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RENEWABLE NATURAL RESOURCES RESEARCH CENTRE
BAJOTHANG, WANGDUEPHODRANG
"Walking the Extra Mile"

REGIONAL RESEARCH PROGRAM PROFILE FOR THE TENTH FIVE YEAR PLAN (2008-2013) THE WEST- CENTRAL REGION

Renewable Natural Resources Research Centre
Bajo, Wangduephodrang
Bhutan

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COUNCIL FOR RNR RESEARCH OF BHUTAN
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1 EXECUTIVE SUMMARY

The Regional Research Program for the 10FYP for RNRRC Bajo presents a review of the 9FYP, priority research issues and opportunities for the 10FYP, objectives and research strategies in the 10th Plan, program structure and a summary of major activities, human resource development, infrastructure required, monitoring and evaluation with prescribed format and budget for the plan period. The set objectives and activities of the 9FYP have largely been accomplished in terms of technology generation, dissemination, publications, human resource development and the utilization of allocated budget.

In the 10FYP, research issues and opportunities in the Field Crops sector include research and development on soil fertility, pest management, crop varieties, post harvest, processing and storage for important food crops like rice, maize, wheat, oilseeds, grain legumes and minor cereals. In Horticulture, citrus greening and fruit fly, chilli wilt, potato blight, viral diseases in cardamom, lack of knowledge and experience managing plantations and orchards, lack of organized market and agro-industry to support cultivation of new crops are areas that need research and intervention. In Livestock, major issues are feed and fodder production, apiculture, rangeland management and availability of livestock inputs for the farmers. In Forestry, choice of species and propagation techniques, degradation of farmlands, unsustainable collection of NWFPs and emergence of pest and diseases are major issues. In Farming Systems, the main issues are declining soil fertility, use of water resources, pest and disease manifestations and human-wild life conflicts. Under Research Communication sector, main issues include farmers' capacity for self-help and research-extension linkages.

The main research objective in the 10FYP are to identify, adapt or develop appropriate technologies, management strategies, and ecologically sustainable farming practices in rice, irrigated wheat, oilcrops, grain legumes, sub-tropical fruits, vegetables, feed and fodder, and agro-forestry for enhancing and optimising the integrated production processes and to effectively support regional extension through technology, information and joint monitoring of activities. Main strategies to achieve this will be to identify regional research priorities and needs through joint annual plans and investigative studies; work closely with the Dzongkhags and functional divisions of MoA and their central and field programs; demonstrate and showcase production technologies through strategically identified Research Outreach sites and link with Regional and International Research Institutes for technical and research material support.

Human resources are an important component of the Centre which would determine the success of the program. In the 10FYP, additional staff, both officers and assistants, are needed to be recruited to strengthen the program. Additional staff are necessary to cover major agro-ecologies and the number of research programs of the centre. As such, additional 26 staff including specialists, research officers, research assistants and support staff are proposed for the 10FYP. Additional 28 Essential Support Personnel (ESP) to

support establishment of research trials and running the centre at Bajo and the newly opened Mithun sub-centre will be required.

In terms of Human Resource Development, MSc is recognized as the basic degree necessary to carry out any research work. Most researchers have this qualification, but a few existing staff and those who will join the system in the future would require to upgrade themselves. It is also foreseen that the existing RAs would have to upgrade themselves to BSc level as required by the PCS once CNR becomes a degree college. As such, 3 BSc and 6 MSc, 3 PhD, and 8 Diploma slots are provisioned for the centre in the 10FYP).

Most of the basic research infrastructures, based on the Master Plan developed in 1994, were realized within the last three FYPs. RC Bajo now has a modest level of facilities and further investment in infrastructure development will not be required in the immediate future. However, with the revival of the Sub-Centre at Mithun in Tsirang, some infrastructure development will be necessary. In the 10th Plan, major infrastructure development include: River Bank Protection adjoining farm boundary at Bajo; Re-surfacing of approach road and parking area of the Centre; Re-surfacing of approach road to Sub-Centre Mithun in Tsirang; New Office building for the Sub-Centre in Tsirang; Concrete lining of drainage networks within the RC Bajo area; Field and laboratory equipment and Purchase 2 pool vehicles for Tsirang and one replacement for Bajo.

The monitoring of technical progress of the research program, using agreed indicators (Annexures 2c, 3c, 4c, 5c,6c and 7c) will be undertaken through the half-yearly reports, annual reports, regional workshop proceedings, research papers, technical bulletins and the final technical report at the end of the 10 FYP.

The proposed 10FYP outlay is **Nu.130.82** million. The plan outlay is in keeping with the Guidelines for Preparation of the Tenth Plan from Planning Commission and the program priorities drawn up for both the national and regional mandates of the Centre. Major donors who supported the implementation of Centre's programs are withdrawing their support by the end of the 9th Plan. Under such circumstances it is understood that that the total Plan Outlay will have to be funded by RGoB. However, the Centre will make every effort to seek donor fund support particularly for the capital works.

2 BACKGROUND

The West-Central region served by RNR-RC Bajo is comprised of 5 Dzongkhags (Gasa, Punakha, Wangdue Phodrang, Dagana, and Tsirang). The region has a diverse range of environment and agro climatic conditions ranging from Alpine to dry and humid subtropics with a corresponding diversity of production and farming systems. The region has a total area of 11,449 sq. kms with 51.31% of forest cover (LUPP/MoA, 1995). The road network includes east-west national highway passing through Wangdue Phodrang and a north-south national high way passing through Wangdue Phodrang and Tsirang. The lateral paved roads connect Punakha and Dagana Dzongkhags. Gasa Dzongkhag Headquarter is not yet connected by motorable road but a feeder road exists till Damji.

The region has comparatively broad valleys (Punakha-Wangdue) and hills (Tsirang, Dagana and Gasa) where farming is concentrated. The region has a range of climates from dry and humid sub-tropical to temperate favouring cultivation of wide range of crops.

The West-Central region contains 16% of the rural population of Bhutan. Within the region, Wangdue Phodrang is the largest Dzongkhag with 30% of the region's population, while Gasa is the smallest with only 4%. The remaining Dzongkhags contain about 20% each of the regions rural population.

2.1 General features of Dzongkhags in the Region

Gasa

Gasa Dzongkhag lies to the north of Punakha Dzongkhag with an area of approximately 4,409 km^2 which makes it the largest of all the Dzongkhags of Bhutan. Two main rivers, Pho Chhu and Mo Chhu, originate from the snow-clad catchments in the northern part of this Dzongkhag. The elevation ranges from about 1500m to 4500m above sea level. Rainfall is scanty and virtually no rain in winter in the upper region. However, there is heavy snowfall in the upper region Precipitation during winter and spring is in the form of snow and the summers are cool and wet. The average rainfall is about 2,000 mm annually.

Gasa Dzong is perched on a hilltop with a small town emerging on the southeastern facing slope. The feeder road from Punakha town to Damji is the only motorable road in the Dzongkhag. From the road head, it takes about 5 hours walk to reach Gasa Dzong. The Dzongkhag is also accessible by mule track from Paro. The Dzongkhag has 8 Renewable Natural Resources (RNR) facilities including extension centres, agriculture extension centres, livestock extension centres, veterinary hospitals and forestry offices.

Punakha

Punakha Dzongkhag lies to the east of Thimphu Dzongkhag and it is an important entry point to Gasa Dzongkhag to the north. It has an area of approximately 974 km^2. The elevation ranges from about 1300 m to 4800 m above sea level. The Punakha Dzong rests on the confluence of Pho Chhu and Mo Chhu. The Punakha Valley splits into two smaller valleys north of the Dzong following the rivers of Pho Chu and Mo Chu. Downstream after the confluence the river is called Puna Tsang Chhu. The valley of Punakha enjoys a subtropical climate with dry and cool winters. The annual precipitation ranges from 500 mm to 1500 mm. There are 18 RNR facilities in the Dzongkhag including RNR extension centres, agriculture extension centres, veterinary hospitals and forestry offices.

Wangdue Phodrang

Wangdue Phodrang Dzongkhag occupies an area of approximately 4038 km^2. The elevation of the Dzongkhag ranges from 800 m to 5800 m above sea level. The summers are moderately hot whereas most of the areas in the north remain under snow during wintertime. The average annual rainfall is approximately 1000 mm.

The west-east lateral highway passes through Wangdue town. The highway to Tsirang Dzongkhag and then further to Sarpang Dzongkhag bifurcates from the lateral highway at the Wangdue Bridge. There are other feeder roads connecting the major settlements to the highways. At the end of the 9th FYP, almost all the geogs are connected by road except Daga and Athang geogs. The Tashila Ropeway situated to the east of Wangdue town leads up to Khotokha and is used for transport of logs, goods and people.

The Wangdue-Phodrang Dzongkhag has 32 Renewable Natural Resources (RNR) facilities including RNR extension centres, agriculture extension centres, livestock extension centres, veterinary hospitals and forestry offices. A model geog centre is also in place in Phangyul geog. The RNR Research Centre at Bajo is a regional research centre located in the Dzongkhag.

Dagana

Dagana Dzongkhag lies between Chhukha and Thimphu Dzongkhags to the west, Wangdue-Phodrang Dzongkhag to the north, Tsirang Dzongkhag to the east and Sarpang Dzongkhag to the south. The Dzongkhag covers an area of approximately 1389 km^2. The elevation ranges from 600 m 3800 m above sea level. The summers are hot while the winters are dry and cool. Dagana Dzongkhag falls within the temperate zone in the north while the lower and more southerly located parts of the Dzongkhag are subtropical. The annual rainfall averages 750 mm.

There are two feeder roads leading to Drukgyegang and Gozhing Geogs. The Dzongkhag has 21 RNR facilities including RNR extension centres,

agriculture extension centres, livestock extension centres, veterinary hospitals and forestry offices.

Tsirang

Tsirang Dzongkhag lies in the mid-south of the country bounded by Wangdue-Phodrang, Dagana and Sarpang Dzongkhags. It covers an area of approximately 639 km^2. Tsirang is the second smallest Dzongkhag in the country after Pemagatshel Dzongkhag. The elevation ranges from 400 m to 2000 m above sea level.

The climate can be classified mainly as subtropical. The summers are hot and humid while the winters are dry and moderately cold. The rainfall is between 1000 mm and 3000 mm per year. The climate and altitude range provide a wide potential for supporting different types of agricultural activities.

The access to Tsirang by motorable roads is from Wangdue-Phodrang in the north and Sarpang to the southeast. Another road connects Tsirang with Dagana Dzongkhag to the southwest. There are a number of feeder roads and farm roads linking different geogs. Tsirang's infrastructure is well developed compared with most of the other Dzongkhags. The Dzongkhag has 19 RNR facilities including RNR extension centres, agriculture extension centres, livestock extension centres, veterinary hospitals and forestry offices.

2.2 Natural resources situation

Forests

The West-Central region has 24% (692028 ha) of the national forest area. Dominant forest types include Fir, Mixed Conifer, Blue pine, Broadleaf mixed, and Chirpine. Broadleaf-mixed type of forest covers the largest area (257,697 ha) in the region which is about 37.12% of the total forest area followed by Conifer-mixed, Fir, Chir pine and Blue pine. Conifer forest is dominant in Gasa and Wangdue, while the broadleaf forest is more common Wangdue, Tsirang, and Dagana.

Gasa has approximately 19% of its total area under true forest cover which is largely intact. Most of the forest occurs in the southern part of the Dzongkhag where mainly species like fir and blue pine thrive. Most of Gasa Dzongkhag falls under the Jigme Dorji National Park, and many different types of valuable medicinal plants and herbs grow in the higher altitude areas. The national animal, Takin, is also found in this Dzongkhag.

Punakha has approximately 85% of its total area under true forest cover. Most of the coniferous forests are of low or medium crown density. Some parts of the Dzongkhag fall under the Jigme Dorji National Park where diverse flora and fauna are found.

Wangdue has about 65% of its total area under true forest cover. Both broadleaf as well as conifer forests are prevalent. Phobjikha valley is famous

as the winter nesting place for the black-necked cranes. A major portion of Wangdue-Phodrang falls under the Black Mountain Forest Reserve, and the Jigme Dorji National Park extends into the northern part of the Dzongkhag.

Dagana has about 79% of its total area under true forest cover consisting mainly of broadleaf species. While the forest itself is a major untapped resource, there are many species of wildlife in the forest. The forests also function as pasture land.

Tsirang has a forest cover of 76% which is largely intact. Species like chir pine, bamboo, *panisaj, simal, chilaune, saj, champ* and oak thrive in the forest. Agro-forestry systems particularly the integration of fodder trees in the farming systems are widely practised in Tsirang and Dagana Dzongkhags. In general, the region has a fairly good forest cover but there is a trend of declining vegetation within the farm vicinity. Availability of fuel wood and timber is becoming a major problem in many areas and shortage of water is commonly reported as a problem in critical watersheds.

There is extensive livestock grazing and pressure on forests thereby decreasing the ability of forest to regenerate. Overgrazing and continuous use of forest resources is leading to depletion of vegetation cover. Forest litter and leaves provide the major source of nutrients for the crops in the wetlands as well as dry land fields. Cropping intensity in the region has increased significantly over the years and there is an increasing demand on nutrients mainly from the forests.

Livestock

Within the region, large ruminants (cattle and buffalo) population numerically dominate the livestock sector. Wangdue Phodrang has the highest large ruminant population (43%), while Gasa has a very small population (2%). Yak is found only in Wangdue Phodrang and Gasa with 60% of the Yak population in Wangdue Phodrang. Small ruminants (goats and sheep) are popular only in Wangdue, Dagana and Tsirang.

In Gasa, the alpine pastures are the homeland of the yaks. Livestock rearing is an important occupation in the northern part of Gasa where agriculture is not possible due to the altitude. The major cash income is from the sale/barter of animal products.

In Wangdue, the higher ridges along the central valleys provide rich pasture for livestock. A significant area (approximately 3.5%) is under Tsamdro (pasture). There are between 45-50,000 heads of livestock, so the number of cattle per household is relatively high. In Dagana and Tsirang, livestock rearing is another important economic activity. Pond fish farming and backyard poultry farming for egg production are gaining popularity in Tsirang and Dagana.

Scarcity of animal feed and green fodder for cattle especially during winter months is a severe problem for wetland farmers in the region. Overgrazing is

increasingly causing depletion of vegetation cover. In the wetland areas, though cropping intensity has increased fodder situation has not improved. The situation may further deteriorate with increase in population of improved breeds. Some of the major constraints are: inadequate suitable feed/fodder crops to meet the increasing requirements, lack of appropriate fodder production techniques, lack of information on fodder resources, farmers' practices and constraints, lack of seeds and seed production techniques, limited land for pasture and fodder production, and competing cash crops in the wetlands.

Field Crops and Horticulture

About 41% of the total arable land is under dryland cultivation, 29% is wetland and the remaining area is under *tseri*. The major field crops of the region include rice, maize, wheat, buckwheat, barley, millet, mustard, and legumes. Forty two percent of the area under field crops is under rice, 33% under maize, 7% each in wheat and millet, and 5% in mustard. Field crops are mainly concentrated in Wangdue, Punakha, Tsirang, and Dagana. Gasa has only 1% of the regional field crop area. Maize is the major cereal in Tsirang and Dagana, while rice is mainly grown in Punakha, Wangdue, Dagana and Tsirang. Wangdue has the largest rice area in the region. The major horticultural crops of the region include cardamom (37% of the regional horticulture area), mandarin (18%), potato (25%), vegetables (16%), and chilli (3%). Cardamom and mandarins are mainly grown in Tsirang and Dagana. Vegetable cultivation is mainly concentrated in Punakha, Wangdue, Tsirang, and Dagana.

Past research and extension work made good impact. The Punakha-Wangdue valley is known to produce and supply many vegetables to the local and Thimphu markets. There has been a substantial increase in farm incomes from the sales of vegetables. The increase in quantity and type of vegetables consumed by the farmers at home has also improved their nutritional status.

Improved rice varieties have produced very good impact in increasing crop production. In rice, since the initiation of on-farm trials in 1986, the results have been remarkably consistent with the best-improved variety yielding between 0.7 and 1.0 t/ha more than the traditional variety under local management practices. It is estimated that the annual increased value of rice production due to improved rice variety IR64 alone is over Nu.10 million in the Punakha-Wangdue Valley.

In Gasa, the major portion of land is of little use for arable purpose. The Dzongkhag has a very small area of Chhuzhing (wetland) and Kamzhing (dryland) in its lower altitudes. Tiny patches of Tseri (slash and burn cultivation) are found as well.

Punakha has a major portion of the agricultural land as Chhuzhing. It occurs mostly along the valleys of Pho Chhu and Mo Chhu. Rice is an important crop. Wheat, maize, potato and barley are other important annual crops. The

Dzongkhag produces some surplus rice, which is sold locally and in Thimphu town. Sharecropping is a common practice in the Dzongkhag.

