptive trials were initiated to evaluate two varieties of apples (Miyabi Fuji and Kohkoh grafted on Maruba rootstock) introduced from Japan through the JICA JPP grass root project in ARDC-Yusipang. Likewise, on-farm trials have been established in target dzongkhags of Thimphu, Paro and Haa in March, 2018.

Figure 6 Miyabi Fuji & Kohkoh apple trials in Paro

Evaluation of Litchi Varieties

Of the four litchi varieties introduced from Thailand, Hong Houy and Sampao Kaew performed the best and are being further evaluated for potential release approval in the next sitting of the VRC.

Evaluation of Mango Varieties

Four varieties of mango: Chinwang, Tommy Atkin and Irwin were introduced in the year 2008. Their performance in the southern belt in terms of adaptation to wet to humid sub-tropical conditions (150m –1200m) is found to be very promising. They are suitable for growing in Samtse, Sarpang, and lower belt of Zhemgang, and will be submitted for release in the next VRC meeting.

2.2.4 Citrus

Evaluation of Citrus Varieties for Processing

Almost all citrus varieties in Bhutan are table-purpose. Given the potential avenues in processing, the ACIAR funded Citrus Project – Adapting Integrated Crop Management technologies to commercial citrus enterprises in Bhutan and Australia - introduced 17 varieties from Australia in 2013. Six of these were successfully propagated and started bearing fruits in 2016 (Table 8). Quality analysis began a year thereafter. Quality parameters of the 6 varieties were comparable to the control variety (Astani Junar). Interestingly, the test varieties were observed to be seedless except Etna (A7) which appears to be seeded but with lower seed content. Subsequent evaluations are ongoing.

Table 8 List of PAVs introduced from Australia

No.	Common name	Scientific name	Variety	Use (purpose)	Status (no. of plants)	
					NCR	W/khar
1	Navel Orange	*C. sinensis*	Cara Cara	Table	25	5
2	Navel Orange	*C. sinensis*	Ryan	Table	23	2
3	Common orange	*C. sinensis*	McMahon Valencia	Table & juice	26	2
4	Common orange	*C. sinensis*	Salustiana	Juice and table	25	2
5	Pigmented orange	*C. sinensis*	TaroccoIppolito	Juice and table	26	4
6	Common mandarin	*C. reticulata*	Amigo	Table	23	2
7	Clementine mandarin	*C. reticulata*	Caffin	Table	24	2
8	Pigmented grapefruit	*C. paradisi*	Cant Star Ruby	Table	21	2
9	Citron	*C. medica*	Buddha's Hand	Ornamental	2	2
10	Common mandarin	*C. reticulata*	Afourer	Table	21	16
11	Common orange	*C. sinensis*	Pera Limeira	Juice only	5	4
12	Sweet orange	*C. sinensis*	Berri Valencia	Juice & table	5	3
13	Common orange	*C. sinensis*	Parson Brown	Juice	5	3
14	Common orange	*C. sinensis*	Natal	Juice	5	4
15	Common orange	*C. sinensis*	Hamlin	Juice	5	4
16	Sweet orange	*C. sinensis*	Keenan Valencia	Juice and table	5	3
17	Sweet orange	*C. sinensis*	Benyenda Valencia	Juice and table	5	3

2.2.5 Mushroom

In an effort to enhance mushroom production and to diversify available options for growers, the National Mushroom Centre (NMC) also ran research trials on:

Fruiting in Oyster Mushroom

Trials conducted in July 2017 at NMC, Wangchutaba on 4 strains of oyster mushroom included Thai strain (*Pleurotus sajor-caju*), Eryngii (*Pleurotus ostreatus* or King Oyster), WO-I (White Oyster Indian) and BO-I (Black Oyster Indian). WO-I is found to be the most suitable strain for summer season cultivation as the strain produced the most fruiting bodies although the Thai strain had good fruit body characteristic (large size, gray and short stipe).

Figure 7 Oyster mushroom fruit bodies; WO-I (left), Thai (middle) and BO-I (right)

Ganoderma (Lingzhi) Mushroom

Cultivation trial on Ganoderma mushroom was conducted in collaboration with a Japanese mushroom expert and a Thai volunteer. The study was initiated in Feb 2017 and ran until August 2017 using sawdust in plastic bags (600gm) and four different wood log types. Sawdust media was found suitable for propagation of mother spawn compared to grain media as it showed shorter incubation period than on logs. However, log cultivation produced better quality fruit bodies. In total 5.97 kg and 1.76 kg of fruiting bodies was harvested from 70 logs and 90 sawdust bags respectively.

Figure 8 *G. lucidum* fruiting bodies from different cultivation methods; wood log in soil (left), sawdust in soil (middle) and sawdust in shelf (right)

2.2.6 MAPS

Morphological & Chemical Analysis of Cordyceps sinensis

Morphological and chemical analysis of Cordyceps was carried out in collaboration with Quantum Pharmaceuticals in Switzerland. While the chemical analysis report is awaited, morphological studies show the following:

- Bhutanese Cordyceps on average weigh 0.38 g/piece
- Average caterpillar length is 35.27 mm
- Average stroma length is 43.34 mm
- More than 70% of Bhutanese Cordyceps are with red eyes
- More than 30% of Bhutanese Cordyceps are with black eyes
- Bhutanese Cordyceps have 6 annulations; 2 pairs of prolegs, 4 pairs of main legs, 2 pairs of hind legs and 2 mandibles

Ex-situ Cultivation Trial of Panax pseudo ginseng (Ginseng) and Paris polyphylla

Ginseng and *Paris polyphylla* are two important medicinal plants species that are heavily and illegally collected all over Bhutan. Fearing possible extinction through poaching the Department of Agriculture initiated a trial at Lamperi. Seeds were collected from all over the country and subjected through various methods to encourage germination. More than 4000 seeds were sown, but not a single one germinated so far. Rhizomes of both the species seized by the DoFPS were used as propagules. The results are promising with a little over 2000 plantlets each growing in the trial area from these rhizomes.

2.2.7 Floriculture

Establishment and Maintenance of Indigenous & Exotic Ornamental Plants

The culture of landscaping and floriculture is still at its nascent stage in the country. However, people in the urban areas have started taking keen interest in growing ornamental plants, either as hobby or as an enterprise. There is growing demand for ornamental plants and flowers during special occasions and celebrations.

Looking at the prospects, ARDC Wengkhar has started floriculture and landscaping activities at the centre through collection and maintenance of both exotic and local ornamental plants. A small shed house has been also established to maintain germplasm which presently hosts around 126 species, including 27 indigenous plants.

3 DEVELOPMENT HIGHLIGHTS

3.1 Field Crops

3.1.1 Rice

The Department supported over 34 acres of spring rice cultivation as part of its effort in up-scaling rice production in Wangdue dzongkhag. On-station purification and maintenance of released rice varieties are being continued.

ARDC Bajo facilitated the supply of improved rice varieties under its commercialization program in potential dzongkhags (See Table 9).

Table 9 Quantity of improved rice seeds supplied to potential dzongkhags

Dzongkhags	Bhur K1	IR 64	Khangma Maap	YRM2	Bajo Maap2	No 11	Total
Sarpang	13030	0	0	0	0	0	13030
Punakha	0	1000	1000	600	1500	0	4100
Wangdue	0	800	0	800	1000	1300	3900
Dagana	0	0	3350	0	650	0	4000
	13030	1800	4350	1400	3150	1300	25030

3.1.2 Maize

Seed Production and Maintenance

Maize continues to be an important cereal crop for farmers as signified by the quantity of seed request and area under cultivation. The Department supplemented maize growers with seeds produced on-station as well as through the establishment of Community Based Seed Production Group (CBSP). Around 1 MT maize seeds were produced on-station in Bajo and distributed to growers in the region covering around 75 acres of plantation. A maize CBSP group with 12 members has been started in Tading Geog (Samtse dzongkhag) with the group already producing 400 Kgs of good quality seed for supply to other farmers.

Crop Intensification through Hybrid Maize Promotion

Farmers have immensely benefitted from the Spring Maize program that was first initiated in 2015 to intensify cropping systems. It mainly focused on rice-fallow system. To sustain the program, seeds were supplied since 2016 season on 50:50 cost sharing basis. Fifteen MT of hybrid maize were supplied for the 2017-2018 growing season that benefitted over 1671 households, covering a total of 1000 acres in Sarpang, Mongar, Dagana, Trashigang, Tashiyangtse and Zhemgang dzongkhags.

3.1.3 Quinoa

Quinoa Promotion

Following its introduction in 2015, quinoa has been aggressively promoted in all 20 dzongkhags. Respective research centres has covered around 185 acres with a total production was 6310 Kgs. Its promotion as a nutrient dense cereal is also being carried out in the south-central region with around 50 acres under cultivation. Over 600 kgs of quinoa seed alone was produced at ARDC Yusipang and supplied to 7 dzongkhags.