In Wangdue Chhuzhing dominates the agricultural activity followed by Kamzhing (dryland), some mixed farming and few patches of Tseri. The majority of the paddy fields are spread along the Dang Chhu and the Tsang Chhu, and cultivation of rice is an important agricultural feature. Potato and wheat are some of the most important dryland crops. Apart from potatoes, which are an important cash crop in the Phobjikha valley, the income from cash crops is limited at present. Only a few apple and citrus plantations are found in the Dzongkhag.

In Tsirang and Dagana Kamzhing is the most dominant land use although Chhuzhing and some Tseri farming practices are also found. In Tsirang, the percentage of land under Chhuzhing is one of the highest in the country. Area-wise, the most important annual crops are maize, rice and millets.

The horticultural crops in Tsirang and Dagana include cardamom, mandarin, other citrus fruits and banana. Tsirang is famous for its mandarin, which are a major source of cash income together with other citrus fruits and cardamom. These cash crops are exported to the Indian towns and Bangladesh markets. Potatoes and dairy products are other cash-earning items in Tsirang and Dagana Dzongkhag.

2.3 History of Research

With the establishment of the Centre for Agricultural Research and Development (CARD) at Bajo, Wangdue in 1982, research work on staple field crops was initiated. The Centre was renamed in 1994 as the Renewable Natural Resources Research Centre (RNR-RC Bajo) to take account of its expanded mandate to cover RNR research. The Centre is located at Bajothang (Bajo) Wangdue Phodrang at an elevation of about 1300m asl on the banks of Puna Tsang Chhu in the Wangdue-Punakha valley system. The Centre has a 62 acres research farm. Some of the basic facilities have been upgraded with the construction of a new administrative cum laboratory building and a general operation building. The centre has a library with small collection of literature and it is connected with internet facilities.

The Centre mainly focused research in the past on rice, wheat, oilcrops and vegetables. Major research emphasis has been on germplasm improvement, production management, soil nutrient management, cropping patterns. On-farm research has been emphasised for further fine tuning of the technologies generated on the station or borrowed from outside. Good linkages are being maintained with extension system of the nearby Dzongkhags through on-farm trials and training programs organised for the extension. To further foster the strengthening of linkage, a unit called Extension Program office established in the centre since 1998 has been re-designated as the Regional Research Communication Office.

To be able to fully support the regional requirements, the Centre has initiated from 1994 additional research activities on sub-tropical fruits, feed and fodder in livestock, and in agro-forestry. From 1997, a Water Management Research program has also been started.

The research set-up and approach in the past was very much commodity oriented and cropping systems focused, which did not allow inter-sectoral or interdisciplinary interactions. In addition, it is also increasingly realised that degradation of off-farm resources has not been given adequate research attention. In the light of this a more holistic approach to research was deemed essential to realize the full benefit of integration. Sustained use and management of natural resources is central to development of sustainable production systems. In view of this, since 1997 the Centre has adopted a Community-based Natural Resources Management as one of the approaches in the Research and Development.

The RNR Research Centre at Bajo has two mandates:

- National Mandate

RNRRC Bajo is mandated to co-ordinate the National Field Crops Research Program. Management of the national mandate is primarily a co-ordination function to ensure that the research activities carried out under a particular program in different RNR-RCs are consistent with the national and regional priorities, are not duplicated and are interlinked. The Co-coordinating Centre is also expected to provide technical support to other RNRRCs.

- Regional Mandate

The primary regional mandates are to undertake RNR research relevant to the region that it serves in all the research program areas, and to backstop regional extension activities. The task of ensuring co-ordination between the regional activities of the national programs and their effective implementation is the responsibility of the RNRRC. Accordingly, the RNRRC West-Central Region has the regional mandates to undertake relevant research for its client Dzongkhags of Gasa, Punakha, Wangdue, Dagana, and Tsirang.

The center's organogram is presented in **Annexure 1**.

3 REVIEW OF NINTH PLAN (REGIONAL)

3.1 Technologies generated/evaluated in the region

Field Crops

Several new crop varieties were evaluated in the region. Three rice varieties, Yusiray Kaap, Yusiray Maap and Machapucherey 3, were tested at Damji (2250 masl) under Gasa. The varieties were grown under farmers' own management practices. During the harvest time, a field day was conducted to

evaluate the varieties and gather farmers' feedback. Farmers noted that Yusiray Kaap (5.1 t/ha) and Yusiray Maap (4.3 t/ha) were difficult to thresh without using pedal threshers. However, the yields were higher than their local Gyembja Maap (4.2 t/ha). Farmers preferred Machapucherey 3 due to its good yield potential (5.8 t/ha) and ease in threshing. In rice production management, rice farmers of Damji experience shochum (*Potamogeton distinctus*) as the most problematic weed in rice. So far intensive hand weeding seems the only practical solution. Awareness creation about adequate and timely hand weeding was therefore carried out. Farmers were briefed and demonstration of uprooting the weed from the deeper layer to expose the underground shoots and collecting and disposing the uprooted weeds outside the field was done. The campaign was conducted several times in Gasa.

In Punakha, high and mid-altitude rice varieties were evaluated. The main aim of the activity was to increase the production through introduction of high yielding varieties for farmers to attain food self sufficiency. Farmers of Guenshari have adopted Machapucherey 3 (6.9 t/ha) as a promising variety. Local variety averaged only 5.0 t/ha. In the mid altitude zone, farmers of Zomi have adopted B2983B (6.8 t/ha) and GUOJING 4 (6.1 t/ha) that were selected from the on farm evaluation. The area grown to these varieties is expanding every year. Different varieties of soybean and groundnut were also tested and promoted among farmers. Shochum is a noxious weed for the farmers of Guenshari. They usually hand weed once due to limited manpower. We sensitized farmers on the need and value of 2-3 weedings to reduce weed pressure. Hand weeding campaigns were organized for two seasons and farmers are following our recommendation. They feel that the weed pressure is comparatively low as that of previous years.

In Wangdue, rice cultivation was introduced in Khotokha, Shellay and Dangchu. Rice was never grown before in these areas, therefore complete package of practices was demonstrated. Now farmers are cultivating rice on their own. Jakar Ray Naap, variety that is grown in Bumthang, is found to be suitable in high altitude areas. In lower elevations, many new varieties were tried. IR 20913 (5.0 t/ha) is preferred by the farmers of Rukha while IR 64 (4.8 t/ha) and B2983B (6.5 t/ha) are promising and adopted by farmers in Samthang. In addition B2983B and GUOJING 4 (6.2 t/ha) have spread in Ruchikha village after the on-farm trial showed an yield advantage of over 23% compared to their local varieties. In the maize growing areas like Samthang, Yangtsipa variety has been introduced and popularized. Free seeds were supplied on a promotional basis. A tengma making machine was also supplied so that by-products of maize could be encouraged.

In Tsirang and Dagana, two varieties, Khumal 2 and Khumal 6, which have been released by RC Wengkhar were tested for yield performance and other agronomic traits. It was found that both these varieties were good performer as compared to the local variety. Khumal 2 yielded 4.3 t/ha while Khumal 6 gave 5.0 t/ha compared to 3.5 t/ha from Local Choti. The varieties were uniform in all aspects and farmers in Reseerboo under Mindrelgang Geog have started adopting these new ones. New maize varieties (Yangtsipa,

Khangma Ashom I and II) were introduced and tested in the dzongkhags. Their performance is better than the local varieties in terms of production. However, farmers noted that the new varieties have poor keeping and storage quality than their locals. As a response to emergence of GLS and TLB diseases, new maize varieties having higher tolerance to the diseases such as Ganesh 2 were evaluated. The results are being validated.

Horticulture

The highlights of achievement in horticulture research include crop improvement, production technology, nursery management and plant propagation techniques.

Crop improvement

Under the regional fruits & nuts and vegetable improvement, improved and superior crops cultivars identified and released for general cultivation after intensive research and validation are:

Table 1: Improved fruits and vegetables cultivars released for general cultivation

Commodity	No. of cultivars	Cultivar Name
Walnut	2	Kanthel Selection and Yusipang2
Almond	4	Taxes, Drake and Debar Badan, Kagzi
Pear	1	Bajo Lea1
Subtropical apple	1	Bajo apple
Grapes	2	Perlitte and Muscat of Alexandria
Peach	2	Bajo Kham1 and Bajo Kham2
Apricot	1	Bajo Khamchung1
Lime	1	Bearss
Radish	1	Bajo Laphu1
Tomato	1	Bajo Lambendha1

The other fruit and nut cultivars identified for further testing are summarized in Table 2.

Table 2: Promising fruits/nuts and vegetable cultivars for further testing

Fruits	No. of cultivars	Cultivar Name
Avocado	2	Bacon and Hass
Pomegranate	2	Bedhana and Khandari
Mango	2	Langra and Amarpali
Walnut	1	Chandler
Pecan nut	2	Desirable and Western schely
Guava	2	Pinkflesh and Local
Beans	2	Chitokha Black and Bajo Dwarf

Crop production management technology

The crop production management technologies recommended for enhancing the crop quality and productivity under local situations are:

- Improved walnut propagation and nursery management practices
- Walnut production management technology
- Mango propagation and production technology
- Improved apricot production techniques
- Backyard fruit crops production through top working technique
- Early chilli production technology
- Chilli production technology
- Tomato production technology

Progress achieved in Research Outreach Program

Based on the Centre's research outreach program objectives of demonstrating and showcasing new technologies and production techniques, the sector initiated the following activities:

- Demonstration of benefits of commercial farming of potato in Nabesa and Tshokothangka villages under Nahi geog in Wangdue Dzongkhag.
- Walnut model village initiated in Nahi geog in Wangduephodrang
- Pear model villages initiated in Beteni village under Tsirang Dzongkhag and Shelley village in Wangdue.
- Demonstration of improved citrus production initiated in Salamjee village in Dagana and Roinang woong in Tsirang Dzongkhags
- Demonstration of improved method of persimmon processing, packaging and marketing conducted for 28 farmers in Nobgang village.
- Promoted two private nursery growers (of improved walnut and pear seedlings) in Beteni under Tsirang Dzongkhag
- Demonstrated early chilli production technology in Zawa village in Wangdue and Salamjee village in Dagana

Forestry

Salamjee community forestry user group under Dagana Dzongkhag was trained on forest nursery establishment for planting in degraded and community land. Species included *Schima wallichi, Leucaena leucocephala, Melia azedarach, Ficus roxburghii*, and Vetiver, Paspalam and Napier grass. Two hectares of community plantation at Salamjee was established with mixed species (*Cupressus corneyana, Tectona grandis, Aesandra butyracea, Acacia catechu, Quercus glauca, Terminalia belerica*). The survival rate was above 90%.

Multi-purpose tree species (MPTS) domestication, propagation techniques and growth performance are being studied at on-station, Bajo. Six pamphlets on *Ficus roxburghii*, *Cupressus corneyana, Thysanolaena latifolia*, Bamboo sp. *Oroxylum indicum,* and *Symplocus paniculata* were developed and distributed regionally and nationally.

Bluepine thinning trial in Khotokha Forest management unit (FMU) was established. The data for the first three years were collected and analyzed in collaboration with the forestry research, RC Jakar. The preliminary findings revealed that moderate thinning yields maximum standing volume per hectare and increment.

Field testing of forest resource assessment methods for outside FMUs was carried out in the Lingmuteychu watershed in collaboration with FRDD and BG-SRDP. The exercise culminated in the development of manual for assessing forest resources outside forest management units by FRDD.

Ex-situ and in-situ study of Yangka (*Yushania sp*.) included establishment of two permanent sample plots at Tangka Tsho in Jala village in Wangdue. Rhizomes were collected and planted in three farmers' field (10 rhizomes each) for domestication.

Livestock

The livestock research in the region mainly focused on improving the fodder production through germplasm evaluation of improved and local fodder species and exploring non-conventional feedstuffs. Fodder plantation and production in alignment to land rehabilitation was emphasized. Further the opportunity of fodder production on paddy bunds and orchards was explored. A modest attempt was made on apiculture, evaluation of performance of exotic breeding boars, hatchability trails and documentation of farming practices of buffalo and goat.

Germplasm evaluation of legume fodder species such as Sweet clover *(Mellitosis spp)*, Australian and Indian Lucerne *(Medicago sativa)* indicated that Australian varieties performed better (4.26 - 9.77 t/ha per harvest on fresh basis and DM production of 1.30 - 3.25 t/ha). The faster growth and higher DM yield of Lucerne in winter could fortify straw feeding as source of protein.

To strengthen the winter fodder base, a total of 22 cultivars of oat *(Avena sativa)* were evaluated. All cultivars did well except 7 which were susceptible to rust disease. The local varieties of sugarcane *(Saccharum officialinis)* were identified to be a promising fodder species.

The impact of irrigation in dry matter production of few promising species was studied and results indicated that Napier performed well in both the conditions (av. dry matter yield of 3.49t/ha and 1.73 t/ha for irrigated and non irrigated treatments respectively. Lucerne produced about 2.36 t/ha dry matter under irrigated condition against 1.52t/ha from non-irrigated plot. Five harvests of all species in a year were possible. Although Napier produced the highest fresh and dry matter it required some level of moisture in the soil.

In view of utilization of degraded land for fodder production and as land management tool, promising fodder species (Napier, Paspalum, Desmodium,

Leucaena, Brachiaria) are propagated, maintained and supplied to different land management sites in the region. Besides testing of suitable legumes under orchards system and evaluation of sub-tropical fodder species for fodder production on paddy bunds are on-going.

To show case promising fodder species to visitors, live fodder herbarium were established at Bajo and RSC, Tsirang

Detailed information on local fodder trees/shrubs species in the region were collected and documented. Survey on local feed resources was completed. Validation of dry matter production from improved pasture was completed and data submitted to RC, Jakar.

Under nationally coordinated program, assessment of the genetic diversity of native pig and poultry through a survey cum blood sample collection for DNA analysis was completed. A study on goat and buffalo farming practices documented and reported. Documentation of local livestock products type, processing techniques and marketing system was completed. Yak herd monitoring to study the herd dynamics, assessment and monitoring of grassland resources including the botanical composition were completed. The honey production from local bees *(Apis cerena)* under improved hive management system is initiated and ongoing.

Comparative study on hatchability of improved and local eggs under farmers' management condition using broody hen yielded equally good result (80%) but the mortality was found to be high.

A study on effect of housing on the performance of exotic breeding boar was conducted. It indicated that improved housing for breeding boar could positively benefit the farming community.

Integration of fish production along with rice was conducted and the result indicated that growth rates of the fish to be were very low.

For promotion of Apiculture in the region, study of *Apis mellifera* production and management was initiated. The results show that honey production was good with average 30 kg/hive per year but to protect bees against predators especially hornet was a big challenge.

Farming Systems

The Farming Systems Support sector comprises of cross-cutting disciplines like Integrated Pest Management (IPM), Soils, Water, Socio-Economics and the Geographical Information System (GIS). In addition to the mandated responsibilities, the sector also undertakes diagnostic studies and surveys that the centre ventures into. The sector also caters to the *ad hoc* requests by the client Dzongkhags in terms of technical advisory services, field visits and capacity building of the extension personnel and farmers. The sector collaborates and provides inputs and services to other four sectors as well. In the 9th plan, the sector achieved most of the planned activities in addition to *ad hoc* activities some of which are underlined as under.

The 9th plan period witnessed some of the following activities in the IPM sector such as the demonstration on chilli cultivation on a large scale to manage Phytopthora blight in farmers' field and *Shochum* weeding campaign at regional level under the guidance of Ex-Hon'ble Lyonpo Sangay Ngedup, the Minister of Agriculture. Through these demonstrations, research was able to convince the farmers that recommended research package of practice is practicable if implemented properly in farmers' field irrespective of the land area. Likewise *Shochum* weeding activity has now become a routine activity in an extension agent's work plan in the region. Management of citrus fruit fly (*Bactrocera minax*) was also successfully implemented in one community in Tsirang through collection and disposal of dropped fruit by the community. Tangible increase in the productivity of mandarin has been recorded in terms of cash income by the farmers of the community. The sector also participated in the survey and identification of the maize disease problems in the east. The surveillance and monitoring of citrus greening disease in the region is ongoing. Training of extension staff and farmers on different aspects of crop protection were also done during the period. In terms of capacity building, the research officer of the sector successfully completed his master's degree overseas.

Under the **soils unit**, some of the major achievements include:

- In Tsirang, the soil fertility is declining due to limited soil nutrient input leading to low crop yield (citrus and rice). Established a baseline soil nutrient status for rice and citrus. Alternative soil nutrient management option tested and identified (green manure) as alternative to farmyard manure for soil organic content improvement for rice. Integrated Orchard Management Trial conducted for citrus and soil nutrient management practices recommended.

- In Dagana, the on-farm soil fertility is declining due to surface soil run-off and soil erosion. In addition land degradation taking place in various forms such as land slides; gullies, exposed bed rock and shallow topsoil are some of the common features. Steep slopes, exposed soil after land preparation, high intensity rainfall during land preparation and lack of awareness amongst the community were common reasons for land degradation. With the average slope of 60 to 70 percent and

rocks and boulders occupying almost 30 percent of the cultivable land, the farmers had been dwelling in the vicious circle of low farm yield leading to poverty.
- Development of community capacity on sustainable farmland management through trainings and farmer in-country study tour
- Formation of Salamjee Phashing Zingchoung Tshogpa
- Linking community group with donor agency
- Established hedgerow using leguminous fodder species, grasses, and fruit crops.
- Construction of stone contour bunds and check dams
- Digging diversion canal for forest run-off water
- Community forest plantation
- A total of 60 farmers trained on the different technologies for sustainable farm land management
- A draft Extension Manual on Capacity Building of Local Institutions for Sustainable Farm Land Management in placed

Punakha (Lingmuteychhu Watershed)
- Land degradation on on-farm due to cultivation on steep slope farms without any soil erosion control measures. Maize trashline has been tested and identified as one of the surface soil run-off control measures for Nabchhey village.
- Low rice yield due to imbalanced fertilizer application in Omteykha, Wangjokha and Shengana villages. On-farm trials on balanced fertilizer application were conducted and fertilizer rates were corrected and recommendation made for rice crop.
- Of-farm land degradation problem leading to formation of gullies and destroying irrigation canals. Gully stabilization through planting of trees and grasses along highly degraded canals and construction of series of live post check dams.

Gasa
- Gasa Dzongkhag is identified as organic farming Dzongkhag with potato as the main cash crop under organic production. Soil fertility management is one of the main components under organic farming. To assess the soil fertility trends under organic potato production, annual soil sample analysis done and data base established for selected farms at different altitude.

The activities implemented by water management research (**WMR**) unit in the 9FYP can be broadly grouped under three major activities: watershed management research activities, water management support to regional Dzongkhags, and engineering services. Brief overviews of these activities are presented as follows.

Lingmuteychu Watershed Management

In 1997 Lingmuteychu Watershed was adopted as the research site for conducting on-farm research by RNR RC Bajo. During the diagnostic survey, irrigation water shortage during the rice transplanting season was the main

issue. The subsequent water balance studies revealed seasonal water shortage problem in the watershed, however based on the annual water availability assessment showed that there is adequate water in the watershed. Parallel studies confirmed that water use efficiency was very poor mainly due to the traditional water sharing arrangements. Water sharing was mainly based on the two principles “first come first serve”, and “upstream users have full right to divert all the water into their irrigation channel irrespective of down stream users”. As a result of this arrangement, downstream users have the full right to the seepage coming out of the upstream irrigation channels.

Therefore, in the watershed there was limited scope of improving conveyance efficiency of the irrigation channels. Very often conflicts arose among the communities whenever some of the communities get government support to line their irrigation channels. The communities have been to courts number of times to resolve their conflicts. In the absence of any legal instruments the courts based their decisions based on the traditional sharing arrangements thus continuing the vicious circle of conflicts in the watershed.

To break this circle of conflicts, the water management team decided to bring all the seven communities in the watershed to one common forum to discuss the problems and issues of water resource management. Role Playing Game (RPG) was used as a tool to bring the communities into a discussion mode. This tool allowed individual community to view their problems from different perspective. It helped them to weigh the advantages and disadvantages of cooperating and not cooperating among the seven communities to resolve the water resource management issues in the watershed. The first RPG was played between the two communities, while other community member participated as an observer in 2003. Subsequently two more RPGs were conducted involving all the communities, local leaders, GYT & DYT members.

The outcome of the three RPGs was the formation of Lingmuteychu Watershed Management Group (LWMG) in the beginning of 2005 backed by By-law. At present the LWMG is in the final stages of developing Watershed Management Plans. Since LWMG was directly linked to the donor agencies, the group has managed to secure some fund support for implementation of their priority development activities. Some of these activities are:-

(1) Rejuvenation of Lumpa irrigation channel in 2006 which was left fallow due to dwindling irrigation water source enabling five household to re-cultivate their wet land,

(2) Stabilization of gullies formed by secondary irrigation channels through the construction of drop structures which help to reduce the sediment deposit in the fields thus improving the rice production in Dompola,

(3) Irrigation channel conveyance improvement by cement lining and providing pipes for gully crossing for Omteykha (Punakha) and Matalumchu (Wangdue) channels, further this activity has evoked constructive discussion between the communities with regards to sharing water at the source (60:40) engaging the respective dzongkhag officials,

(4) LWMG committee members went for a study tour to India, some community members went a study tour to Radhi Watershed in Trashigang.

(5) Water harvesting training was conducted in watershed in 2008, with the main objective to help the farmers to analyse the water shortage problems, develop solutions to address it, and develop action plan for activities.

(6) Water resource management training was conducted in Nabchee in 2004 with the objective of analysing dwindling drinking water sources, to develop action plan to address the problem. The outcome of the training was the construction of water harvesting structures.

Regional Activities

Irrigation System Management Study: was conducted for four irrigation schemes in Punakha-Thimphu, and Wangdue as part of the researcher capacity development for action research. The objective of the study was to assess the performance of irrigation schemes as envisaged in the National Irrigation Policy (NIP). Some of the findings are discussed hereafter:-

In all four schemes there was weak or dysfunctional Water User Group (WUG) despite NIP policy vision of self-supporting schemes. The maintenance fund development through user fee collection was completely dysfunctional, in some cases even getting access government support for major renovation or maintenance work was not possible due to the over lapping of command area across Dzongkhags (between Thimphu and Punakha Dzongkhag for Labtshakha Irrigation Scheme. Similar situation existed for the command area lying within same Dzongkhag but overlapping between different Geogs in case of Gun-karm Irrigation Channel in Punakha. In such cases social cohesion and cooperation was poor, irrigation water distribution was not based equality.

Most of the distribution channels which were running down the slope were the main causes of farmland degradation in under Laptshakha irrigation scheme. The nature of water sharing arrangement also influences the rate of gully formation. In Laptshakha water turn is done by distribution channel – in one time all the flow in the channel is diverted into one distribution channel thus increasing the gully formation process due to big flow of water gushing down the secondary channel.

As per the NIP policy villages or communities or villages comprising of less than ten households are not eligible for government support for irrigation scheme development. Palukha Irrigation in Rubesa Geog in Wangdue did not receive any form of support from government so far. As such their earthen channel has very poor conveyance efficiency. Since they are the marginal poor farmers they can never afford to improve it even in the future if NIP policy remains same.

Conveyance Improvement of Irrigation Channels: in Lomtshokha, and Samthang in Athang Geog, in Wangdue Dzongkhag. The cost of cement, pipes, skilled labour, and transportation up to the nearest road head was provided by RC Bajo which was sourced from the donor agencies. The

farmers provided the local materials, labour, and the transportation of pipes and cement form the road head. The wetland in Lomtshokha village was once again brought under paddy cultivation after leaving it fallow for last 14 years. Farmers in the village could not transplant paddy because they could not replace the old wooden flumes that conveyed water across the cliff face. Similarly in Samthang Irrigation Channel conveyance was improved and more wetland was bought under paddy cultivation. The farmers are even rearing fish with the irrigation water thereby bringing the additional benefit to the farmers.

Water Resource Management: Water Resource Management Training was conducted in Tshokhorthang in Nahi Geog, under Wangdue Dzongkhag. The surrounding water sources which used to be adequate for drinking and even for transplanting few terrace of paddy fields in the past have become smaller over the years. Some nearby sources have completely dried up resulting in water shortage problem in the village. Therefore, the objective of the training was to address the dwindling water resources problem in the village. The training focused on facilitating farmers to analyse the problem, explored various options and strategies, and to develop action plans for the future to sustain the water resource base.

The short term strategy was to address the water shortage problem by developing a water harvesting system that would harvest water sources further away from the village. RC Bajo secured fund support and water harvesting system was in placed by the 2006. The long term strategy was to encourage the farmers to manage the surrounding forest for enhancing water productivity.

Engineering Services

Apart from the carrying out research activities, Water Management Research provided engineering services for the region. The major engineering activities that were implemented were (1) constructed boundary fencing wall between new Wangdue Township and RC-Bajo farm, (2) chain-link fencing in the lower part of the RC Bajo farm, (4) constructed staff quarter, (5) constructed of water servicing ram for the centre, (6) constructed rice breeding house, (7) constructed grain drying area-cum tennis court, (8) renovation of Tsirang RNR Sub-centre, (9) construction of machinery shed, retaining walls, river bank protection walls and other technical services to Regional Agricultural Machinery Center (RAMC) at Bajo, (10) engineering services for regular engineering maintenance work for the RC Bajo. More than 40% of the staff time was allocated for the engineering works.

The **Agricultural Economics** unit carried various studies on Agriculture economics like economic of rice production, winter crops budgeting and on-farm and on-station crop analysis. The economics of Rice production in the region shows that rice production is indeed labour intensive. Labour comprises of about 70 percent of the total production costs. The total production costs (Nu/acre) of rice of the four Dzongkhags were different in diiferent dzongkhag like in Punakha – Nu 22,448 per acre; Wangdue - Nu.20, 675 per acre; Tsirang – Nu. 6,330 per acre and Sarpang – Nu. 4,928 per acre.

This shows that the production cost in Punakha and Wangdue were much higher than Tsirang and Sarpang. Winter crop budgeting was done in Limbuteychu watershed area to find out the production economics of winter crops (wheat, mustard and potato).

Two major impact assessment studies are carried out nationwide on rice and maize. Fifteen improved modern varieties of rice and three maize varieties have been released. The modern varieties are grown by 60% of the households for both crops and covers 35% of the rice area and 49% of maize area. The study shows the gain in net returns nationally of Nu 58 million to 118 million for rice and of Nu 105 million to 121 million in case of maize.

Few diagnostic and baseline surveys were carried out for poor and remote communities like Guenshari, Taksha-Shilly and Nahi. Reports were documented and action plan made and implemented by other sectors.

Research Communication

In the initial stage of 9th FYP, the extension support program concentrated on building a sound research – Extension linkages, packaging extension materials and built farmers organizations.

Technology Packaging

Under this sub-program translation of research result of respective RCs into extension materials in collaboration with concerned sector head had been carried out to cater the need of information requirement of extension staff in the region. Base line data collection and compilation of available research technologies concerning RC Bajo was done and inventory updated. The following leaflets had been produced and distributed to regional Dzongkhag and other central agencies.

Table 3: Leaflets produced and distributed to regional extension staff
Field Crops

- Rice cultivation in medium altitude
- Rice cultivation in low altitude
- Recommended practices of direct seeding of rice
- Pre- rice green manure
- Rice double cropping in dry subtropical zone
- Rice ratooning
- Bajo Kaap 1
- Bajo Kaap 2
- Recommended rice seedling production practices
- Khangma Maap (Chhumro)
- Recommended practices for rice production in warm temperate zone (High altitude)
- Mustard cultivation in wetland production system
- Wheat cultivation in wetland production system

- Technical guidelines for measuring crop yields in Field Crops

Horticulture

- Pointer for successful walnut grafting
- Apricot cultivation in mid altitude
- Additional New Technologies in Horticulture

Farming system

- Maize Trash Line to control Surface Run - Off

Forestry

- Tsakusha propagation and management
- Tshenden propagation and management
- Propagation of bamboo though seed and its management
- Propagation and management of Pangtse shing
- Propagation and management of Tsampakha metog
- Propagation and management of fig tree
- Nursery preparation for the cuttings

Training

Extension Agents training at the Region was found to be one platform where research and extension personnel could interact positively and has been found useful in the East. The following trainings were carried out:

- National Irrigation Policy Training for 40 RNR extension staff of this region for 5 days was conducted
- RNR EAs in-country study tour for 5 day was coordinated.
- Hands on training on Shitake Mushroom cultivation for 14 members of Dompala farmers group
- Group Formation Training at Limbukha.
- Training on minor Repair and Maintenance of Farm Machinery for 3 days, for 14 farmers

Extension- research linkage

a) Pre-regional meeting

To enhance research extension linkage pre-regional meeting was conducted to get input from extension such as researchable issues. This was done once in 2003-2004 in the five regional Dzongkhag.

b) Annual Review and planning workshop

This meeting was conducted annually. It was the only single forum in the region where researchers and Dzongkhag RNR extension staff get together and deliberated important and pressing need of field in presence of various stake holders such as public representative the gups, central inputs supply agencies, representatives of line departments including PPD. This was also a important forum where research technologies are presented and disseminated.

Coordinate centre visit by farmers, students and official guests

This research centre is regularly visited by various groups comprising of farmers, students from various school, students from College of Natural Resources, Sherubtse College, Dzongkhag RNR Extension staff and other training institutes including school agriculture focal teachers. On an average this centre was visited by 450 - 500 visitors every year. Farmers who come to visit this centre were provided lodging facility.

3.2 Publications

Below are the publications accomplished by different sectors during the 9th FYP apart from the Centre's Annual Report.

Field Crops

List of publications made in Field crops program

No.	Title	Year of publication
1	An Economic Impact Assessment of Rice Research Program in Bhutan	2004
2	Recommended practices of direct seeding in Rice	2004
3	Pre- rice green manure	2004
4	Rice double cropping in dry subtropical zone	2004
5	Mustard cultivation in wetland production system	2004
6	Technical guidelines for measuring crop yields in Field crops	2004
7	Rice cultivation in medium altitude	2005
8	Rice cultivation in low altitude	2005
0	Rice ratooning	2005
10	Recommended rice seeding production practices	2005
11	Recommended practices for rice production in warm temperate zone (high altitude)	2005
12	Wheat cultivation in wetland production system	2005
13	Adoption and Impact of improved Maize technology in Bhutan	2006
14	A review of rice research in Bhutan with emphasis on rainfed rice	2008

Forestry

List of publications made in Forestry research program

No.	Title	Year of publication
1	Ecological and Social Aspects of Transhumant Grazing in Bhutan. Mountain Research and Development	2004

2	Comparison of regeneration, biodiversity and structure in single-tree selection logged and unlogged mixed conifer forests in western Bhutan Himalayas. Forest Ecology and Management	2004
3	Species composition, structure and regeneration establishment in group selection logged and unlogged mixed conifer forests in western Bhutan Himalayas.	2004
4	Forest Function Mapping Lingmuteychu Watershed. Identification of forest functions and implications for local use forest management Project Document No. 65.	2004
5	Six pamphlets on Ficus roxburghii, Cupressus corneyana, Thysanolaena latifolia, Bamboo sp. Oroxylum indicum, and Symplocus paniculata	2004

Farming Systems

List of publications made in the Farming Systems research Program

No.	Title	Year of publication
1	Maize Trash Line to Minimize Surface Soil Run -Off	2004
2	Equity and Traditional Irrigation Water Sharing Systems in Lingmuteychu Watershed	June 2006
3	Facilitating Change: Research-led Watershed Experiences from Lingmuteychu Watershed	July 2006
4	Management Options for Phytopthora Blight in Chilli in Bhutan (MSc. Thesis)	July 2005
5	Economically Important Diseases of Maize Prevalent in High and Mid Altitude Areas of Bhutan	January 2008
	An Economic Impact Assessment of the Rice Research Program in Bhutan	2002
7	Adoption and Impact of improved maize technology in Bhutan'	2004
8	Socio-economic impact assessment of dairy farmers' group in Sha Gogona	2006
9	Water resource management training report for Nabchee	2004
10	Report on Role Play Game between Limbukha and Dompola	2003
11	Report on First Role Play Game at Lingmuteychu Watershed level	2004
12	Report on Second Role Play Game at Lingmuteychu Watershed level	2004
13	Water resource management training report for Tshokhorthang, Nahi Geog	2005
14	Environmental Conservation Policy in Bhutan – Impacts and implication on the rural livelihood & natural resources	2007

3.3 Human Resource Development (HRD)

During the 9th FYP (2002-2008), the Centre received three additional staff – one technician, one Asstt. Librarian, and a telephone operator - out of 14 additional staff proposed in the plan. There was no new technical staff deployed to the Centre. As a result the programs on oilseeds and Legumes research suffered in this period.

However, in the area of staff capacity development, 85 staff have received short-term trainings in various subjects both in-country and abroad, 9 staff have made study visits abroad, and two staff have completed MSc degree programs.

4 PRIORITY RESEARCH ISSUES AND OPPORTUNITIES

4.1 Field Crops

There are a number of research issues as well as opportunities for field crops in the region. Across commodities there are issues of soil fertility, pests management, low yielding varieties, post harvest, processing and storage. With adequate resources and application of suitable technologies, the issues can quickly be turned around into opportunities. The major crop-wise issues and opportunities are summarized below.

Rice

Availability and adoption of improved varieties
A number of improved rice varieties have been introduced or bred for the mid-altitude valleys which have been gradually adopted by farmers, particularly in the dry sub-tropical Wangdue-Punakha valley. However, the same varieties when grown in the humid sub-tropical areas of Tsirang and Dagana fail to perform well. Hence there are no credible rice HYVs for the humid region. This would be an opportunity for research to develop or identify varieties suitable for Tsirang and Dagana. The other issue is the regular or adequate supply of seeds of the released varieties that needs to be improved.