Additionally, the Field Crop Research Program (FRCP) produced and supplied 319 kgs of quinoa seed of variety Amarilla Marangani to Euglena Co. Limited, Japan, to help start the commercial cultivation of quinoa in Haa and Paro dzongkhags. Five quinoa milling machines were procured and supplied to ARDCs and dzongkhags.

3.1.4 Oilseeds

8500 kgs of mustard seeds was procured and distributed to Dagana, Punakha, Lhuentse, Samdrup Jongkhar and Paro dzongkhags in addition to around 271 kgs of varieties Yusi Peka 1 and Yusi Peka 2. To enhance oilseed diversification, 1000 kg of groundnut seeds were supplied to farmers in Dagana, Sarpang and Tsirang.

To support oilseeds processing and value addition three 4-bolt oil expeller was distributed to farmers in Chukha and Zhemang. The Department also supported the purchase of 5 multipurpose oil expeller for ARDC Bajo, ARDC Samtenling and ADTC Chimipang for various research and development initiatives.

3.2 Horticultural Crops

3.2.1 Vegetables

Winter Chilli and Vegetable Commercialization

The Department continued its efforts on minimizing vegetable imports from India through its commercialization programs. Winter chili production program was implemented in 56 geogs of 8 dzongkhags beginning August 2017 on a staggered production system. The production program was implemented in collaboration with Farm Machinery Corporation Limited (FMCL), based on a comprehensive production plan developed in consultation with respective dzongkhags targeted making fresh green chilies - a favourite Bhutanese food item – available in the domestic market during the winter months of December to March. The overall total spending for the program was Nu. 22.549 million - inclusive of expenses for production inputs.

Table 10 Summary of expenditure made on production inputs for each of the production sites (Nu. in Million)

dzongkhags	Hybrid seeds	*Nursery materials	**Protected cultivation materials	***Irrigation materials	TOTAL
Chukha	0.120	0.063	0.292	0.348	**0.822**
Dagana	0.438	0.124	0.247	1.620	**2.428**
Pemagatshel	0.984	0.135	0.308	2.871	**4.297**
Samtse	0.571	0.210	1.670	1.457	**3.907**
Sarpang	0.568	0.210	1.585	2.454	**4.816**
Samdrupjongkhar	0.594	0.090	0.157	0.706	**1.547**
Tsirang	0.307	0.092	0.470	1.534	**2.403**
Zhemgang	0.072	0.029	0.216	0.685	**1.002**
FMCL Farms	0.366	0.000	0.000	0.000	**0.366**
TOTAL	**4.018**	**0.952**	**4.943**	**11.676**	**21.588**

***Plug trays and watering cans**

****Poly-house plastics, nylon belts, shade nets, rabbit fencing nets and plastic mulches.**

*****Syntax, HDPE pipes, flexible pipes, drip sets, sprinklers, water harvesting (Silpaulin sheets) and electric water pump

The production was not as expected, owing particularly to heavy and continuous monsoon (above average monsoon rainfall) between August and October that almost destroyed the first three staggered production in most sites. Low temperature affect on plant growth and development and incidence of pests and diseases also affected production.

Nonetheless, the program has greatly benefited the farmers involved as they received free inputs, gained practical know-how on production practices, and earned adequate cash income from readily available domestic market for fresh green chillies. A simple cost-benefit analysis indicates positive return and therefore the financial viability of investing in such focused approach production program (Figure 9). At an average market price of Nu. 200/kg for the fresh local green chilies produced (140.64 MT), the estimated return from the program was Nu. 28.128 million, with a profit of Nu. 5.579 million over the overall total investment of Nu. 22.549 million.

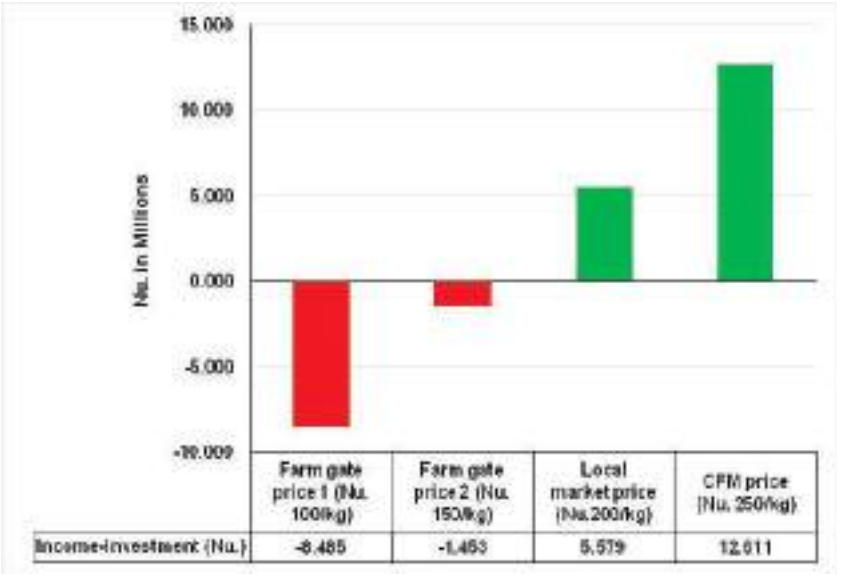

Figure 9 Cost benefit of winter chili production at different market prices

Additionally, a total of 7 commercial vegetable production sites were established in the east alone where chilli and onion cultivation were promoted. The Commercial Agriculture and Resilient Livelihoods Enhancement Program (CARLEP) in the east helped expand onion farming with 754 households cultivating onions on a little over 763 acres with a total income earning of Nu 1.03 million. Support was also provided to produce 11 MT of watermelon in Zhemgang as well as in establishing 450 numbers of kitchen gardens in south central region.

Protected Vegetable Cultivation for off-season Production

Protection cultivation technology is being promoted to expand the growing season and subsequent production. Protected technologies like green houses along with water use efficient technologies (micro irrigation system) can help increase production during the winter season.

Table 11 Protected Structures & water efficient inputs supported

Inputs for protected cultivation	Specification	Unit	Quantity	Fund Source
Prefabricated Greenhouse set	20 x 5 m	Set	62	EU-RDCRRP
Prefabricated Greenhouse set	20 x 5 m	Set	4	RGoB
Prefabricated Greenhouse set	10 x 5 m	Set	1	EU-RDCRRP
Low cost poly house plastic & rope	9 x 17 m	Nos.	122	EU-RDCRRP
Low cost poly house plastic & rope	9 x 17 m	Nos.	220	FSAPP
Low cost poly house plastic & rope	9 x 17 m	Nos.	45	RRCDP
Low cost poly house plastic & rope	9 x 17 m	Nos.	298	RGoB
Green Shade Net	50% shade	Nos.	88	FSAPP
Green Shade Net	50% shade	Nos.	65	RGoB
Drip irrigation kits	250 m^2	Set	107	FSAPP
Drip irrigation kits	250 m^2	Set	74	EU-RDCRRP
Drip irrigation kits	250 m^2	Set	31	RRCDP
Drip irrigation kits	250 m^2	Set	444	RGoB
Plastic Mulch Sheet	Silver-Black 25 microns, 400 m	Bundle	55	FSAPP
Plastic Mulch Sheet	Silver-Black 25 microns, 400 m	Bundle	122	EU-RDCRRP
Plastic Mulch Sheet	Silver-Black 25 microns, 400 m	Bundle	38	RRCDP
Plastic Mulch Sheet	Silver-Black 25 microns, 400 m	Bundle	824	RGoB
Sprinklers	Three way (Brass)	Nos.	181	FSAPP
Sprinklers	Three way (Brass)	Nos.	25	RGoB

Demonstrations were also successfully carried out on early vegetable production using poly-tunnels in Damchena and Lango villages, Paro. Farmers are now keen to take up and continue off-season vegetable cultivation particularly due to the premium prices they fetched. Farmers were able to harvest their cole crops by April end in contrast to June when grown conventionally.

Minimizing Postharvest Loss in Vegetables

In Bhutan the post-harvest losses of major vegetables were reported to range from 15-20% for cabbage, 22-25% for tomato, 20-22% for beans, 30-35% for peas, and 15-18% for cauliflower. Eleven onion curing structures were promoted in 6 dzongkhags as intervention in reducing postharvest handling and processing losses in onions.

3.2.2 Potato

The Potato Program achieved more than 100% of all its set targets in 2017-18 where it continued working with its major thrust areas of enhancing potato production through off-season cultivation, technology transfer through demonstration of new varieties, farmers' capacity development and evaluation of different potato germplasm. These activities also address decline and stagnation of yield due to degenerating seeds and varieties.

Some of the key highlights were:

a) Potato demonstration and trials in the 13 potato growing dzongkhags as well as RDC Yusipang, Khangma and Phobjikha for evaluation of new resilient verities in different agroecological zones.
b) Promotion of winter/off-season potato production in Samtse, Samdrupjongkhar and Tashigang dzongkhags.

c) Capacity development of 566 farmers in 13 dzongkhags on potato crop management practices and pest and diseases control measures.
d) Enhancing production by supporting 30 irrigation sets for potato cultivation in Bumthang, Phuntsholing, and potato farms in Naseyphel and Khangma.