Soil fertility management
The level of external inputs to manage soil fertility for rice production is low, leading to low productivity. This is largely due to the subsistence nature of rice farming. In Tsirang and Dagana, even the use of FYM is limited and soils are deficient in organic matter. In Gasa, where organic production is being promoted, efficient fertility management is an issue. Increased use of inputs will optimize production. There is opportunity for popularizing the use of green manures for sustainable fertility management.

Disease and Pest management

Rice blast is a major disease in the region, especially in the local varieties. Sheath blight is another problem in the humid areas. Among insects, leaf defoliators and stem borers cause damage. Weeds are another production constraint in all the dzongkhags; manual control is compounded by shortage of farm labour. Opportunities include breeding for blast resistance and the development and promotion of IPM technologies.

Milling and grain quality

There are problems with the current practice of rice milling and the milling equipment used. High ratio of broken rice is a concern for both the producers and consumers. The moisture content at harvest, storage conditions and milling equipment affect milling quality of rice. Opportunity lies in exploring limiting factors in quality aspect and providing options to the producers and millers.

Maize

Disease and Pest Management

Gray Leaf Spot and Turcicum Leaf Blight have emerged as major diseases in the region, especially in Tsirang and Dagana. There are also a number of insects attacking maize. Storage pest of maize accounts for one of the highest losses. IPM technologies need to be developed for maize farmers. Management of weeds requires high labor input which is not readily available. The use of appropriate technologies for weed management is necessary.

Improved varieties and seeds

There are currently three improved maize varieties, with Yangtsipa being the most popular among growers. However, the awareness and use of the HYVs is limited in the region. This is partly linked with the availability of quality seeds with the only commercial supplier, DSC, unable to meet the demand. In the 10FYP, identification of optional varieties that are suited for the region and their promotion will be stepped up. There is opportunity of community seed production to fulfill regional demand.

Soil fertility

Maize is grown mostly in marginal areas with limited inputs. Maize areas are often steep and landslips and soil erosion are major problems. Research in intercropping with legumes and other land management practices will be taken up to increase maize production. Integrating green manuring crops in maize cropping system could be an opportunity.

Processing and marketing

Since maize is not the preferred staple for many producers, processing and value addition for markets becomes indispensable. Maize by-products are limited to *tengma* and *ara* (not officially encouraged). The equipment available for processing maize into *tengma* is not very efficient, affecting the quality of *tengma* presently produced. There is opportunity in improving its quality,

packaging and presentation. Diversification of by-products needs to be looked into.

Wheat

Improved varieties and seeds

There is modest wheat cultivation in the region in the wetland system. Research and development focus in the past has been on improved varieties and production packages. Three wheat HYVs have been recommended. However, ready availability of seeds has been a constraint that needs improvement. Attention will be given to accessing improved germplasm from the region for possible adaptation in the country.

Storage pests

Among cereals, wheat grains are most prone to storage losses. Farmers find it difficult to store wheat seed for the ensuing crop season. The traditional storage system is not full proof, requiring research on more efficient storage technologies. Bio-insecticides could be explored.

Water and soil management

Wheat crop is grown under very poor nutrient conditions and yields are very low. Water management is another area that will improve productivity. Opportunities to increase yield exist through proper management of soil and water.

Oilseeds

Improved varieties and seeds

In the region, many farmers grow oilseeds (mostly Brassicas) in small scale mostly for their own use. Within the research system, there is interrupted research efforts on oilseeds and not many good varieties or other technologies have been developed and promoted. Being cross-pollinated, seed quality rapidly degenerates in the field and productivity goes down. Assured supply of quality seeds is an issue. In the 10FYP, more attention to technology development and promotion will be given.

Processing technology

Small scale and affordable oilseeds processing technology is a big limitation to increasing area and production. Presently growers have to travel long distances to a few processing unit located mostly in urban centres, which is inconvenient and time consuming. Some farmers still use their traditional method of oil extraction, in the absence of any alternative. Efforts will be directed to make available portable and efficient expellers for the farmers.

Pest management

Oilseed crop is highly vulnerable to insect pests and diseases. The yield in some cases has been reported to be nil due to pest and diseases. Effective strategies for pest control will lead to higher production. Research emphasis will be placed on the management of major diseases and insects in oilseeds.

Grain Legumes

Improved varieties

Among grain legumes, mungbeans are popularly grown in the region for food. Although legumes have been traditionally grown by the farmers they have not received much research attention. This is mostly due to lack of adequate and trained manpower in RCs to do research on legumes. There is ample opportunity for research and development of legumes as they will play an important role in fertility management, food and cash income of farmers. Access to germplasm of grain legumes is a problem, therefore linkages need to be established and a focal researcher appointed for grain legumes.

Processing and Marketing

Processing of legumes has been limited so far but opportunities exist for processing and value addition. Products could be diversified and value added for internal and external markets. Markets and marketing channels need to be looked into.

4.2 Horticulture

Research Issues and Opportunities

Beside in Wangdue-Punakha valley, the most of the arable lands in the West-Central region have steep slopes where planting fruit trees would provide a sustainable livelihood option. In low elevation (<1400masl) investment on citrus provided high economic return besides generating lots of employment. Apple, potato and vegetables have emerged as cash crops and provided viable source of income and better livelihood for the farming communities living in higher elevation areas (1800masl) with access to market. Farmers living in farflung areas of all agro-ecological conditions and in elevation of 1500 to 2500mals are dependent on subsistence farming with no viable cash crop option and they remain poor. Therefore, research thrust has to be on generating knowledge and technologies for potential cash crops alternatives, besides conducting problem solving and nationally prioritised commodities research.

At the regional level major problems that need attention are: citrus greening & fruit fly, chilli wilt, potato blight, viral diseases in cardamom, and wild boars. The other constraints in horticulture development are the lack of knowledge and experience with farmers in establishing and managing plantations and orchards, lack of organised market and agro-industry to support cultivation of new fruits and nuts crops. At present detailed diagnostic studies in the region are lacking. However, a subjective assessment of constraints in relation to development problems is attempted at the regional level through research – extesnion workshop in May 2008, the production constraints are as outlined:

- Citrus greening disease and declining orchards
- Poor citrus management practices at farm level
- Poor market information and intelligence to kick start on new tree crops as alternative cash crops
- Shortage of quality seeds & plants of recommended varieties.
- Limited publications on recommended technologies and information
- Limited improved crop production technology for increasing crop production

For sustaining or improving the existing horticultural cash crops in the region, strategies to contain citrus greening disease, potato late blight, wild boars damage and adoption of improved citrus production technologies & management practices are utmost important. The supply of quality seeds and plant has remained perennial bottleneck and it can only be resolved with farmers and private sector participation. The private nursery growers have been promotion initiated in the 9th FYP and these initiatives needs to be institutionalised. For development of new horticultural enterprise in the region the presence of assured market and organized marketing or agro-industry is absolutely necessary. It is as area where consideration should be given in inviting private sector corporate from within the country or from outside to invest in agro-industry giving favourable public sector support. The agribusiness in the area like plant nursery, floriculture, mushroom, vegetable, fruit and nuts production, packers and exporters' group and societies need to

be developed such that Bhutanese products continue to compete in the market and penetrate into new market. This is an area that also provides employment opportunity and therefore due consideration should be given to realise it in the 10th plan.

4.3 Forestry

Issues and Priorities

Forestry research in the region is relatively young. Research in forestry has been constrained due to limited research capacity of the research assistant and staff in the centre. However, a good start had been made in social forestry research concentrating on MPTS. Choice of species and suitable domestication and propagation techniques are main bottlenecks. Degradation of farmland through soil erosion and landslides, and natural resources depletion in the region in general and in the two southern Dzongkhags; Tsirang and Dagana in particular are the most urgent and priority issues. Unsustainable collection jeopardizing the regenerative capacity of Non-Wood Forest Products like Yanka and bamboo are emerging priorities. Non-Wood Forest Products assumes special significance due to its high potential for increasing household subsistence economy contributing to poverty alleviation. Accordingly, emphasis will be given to NWFPs that are high value and low volume with potential niche markets. Where feasible, NWFPs will be integrated into community and private forestry programs. Regeneration dynamics vis-à-vis cattle herbivory of broadleaf and conifer forests are inadequately documented, which impairs appropriate management interventions. Forest protection including the emergence of nursery pest and diseases in forest nurseries necessitates timely control measures.

Strategy

Social Forestry

In order to contribute to poverty reduction in the west central region, social forestry research program will focus on participatory research in community, private, and agro-forestry and watershed development. Soil and water conservation techniques in community and watersheds, integration of domestication and propagation of MPTS including the commercially important NWFPs in community and private forestry will be undertaken. Under agroforestry, crops/livestock/MPTS production options for farmers will be explored using participatory diagnostic surveys and document local agroforestry practices ushering model farm forestry development. These activities will be undertaken in close collaboration with Social Forestry Division, DzFOs and farmers in the region.

Non-Wood Forest Products

Bamboos, rattans and mushrooms are important non-wood forest products which, requires documentation of distribution, uses, availability and potential

by Dzongkhag. Commercially important NWFPs domestication and propagation techniques including post-harvest practices will be developed. These activities will be undertaken in collaboration with DzFOs and farmers in the region.

Conifer and Broadleaf Forest Management

Research into management of natural forest falls into two sub-programs viz. conifer and broad-leaved forests. Sustainable management of these natural forests calls for sound knowledge generated on dynamics, composition and structure of the forests for appropriate harvesting and utilization.

Forest protection

Forest protection studies will include providing technical assistance on nursery pest and diseases as and when demand arises from the clients.

4.4 Livestock

Research issues and opportunities

The livestock research in west central region focused into fodder production, evaluation of fodder germplasm, local fodder trees, apiculture, rangeland studies and land reclamation. Some of the pressing issues were the unavailability of extension materials especially pertaining to improved livestock production for assisting dairy farmers. Fatalities in dairy animals due to fodder trees toxicity was reported as a great concern in southern resettlement areas of the region. Honey production from improved hive and extraction techniques with local bees *(Apis cerena)* as a tool for poverty reduction to be promoted. Unavailability of replacement stocks in poultry farming and inadequate supply of piglets from breeding farms for pig production required immediate alternatives to be sought. Revitalizing of community based contract breeding bull keeping in areas inaccessible by artificial insemination program for crossbreeding.

Strategies

Extension materials on improved dairy management
In collaboration with relevant institutions, a hand book for improved dairy management including feed formulation using locally available ingredients will be worked out for extension uses

Fodder toxicity
Identification of the fodder species, sample collection, study of the toxic ingredients and recommended line of treatment along with antidotes in collaboration with Regional Veterinary Laboratory, District Veterinary Hospital & National Centre for Animal Health

Promotion of beekeeping in improved hives
The traditional log hive beekeeping in practice yields low and associated to difficulty in extraction which often depreciates the quality of honey produced. Improved hive beekeeping will be promoted through farmers training and formation of honey producers group.

Poultry Hatchery management
The feasibility for establishment of an exclusive hatchery farm studied so that the farms remain undisturbed in the events of *avian influenza* out breaks in the border towns. Where ever necessary technical backstopping on hatchery management such as candling and maintenance of microenvironment will be provided.

Augment inadequate piglets supply from breeding farms
The feasibility for establishment of private/group piglet production be studied and provision of technical support and trainings on commercial piglet production farm.

Cattle Breed improvement through Community based contract bull keeping
As a collaborator with Dzongkhag Livestock Sector and National Livestock Breeding Program, improved breeding bulls supplied for crossbreeding under community based contract bull management. Technically assist to formulate management strategies and develop community based model.

4.5 Farming Systems

Issues

Although some progress has been made in the Farming System Research in the 9FYP, much remains to be done in the 10FYP to be at par with the progress that are being made in agriculture, livestock, and forestry sectors. Despite the prevalence of a strong concept of RNR approach not much progress was made in translating it into actions. This was mainly due to the strong sectoral orientation existed in the past compounded by limited capacity to foresee the inter-sectoral issues. As a result Farming Systems received less priority in the past plan periods. Some of the evidences of overlooking inter-sectoral issues are becoming the overarching issues which are summarized hereafter.

Declining Soil Fertility

Declining soil fertility is a major concern as it is directly linked to the decline in crop yields thereby reducing the production. On the other hand, even with the availability of high yielding varieties (HYV) the potential will not be realized unless the soil is rich in nutrient. Therefore, the solution is to improve or at least stabilize soil fertility. To do this we have to understand the cause of soil nutrient decline, its management history and the methods through which our

forefathers sustained without the use of so called "modern technologies" (inorganic fertilizers)? What does 'organic farming' actually mean? What is it not trying to say? Unless these questions are answered, it will not be possible to address the declining soil fertility problem. In short we can find the solutions if only livestock, forestry, and soils sectors work in conjunction and not soils as a separate entity.

Declining Water Resources

Compared to the neighboring countries, Bhutan is rich in water resources. The per capita water availability is 60,000m^3 annually. Although per capita water availability at the national level is very high, the actual water that is being managed and used accounts about 650m^3 (1%) per person annually in Lingmuteychu Watershed. This shows that even if the per capita figure is very high, people do not have the capacity to use it. This situation is explained by the fact that farmers' dependence on small water sources that are seasonal in nature. Owing to the increasing fluctuating rainfall pattern, these water sources have become equally become unreliable affecting the farming practices. Over the last couple of years, there were many instances where farmers were not able to transplant their paddy on time. In some cases farmers had to leave their wetland fallow due to shortage of irrigation water. In Lingmuteychu watershed there are fallow wetlands, abandoned drinking water supply sources and spring points, and dwindling water sources indicating declining water resources. Further, there are numerous tales of drying water sources but not a single tale has been told about emerging new sources. This implies that our water resources are declining in general.

IPM: Human-wildlife conflict and other crop pest and diseases

Except for Thedtsho Geog all other 14 geogs features human-wildlife conflict as the main constraint to crop production. Number of studies done in the past indicates that direct crop damage ranges from 15 to 20% of annual crop production from wild-boar alone. Considering the damages from other animals and indirect cost of crop overall crop protection, total cost incurred to a farmer cannot be less than 30% of the annual farm production. In elephant damage affected area in south this cost can be even more than 100%. The question is, is it justifiable not to address these losses? Is it not an RNR issue?

Similarly, on the citrus production front, Tsirang and Dagana are listed in the top mandarin growing Dzongkhags in the country. However the productivity has been declining over the years due to pests and diseases the primary causes being huanglongbing (HLB) disease and Phytopthora diseases among others. A study needs to be initiated immediately to confirm the absence or presence of citrus HLB in these two Dzongkhags through scientific methods such a polymerase chain reaction (PCR) test. Similarly a delimitation study has to be planned to identify areas where citrus are prone to Phytopthora diseases so that appropriate measures could be planned to mitigate the problems.

These Dzongkhags also produce maize on a substantial area. However yields have been declining due to fungal diseases such as Turcicum leaf blight (TLB) and Gray leaf spot (GLS) since 2007. To manage these diseases, training of extension personnel and farmers on the disease awareness campaign has been actively carried out. Further works on identifying resistant maize lines to these diseases need to prioritized and implemented with the plan period. RC Wengkhar in collaboration with RC Bajo has initiated the testing and development of resistant lines with CIMMYT materials. As an interim measure, a systemic fungicide has been identified to control the disease at commercial recommended rates. The fungicide and other potential chemicals need to be tested for their efficacy in controlling the maize diseases at different rates and stages of crops which can be recommended to the local farmers.

4.6 Research Communication

Issues and Opportunities

Sl. No.	Sub -program	Issues	Opportunities
1	**Technology park**	Budget constraint for fencing, water supply, land development The TP not fully functional	Discuss with Dzongkhag RNR sector heads and streamline and incorporate in the dzongkhag RNR budget
2	**Coordination of Centre's visitors**	Boring and stereotype Institutions Objective and farmers' objective not matching.	Audio Visual development on research centre's activities Proper farmer selection based on a committee and a set criteria
3	**Co-ordinate Research Outreach Program.**	Limited involvement of RRCO Outdated equipment (Digital camera, video camera, laminator , paper-cutter etc,) Limited staff Lack of training	RRCO will fully be involved in this activity for coordination, communication and linking farmers with the RC, during the 10th FYP. More modern/up-to-date equipment could be bought through projects. Recruit one data manager and an assistant. Refresher course and short term training on desk top publication, audiovisual etc.
4	**Support Farmers group / co-operatives**	Homogeneity is rare in the Bhutanese farming community Leadership problem, Lack of trained accountant and conflicts are common.	Follow participatory approach. Groups start maturing for proper feedback and demonstrate the quality of group.
6	**Information management**	No data manager	Staff recruitment/deployment
7	**Research Extension Linkages**	Limited platform for RE linkages Institutional polarization	Increased RE workshops and meetings Research involve in extension planning meeting and vice versa R and D instead of pure research mandate (TP). Strengthen RNR concept further Working as multi-sectoral and multidisciplinary team

5 OBJECTIVES

The main objective is to identify, adapt or develop appropriate technologies, management strategies, and ecologically sustainable farming practices in rice, irrigated wheat, oilcrops, grain legumes, sub-tropical fruits, vegetables, feed and fodder, and agro-forestry for enhancing and optimising the integrated production processes. Equally important objective is also to effectively support regional extension through information and monitoring of activities.

6 RESEARCH STRATEGIES

6.1 Research thrust/focus in the 10th FYP

Field crops

- To continue to introduce/identify/breed for superior crop varieties resistant to major diseases and pests
- Continue to develop improved production management practices through weed, nutrition, and water management
- Continue to collect and maintain local germplasm for future use
- Maintain and adequately supply the breeder and foundation seed to DSC

Horticulture

- To identify subtropical fruit species appropriate to the non-citrus growing parts of the region
- Improvement of production management of mandarin and other fruits
- Improvement of post-harvest and marketing of major horticulture commodities
- Diversification of vegetable crops grown in the region
- Assessment of potential of popular local vegetable crops
- Maintenance of breeder seeds of released vegetable crop varieties
- Assessment of potential for off-season production

Livestock

- Identification of good winter fodder species
- Understanding of local feed resources
- Understanding of local livestock production potential

Forestry

- Continue agro forestry research
- Document process, conflicts, and community behaviour in establishment of community forest
- Develop case studies on private forestry

Research Communication

- Production of appropriate extension and training materials, reference books etc
- Formation and development of local level institutions like self-help groups and farmer's associations, for overall community development, improve planning capacity and organizational skills of the members, facilitating bulk purchase of inputs, bulk marketing of produce etc
- Assessment of research technologies for its social acceptability, field applicability, environmental impact and economic viability and appropriateness will constitute another important thrust area.
- Improving managerial and leadership management skills of sector heads and members of farmer's groups are expected to serve as the main platform on which other development to take place.

6.2 Strategies

The research strategies that will be adopted in the 10th FYP will be to:

- Identify regional research priorities and needs through appropriate diagnostic and investigative studies;
- Prioritize research needs/activities to suit the available human resource
- Research plans with high impact potential for poverty alleviation will receive priority
- Work and liaise closely in a supportive and co-operative role with the Dzongkhag RNR sector staff, functional divisions of MoA and their central and field programs;
- Emphasise primarily off-station and collaborative RNR research particularly in areas of field crops, sub-tropical horticulture, feed and fodder, and water management,
- Organize annual regional workshops for the preparation and evaluation of the annual work program of the RNRRC and Dzongkhag Extension
- Ensure that the regional research program is implemented and coordinated according to the agreed national programs
- Support the Dzongkhag RNR sector staff in technical matters, extension activities, and farmers' training at the regional level;
- Employ community-based natural resource management process in improvement of communal resources management and invoke community participation
- Demonstrate and showcase production technologies through strategically identified Research Outreach sites
- Link with Regional and International Research Institutes for technical and research material support

7 PROGRAM STRUCTURE AND ACTIVITIES FOR THE 10TH FYP

7.1 Field Crops

The Field Crops Research Program (FCRP) refers to the staple cereals (including major cereals like rice, maize and wheat), oilseeds and some grain legumes. At the national level, RC Bajo coordinates FCRP. At the regional level RC Bajo will mainly focus on rice, maize, irrigated wheat and oilcrops.

In line with the 10FYP theme of poverty alleviation, research and development activities will focused on pro-poor farmers and will be and participatory in nature. Research will be need based seeking solutions that are practical and applicable. Out reach programs and technology parks will provide opportunity to involve communities more meaningfully.

The FCRP is divided into sub-programs, projects and activities for simplicity of implementation and monitoring. The proposed projects will have inputs from crop breeders, agronomists, pathologists, entomologists and other relevant disciplines. The program structure is follows.

Table 4: Program Structure for Field crops in 10FYP

Subprogram 1: Rice	**Projects**
Project 1	Variety improvement
Project 2	Soil Fertility Management
Project 3	Pest Management
Project 4	Post Harvest and Grain Quality
Subprogram 2: Maize	
Project 1	Variety improvement and seeds
Project 2	Soil Fertility Management
Project 3	Pest Management
Project 4	Processing and Marketing
Subprogram 3: Wheat	
Project 1	Variety Improvement
Project 2	Water and Soil Management
Project 3	Pest (storage) Management
Subprogram 4: Oilseeds	
Project 1	Variety Improvement
Project 2	Pest Management
Project 3	Processing
Subprogram 4: Grain Legumes	
Project 1	Variety Improvement
Project 2	Processing and Marketing

Major Activities

Variety improvement

Introduction, evaluation and cross breeding activities will be carried out for major crops to increase the range of varietal choices to farmers. Emphasis will be given on the utilisation of indigenous germplasm. In rice, improvement of local varieties through cross breeding will continue with focus on humid areas (Tsirang and Dagana). In maize, breeding for disease resistance will be accelerated. The evaluation of introduced exotic varieties for other crops will be continued.

Soil fertility management

Limited use of inputs is a constraint to achieve higher yields. Activities, focused in development and promotion of integrated plant nutrient system, will receive attention. In rice, the use of balanced fertilization will be promoted. Green manuring in areas where organic matter is deficient will be encouraged. In maize, which is grown in erosion-prone areas, land management using different techniques will be researched and accelerated. Water and soil improvement will receive attention particularly in wheat. For Gasa, special efforts to develop fertility management options for organic production will be stepped up.

Pest management

Efforts will be exerted in refining integrated pest management technologies in all the crops. This will include crop breeding for pest resistance, especially in rice and maize. Blast is a major constraint in rice, and newly emerged GLS and TLB are main problems in maize. Activities already underway in cross breeding will be emphasized. In other crops, appropriate IPM options will be explored. Field crops program will work closely with the Farming systems sector in pest management.

Processing and marketing

So far, research and development activities have been largely focused on mainstream technology development ignoring post harvest, processing and marketing aspects. For holistic development of any commodity, the latter aspects are very important. Special attention will be given to developing and promoting processing, product development and value addition together with market promotion and market linkages.

The table below summarizes project-wise activities.

Table 5: Major projects and activities in field crops

Crop	Projects	Major activities
Rice	Variety improvement	• Develop/identify better varieties for humid areas • Promote improved varieties in mid-altitude region

	Soil Fertility Management	• Promote IPNS in major rice growing areas • Develop organic fertility management options
	Pest Management	• Develop/promote IPM technologies to reduce yield losses • Identify suitable weed management techniques
	Post Harvest and Grain Quality	• Research in post harvest technologies • Improve grain quality and rice milling
Maize	Processing and Marketing	• Research in processing, by-products and value addition • Link production with marketing
	Fertility Management	• Develop IPNS technologies • Land mgt/development for sloping areas
	Variety Improvement and Seeds	• Develop suitable high yielding varieties for different AEZs • Identify and promote seed production techniques
	Pest Management	• Develop resistant varieties to major diseases • Identify and apply IPM technologies
Wheat	Variety Improvement	• Accelerate variety introduction and evaluation • Promotion of new varieties and seed production
	Pest (storage) Management	• Identify appropriate storage technologies • Study major pests and diseases in wheat
	Water and Soil Management	• Conduct research in water management • Develop soil fertility management options
Oil-seeds	Variety Improvement	• Introduce, assess and promote new high yielding varieties • Demonstrate HYVs widely
	Pest Management	• Study important pest and diseases • Develop suitable pest control methods
	Processing	• Identify and promote oil extraction equipment for remote areas • Study processing and marketing aspects
Grain Legu-mes	Variety Improvement	• Introduce and evaluate new crops and varieties • Study legumes under organic farming
	Processing	• Explore processing possibility and value addition • Study marketing aspects

The Field Crops Research Program matrices for 10 FYP are in **Annexure 2 (a-c).**

7.2 Horticulture

Horticulture research program (HRP) refers to wide varieties of fruit and nut crops, vegetables, root and tuber crops, mushrooms, floriculture and landscape, medicinal and aromatic plants, plantation crops, and spices and condiments. In the 10th Plan horticulture research program is compartmentalized into 10 sub-programs consisting of single crop (groups of crops) to give much needed impetus to the commodity and to be in consistent to the commodity program priority of the Department of Agriculture. The 10 sub-program have a lead researcher each with a mandate to coordinate research at the national level and they are placed in different RNRRCs. At the national level, RC Wengkhar coordinates the overall HRP. At the regional level RC Bajo will mainly focus on citrus, walnut, mango, peaches, potato, vegetables and other fruits and nuts crops. The HRP is divided into sub-program, projects and activities for addressing the developmental issues and monitoring. The proposed projects will have inputs from lead researcher for each subprogram, pathologists, entomologists, post-harvest and other relevant disciplines. The program details are as in Table 10.

Table 6: Program Structure for Horticulture in 10FYP

Subprogram 1: Citrus	**Projects**
Project 1	Germplasm improvement
Project 2	Production Management
Project 3	Post Harvest
Project 4	Marketing
Subprogram 2: Other fruits and nuts (Walnut)	
Project 1	Germplasm improvement
Project 2	Production Management
Project 3	Post Harvest
Project 4	Marketing
Subprogram 3: Others fruits and nuts (mango, avocado, litchi, peaches, loquat, pecan, kiwi, banana, passion fruit, guava, chestnut, etc)	
Project 1	Germplasm improvement
Project 2	Production Management
Project 3	Post Harvest
Subprogram 4: Pear and Persimmon	
Project 1	Germplasm improvement
Project 2	Production Management
Project 3	Post Harvest
Project 4	Marketing
Subprogram 5: Roots and Tubers (Potato)	
Project 1	Germplasm improvement
Project 2	Production Management
Project 3	Post Harvest
Project 4	Marketing
Subprogram 6: Species and Condiments (cardamom)	
Project 1	Germplasm improvement
Project 2	Production Management

Project 3	Post Harvest
Project 4	Marketing
Subprogram 7: Vegetables	
Project 1	Germplasm improvement
Project 2	Production Management
Project 3	Post Harvest
Project 4	Marketing

Major Projects and Activities

Across the 6 sub-programs, four projects have been identified which are common to all. The four projects allow us to focus considering the research needs and also the available capacities. Further it broadly permits disciplinary focus like breeding, agronomy, processing, marketing and socio-economics.

Among the projects highest (50%) priority is placed on production management, which focuses on cultural practices of crop ranging from plant propagation, planting, plant canopy management, water and nutrient management to crop harvesting. It is also considered most important as it provides farmers to change their management strategies of the existing crops. Improving crop management practices is expected to have wider and long lasting impact on the system.

Germplasm (*or varietal)* improvement is the next important project (30%) mainly as it can have immediate impact on production increase. Further it also allows utilizing the local germplasm in production enhancement strategies. The remaining projects (Post harvest and Market) are assumed equal (10%) as there are independent agencies mandated to address the issues. However, there will be researchable areas wherein RNRRCs can be drawn in. The Table 11 summarizes sub-program and project-wise activities.

Table 7: Priority research activities under each sub-program and projects in 10FYP

Sub-program	Project	Research Focus
Citrus	1.Germplasm improvement	• Information on the genetics of national diversity of citrus • Rootstocks selection for local mandarin under different conditions • National collection of citrus selection from local diversity at Tsirang & Bajo
	2.Crop production management	✓ Orchard management including soil and water (irrigation) management ✓ IPM practices for greening disease ✓ Irrigation systems and water requirement, and management practices ✓ Research outreach program: Citrus Production demonstration orchards at a

		community level-Salamji & Tsirangtoe ✓ Technical support to private nursery growers and farmers/ growers groups
Walnut)	1. Germplasm improvement 2. Crop production management 3. Postharvest and marketing study	• Germplasm collection and evaluation • National collection of walnut varieties at Bajo ,Yusipang and Khangma • Information on the genetics of national diversity of walnut ✓ Walnut production economics study ✓ IPM practices for major pest and diseases (trunk borer, die back disease) ✓ Research outreach program: Walnut model villages, Nahi geog(Large scale production and marketing demonstration) ✓ Training or provide technical support to private nursery growers, farmers and Dzongkhag Agri. Exten ➢ Desk assessment of domestic and export market ➢ Product development/value addition ➢ Support in organised marketing of Nahi walnut in domestic market
Other fruits and nuts (mango, avocado, guava, chestnut, litchi, peaches, loquat, pecan, kiwi, banana, etc)	1. Germplasm improvement 2. Crop production management	• Germplasm collection and evaluation • Improvement of local peaches through topwroking using improved variety • Propagation techniques and publication of crop production guidelines
Root and Tubers (Potato)	1. Germplasm improvement 2. Crop production management	• Germpalsm introduction and evaluation • Seed prodn technology at farm level using seed plot technique ✓ Study on organic potato production technology ✓ Crop prodn trial breaking yield barriers and bridging yield gap ✓ IPM practices development for late blight control ✓ Technical support to Nabesa and Tshokothangkha farmers groups/regional extension
Pear & Persimmon	1. Germplasm improvement	• Germplasm evaluation and selection • Local pear improvement through

	2. Crop production management 3. Postharvest and marketing study	topworking • Research outreach program: Model pear village-Beteni, Tsirang • Regional farmer and EAs training on pear production technology • Technical support for pear nursery grower • Support in Beteni pear grading, packaging and marketing in local market
Vegetable	1. Germplasm improvement 2. Crop production management	• Broaden the diversity with releasing more vegetable crops and their varieties • Develop plant protection techniques for major vegetables • Popularise year round vegetable cultivation in home gardens • Develop plant nutrient management • Maintenance of breeder seeds
Spices and condiment(Cardamom)	1. Germplasm improvement 2. Crop production management	• Collection of varieties and their evaluation at Tsirang sub-centre • Clonal propagation technique • Production economics, environmental impact and market studies

All activities will be implemented in close collaboration with RNRRC Wengkhar, lead researchers for a specified commodity and the Horticulture Division, Department of Agriculture, Thimphu. The research projects have been identified based on research focus (Table 10) derived from the synthesis of importance at national level, production constraints at the regional and national level. A list of proposed regional research sub-programmes priority, projects focus and regional research thrust provided in Table 11. The logical framework for regional horticulture research program (**Annexure 3a**) and sub-program, project and activities (**Annexure 3b**) for the purpose of effective monitoring and evaluation has been outlined for 10th FYP.

7.3 Forestry

The program structure and priority activities for forestry sector in the 10th FYP are as in Tables 12 and 13.

Table 8: Program Structure for Forestry in 10th FYP

Subprogram : Conifer Forest Management	**Project**
Project 1	Ecology
Project 2	Silviculture
Subprogram : Broadleaf Forest Management	

Project 1	Ecology
Project 2	Silviculture
Subprogram : Social Forestry	
Project 1	Community Forestry
Project 2	Private Forestry
Project 3	Agroforestry
Project 4	Watershed
Subprogram : Non-Wood Forest Products	
Project 1	Resource Inventory
Project 2	Bamboo and Cane
Subprogram : Forest Protection	
Project 1	Pest and Disease
Project 2	Fire

Table 9: Major activities by Projects and Sub-program in the 10FYP

Sub-program	Project	Activities
Conifer Forest Management	Ecology	
	Silviculture	• Bluepine thinning trial in Khotokha FMU
Broadleaf Forest Management	Ecology	• Grazing exclusion trial in broadleaf forest in Rimchu
	Silviculture	
Social Forestry	Community Forestry	• Soil conservation techniques in community forests
		• GPS and GIS training for forestry extension agents
	Private Forestry	• Peoples interests and perspectives on private forestry
	Agroforestry	• Domestication and propagation of multi-purpose tree species • Nursery raising of native tree species in Tsirang • Model farm forestry development
	Watershed	
Non-Wood Forests Products	Resource inventory	• Assessment of NWFPs in community forestry • Resource assessment methodology for *Artemisa vulgaris* and *Emblica officinalis*
	Bamboo and Cane	• Edible bamboo shoot production trial • Domestication and propagation of bamboo species • *In-situ* and *ex-situ* Yanka domestication and propagation trial

Forest Protection	Pest and Disease	• Nursery pests and diseases
	Fire	

The Forestry Research Program Matrices for the 10th FYP are as in **Annexures 4 (a-c).**

7.4 Livestock

The Livestock Research Program adopts commodity (milk, meat, eggs, honey, hair and animal energy) based animal production across different AEZ (dry land, wet land, pastoral and orchard systems) to feed and fodder issues. The major research emphasis is laid on enrichment of crop residues and optimizing fodder from integrated system. At the national level RC Bajo will lead livestock production researches pertaining to the wetland system and region specific issues besides collaborating in nationally coordinated trials.

Livestock research program is divided into sub-programs, projects and activities for implementation and monitoring ease. The program structure is as follows.