Table 12 Farmers training/ Field day and PVS 2017

S/N	Dzongkhag	Geog/details	Participants	Funding Source
1	Lhentse	Gangzor	30	ITPGRFA/FAO/CIP
2	Trashigang	Khaling	31	
3	Mongar	DraMTse	30	
4	Mongar	Narang	22	
5	Pema Gatshel	Zobel	17	
6	Thimphu	Kawang	21	
7	Thimphu	Gayneykha	29	
8	Paro	Tshento	28	
9	Dagana	Drujigang	95	FSAPP
10	Chhukha	Bongo	97	
11	Haa	Sammar	66	
12	Haa	Eusu	53	
13	Khangma	RDC	64	ITPGRFA/FAO/CIP
14	Bumthang	NSC	59	
	Total No.		**642 Farmers**	

Figure 10 Participatory Variety Selection

3.2.3 Fruits and Nuts

Some of the primary development highlights for the Fruits & Nuts Program of the Department were:

a) **Rehabilitation** of old orchards in Haa, Paro and Thimphu dzongkhags wherein a total of 34717 numbers of apple seedlings were supplied to 1041 households in 21 Geogs. The highest number of seedlings (11, 777) was supplied to Paro dzongkhag. To promote ownership among beneficiaries, the seedlings were provided on a cost sharing basis where 20% cost was borne by the beneficiaries.

b) **Support to agro-industry** in the form of 53811 passion fruit seedlings to six eastern dzongkhags covering 10 acres plantation in preparation of fresh raw material for upcoming BAIL plant.

3.2.4 Citrus

Citrus mandarin still continues to be one of the highest incomes earning horticultural produce for Bhutanese farmers. The department put in place and implemented a series of activities to keep the momentum of sustaining and developing the citrus industry in pace.

Citrus Nursery

The NSC's farm in Trashiyangtse has started supplying mandarin seedlings to growers. The centre has supplied more than 23,918 seedlings within a year and has raised another 25,000 seedlings to be supplied in the coming season. These seedlings were raised under conventional poly tunnels and are targeted to help supplement the availability of disease-free citrus planting materials. Through this the NSC is expected to be able to supply at least 100,000 grafted seedlings annually.

Establishment of Commercial Orchard

In collaboration with FMCL, more than 101 acres of mandarin orchard has been established in Dolebchen (Kana geog, Dagana). The orchard with more than 20,000 mandarin grafts is being managed by FMCL following standard management practices and is the first of its kind promoting citrus production on a larger commercial scale. In the last financial year, additional activities such as fencing, land improvement, and establishment of irrigation systems completed.

Standards, Guidelines and Strategies

A number of formal documents were put together to help standardize citrus nursery management and guide growers and other stakeholders in planning and implementing mandarin production.

a) A minimum standard for citrus planting materials has been developed and submitted to be included in "Minimum Standards of Seeds and Seedlings under the "Seed Rules and Regulations of Bhutan 2018".

b) The standard operating procedure for citrus nursery was reviewed and necessary amendments made.

c) Citrus repository protocol has been developed and reviewed based on repository protocols in Australia, and with reference to some very significant citrus repositories elsewhere in the world.

d) Citrus rehabilitation strategies has been drafted and presented in some of the forums and meetings. It is in its second draft stage.

e) A second edition of "Production Guide for Mandarin Orchards in Bhutan", has been reviewed, edited and published.

f) A strategy for development of citrus in the 12 FYP is being drafted and would entail further consultation for finalization before the launch of the 12 FYP.

Capacity Building of Agricultural Staff

a) A 5-day training on citrus production management was organized with fund support from FSAPP, and with resource personnel from ICAR-CCRI Nagpur, India. More than 27 agriculture officers from selected geogs and central agencies attended the program. This training equipped the geog agriculture extension officials in subsequently carrying out their planned capacity development program for farmers on citrus canopy management, area-wide management of pests and in orchard establishment. Further, it also provided a platform to draw up action plans to rehabilitate declining orchards, and other advocacy programs

b) An 8-day exposure trip to Nepal was organized for Food Security for Agriculture Production Project (FSAPP) beneficiary geog extension offices and agriculture officers of FSAPP supported districts. An additional official from ARDC Wengkhar was supported through the ACIAR fund balance. The program provided opportunity to look at climate smart production practices in Nepal.

c) Three officials attended the 2-day World Orange Festival in Nagpur. Citrus varieties from Bhutan were put up for exhibition at the festival. It was a major opportunity to present Bhutan's production scenario, showcase citrus varieties grown in Bhutan, and interact with citrus growers in India and other countries, as well as network with inputs suppliers, processing industries and scientists from different institutions.

d) An officer from the NSC attended the Citrus Nurserymen Conference in Australia with ACIAR project fund support. He also visited commercial nurseries in Australia and picked up various skills and new options to manage citrus nursery back in Bhutan. He is currently managing the new citrus nursery at Trashiyangtse.

e) Two officers of ARDCs attended a 5-day training on citrus repository management in Thailand. The participants acquired additional ideas to help guide proper management and establishment of citrus repository and nurseries.


Figure 11 Capacity building program on aspects of citrus production

f) Three engineers with fund support of ACIAR visited different places in India to look at different options in establishing high quality protected structures, use of solar pumps, and smart irrigation technologies under greenhouses and field conditions. The visit was followed by the workshops at Jain Irrigation that discussed emerging and available technologies, and potential schemes for collaborations. A very important outcome of this visit is the initiation of the new citrus nursery at Trashiyangtse.

3.2.5 Mushroom

Contributions made in terms of mushroom development for the financial year include spawn production and supply, supporting rural farmers and commercial growers and capacity building of mushroom cultivators is as detailed in Table 13 .

Table 13 Support to mushroom production (2017-18)

No	Activities	Achievements	Remarks
1	*Spawn Production*		
	i. Shiitake	21,661 bottles	
	ii. Ganoderma	90 bottles	
	iii. Oyster	14,521 bottles	
2	*Spawn Supply*		
	i. Shittake	19,186 bottles	
	ii. Oyster	8,999 bottles	
	iii. Button	92 bottles	Chhukha
3	*Cultivation*		
	i. Shiitake	1,39,588 logs/billets	Growers in 16 dzongkhags
	ii. Oyster	26549 bags	NMC, ARDCs
	Backstopping growers		

4	i. Field/farm monitoring	134 farms	Mostly western dzongkhags
	ii. Capacity building	a) 669 farmers and staff trained on b) 700 individuals	- mushroom cultivation - wild mushroom identification and sensitization

As part of its annual initiative in creating awareness on sustainable harvesting of mushroom and the threat of mushroom poisoning amongst stakeholders, the National Mushroom Centre (NMC) attended the Third Annual Mushroom Festival, Thimphu (15-16th August 2017), Mushroom Festival in Ura, Bumthang (23-24 August 2017), and the Jomolhari Mountain Festival (on 14th & 15th October 2017).

Figure 12 Third annual mushroom festival, Thimphu

3.2.6 MAPS

Spices Promotion

The Medicinal, Aromatic Plants & Spices Program supported communities directly affected by the human wildlife conflict in section of Zhemgang and Samtse. The program through promotion of cardamom, ginger, turmeric and black pepper cultivation aimed to improve income generation and enhance livelihood options of the communities as well as support the initiatives of other partners. Three groups: Panibi group of young entrepreneurs, Tashibi group and Gongphu Tshesey Gongphel Peyten Tshogpa in Zhemgang Dzongkhag, and Tashicholing ginger cooperatives in Samtse dzongkhag were supported through capacity building on cultivation practices, post harvest and value addition options for these crops.

Community Cultivation of Medicinal Plants

The department continued supporting medicinal plants cultivation as an integral means of enhancing rural income. Technical backstopping to all stakeholders of the Nubi Menchong Nyamley Tshogdey (NMNT) was provided as well as handing over of the Common Facility Centre (CFC) constructed by the department to Kabab Organics to help community in efficient product diversification. 250 women (spouses of the armed

forced personnel) in Haa Damthang were trained in growing 3 species of medicinal plants.

Chiraita Cultivation

Chiraita (*Swertia chiraita*) cultivation trial supported by the French Chanell P B Company has been very successful. Based on the success of 9 trial farmers in Dungmanma, Betseling, Tshothang, Lauri, Momri, Reynang and Serzor villages of Lauri geog in Sjongkhar, more farmers have come forward. By 2017 year-end farmers produced more than 200 kgs of dry Chiraita, which subsequently exported to the company in France. More than 70 farmers have now opted to cultivate the plant.

3.2.7 Floriculture & Amenity Landscaping

Production of Assorted Ornamental Plants

The Department produced 1, 70,000 assorted ornamental plants at the Floriculture and Amenity Landscaping Centre in Dechechholing, ARDC-Bajo and Samtenling. The flowers were used for garden development, landscaping and for display during significant national events.