Table 10: Program Structure for Livestock in 10th FYP

Subprogram : Dairy/Milk	**Project**
Project 1	Large Ruminant (Yak)
Project 2	Large Ruminant (Cattle)
Subprogram : Meat	
Project 1	Pig
Sub-program : Animal Energy	
Project 1	Draft Energy
Subprogram : Honey	
Project 1	Apiculture

Table 11: Sub-projects and major activities in Livestock

Project	Sub-project	Major activities
Large Ruminants	Pastoral system (rangeland)	– Documenting indigenous knowledge on pastoral production system – Mapping of rangeland resource – Study of carrying capacity /stocking rate rangelands at different altitudes
	Dry land system	– crop residues enrichment – identify and popularize legume intercropping practices – Nutrient analysis – Feeding trial – Fodder production on degraded land – Propagation and maintenance of promising fodder trees

	Wet land system	– crop residues enrichment – straw nutrient composite making – Nutrient analysis – Feeding trial – Suitable legume fodder with and after rice – Fodder production on paddy bunds – Improve national herd through identification, recording and crossbreeding
	Orchard system	– Identify and popularize suitable fodder species to be grown with horticultural and plantation crops
	Silvo-pastoral system	– Identify and popularize suitable fodder species to be grown in community forestry system
Pig/poultry	Wet land system	– Test Paddy straw/husk treatment IMOs – Feeding trial
Animal energy	All systems	– IK capturing
Apiculture		– Effects and promotion of improved hive honey production from local bees *(Apis cerena)* – Production management of *Apis mellifera*

The livestock research program matrices for the 10th FYP are presented in **Annexures 5(a-c).**

7.5 Farming Systems

Farming Systems in the 10FYP will include Plant protection, Soils, Water and Socio-Economics disciplines. These disciplines will work as a team to look into farming system problems and issues in collaboration with other allied sectors. As emphasized by other sectors, the FS sector's research approach will be pro-poor farmers and will be and participatory in nature. As much as possible, technologies generated will be practical and applicable to farmers and communities.

The FS programme is divided into sub-programs, projects and activities to enable for ease of implementation and monitoring. The proposed projects under each sub-program will be linked to other sub-program and projects of other programmes. The program structure is follows.

Table 12: Program Structure for Farming Systems in 10FYP

Subprogram 01:	***Soils***	**FC**	**Horti.**	**Livestock**	**Forestry**	**Farming Systems**			
						Soil	**Water**	**IPM**	**SE**
Project 1	Plant nutrient management for FCs	x	x	x	x	o			x
Project 2	Plant nutrient management for Horticulture Crop		x	x	x	o			x
Project 3	Land management	x	x	x	x	o			x
Project 4	Soil fertility technology for organic farming	x	x	x	x	o			x
Subprogram 02:	***Water Management***								
Project 1	Watershed Management	x	x	x	x	x	o	x	x
Project 2	Irrigation System Management	x	x		x	x	o		x
Project 3	On-farm Water Management	x	x			x	o		x
Project 4	Water Harvesting	x	x	x	xx	x	o		x
Subprogram 03:	***Integrated Pest Management (IPM)***								
Project 1	Insect Pest Management	x	x					o	
Project 2	Disease Management	x	x					o	
Project 3	Weed Management	x	x					o	
Project 4	Organic pest & disease management	x	x					o	
Subprogram 04:	***Socioeconomic***								
Project 1	Production economics	x	x	x		x	x	x	o
Project 2	Diagnostic studies	x	x	x	x	x	x	x	o
Project 3	Adoption/Impact assessment	x	x	x	x	x	x	x	o
Project 4	Gender studies in NRM	x	x	x	x	x	x	x	o

Table 13: Program structure and linkages to other major research programmes for Farming Systems in the 10FYP

Sub-program	Project Code/Description	Research Programs				Farming Systems			
		FC	HC	L	F	SR	WMR	IPMP	SER
Soils	1.1 Plant nutrient management for FC	√	√	√	√	x			√
	1.2 Plant nutrient management for HC		√	√	√	x			√
	1.3 Land management	√	√	√	√	x			√
	1.4 Soil fertility technology for OF	√	√	√	√	x			√
Water	2.1 Watershed Management	√	√	√	√	√	x	√	√
	2.2 Irrigation System Management	√	√		√	√	x		√
	2.3 On-farm Water Management	√	√			√	x		√
	2.4 Water Harvesting	√	√	√	√	√	x		√
IPM	3.1 Insect Pest Management	√	√		√			x	
	3.2 Disease Management	√	√		√			x	
	3.3 Weed Management	√	√		√			x	
	3.4 Organic pest & disease management	√	√		√			x	
Socio-economic	4.1 Production economics	√	√	√		√	√	√	x
	4.2 Diagnostic studies	√	√	√	√	√	√	√	x
	4.3 Adoption/Impact assessment	√	√	√	√	√	√	√	x
	4.4 Gender studies in NRM	√	√	√	√	√	√	√	x

Major Activities

Variety improvement

Introduction, evaluation and cross breeding activities will be carried out for major crops to increase the range of varietal choices to farmers. Emphasis will be given on the utilisation of indigenous germplasm. In rice, improvement of local varieties through cross breeding will continue with focus on humid areas (Tsirang and Dagana). In maize, breeding for disease resistance will be accelerated. The evaluation of introduced exotic varieties for other crops will be continued.

Soil fertility management

Limited use of inputs is a constraint to achieve higher yields. Activities, focused in development and promotion of integrated plant nutrient system, will receive attention. In rice, the use of balanced fertilization will be promoted. Green manuring in areas where organic matter is deficient will be encouraged. In maize, which is grown in erosion-prone areas, land management using different techniques will be researched and accelerated. Water and soil improvement will receive attention particularly in wheat. For Gasa, special efforts to develop fertility management options for organic production will be stepped up.

Pest management

Efforts will be exerted in refining integrated pest management technologies in all the crops. This will include crop breeding for pest resistance, especially in rice and maize. Blast is a major constraint in rice, and newly emerged GLS and TLB are main problems in maize. Activities already underway in cross breeding will be emphasized. In other crops, appropriate IPM options will be

explored. Field crops program will work closely with the Farming systems sector in pest management.

Processing and marketing

So far, research and development activities have been largely focused on mainstream technology development ignoring post harvest, processing and marketing aspects. For holistic development of any commodity, the latter aspects are very important. Special attention will be given to developing and promoting processing, product development and value addition together with market promotion and market linkages.

The table below summarizes the project-wise activities.

Table 14: Major projects and activities in Farming Systems

Sub-program	Projects	Major activities
Soil	Plant nutrient management for FCs	• Integrated nutrient management on rice
	Plant nutrient management for Horticulture Crop	• Study on farmers' nutrient management for citrus orchard
	Land management	• Study on the impact of shifting cultivation practice in Patale, Tsirang • Sustainable farm land management
	Soil fertility technology for organic farming	• Literature review on soil nutrient management for rice and potato • Testing and validation of the management technologies • Vermi-composting • Study on manure value of livestock under traditional farmers' management
Water	Watershed Management	• Gairigoun watershed management • Provide TA to LWMG (Lingmuteychu WS) • River Basin Management plan development studies • Study on development of PES
	Irrigation System Management	• Catchment management studies • Secondary conveyance system improvement • Irrigation water sharing system • Water user group studies
	On-farm Water Management	• Study on improvement of on-farm water availability • Water demand management
	Water Harvesting	• Rainwater harvesting • Surface water harvesting • Groundwater harvesting • Storage system development
IPM	Insect Pest Management	• Study on stored pest management for maize, rice & wheat • Study biology of citrus HLB psyllid
	Disease Management	• Study on the mycotoxin content in maize & maize products • Test efficacy of fungicides for control of maize diseases (GLS & TLB) • Delineation of Phytopthora prone zone in citrus orchards in Tsirang • Reconfirm HLC presence or absence in Tsirang & Dagana through PCR test
	Weed Management	• Weed management in potato & rice

	Organic pest & disease management	• Literature review on organic pest & disease management on rice & potato • Testing and validation of organic pest management technologies
Socio-economic	Production economics	• Economic analysis of field crops, mandarin and walnut • Economics of livestock production (poultry & piggery)
	Diagnostic studies	• Diagnostic studies
	Adoption/Impact assessment	• Adoption of farm mechanization (power tiller) • Impact assessment of research technologies
	Gender studies in NRM	• Gender studies on CBNRM in action research sites (ARC) • Socio-economic impact of alcohol consumption on Taksha-Silli Community • Study on gender participation in water management

The Farming Systems Research Program Matrices for the 10th FYP are in Annexure 6(a-c).

Research Communication Sector

The purpose of the communication sector in the regional RCs is to mainly make the research findings available to the farmers through the extension agents. Thus production of extension material and dissemination of research findings are the two major roles of this sector.

The Research Communication Sector will adopt the following program structure in the 10th FYP.

Table 15: Program Structure for Research Communication in 10th FYP

Subprogram : Research Communication	**Project**
Project 1	Technology Packaging & Publication
Project 2	Training
Project 3	Research Extension Linkages
Project 4	VERCON
Project 5	Information Corner
Subprogram : Farmer Groups and Cooperatives	
Project 1	Farmers Group Formation
Project 2	Group Support, Monitoring and Evaluation
Subprogram : Extension Methodology Research	
Project 1	Research Outreach Program
Project 2	Technology Park
Subprogram : Information Management	
Project 1	Library
Project 2	Regional RNR Database

Strategies

In order to fulfill the national goal of poverty eleviation and self sufficiency, increase in production is limited to the use of improved varieties and breeds.

Hence swift uptake of new technology by the farmers is of utmost importance. Thus during the 10th Five Year Plan, following strategies will be adopted to pursue the objectives of this sector.

- Production of high quality useful and relevant extension information for farming
- Training of EAs and Farmers
- Make extension information available at the extension centres
- Improve the research extension linkages through meetings and other discussion forums
- Support the extension service through use of VERCON website
- Organize farmers into self help groups
- Showcasing research technology at the geog using Technology park mechanism.
- Research into finding appropriate extension methodology such as the Research Outreach Program
- Building a strong regional database for the purpose of RNR planning.

Research communication

Under the Research communication Sub-program, there are five Projects aimed at achieving the goal at subprogram level which is to increase the adoption rate of technology which will contribute further achieving the national goal of food self sufficiency, poverty alleviation, income generation etc.

Here the focus is on the selection, publication and distribution of quality extension materials for the extension agents and farmers. Further efforts will be put to improve the extension –research linkage through meetings

VERCON website will be fully utilized to support the EAs at regional level in providing information and solving field level problems which will be otherwise time consuming, cumbersome and not possible at their level.

Farmers Group

This subprogram aims at harvesting the full advantage of farmers' group in the endeavour to make agriculture more prosperous by providing technical assistance from the RC. More farmers' group with varied objectives will be formed and further support provided to the already formed groups until they reach maturity whereby the can plan, execute, monitor and evaluate their program on their own without external assistance.

Extension Methodology Research

Research into a more efficient and effective extension methodology will be done through the RC. Efforts have already been made by RCs and these studies such as the Research Program will be continued in the 10th Plan. Technology Park is another avenue being pursued .These parks will be made

fully functional so that farmers are impressed by such new technologies which they can try at home after visiting these sites.

Information Management

For proper planning of RNR programs at regional level data base for the region is a prized asset which is lacking at present. The RC will make concerted efforts in establishing an RNR data bank at the regional level which will be useful once complete.

The existing library will be updated and maintained for information support to the researchers and extension personnel of the region.

The detail program matrices for the 10th FYP is in **Annexures 7 (a-c).**

8 HUMAN RESOURCE DEVELOPMENT

8.1 Existing staff strength and proposed staff requirement

Human resource development is an important component of the Centre's Research Programs, which would determine the success of the program. In terms of Research Assistants (RAs), there are currently 16, based in different centres and sub-centres.

In the 10FYP, additional staff, both officers and assistants, needed to be recruited to strengthen the FCRP. Additional staff are necessary to cover major agro-ecologies and the number of commodities under FCRP. It is envisaged that the major commodities of the FCRP (rice, maize, wheat, other/minor cereals, oilseeds and grain legumes) have at least one trained and dedicated staff at the scientist level, supported by adequate RAs. As such, additional 8 Research Officers and 15 Research Assistants are proposed for the 10FYP for the FCRP.

It is also strategically important to strengthen the research sub-centres at Bhur, Gelephu and Mithun, Tsirang in the 10FYP. These two sub-centres are strategically located where technological opportunity for increased production is maximum. Bhur covers the low altitude zone including the districts of Samtse and Samdrupjongkhar, besides Sarpang. Currently, the FCRP is manned by a single RA, which is grossly inadequate to cater to the research and development needs of the region. Mithun covers the mid/humid subtropical zone which is distinct and demands a different research approach. The proposed additional staff requirement takes these into consideration.

Table 16: List of existing staff and additional staff requirement in the 10 FYP

Sl.No.	Name of post	Level	No. Existing staff	Additional Requirement 10FYP	Remarks
1	Program Director	P1	1	-	
Field Crops Program					
	Rice Specialist	ES	0	1	
2	Principal Res. Officer	P1	1	-	
3	Dy. PRO	P2	nil	1	Additional staff for Bajo to handle cereals Maintenance breeding
4	Sr. Research Officer	P3	nil	-	
5	Research Officer	P4	1	2	1 for Oilseeds program and 1 for Legume research program
6	Senior Research Asstt.	P5	2	-	
7	Research Asstt. I	S1	nil	2	1 each for seed maintenance breeding at Bajo and Tsirang
8	Research Asstt. II	S1	2	2	1 replacement of a retiring civil servant and 1 new for seed maintenance
9	Research Asstt. III	S3	1	-	
Horticulture Program					
10	Principal Res. Officer	P1	nil	-	
11	Dy. PRO	P2	nil	1	
12	Sr. Research Officer	P3	1	-	
13	Research Officer	P4	nil	1	for vegetable research at Bajo
14	Senior Research Asstt.	P5	2	-	
15	Research Asstt.I	S1	1	-	
16	Research Asstt.II	S2	2	-	
17	Research Asstt.III	S3	1	-	
Livestock Program					
18	Principal Res. Officer	P1	nil	-	
19	Dy. PRO	P2	Nil	-	
20	Sr. Research Officer	P3	nil	-	
21	Research Officer	P4	1	2	1 fodder agronomist and 1 animal nutritionist
22	Senior Research Asstt.	P5	1	-	
23	Research Asstt.I	S1	1	1	

24	Research Asstt.II	S2	1	1	
25	Research Asstt.III	S3	nil	1	
Forestry Program					
26	Principal Res. officer	P1	nil	-	
27	Dy. PRO	P2	1	-	
28	Sr. Research Officer	P3	1	-	
29	Research Officer	P4	nil	1	
30	Senior Research Asstt.	P5	1	-	
31	Research Asstt.I	S1	2	-	
32	Research Asstt.II	S2	nil	1	
33	Research Asstt.III	S3	nil	-	
Farming Systems Support Program					
	FS Specialist	ES	0	1	
34	Principal Res. Officer	P1	Nil	-	
35	Dy. CPO	P2	Nil	-	
36	Sr. Research Officer	P3	3	-	
37	Research Officer	P4	Nil	2	1 for soils research and 1 agrieconomist
38	Senior Research Asstt.	P5	3	-	
39	Research Asstt.I	S1	1	-	
40	Research Asstt.II	S2	2	2	1 for Tsirang and 1 for Bajo
41	Research Asstt.III	S3	nil	-	
Research Communication Program					
42	Pricipal Res. Officer	P1	Nil	-	
43	Dy. CPO	P2	1	-	
44	Sr. Research Officer	P3	Nil	-	
45	Research Officer	P4	nil	1	For data management
46	Senior Research Asstt.	P5	1	-	
47	Library Asstt. III	S5	1	-	
ADM Support Unit					
48	Adm Officer	P4	1	-	
49	Accounts Officer	P4	Nil	-	

50	Accountant Asstt. I	S1	1	-	
51	Adm. Asstt. III	S5	1	1	for Tsirang Sub-Centre
52	Store Keeper	S3	1	-	
53	Telephone Operator III	S5	1	-	
54	Technician II	S2	1	-	
55	Driver I	O1	2	-	
56	Driver II	O2	3	-	
57	Driver III	O3	2	2	1 for Bajo and 1 for Tsirang Sub-Centre
58	Office Messenger	GSC 1	1	1	for Tsirang Sub-Centre
59	Nightguard	ESP	1	1	For Tsirang Sub-Centre
	Total		50		
60	Essential Services Personal ESP		32	28	For recently reactivated Tsirang Sub-Centre with 64 acres of land

Table 17: Existing staff strength by programme at RC Bajo and Sub-Centre Tsirang

Programme	RO	RA	Adm. Support staff	ESP
Field crops	2	5	-	
Horticulture	1	6	-	
Livestock	1	3	-	
Forestry	2	3	-	
Research Communication	1	1	-	
Farming Systems	3	6	-	
Total	10	24	15	33

Note: Four technical staffs with one driver and 9 ESP are in Tsirang Sub-Centre

Table 18: Summary of additional staff requirement by programmes in the 10FYP for RC Bajo

Programme	Specialist	RO	RA	Support staff	ESP
Field crops	1	3	4	-	
Horticulture		1	-	-	
Livestock		2	3	-	
Forestry		1	1	-	
Research Communication		1	-	-	
Farming Systems	1	2	2	-	
Adm. support		-	-	4	29
Total	2	10	10	4	29

Mithun Sub-Centre which remained non-functional since 1992 will be revived. The existing infrastructures at Mithun were rehabilitated in the 9th plan through the support of SDC/Helvetas funded Project. Few staffs have been already deployed and some research works have been also started. It is planned that in the 10th plan Mithun Sub-Centre will become fully operational to support research for the humid subtropics. In order for the centre to be fully operational, the centre will require a minimum of 28 Essential Support Personnels (ESP) to support establishment of research trials on field crops, horticulture, livestock and forestry. It is assumed that ESP staff will be made available and the centre's 64 acre area justifies for maintaining this number of ESP.