Floral Decoration and Displays

Professional floral displays were put up at various sites in the country as part of the celebrations marking significant events. Besides lending a visual and aesthetic vista to the event and deepening their ambience, these extensive displays help advocate the

importance and underlying fundamentals of floriculture and amenity landscaping among general Bhutanese. Some of the major events the department organized and put up floral displays were the Royal Wedding Anniversary, Haa; National Day Celebrations in Haa, Birth anniversaries of His Majesty the King, Royal Highness the Gyalsey, and Her Majesty the Gyaltsuen.

Royal Bhutan Flower Exhibition

The 4th Royal Bhutan Flower Exhibition was organized at Thangzona, Punakha from 25 to 30 April 2018. The exhibition showcased different garden themes by national as well as international participants. It aimed to stimulate appreciation for beautiful spaces, contribute to the development of floriculture, tourism and other associated industries. Dedicated to the 50 years of diplomatic ties between India and Bhutan, the exhibition included long term plans and initiative to enhance the landscape of areas around the Punakha dzong.

The event was graced by His Majesty the Druk Gyalpo, Her Majesty the Gyaltsuen, His Royal Highness the Gyalsey, His Majesty the Fourth King, their Majesties the Queen Mothers, and other members of the Royal Family. The Hon'ble Prime Minister, cabinet ministers and other senior government officials also attended the opening program.

Figure 13 The Fourth Royal Bhutan Flower Exhibition in Punakha

National and international participants displayed a total of seventeen gardens and twelve stalls. International participants include entries from India and Thailand. For the first time this year, the Zhung Dratshang (Central Monastic Body) and two schools (Punakha Central School and Ugyen Academy) also participated in the exhibition. The exhibition saw a total of 34,590 visitors comprising 32,611 Bhutanese and 1,979 non-Bhutanese visitors.

Capacity Building

Capacity building programs on floriculture and landscaping were organized for staff members as well as stakeholders outside the Ministry of Agriculture & Forests.

a) 32 officials and ESPs attended a hands-on training cum garden development course. The participants were briefed on basic landscape ideas such as site analysis, area measurement and layout plan, handling of tools and equipment required for garden development. The program involved practical exercises such as working on site, cleaning, marking and layout plans, planting and beautifying the area.

b) Hands-on training and field practical workshop on basic floriculture nursery and flower arrangement skills were organized for 29 participants that included private florists, royal project staffs, ESPs, and participants from other institutes. The program was organized at the Royal Project, Dechenchholing and involved general nursery management plan, media preparation, basic tools and equipments required, seed sowing, transplanting and after care, plant propagation techniques, identification of common flowers and basic flower arrangements.

c) Field visits to private nurseries in Samtse and Sarpang dzongkhags was organized for 25 officials and support/field staff of the Royal Project, Dechenchholing, Samtenling and the Royal Project Coordination Office (RPCO).

3.3 Organic

The department built up on its efforts from previous years in putting in place an assurance system for the country's organic products, in the absence of which, consumers attached little or no premium for such products.

Local Organic Assurance System (LOAS) & Organic Standards

Eight LOAS certified products were launched on 26 June 2018 by Hon'ble Minister, MoAF. The products were turmeric powder produced by farmers group in Zhemgang, 3 types of herbal tea (camomile, sea buckthorn and mint) from Bumthang, green tea from Trongsa and potato, garlic and carrot from Gasa. The event provided opportunity for organic operators to showcase and promote their products as well creates awareness amongst consumers. The event was supported by National Adaptation Plan of Action (NAPA III), an RGOB initiative funded by Global Environment Fund (GEF-LDCF).

Figure 14 Launching of organic products

The National Organic Program finalized the Bhutan Organic Standards (BOS) through an extensive stakeholder consultation workshop that included the private entrepreneurs, NGOS and representatives from different agencies within the ministry. Experts from the International Federation for Organic Agriculture Movement (IFOAM) facilitated the workshop. The Department expects to endorse and publish the BOS soon.

Organic Asparagus & Buckwheat Production

Organic asparagus and buckwheat cultivated were supported by the Department. A total area of 131 acres spread across 14 dzongkhags is under organic asparagus cultivation and in the FY 2017-18, 40,000 asparagus seedlings were supplied to growers in Thimphu and Punakha. The current organic asparagus production stands at 98.25 MT.

Organic buckwheat is presently grown on a total acreage of 3124 acres with a corresponding production of 1677 MT. Primary focus dzongkhags are Chhukha, Haa,

Gasa, Bumthang and Samdrup Jongkhar. The department supported buckwheat seeds of around 1.1 MT for growers in Gasa and Chhukha.

Capacity Building

Four training of trainers (ToT) were provided by the NoP for 80 staff. The program focused on principles of organic agriculture, organic certification and organic technologies. 840 farmers were also trained in 9 dzongkhags on organic production of asparagus, vegetables, non-wood forest product, buckwheat, and on aspects of product development. These were all aimed at promoting sustainable agriculture growth and enhancing rural income. An additional 274 farmers attended training program organized on bio-slurry preparation, low-cost vegetable production and on the concepts of organic village models.

Figure 15 Farmer Training (Gomder, S/Jongkhar)

Through the Asian Food & Agriculture Cooperation Initiative (AFACI) and EU- TCP funding, select officials within the department participated in capacity building programs in South Korea and Thailand. Seven department staff and two private sector representatives also attended the 19th Organic World Congress in Delhi (India).

4 SUPPORT SERVICES

4.1 Farm Mechanisation

4.1.1 Research

The Department continued its effort into innovations in farm mechanization in its drive to improve on existing farming practices and adapt modern technologies into Bhutanese farming context and make farming attractive and drudgery-free.

Development of Hedge cutter

The Agriculture Machinery Centre (AMC) Paro conducted a series of tests on hedge

cutter samples from Japan involving paddy growers. Based on the results presented, the Department endorsed the technology, which was followed by demonstrations at AMC's technology display event. Farmers are already using the technology in addition to a number of them being procured and distributed on a cost-sharing basis.

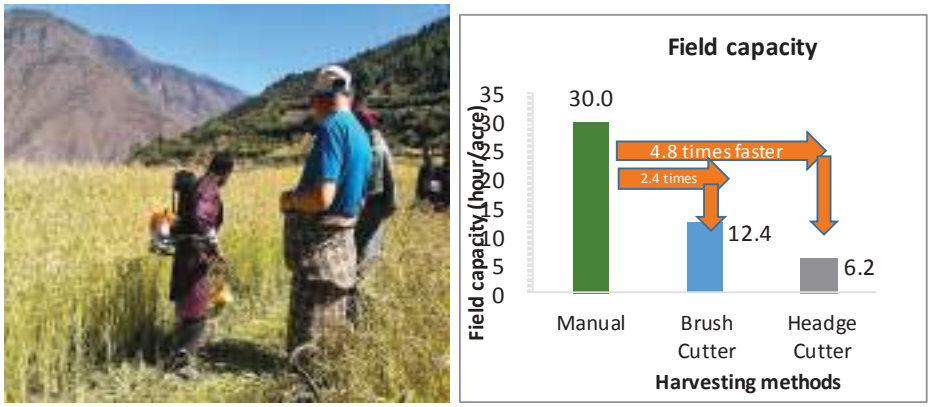

Figure 16 Awareness program (left) & hedge-cutter performance (right)

Power Tiller attached Potato Digger

Diggers for KR 120 power tiller were developed and series of tests in the farmers' fields in Phobjikha, Bumthang, Khotokha and Paro showed significant differences in the time duration of collecting potato as against in conventional hand collection or through plough Figure 17. Standards for the digger has been developed and endorsed, and the technology shall be made available from next season.

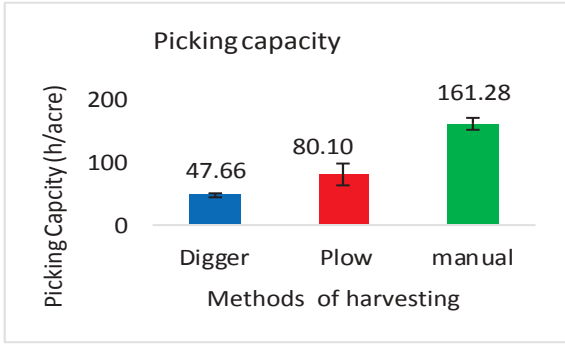

Figure 17 Digger performance

Standard and Test Codes

Standards and codes were developed for a number of farm machinery in collaboration with the Bhutan Standards Bureau (BSB) as part of its mandate to ensure safety and quality of farm machines and implements in the country. Standards for cardamom dryer is at a draft stage.