Bajothang has an allocation of 32 ESPs and there is no need for additional ESP requirement during the 10th Plan.

8.2 Staff training

Generally, MSc is recognized as the basic degree necessary to carry out any research work. Most researchers in the FCRP have this qualification, but a few existing staff and those who will join the system in the future would require to upgrade themselves. It is also foreseen that the existing RAs would have to upgrade themselves to BSc level as required by the Position Classification System (PCS) once CNR becomes a degree college. As such, 8 BSc and 4 MSc slots are provisioned for the FCRP and for the Farming Systems Sector at Bajo in the 10FYP (Table 19).

In terms of priority, MSc programs would receive higher priority as this is a basic requirement, but PhDs should also form an essential component of an HRD strategy for a research system. With the maturity of the research system and the emerging challenges confronting research, PhD provides an opportunity to have higher competence among staff. Present day research issues need deeper knowledge and specialization to be able to come up with viable options. Scientists need PhD degree to be able to exchange and understand the information available from outside of the system. Higher degree provides the needed research knowledge/skills, introduces new methods into the research system, and can take up basic research on a specific and relevant subject. At least 3 PhDs are foreseen for FCRP in the 10FYP. Priority areas are breeding and agronomy of major commodities.

Table 19: Degree training needs for FCRP in the 10th FYP

Year	Postgraduate study			Field of study	Remarks
	BSc.	MSc.	PhD		
1	1	1	-	Agronomy/Plant Breeding	Oilseed
2	2	-	1	Agronomy/Plant Breeding/soils	Rice/maize
3	2	2	1	Agronomy/agri-economics	Rice/maize
4	2	1	-	Agronomy/plant protection	Minor cereals
5	1	-	-	Agronomy/Plant Breeding	Rice/legume
Total	8	4	2		

Besides the formal degree programs, the short-term training programs are instrumental building capacity of staff thereby improving the performance of staff. Some of the broad short-term training needs are listed below. Other relevant training needs would be identified and taken up during the course of implementation of the program.

Table 20 provides the broad area of study, the number of slots allocated and budget for human resource development for Field Crops program.

Table 20: Proposed area, slots and budget for HRD, Field Crops program

Level	Broad Field of Study	No. of slots - In-Country	No. of slots to be conducted Ex-Country			Duration (months)	Budget (Nu. Million)		Total Budget	Target Group	Priority	Budget Status
			Dev Country	South-East Asia	South Asia		In-Country	Ex-Country				
1	Rice/Maize		2			24		0.131	3.144	Sr. Resh Offcier, FC	**2**	Not committed
2	Cereals/legumes/oilseed		2			48		0.131	6.288	Resh Offcier, FC	**1**	Not committed
3	Water management/ Crop Agronomy/Farming/agri systems			5		50		0.068	3.400		**1**	Not committed
5	B.Sc. Agriculture				8			0	0.000	Ras/AROs	**1**	Not committed
5	B.Sc. Agriculture	**10**						0	0.000		**1**	Not committed
7	Cereals/legumes/oilseed			11		8.25		0.428	3.531	Filed Crops Resh Staff	**1**	Not committed
8	Conference/Seminar/workshop/study tour			10		2.5		0.293	0.733		**3**	Not committed
	Total								**17.096**			
	Total (4RCs+ISC+HQ)								**100.066**			

Training Code

1 = Ph.D/ Specialization after Masters
2 = Masters
3 = Post Graduate Diploma
4 = Post Graduate Certificate
5 = Bachelors
6 = Diploma
7 = Short-term Course
8 = Special Training Arrangement (mentoring/attachment/on-the-job training)

- Plant genetic resources
- Oilseed agronomy and breeding
- Legume agronomy and breeding
- On-farm research/Participatory technology development
- Survey design and analysis

- Project proposal development
- Identification of research needs
- Participatory plant breeding
- Farmers' need assessment
- Crop breeding/ agronomy (rice, wheat, maize, oilseed, legumes, minor cereals)
- Experimental design and analysis
- Organic/ Sustainable agriculture
- Scientific writing
- Plant protection
- Nutrient management
- Water management
- Agriculture economics
- Research planning and management
- Soil improvement
- Research proposal development
- Inter/multi disciplinary research
- Gender analysis
- Watershed management
- Community-based Natural Resource Management
- Integrated rural development

Table 21: Training needs by type and program for RC Bajo in the 10FYP

Programmes	Ph.D.	M.Sc.	B.Sc	PG Diploma	Remarks
Horticulture	1	1	1	2	
Field Crops	1	1	1	2	
Forestry		1		1	
Livestock		1	1	1	
Research Communication				1	
Farming Systems	1	2		1	
Total	3	6	3	8	

9 INFRASTRUCTURE

Most of the basic research infrastructures, based on the Master Plan developed in 1994, were realized within the last three FYPs. The RC Bajo now has a modest level of facilities and further investment in infrastructure development will not be required in the immediate future. However, with the revival of the Sub-Centre at Mithun in Tsirang, some infrastructure development will be necessary to provide a modest working environment for the staff. Further, with the development occurring around the research centre, it has also become necessary for some infrastructure to protect the existing establishments.

In the 10th Plan, the following infrastructure development and maintenance is proposed.

- River Bank Protection adjoining farm boundary at Bajo. With the construction of Punatsangchu power dam a few kilometers downstream, the back water flow will raise the river water level and is certainly going to inundate the center's rice fields. It has become imperative to carry out protection measures to save the precious paddy lands.
- Re-surfacing of approach road and parking area of Bajo Research Centre
- Re-surfacing of approach road to Sub-Centre Mithun in Tsirang
- New Office building – two storeyed for the Sub-Centre in Tsirang
- Concrete lining of drainage networks within the RC Bajo area (3 different sections)
- Fencing on eastern boundary of the Bajo Centre's research area
- Field and laboratory equipment
- Purchase 2 nos. of Pool vehicles – one new for Sub-Centre Tsirang and one replacement for Bajo

  Pool vehicles have helped in the past to reach out and in providing timely services to extension and farmers from the center. With the increasing improvement of accessibility to geogs and villages, it is an opportunity to take new knowledge and production technologies to remoter farmers. Further, it is strategic for efficient use of time of limited available staff for the program. Therefore, purchase of 2 numbers of pool vehicles is proposed – one for Tsirang and one for Bajo.

10 PROGRAM PLANNING

The 10th Plan strategies and policies for research and extension will form the basis for developing annual regional plans. Annual Regional RNR Review and Planning Workshops will be organized by the Centre together with the DoA to plan, implement, and monitor the research activities.

10.1 Implementation methods/ mechanism

The program implementation is the responsibility of the RNRRC-Bajo. The research programs will be closely linked with extension, implemented on-farm and based on adaptive work, either of recommendations of technologies produced from RNR-RC or drawn from sister RNR-RCs or from outside Bhutan. Applied and adaptive research would be undertaken, both "on-station" and "on-farm" and demonstration sites, to identify suitable location specific varieties and appropriate production technologies.

RNRRC Bajo will also closely collaborate with concerned Programs and Projects under the Ministry of Agriculture for effective implementation of the planned programs.

The content of the program will be closely tied to the specificities of individual Dzongkhag requirements and rural economies. Emphasis is placed on

technologies to benefit the many small subsistence farmers in the country, the majority of who practice subsistence farming and incorporate crops, animals and trees in their farms. These are the ultimate clients of research and must be the major beneficiaries of research outputs.

Research approach

Adaptive research

The major effort will made to introduce and adapt technologies either generated by the national programs within the country or by other national and international agricultural research systems to the regional climatic and adaphic conditions. This adaptive research will begin at the station and will be quickly advanced to on-farm to hasten the research process. On-farm research with multilocation trials will be emphasized in collaboration with the regional extension agents.

Community based Natural Resources Management (CBNRM)

The CBNRM process will be adopted to understand and study the management of communal resources and the local institutions were applicable. The focus will also be on interdisciplinary and intersectoral research as opposed to disciplinary and commodity research thus leading to a problem-based research. In addition, the watershed study efforts started in the 8th FYP will continue to help understand the complexity of integrated use and management of natural resources.

Farming systems perspective

In order to keep the technology relevant to the dynamism of farming systems the process of technology development will ensure that perspective of farming needs are not lost. Research will support by developing technologies relevant and cost effective to the regional growers for both subsistence and market.

Research Management

A regional Research-Extension Committee will be established and will meet once a year, to plan the research program for the forthcoming year's activities including joint research-extension activities and to report on and review the activities that have been undertaken during the previous year. The Annual Regional RNR Review and Planning Workshops will be organized by the Centre to plan, implement, and monitor the research activities.

The Regional research management will have overall responsibility to ensure :that research-extension linkages are promoted and developed, that the Research-Extension committee meets as planned, that the research program remains consistent with the 10th FYP strategy, that reporting is undertaken in a timely and comprehensive manner, that resource utilisation is fully monitored and remains consistent with objectives and that the quality of research is maintained and developed. In addition regional research

management will seek to actively develop linkages with National Research Programs in Field Crops, Horticulture, Livestock and Forestry.

Research- Extension Linkages

RNR-RC Bajo will actively seek to develop and strengthen research-extension linkages through direct contact with Dzongkhag extension staff, through the undertaking of joint research-extension activities including on-farm experimentation, diagnostic surveys and investigation and joint training activities. Apart from these the Research Communication Program Unit under the Center will provide necessary backstopping to extension in planning, implementation and M&E of extension activities.

Reporting

The RNR-RC Bajo will produce an annual technical report within three months of the end of each financial year (i.e. by September 30). The report will also contain an executive summary, written for a non-technical audience, of the highlights of the year's research program emphasising achievements, progress as well as shortfalls and constraints in the planned program and steps that are being taken to address these, and new research recommendations.

- a technical report by program. A full report for those activities that are completed.
- a summary of resources both financial and human that have been used
- a summary on joint research-extension activities including training, field days etc.
- annual meteorological data
- a summary of research recommendations of the year if any.

At the end of the 10th FYP a comprehensive report covering the five-year period along the line of the annual report will be prepared. This will include in addition, a detailed analysis of the diffusion and adoption of selected research recommendations and technologies. Based on the outcome of the five-year period and a review of the development in the client Dzongkhags, a program of commodity priorities, constraints and opportunities for the forthcoming five-year plan will be included.

11 MONITORING AND EVALUATION

The monitoring of technical progress of the research program, using the indicators (Annexures 2c, 3c, 4c, 5c,6c and 7c) will be undertaken through the half-yearly reports, annual reports, regional workshop proceedings, research papers, technical bulletins and the final technical report at the end of the 10th FYP. Monitoring of resource allocation and utilization will be undertaken using research time allocation as factor indicator.

12 BUDGET

The proposed 10th Five Year Plan Outlay is **Nu.130.82m** (Table 22). The plan outlay is in keeping with the Guidelines for Preparation of the Tenth Plan from Planning Commission and the program priorities drawn up for both the national and regional mandates of the Centre. Major donors who supported the implementation of Centre's programs are withdrawing their support by the end of the 9th Plan. Under such circumstances it is understood that that the total Plan Outlay will have to be funded by RGoB. Notwithstanding, the Centre will make every effort to seek donor fund support particularly for the capital works.

Table 22: Estimated 10th Plan Outlay for RNRRC Bajo

Budget Head	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	
HRD						
TA	0.000	1.000	1.000	1.000	0.000	
Infrastructure	3.000	6.100	2.100	1.500	0.000	
Total	**3.570**	**7.100**	**3.100**	**2.500**	**-**	
Personnel emolument	5.982	6.000	6.100	6.300	6.500	
Othe Pers emolument	1.223	1.223	1.223	1.223	1.223	
Operational cost	18.050	14.010	14.490	15.400	16.190	
Total	**25.250**	**21.230**	**21.813**	**22.923**	**23.913**	
G. Total	**28.250**	**28.330**	**24.910**	**25.423**	**23.913**	**130.820**

At the national level, the allocation of resources between the four programs (Field Crops, Horticulture, Livestock and Forestry) is based on the importance of the program (Table 10). The Field Crops program receives 24% of the total allocation.

Table 23: Program-wise and centre-wise resource allocation for 10FYP.

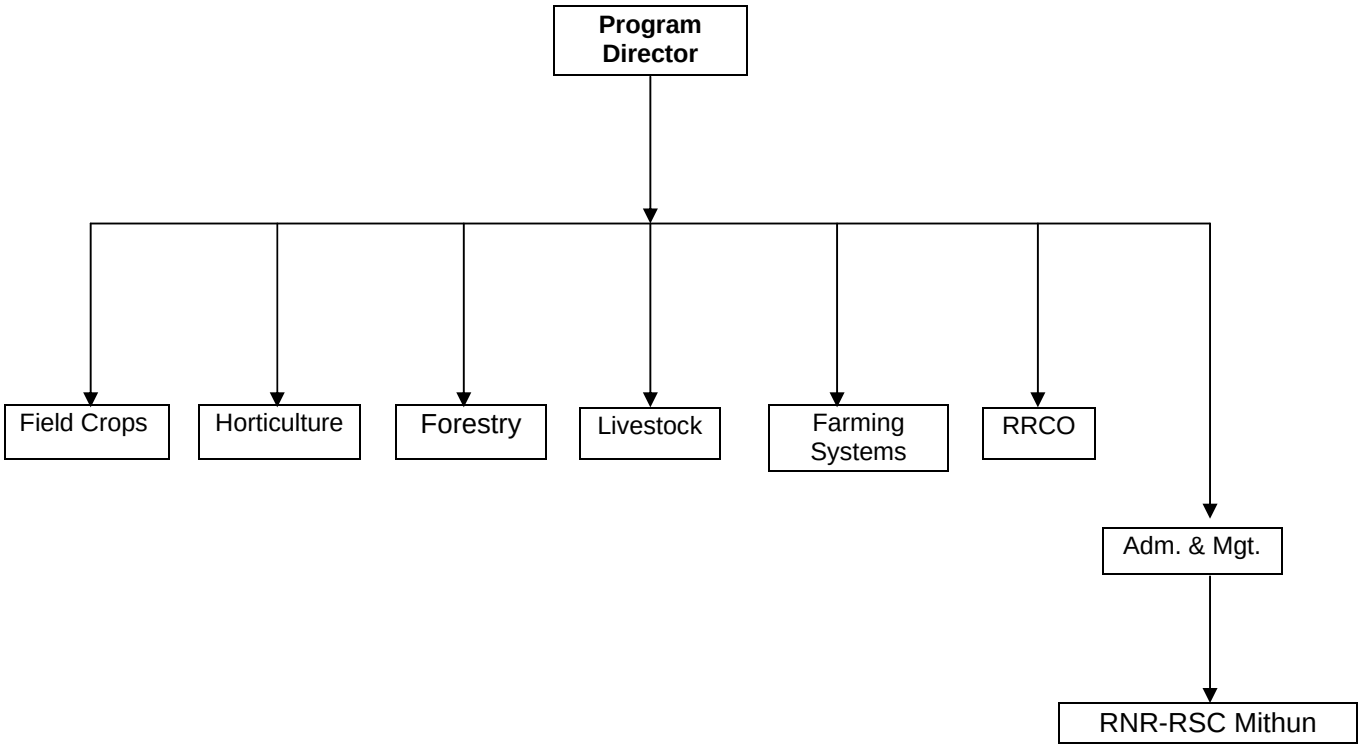
Research Programme	Budget (Nu. In Million)					
	Yusipang	Bajo	Jakar	Wengkhar	Program Budget	% for Program
Forestry Research	52.58	6.55	19.62	7.75	86.50	16%
Field Crops Research	26.29	52.36	19.62	31.01	129.28	24%
Livestock Research	13.15	13.09	52.33	7.75	86.32	16%
Horticulture Research	26.29	32.73	26.16	62.02	147.20	27%
RNR Systems Program	6.57	19.64	6.54	23.26	56.01	10%
RCO	6.57	6.55	6.54	23.26	42.92	8%
Centre Budget	131.45	130.90	130.82	155.05	548.22	100%
Annual Allocation for centre (Nu. Million)	26.29	26.18	26.16	31.01		
% Centre	24%	24%	24%	28%		
% of overall budget						

Within the Centre's programs, the financial resources are allocated as below. The proportionate allocation is in keeping with the 10th plan objectives of improving food security and income of the farming communities.