Table 14 Standard and test codes developed based on advice of BSB

Sl/No	Standards	Level	Status	Remarks
1	Mini tiller	National Level	Endorsed at BSB Board	Publication
2	Cereal Flaking	National Level	Endorsed at BSB Board	Publication
3	Oil Expeller	National Level	Endorsed at BSB Board	Publication
4	Corn Sheller	AMC-level	Draft	Review and testing for confirmation of standards needed
5	Hedge Cutter	AMC-level	Endorsed at AMC-TC	Further submission to TC-08 (BSB)
6	Food grade material (Guidelines)	National Level	Endorsed at BSB Board	Incorporate the guidelines for post-harvest machineries
7	Potato Digger	AMC-level	Draft	Review of documents
8	Cardamom Dryer	AMC-level	Draft	Review and testing for confirmation of standards needed
9	Grain Mill	AMC-level	Draft	Review and testing for confirmation of standards needed


Figure 18 Testing of farm machinery for adoption

4.1.2 Developments

Off- grid Improved Cardamom Dryer

A total of 66 improved cardamom dryers were developed and successfully handed over to farmers following the completion of field days that involved all stakeholders including agriculture officials of concerned dzongkhags. These dryers were funded by the AMC, SMAP Program and respective dzongkhags. The AMC (Paro) also invited

private sectors to its technology display hosted at Paro where the dryer was also showcased.

Capacity Building

Farmers, extension officers, entrepreneurs, students and drivers were trained on a number of aspects of essential farm machinery operation and maintenance including laboratory skills (Figure 19).

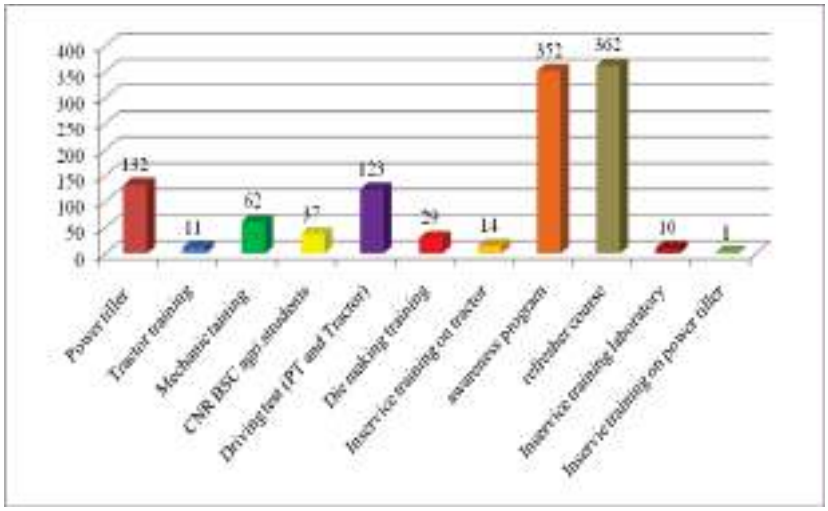

Figure 19 Training of various stakeholders on aspects of farm machinery

4.2 Plant Protection Services

Highlights of the plant protection services for the past fiscal year by the Department's National Plant Protection Centre (NPPC), Simtokha, besides the general functions like distribution of plant protection chemicals, include:

4.2.1 Research

Determination of Paddy Hoppers Movement

Study on the movement of paddy hoppers in the field using sticky traps (220mm x 330 mm) in all four directions at 2.44 m above the ground surface revealed the highest in number of hoppers trapped in traps placed in north direction while that of south captured the least number of hoppers (Figure 20 & Figure 21). Traps are therefore recommended to be placed towards the north direction. Hoppers trapped were counted weekly, and the study was conducted in ARDC-Samtenling.

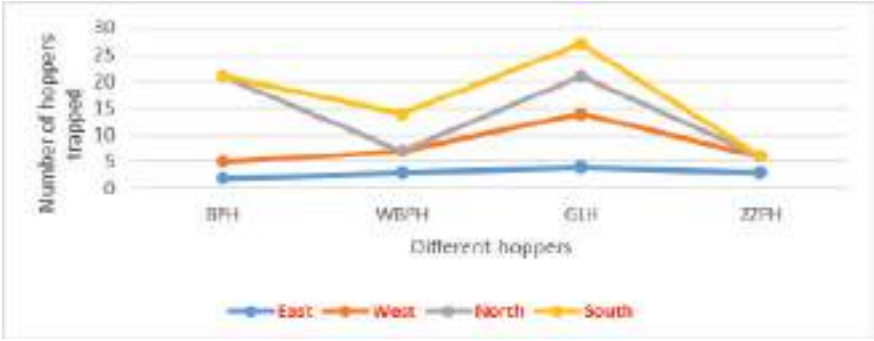

Figure 20 Different hoppers captured in traps placed in 4 directions (BPH; brown plant hoppers; WBHP: white backed plant hopper; GLH= green leaf hopper; ZZPH: zig zag plant hopper)

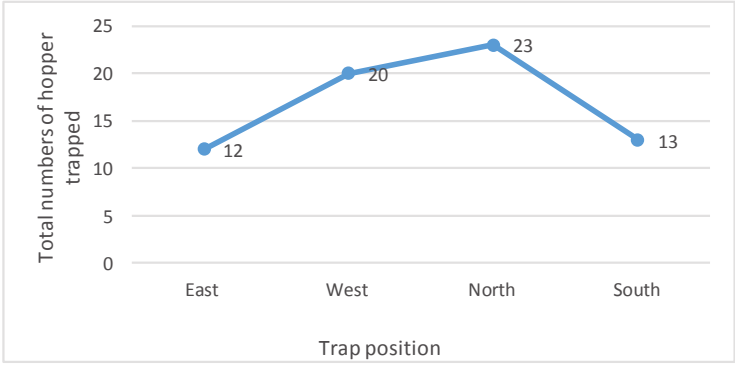

Figure 21 Graph showing hoppers captured in different trap positions

Potato Tuber Moth Population Monitoring

Potato Tuber Moth (PTM) can result in losses up to 35% of potatoes in the field as well as in storage conditions. The insect pest has been recorded from the major potato growing dzongkhags. Monitoring by means of pheromone traps is one way of determining the pest pressure in farmlands. There is little information on the emergence time, population trend and use of pheromone traps to monitor and control PTM. A study to determine the emergence time and population trend of PTM using pheromone trap was therefore conducted in two farmers' field in Chapcha, Chukha from May (2nd week) to July (1st week). The results show that PTM emerges in May and stays up to August in the field while it survives in stores from August to until the tubers are sold. PTM can also overwinter as pupae in seed tubers and in cracks in stores. Pheromone traps are recommended to monitor PTM.

PCR Analysis of Citrus Samples for HLB Pathogen

Screening of citrus plants for huanglongbing (HLB) pathogen from the nursery at Jachedphu in Tashi Yangtse (423 samples) and from ARDC- Wengkhar (188 samples) through PCR analysis returned positive for HLB from Wengkhar samples while those from Jaedchaedphu were negative. It is recommended not to use citrus plants from ARDC Wengkhar for propagation while periodic testing to continue at the nursery in Jachedphu.

Isolation of Trichoderma and *Phytophthora capsici* spp.

Isolation of putative strains of *Trichoderma* sp. for control of *Phytophthora capsici* - causal agent of chilli blight was done from soil samples collected from Bjimina in Thimphu and Wangcha in Paro.

This activity was conducted with objective to isolate putative strains of *Trichoderma* sp. for control of *Phytophthora capsici*, the causal agent of chilli blight. Soil samples were collected from Bjimina (Thimphu) and Wangcha (Paro), and plant samples from Kabjisa (Punakha). Eight putative isolates were obtained and their bio-assay against *Phythophthora spp* is being carried out.

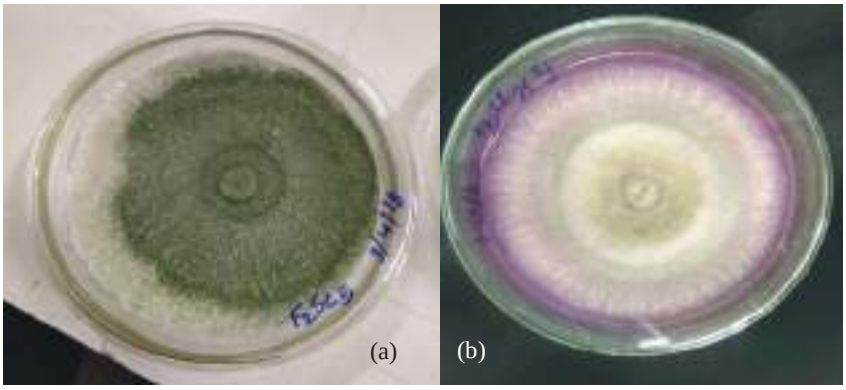

Figure 22 *Trichoderma* cultured on (a) PDA and (b) TSM

Additionally, *Phytophthora capsici* isolates were done from a total of 76 plant and soil samples collected from chilli fields of Kabjisa (Punakha) and Bjimina (Thimphu) as part of the study to evaluate of efficacy of *Trichoderma spp*.

Wheat Rust Surveillance

As part of its annual pest surveillance program, the NPPC carried out survey on wheat rust pathogens such as stripe rust (*Puccinia striiformi*), leaf rust (*P. triticii*) and stem rust (*P. graminis*) which are knwn to cause serious threat to wheat production. The survey in major wheat growing areas (Bumthang, Haa, Punakha, Paro, Thimphu and Wandue) found Stripe rust to be prevalent in cooler region, leaf rust in warmer region

and stem rust in tropical region. To date, stem rust is not recorded in Bhutan. Wheat rust spore survives on wheat during the growing season and on the alternate host like barberry plant (*Berberis* spp) during off season. Barberry plant acts as an alternate host for stripe and black rust. Overall rust incidence in the country was found low compared to the previous year. Yellow rust incidence recorded was the highest while only few traces of leaf rust was detected in Punakha and Wangdue.

Enhanced ePest Surveillance System

The Department's ePest Surveillance System was modified and enhanced to make it more user-friendly. ToTs of 10 extension officials from four pilot dzongkhags (Chukha, Paro, Punakha and Wangdue) on ePest Surveillance system on mobile and web applications was conducted.

National Plant Pest Database

The National Plant Pest Database (NPPD) containing all pests present in Bhutan (arthropods, molluscs, nematodes and micro-organisms), their economic importance, and identification and management regimes seeks to act as a repository of plant protection knowledge. It is based on the experiences and data collected over the past 30 years and is expected to provide a platform for prioritizing and guiding future research, surveillance and extension activities. The database presently includes data on 711 pest species, 63 crops and 949 pest crop interactions. All pests of economic importance are shared with India, who is also our primary trading partner. Over 80% of these pests in our database is widely distributed in Asia.

4.2.2 Developments

Citrus Fruit Drop Management Campaign

The Chinese citrus fruit fly (*Bactocera minax*) is a pest of economic importance in Bhutan. In poorly managed orchards, it is responsible for approximately 20-70% of fruit drop. A community based citrus fruit drop collection and destruction campaign was conducted in Gakiling (Laring) and Dekiling (Nubgang) Geogs in December 2017. Approximately, 200 farmers attended the campaign that covered 10 acres of citrus

orchards, and involved collection and destruction of fruits in pits of 1.2 m depth. The campaign also included presentation on life cycle and management strategies of insect pests, diseases and weeds.

Awareness Campaign on Shochum Management

NPPC in collaboration with the Agriculture Sector, Bumthang conducted a campaign-cum-training program on Shochum (*Potamogeton distinctus*) management in paddy. Shochum was first detected in Bumthang in 2016, and is believed to be introduced with paddy seedlings from Punakha and Wangdue dzongkhags. Thirty-two farmers from paddy growing areas of Jalikhar (south), Chamkhar (central), Wangduechhoeling (central) and Jambay Lhakhang (North) attended the program.

Electric Fence Installation, Survey and Monitoring

Following the command of His Majesty the King, the NPPC conducted feasibility study following which a total of 7 km electric fence was installed for 21 households in Drang village under Dranghal chiwog, Phobjikha. The fencing covered about 91 acres of potato fields from wild boar and deer.

Figure 23 Electric fencing site (left) and villagers setting up the electric fence in Phobjikha

Further, an extensive survey carried out in eight geogs of Zhemgang using gps (global positioning system) resulted in the installation of 73.662 km of electric fence.

Since its first installation in 2013 on a trial basis, the country now has a total of 2487 km of electric fence benefiting 10841 households. A major part of this is funded by the RGoB while some are privately installed. However, these networks of electric fences are not monitored. The NPPC carried out field verification of 27 sites in three dzongkhags of Dagana, Tsirang and Sarpang and found that most fences were poorly maintained, did not follow technical requirements and approved components. Some farmers' groups formed for electric fence were not functional. It is hence recommended that beneficiaries and geog agriculture officials follow proper installation and maintenance procedures; revise or amend by-laws on electric fence' groups, and

conduct pre-survey prior to proposing electric fencing to avoid fencing of unnecessary areas or forest land that do not serve the purpose.

Farmers Field Day

Farmers' field day was conducted for 150 participants in Shawapang, Yueling and Pangzor Chiwogs under Chhuzaggang geog in November 2017 with the objectives to provide first-hand information on identification and management of different insect pests during the ripening stage of paddy. As part of the program, questionnaire-based farmers' survey was conducted to gather information on paddy pests' infestation in these chiwogs. 90% of participants were aware of various rice pests but had little knowledge on their management. Most of the farmers were able to identify stem borer, army worm, case worm, leaf folder, green horned caterpillar, rice Gundhi bug and their damage symptoms in comparison with hoppers and mealy bug.

Figure 24 Farmers' field day at ranking rice pests damage

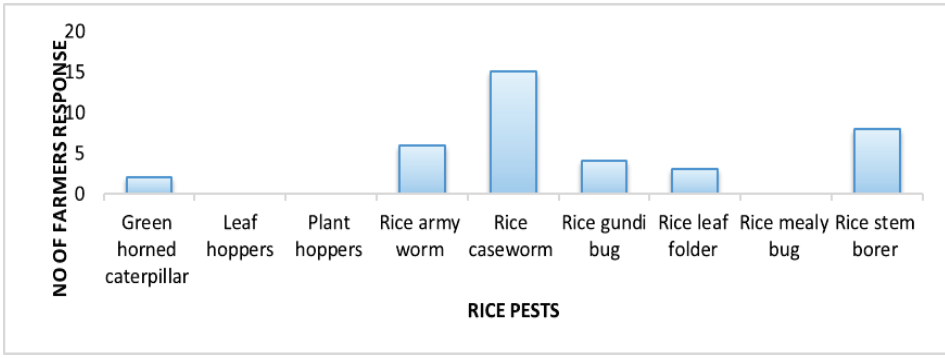

Figure 25 Farmers' ranking of pests damage severity on rice

Capacity Development

The past fiscal year saw the Department implementing a number of capacity building programs on pest management.

a) ToT on maize storage pest management was attended by 32 DAOs, extension officials, regional plant protection officers, ARDC and Farm Machinery Corporation Ltd (FMCL) staff. This is expected to help the rregional plant pprotection focal to provide technical backstopping to extension officials on issues concerning maize storage pest problems.

b) A total of 18 participants from Zhemgang attended a training program on fundamentals and practical applications of GIS. Participants learned how to map farm lands for electric fence, calculate areas, measure distance and furnish spatial data to manage human-wildlife conflict in communities. It will prepare agriculture officials in utilizing real-time data for precision agriculture.

c) ToTs on "Weed and herbicide management" for 40 agriculture officials of Paro, Punakha, Thimphu and Wangdue involved update of knowledge and information on weed management, usage of new herbicide (Ethoxysulfuron – "Sunrice") in transplanted rice, and awareness on the use, safety and health hazards of existing herbicides.

d) A total of 1449 farmers were trained on management of maize storage pests, proper drying and storage methods. They were also provided with super grain bag to store maize and make informed comparison against traditional practices.

4.3 Post Harvest Program

4.3.1 Research

Product Development

A number of products have been developed by the National Post Harvest Centre (NPHC) to help value-add and diversify farm products. In the past year, the centre developed the following products at its centre in Paro.

i. Hemp tea
ii. Jackfruit seed cookie
iii. Chayote product development (Dehydrated, jam and pickle)
iv. Ginger products (candy, pickle, powder)
v. Green chilli powder
vi. Pear jelly
vii. Kimchi (cucumber and radish)
viii. Dandelion tea products
ix. Maringa products (tea and powder)
x. Tomato ketchup
xi. Groundnut products (candies, caramelized products, cookies, cupcake, *pickles*)
xii. Quinoa product (cookie, cupcake and pasta)
xiii. Kiwi wine
xiv. Garlic products (chips, powder, cookie, pickle, paste)

Knowledge Management

Three papers were submitted for publication in the Bhutanese Journal of Agriculture (BJA). These were based on findings from studies on postharvest losses in rice, apples and oranges. An extension manual on post-harvest handling of apples was put together – both in Dzongkha and English – and have published distributed to all agriculture officials in all apple growing districts.

4.3.2 Developments

Capacity Building on Post Production Technologies

The NPHC trained a total of 1007 individual from various institutes, schools, agriculture extension officials and farmers on post-harvest management and processing approaches to help value addition of agricultural products. These programs conducted within the past fiscal year were also additionally funded by projects like CARLEP, FSAPP, PHT (ARDC-Wengkhar), etc, as well as supported by SFD (DoFPS), RAMCO (DAMC) and respective dzongkhags (Table 15).

Table 15 Capacity building program on postharvest (2017-18)

Beneficiaries	Postharvest Aspects	Numbers	Duration	Remarks
Farmers (Yangthang, Haa)	Processing of potato chips	25	1 day	READ Bhutan
Youth Business Cooperative (Paro), 5th Batch FMCL farm assistants & Tshetshey Tshongdrel Tshogpa (Gasa)	Hands on training on food processing and preservation	95	2 - 5 days	NPHC
Farmers (Thetso, Wangdue)	Processing of jam, pickle and juice	30	3 days	NPHC
Farmers (Chhukha, Samtse, Sarpang, Dagana, Haa)	Processing and value addition of ginger, citrus and potato	285	3 days	FSAPP
Hoteliers (Mongar Dzongkhag), Thrimsung Aumtshug Detshen (arm force wives of Mongar & Gyelposhing)	Cookies processing	53	1 day	ARDC (Wengkhar), CARLEP, IFPP (Lingmethang)
Youth Group (Gulibi, Lhuntse)	Maize product development such as cookies, donut, spicy maize	21	1 day	ARDC (Wengkhar), IFPP (Lingmethang)
Farmers group (Tachema, Jamkhar, Tashi Yangtse)	Pear candy and vegetable processing	33	3 days	SDF (PHT Project), IFPP (Lingmethang)
Entrepreneurs/farmers (Chukha,Paro,Tsirang, Dagana, Samtse, Gelephu, Mongar, Tashigang, Lhuntse, Trongsa, Thimphu)	Fruit candy processing	31	5 days	Queen's project, IFPP (Lingmethang)

Youth Group (Gulibi, Menjey, Lhuntse)	Fruit candy and vegetable pickling	21	3 days	IFPP (Lingmethang), PTH project
Lead farmers of six Eastern dzongkhags	Value addition of fruits and vegetables	24	2 days	CARLEP, IFPP (Lingmethang)
Forest Community Group of Kalapang, Dremetse and Gungdu	Wild goose berry processing and product development	31	7 days	SFED (DoFPS.), IFPP (Lingmethang)
Farmers of Autsho. Lhuntse	Maize product development	28	1 day	ARDC (Wengkhar). IFPP (Lingmethang)
Farmers of Muktangkhar, Bartsham, Tashigang	Sticky rice product development	22	1 day	ARDC (Wengkhar). IFPP (Lingmethang)
Farmers (Pema Gatshel, Mongar & Samdrup Jongkhar)	Vegetable pickling and maize cookies, donut processing	57	1 day	CARLEP, IFPP (Lingmethang)
Youth Group	Processing of fruits, vegetables and cookies	5	5 days	RAMCO, CARLEP. IFPP (Lingmethang)
2nd Batch Lead Farmers	Technology available at the Center	26	1 day	CARLEP, IFPP (Lingmethang)
Teachers of Sherab Reldri Higher Secondary School	Cookies processing from maize, pumpkin and cassava	7	1 day	IFPP (Lingmethang)
Farmer of Gangzorgeog, Lhuntse	Cookies (Pumpkin, millet, maize) and vegetable pickle processing	33	2 days	Dzongkhag, IFPP (Lingmethang)
Women Group, Drujegang. Dagana	Frying of cornflakes	8	3 days	PHT Project, IFPP (Dagapela)
Women group. Drujegang. Dagana	Vacuum packaging of legumes and pulses	4	1 day	DDG, Dagana. IFPP (Dagapela)
Youth Group, Dagapela .Dagana	Mustard oil extraction and operation of machine	4	2 days	Dzongkhag, IFPP (Dagapela)
Farmers of Dagor, Shumar	Value addition of jaggery and peanut	37	2 days	Funded by CARLEP and conducted by IFPP, Pema Gatshel
Mongar geog (Mongar)	Proper utilization and operation of electrical dryers	13	2 days	IFPP, P/Gatshel
Farmers of Chokhorling geog (P/Gatshel)	Cookies processing from cassava, pumpkin and maize	14	1 day	DDG (Pema Gatshel), IFPP (Shumar)
Agriculture Extension Supervisors (S/Jongkhar)	Post-harvest handling and value addition of fruits and vegetables	12	5 days	CARLEP, IFPP (Shumar)
Farmers Group (Sipsoo, Samtse)	Postharvest handling and management of ginger. Technologies available for ginger processing	20	3 days	MAPS (DoA), AED (DoA)
Agriculture Extension Officers (Mongar, Thimphu, Paro, P/Gatshel, S/Jongkhar & Zhemgang)	Training of Trainers "Post Harvest Management and Value addition of fruits"	54	3-5 days	PHT Project, SDF, AFACI Project
	Total Beneficiaries	**993**		

4.4 Seeds and Plants Development Program

4.4.1 Developments

For the financial reporting year ending June 30, 2018, the National Seeds Centre (NSC) managed to make an overall average physical achievement of 138 % against its target in supply of seeds and seedlings. This is attributed to the huge spike in the demand for temperate fruit plants although fertilizer sales took a slump compared to the previous years (see Table 16). The Department is concerned that this could be partly due to illegal vendors engaging in fertilizer supply.

Table 16 Annual sales against target (2017-18)

Commodity	Unit	Target	Quantity Supplied	Percentage Achievement (%) against target
Cereals	MT	188	216.12	115
Temperate fruit plants	Nos.	60,000	61,533	103
Sub-tropical fruit plants	Nos.	75,800	165,184	218
Vegetable seeds	MT	10.00	10.75	108
Seed potato	MT	305	387.19	127
Oil seeds (mustard, soy bean)	MT	10	13.29	133
Asparagus seedlings	Nos	50,000	63,850	128
Cardamom seedlings	Nos.	150,000	117,696	78
Strawberry seedlings	Nos.	2500	5107	204
Fertilizer supply	MT	3520.5	3244.65	92
Over all Achievement				**138**

The significant program wise achievements are summarised as follows:

Seeds Production and Supply

A total of **627.42MT** seeds of vegetables, cereals, oilseeds and seed potatoes were produced on-farm, procured from Registered Seed Growers (RSGs) or imported and supplied to the farmers across the country. Following the ban on chilli import, and to encourage winter chili cultivation to meet in-country demand, the centre supplied around 148.5 kgs of hybrid chili worth **Nu.5.79** million. Most open pollinated variety (OPV) seeds of cereals, oilseeds and vegetables seeds are produced on farm and by RSGs while hybrid vegetables are mostly imported. In total, annual revenue of **Nu.51.51** million was generated from sales of seeds (cereals, vegetables, oilseeds and seed potatoes).

Figure 26 Turnip seed production in Phobjikha

Forecasting and precisely matching the demand and supply of seeds has always been the challenge. The centre is at times faced with market glut scenarios, for instance, there were few or no buyers for its seed potatoes last year owing to introduction of GST, demonetization and also as result of a bumper harvest in India. Potatoes did not fetch premium prices that year. NSC had to sow the unsold stock as well as dispose them off at purchase price.

Seedling Production and Supply

Figure 27 Citrus seedling production, Jachedphu (Trashiyangtse) & litchi marcottage (Sarpang)

A total of **4, 22,564** numbers of high quality seedlings of temperate and sub-tropical fruit crops, asparagus and cardamom were produced, procured and supplied to farmers.

The dip in the sales volume of seedlings and planting materials is due to decreased sale of cardamom seedlings, and the inability to supply citrus grafts in light of HLB infection. Further, the citrus production nursery had to be relocated to Jachedphu farm in Tashiyangtse. The centre hopes to be able to continue production of clean disease free citrus grafts following the completion of the production facility at the new location

soon. Nu 13.36 million alone was generated from the sale of horticulture seedlings and planting materials in the 2017-18 financial year.

Fertilizers supply

A total of **3244.65 MT** of fertilizers were procured and supplied across the country generating revenue to the tune of **Nu.86.08** million. An assorted number of different industry standard fertilizers are being supplied in an effort to help farmers enhance crop yield and productivity.

Capacity Building

With fund support of various projects (EU-TCP, GOI PTA-RCSC, GAFSP, etc) 36 NSC staff participated in capacity building programs both in-country and abroad. These include:

a) Two officials trained in seed production and management, and another in horticulture production and management in Thailand.

b) Four accounts staff trained in advance tally ERP9 at New Delhi.

c) Fourteen staff comprising farm managers and agriculture supervisors took part in a 10-day protected cultivation training at the Institute of Horticulture Technology, India.

d) Participation at the international AFACI workshop on Seed Extension and Seed Potato Project in LAOs, Indonesia and Thailand.

e) A month-long apple production training for an official at Hirosaki University, Japan.

4.5 Soil Services Program

4.5.1 Research

A number of activities intended to build the research capacity of the Soil Services Program as well help better understand and build knowledge and information on soil and nutrient management were initiated and/or completed in the past fiscal year. They include:

a) Implementation of a "**balanced fertilizer trial**" on spring paddy on 50 acres each in Gelephu & Samtse.

b) **Digital soil mapping** of soil organic carbon stock in Bhutan at 1 km resolution and produced Soil Organic Carbon Map of Bhutan.

c) Preparation and mounting of **two soil monoliths** – Histosols and Inceptisols.

d) **Documentation and mapping** of past SLM sites under Chhukha, Trashigang and Zhemgang dzongkhags.

e) Collection of **reference soil data** from Samdrupjongkhar, Sarpang and Zhemgang dzongkhags to produce the first ever Reconnaissance Soil Map of cultivated areas of Bhutan by 2021.

f) Completion of **soil survey** of LDCF model chiwogs at Nimshong (Trongsa), Legpa (Lhuentse) and Ngatse (Haa).

g) **Installation** of a segmented flow analyzer and other laboratory equipment for Soil & Plant Analytical Laboratory, viz. elliptical auto shaker, sample grinder, air compressors and scrubber system for digestion assembly.

h) **Capacity building** of 64 staff members on baseline data collection for LULC, soil survey & SOC in the country.

4.5.2 Developments

In delivering effective soil and nutrient management services to growers and other stakeholders round the country, the Department's Soil Services Program implemented the following in the past one year:

a) Analysis of some 3,047 samples (2,981 soil; 85 plant and 29 water samples), including samples from the National Forest Inventory, by the Soil & Plant Analytical Lab.

b) IPNM on paddy crop (main season) on 20 acres in Singye geog, Sarpang, 20 acres in Wangdue, and 32 acres in Shaba, Paro. IPNM on wheat carried out on 82.71 acres in Punakha; IPNM on citrus in Dagana and Sarpang covering 885 trees; and on cardamom covering 3 sites in Tsirang and Chukha.

c) Capacity building of 738 participants from Dagana, Sarpang, Paro, Tsirang, Wangdue and Chukha on soil fertility management of various crops.

d) Hands-on training on SLM techniques to farmers of 252 households in Wangphu geog (Samdrup Jongkhar) including study visit for farmers of the geog to SLM sites in Jarey and Thangrong.

e) Supply of farm tools set to SLM adopters of Wangphu geog (237 households) including planting materials for SLM bio-engineering activities, legume and vegetable seeds, fruit seedlings, and barbed wire fencing materials for critical drinking water sources in the geog.

f) Around 148.68 acres of land in Wangphu geog brought under SLM interventions like hedgerow, stone bunds or both; bench terracing etc.

g) Green manuring (using pea) on 7 acres in Shaba, Paro, and through use of dhaincha in 15 acres in Tsirang; 31 acres in Sarpang; 15 acres in Samtse, and 32 acres in Dagana.

h) Procurement and distribution of 2,000 liters of EM, 17.958 MT of bio-fertilizer to ARDCs, and 200 Kg of legume & vegetable seeds to farmers.

i) Land development through bench terracing, surface sMTe removal and consolidation on 18.25 acres in Lhuentse (29 households) and 11.30 acres in Zhemgang (20 households).

j) Demonstration of different SLM, IPNM and climate smart agriculture (CSA) approaches and technologies at three SLM model villages covering 35 acres.

k) Optimization of marginal land use of 400 households in Jarey and Thangrong through promotion of horticulture seedlings (avocado, peach, persimmon, apple, walnut (3,225) and cardamom (10,385). Farmers of these households in Jarey & Thangrong (330HH) also trained on orchard management.

l) Landslide stabilization program on six acres – 3 acres each in Jarey and Thangrong through planting of bamboo cuttings and check dam construction.

m) Supply of field equipment (soil color book, GPS, clinometer, compass and tent for data collection from six SLM pilot dzongkhags covering 18 Geogs & ARDCs.

n) Feasibility study for land user rights certificate (URC) jointly with NLCS at Chhukha, Paro, Pema Gatshel, Samdrupjongkhar, Trashing and TrashiYangtse dzongkhags

o) 304 cases of land conversion activities carried out in Chhukha, Paro, Punakha, Samtse, Thimphu and Wangduephodrang dzongkhags

p) Video documentation of project sites in Jarey & Thangrong, also covering 9 past SLM sites, and organized a national level UNCCD-LDN workshop.

q) Airing of advocacy program on SLM aired through Bhutan Broadcasting Service

5 SCHOOL AGRICULTURE PROGRAM

The School Agriculture Program (SAP) is collaboration with the Department of School Education, Ministry of Education (MoE) and the Ministry of Agriculture & Forests. The program has been functional since 2000 with the lead agency being the Ministry of Agriculture & Forests. Following the organizational development exercise in 2015, the SAP is now with the Department of Agriculture. Initially started with the prime objective of providing agriculture education and dignity of labour for self-employment opportunities, the SAP now also focuses on supplementing food and nutrition in school feeding program to help address shifting priorities.

The SAP currently supports 315 schools inclusive of 63 central schools, with about 68% coverage and contributing 23% of fresh vegetables and over 50% of livestock produce such as eggs and meat to the school feeding program. The program provides its support in the form of trainings, inputs supply such as agriculture tools, farms machineries, seeds, seedlings, small scale livestock for educational and nutritional supplement, and awards. During the reporting period SAP successfully linked and sourced additional funds for activity implementation from FSAP Project, WFP, FAO and Asia Pacific Natural Agriculture Network (APNAN).

Food Production for Nutrition Supplement

In the academic year 2017, 280 member schools with vegetable gardens produced a total of 197 MT of fresh green vegetables and potatoes (Figure 28). 80 schools had poultry program including 24 schools that ran poultry program for the "3 eggs/child/week policy". A total of 15, 00,000 eggs were produced that not only contributed to the school feeding program but also generated substantial fund for sustenance of the program. 82 schools having piggery program with atleast 5 pigs each, and produced 77 MT of pork .

Figure 28 Production for food & nutrition supplement in schools in 2017

6 FARM INFRASTRUCTURE

The Agriculture Engineering Division (AED) is oversees all infrastructure development programs of the department and the ministry which involves building new irrigation systems, rehabilitating old ones, coordination of farm road programs and civil construction works. However, its primary focus is on irrigation and improving crop productivity and production. Some of the associated activities carried out by department in collaboration with other stakeholders for the past fiscal year are summarized as follows.

6.1 Farm roads/Machinery

Construction and maintenance of farm roads remain a priority and are being constructed either through hire of machineries from the Central Machinery Unit (CMU) in Bumthang, and Regional Machinery Units in Samtenling and Khangma on cost-sharing basis or through machines already allocated to dzongkhags. A total of 466.31 km of new farm roads have been constructed and 728.13 km of existing farm roads were maintained using CMU excavators. These machines were also deployed in developing new and or widening terraced land (498 acres) for agriculture in Trashiyangtse,

Lhuentse, Bumthang, Dagana, Gasa, Haa, Mongar, Paro, Punakha, Samtse, Trashigang, Thimphu, Trongsa, Wangdue and Zhemgang dzongkhags.

6.2 Irrigation

The Department of Agriculture's Irrigation Section is responsible for building appropriate irrigation systems to enhance crop production, food and nutrition security of rural communities and RNR sector growth. It also emphasizes on the participation of the community beneficiaries to promote sustainable management of infrastructures and proper utilization of natural resources through formation of water user associations/groups (WUA). WUA members are trained on the operation and maintenance of their irrigation system.

Figure 29 Initial Intake structure (left) and present intake structure (right) at Baychhu (Wangdue)

Figure 30 Dreychhu irrigation during its implementation and at completion (Kana, Dagana)

Additionally, the Department provides technical backstopping to dzongkhag agriculture and engineering sectors in implementing technically challenging irrigation schemes either by through engineers based at regional engineering sections at the ARDCs or by deputing the engineers from the department's Agriculture Engineering Division. The Department was involved in construction of 14 new irrigation systems and

rehabilitation of 15 existing ones translating to about 180 kms of channels/pipeline covering 5,453 households.

Table 17 Irrigation systems (open & piped) built or renovated during in FY 2017-18 by the department

Sl. No	Name of Scheme	Length (km)	Benef/ HH	Command Area (Ac)	Expend (Mn Nu)	Funding Agency
1	Dreychhu Irrigation channel, Dagana	8.00	95.00	150.00	25.20	GoI
2	Thargom/Chokpagang Irrigation channel, Trashiyangtse	8.00	314.00	610.00	33.94	GoI
3	Baychhu Irrigation Channel, Wangdue	14.00	70.00	300.00	9.51	GoI
4	Takabi Irrigation Channel, Zhemgang	3.50	100.00	30.00	6.80	GCCA
5	Zhamangchhu_Yamalung Irrigation channel, Lhuntse	7.00	50.00	80.00	2.59	GCCA
6	Maogoan irrigation Channel, Sarpang	7.60	125.00	1000.00	3.00	GoI
	Total Achievement	**48.10**	**754.00**	**2170.00**	**81.04**	

While paddy cultivation is given the top priority, other irrigation systems for tree crops and vegetables are also considered important, and a sizeable dry land irrigation systems has been initiated, particularly for cash crops like potato and citrus. More than 300 acres of dry land were brought under irrigation to support winter chili and other vegetables production.

6.3 Building and Infrastructures

In the past year, the department implemented a total of 70 different civil construction works. Construction and maintenance needs of all RNR infrastructures within the ministry is also handled by the department's Engineering Division involving all stages of design, estimates, bid preparations, bid call and evaluation, and supervision and monitoring of the works. Very few large scale RNR civil works are being outsourced to private firms and are mostly donor-funded.

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