Field crops	: 40.0%
Horticulture	: 20.0%
Livestock	: 10.0%
Forestry	: 5.0%
Farming System and Support Services	: 20.0 %
Research Communication	: 5.0%

13 ANNEXURES

Annexure 1: Organogram of RNR RC, Bajo



Annexure 2a: Field Crops Research Program Matrix for 10FYP

Result level	Indicator description	Baseline indicator	FYP targets	Link to DoA/MoA 10FYP targets
Impact: Increased production of rice, maize, wheat and oilseeds	Yield (t/ha) of rice, maize, wheat and oilseeds in the region	Rice: 2.75 t/ha; maize: 2.18; wheat: 1.01; oilseeds: 0.74; legumes: 1.0	15% increase by 2013	
Outcome 1: High yielding crop varieties	No of HYVs	Rice: 8, maize: 3, wheat: 3 oilseeds: 3	Additional varieties Rice: 4, maize: 3, wheat: 3, oilseeds: 3	
Output 1.1: Improved germplasm introduced and evaluated	No of introductions from IARCs	Average 50 per year	Average 100 per year	
Output 1.2: Local varieties improved through cross breeding	No of crossed population	5-10 per year	10-20 per year	
Outcome 2: Soil fertility management practices	No of technologies	3-5 technologies	At least 5 -10 technologies	
Output 2.1: IPNS methods refined and used by farmers	Proportion of hh using post harvest technologies	Less than 1% use technologies to reduce losses	5% rural households use improved technologies	
Output 2.2: Soil mgt practices for organic farming developed and demonstrated	No of practices	Nil so far	At least 5 practices	
Outcome 3: Pest management technologies	No of available technologies	3-5 technologies	Additional 4-6 technologies	
Output 3.1: IPM technologies developed and popularized	% farmers using IPM technologies	< 5%	At least 15%	
Output 3.2: Weed management technologies evolved	No of technologies	< 3	At least 6	
Outcome 4: Improved post harvest, processing, grain quality and marketing	No of technologies	< 5	At least 10	
Output 4.1: Efficient processing/milling equipment identified and demonstrated	Range of equipment	None	3-5	
Output 4.2: Marketing of produce/products improved	No of market outlets	-	4-6	

Annexure 3b: Subprogram, project and other details of FCR for 10FYP

Sub-program/ project	Impact/output/ outcome	Program/ project type	Geographical coverage/ Beneficiaries	Start date	End date	Lead agency	Collaborating agencies
1. Rice							
1.1 Variety improvement	Impact: Increased rice production Outcome: New high yielding varieties (HYVs)	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	RNRRCs, Dzongkhags
1.2 Soil fertility management	Impact: Increased rice production Outcome: IPNS technologies for farmers	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NSSC, RCs, Dzongkhags
1.3 Pest management	Impact: Increased rice production Outcome: Integrated Pest Management (IPM) technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
1.4 Post harvest and grain quality	Impact: Increased rice production Outcome: Post harvest technologies; efficient milling equipment	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPHC, RCs Dzongkhags
2. Maize							
2.1 Variety improvement	Impact: Increased maize production Outcome: Improved varieties	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	RCs Dzongkhags
2.2 Soil fertility management	Impact: Increased maize production Outcome: Suitable IPNS technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NSSC, RCs, Dzongkhags
2.3 Pest management	Impact: Increased maize production Outcome: Appropriate IPM technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
2.4 Processing and marketing	Impact: Increased maize production Outcome: diverse products; efficient	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	NPHC, RCs, Dzongkhags

	equipment						
Sub-program/ project	**Impact/output/ outcome**	**Program/ project type**	**Geographical coverage/ Beneficiaries**	**Start date**	**End date**	**Lead agency**	**Collaborating agencies**
3. Wheat							
3.1 Variety improvement	Impact: Increased wheat production Outcome: HYVs for different areas	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	RNRRCs, Dzongkhags
3.2 Water and soil management	Impact: Increased wheat production Outcome: Better technologies for soil and water mgt	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NSSC, RCs Dzongkhags
3.3 Pest management (storage)	Impact: Increased wheat production Outcome: Pests management technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
4. Oilseeds							
4.1 Variety improvement	Impact: Increased oilseeds production Outcome: HYVs for different regions	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	RCs, Dzongkhags
4.2 Pest management	Impact: Increased oilseeds production Outcome: IPM technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
4.3 Processing	Impact: Increased oilseeds and oil Outcome: efficient oil extraction equipment	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPHC Dzongkhags
5. Grain legumes							
5.1 Variety improvement	Impact: Increased production of grain legumes Outcome: New crops and HYVs	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	NSSC, RCs, Dzongkhags
5.2 Pest management	Impact: Increased legumes production	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags

	Outcome: IPM technologies						

Annexure 4c: Monitoring and Evaluation of Field Crops program

Result level	Indicators	Baseline	Target	Data source	Reporting frequency	Responsibility	Report to
Increased production of rice, maize, wheat and oilseeds	Yield (t/ha) of rice, maize, wheat and oilseeds in the region	Rice: 2.75 t/ha; maize: 2.18; wheat: 1.01; oilseeds: 0.74; legumes: 1.0	15% increase by 2013	DoA statistics Research results	Annual	RCs, Dzongkhag Extension	CoRRB DoA
High yielding crop varieties	No of HYVs	Rice: 8, maize: 3, wheat: 3 oilseeds: 3	Additional varieties Rice: 4, maize: 3, wheat: 3, oilseeds: 3	VRC records	Every 2 years	RCs	CoRRB
Better soil fertility management practices	No of technologies	3-5 technologies	At least 5 -10 technologies	RC/DoA records	Every 2 years	RCs NSSC	CoRRB
Improved pest management technologies	No of available technologies	3-5 technologies	Additional 4-6 technologies	RC/DoA records	Every 2 years	RCs, NPPC	CoRRB
Improved post harvest, processing, grain quality and marketing	No of technologies	< 5	At least 10	RC/DoA records	Every 2 years	RC NPHC	CoRRB

Annexure 5a: Horticulture Research Program Matrix for 10FYP

Result level	Indicator description	Baseline indicator	FYP targets	Link to DoA/MoA 10FYP targets
Impact: Increased production of citrus, vegetables, cardamom, potato, pear, persimmon, Other fruits and nuts	Yield (kg/tree or t/acre) of citrus, vegetables, cardamom, potato, Other fruits and nuts in the region	5t/ha for potato, 45kg/tree for citrus	10% increase by 2013	
Outcome 1: High yielding crop varieties	No of HYVs	Citrus: 1, potato: 4, vegetables : 22, others fruits and nuts: 15, cardamom: 2	Additional varieties Citrus: 1, potato: 1, vegetables : 4, others fruits and nuts: 5, cardamom: 1	
Output 1.1: Improved germplasm introduced and evaluated	No of introductions from India and abroad	Average <10 per year	Average >10 per year	
Output 1.2: Local varieties improved through selection from local diversity	No of selection	2- 3 per plan period	about 5 in plan period	
Outcome 2: Crop production management technologies evaluated	No. of available technologies	5-8 technologies	At least 15 technologies	
Output 2.1: Plant propagation technologies evaluated	No. of plant propagation techniques	3-4 technologies	At least 5-10 technologies	
Output 2.2: Vegetative propagated fruit crops used by farmers	Proportion of orchards established using grafted fruist and nuts	Citrus -0, other fruits and nuts- at backyard only	Citrus-10% of orchard in the country	
Output 2.3: Seed plot techniques for potato and vegetables refined and used by farmers	Proportion of hh using seed plot technique technologies	Less than 1% use technologies to improved seeds quality	10% rural households use improved technologies	
Output 2.4: Soil fertility management practices	No of technologies	2-4 technologies	At least 5 -6 technologies	
Output 2.5: IPNS methods refined and used by farmers	Proportion of hh using post harvest technologies	Less than 1% use technologies to reduce losses	5% rural households use improved technologies	
Output 2.6: Soil mgt practices for organic potato farming developed and demonstrated	No of practices	Nil so far	At least 1 practices	
Output 2.7: Pest management technologies	No of available technologies	5-6 technologies	Additional 8-10 technologies	
Output 2.8: IPM technologies developed and popularized	% farmers using IPM technologies for various horticulture crops	< 5%	At least 20%	
Output 2.9: Weed management technologies evolved	No of technologies	< 2	At least 5	
Output 2.10: Crop water	No of technologies	<2	About 3	

management technologies generated				
Outcome 3: Improved post harvest, processing, grading, packaging and marketing	No of technologies	< 4	At least 10	
Output 3.1: Quality standards and efficient grading and packaging technologies identified and demonstrated	No. of quality standards	2	5-6	
Output 3.2: Marketing of produce/products improved	No of market outlets	2	5-8	

Annexure 6b: Subprogram, project and other details of horticulture research program for 10FYP

Sub-program/ project	Impact/output/ outcome	Program/ project type	Geographical coverage/ Beneficiaries	Start date	End date	Lead agency	Collaborating agencies
1. Citrus							
1.1 Germplasm or Variety improvement	Impact: Increased citrus production season Outcome: HYVs	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	RNRRCs, Dzongkhags
1.2 Improved crop production technologies	Impact: improved citrus quality and production Outcome: IPNS, IPM technologies,	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NSSC, RCs, Dzongkhags
1.3 Improved plant propagation technologies	Impact: enhanced citrus production production Outcome: Plant propagation technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
1.4 Improved post harvest technologies	Impact: improved return from citrus industry Outcome: Post harvest technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPHC, RCs Dzongkhags
1.5 Improved market intelligence and marketing	Impact: improved return from citrus industry Outcome: Market information	Non-infrastructure	West central region Farmer	July 2008			
2. Potato							
1.1 Germplasm or Variety improvement	Impact: Increased potato production season Outcome: HYVs	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	RNRRCs, Dzongkhags
1.2 Improved crop	Impact: improved potato quality and	Non-infrastructure	West central region	July 2008	June 2013	RC Bajo	NSSC, RCs, Dzongkhags

production technologies	production Outcome: IPNS, IPM technologies for organic and conventional practices		Farmer				
1.3 Improved seed plot technique	Impact: enhanced potato production production Outcome: seed technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
1.4 Improved post harvest technologies	Impact: improved return from potato farming Outcome: Post harvest technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPHC, RCs Dzongkhags
1.5 Improved market intelligence and marketing	Impact: improved return from potato industry Outcome: Market information	Non-infrastructure & infrastructure	West central region Farmer	July 2008			
3. Vegetables							
1.1 Germplasm or Variety improvement	Impact: Increased vegetable diversity and production Outcome: HYVs	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	RNRRCs, Dzongkhags
1.2 Improved crop production technologies	Impact: improved vegetable quality and production Outcome: IPNS, IPM technologies,	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NSSC, RCs, Dzongkhags
1.3 Improved seed production technologies	Impact: enhanced vegetable production Outcome: seed technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
1.4 Improved post harvest technologies	Impact: value added and improved return from vegetable farming Outcome: Post harvest technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPHC, RCs Dzongkhags
4. Other Fruit and Nuts (walnut, pecan, almond, mango, grapes, peaches, plum, apricot, litchi, kiwi, loquat, banana, arecanut, avocado, guava, etc)							
1.1 Germplasm or Variety improvement	Impact: Increased fruits and nuts diversity and production Outcome: HYVs	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	RNRRCs, Dzongkhags
1.2 Improved crop production	Impact: improved fruits and nuts quality and	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NSSC, RCs, Dzongkhags

technologies	production Outcome: IPNS, IPM technologies,						
1.3 Improved plant propagation technologies	Impact: enhanced fruit and nuts production Outcome: Plant propagation technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
1.4 Improved post harvest technologies	Impact: improved return from citrus industry Outcome: Post harvest technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPHC, RCs Dzongkhags
1.5 Improved market intelligence and marketing	Impact: Commercialization of few potential fruits and nuts crops Outcome: Market information and market established	Infrastructure and non-infrastructure	West central region Farmer	July 2008			
5 Pear and Persimmon							
1.1 Germplasm or Variety improvement	Impact: Increased pear and persimmon production Outcome: HYVs	Non-infrastructure	West central region Farmers	July 2008	June 2013	RC Bajo	RNRRCs, Dzongkhags
1.2 Improved crop production technologies	Impact: improved pear and persimmon quality and production Outcome: IPNS, IPM technologies,	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NSSC, RCs, Dzongkhags
1.3 Improved plant propagation technologies	Impact: enhanced fruit and nuts production Outcome: Plant propagation technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
1.4 Improved post harvest technologies	Impact: improved income of growers Outcome: Post harvest technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPHC, RCs Dzongkhags
1.5 Improved market intelligence and marketing	Impact: Commercialization farming of pear Outcome: Market information and market established	Infrastructure and non-infrastructure	West central region Farmer	July 2008			
6. Spices and condiments (Cardamom)							
1.1	Impact: Increased	Non-	West central	July	June	RC	RNRRCs,

Germplasm or Variety improvement	cardamom production Outcome: HYVs	infrastructure	region Farmers	2008	2013	Bajo	Dzongkhags
1.2 Improved crop production technologies	Impact: improved cardamom production Outcome: IPNS, IPM technologies,	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NSSC, RCs, Dzongkhags
1.3 Improved plant propagation technologies	Impact: enhanced cardamom production Outcome: Plant propagation technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
1.4 Improved post harvest technologies	Impact: improved return from cardamom industry Outcome: Post harvest technologies	Non-infrastructure	West central region Farmer	July 2008	June 2013	RC Bajo	NPHC, RCs Dzongkhags

Annexure 7c: Monitoring and Evaluation of Horticulture Research Program

Result level	Indicators	Baseline	Target	Data source	Reporting frequency	Responsibility	Report to
Increased production of citrus, potato, vegetables, cardamom, pear, other fruits and nuts	Yield (kg/tree or t/acre) of citrus, vegetables, cardamom, potato, Other fruits and nuts in the region	5t/ha for potato, 45kg/tree for citrus	10% increase by 2013	DoA statistics Research results	Annual	RCs, Dzongkhag Extension	CoRRB DoA
High yielding crop varieties	No of HYVs	Citrus: 1, potato: 4, vegetables : 22, others fruits and nuts: 15, cardamom: 2	Additional varieties Citrus: 2, potato: 1, vegetables : 4, others fruits and nuts: 5, cardamom: 1	VRC records	Every 2 years	RCs	CoRRB
Crop production management technologies	No. of available technologies	5-8 IPNS, IPM plant propagation technologies	At least 15 IPNS, IPM plant propagation technologies	RC/DoA records	End of plan period	RCs NSSC	CoRRB
Improved post harvest, processing, grading and packaging and marketing	No of technologies	< 4	At least 10	RC/DoA records	En of plan period	RC NPHC	CoRRB

Annexure 8a: Forestry Research Program Matrix for 10 FYP

Result level	Indicator description	Baseline indicator	FYP targets	Link to MoA Target
Impact: Sustainable utilization and conservation of forest resources in the west central region	More forest resources available vis-à-vis less forest depletion	LUPP, FRDD data base, regional database		DoF
Outcome 1: Suitable thinning option available and adopted in Forest management code by DoF	Thinning options incorporated in the management code	Nil	1	DoF
Output 1.1: Bluepine stand productivity and stability improved	Increased volume/ha/year	Nil	1	DoF
Outcome 2: Broaden the knowledge base on herbivore (cattle) effects on broadleaf forests dynamics	Forest managers are informed and aware of cattle impacts through reports, field visits	Grazing reduces timber species but favours non-timber species	1	DoF
Output 2.1 : Grazing effects on broadleaf forests consolidated	Data analyzed/reported according to species	Fence promotes regeneration	1	DoF
Outcome 3 : Environmental conservation in community, private and agroforestry	Reduces soil erosion and forest composition and structure remain intact	Indigenous knowledge/methods	1	
Output 3.1 : Soil conservation in community forestry improved	Techniques tested and applied in community forests	Nil	1	DoF
Output 3.2 : Farmers interests and perspectives on private forests documented	Reports produced	Nil	1	DoF
Output 3.3 : MPTS domestication and propagation consolidated	Additional pamphlets developed	6 MPTS pamphlets	5	DoF
Outcome 4 : NWFP domestication and propagation technology available to farmers	NWFP reports	Few reports available	1	DoF
Output 4.1 : NWFP distribution, uses and resource availability assessed	Reports produced	Methods available in CF manuals, FRDD	1	DoF
Output 4.2 : Domestication and propagation of selected bamboo species promoted	Pamphlets developed and distributed to farmers	1	3	DoF
Outcome 5 : Forest Protection	Pests/diseases outbreak incidences reports	Reports available	1	DoF
Output 5.1 : Nursery pest and diseases control methods	Reports distributed and pests/diseases incidences curtailed	Reports available	1	DoF

Annexure 9b: Subprogram, project and other details of Forestry Research for 10FYP

Sub-program/ project	Impact/output/outcome	Program/ project type	Geographical coverage/ Beneficiaries	Start date	End date	Lead agency	Collaborating agencies
Conifer Forest Management							
Silviculture	Impact: Increased stand productivity and stability Outcome: Bluepine stand productivity and stability improved	Non-infrastructure	Khotokha, Wangdue	July 2008	June 2013	RC Bajo	RNRRC Jakar, DFO Wangdue
Broadleaf Forest Management							
Ecology	Impact: Broaden the knowledge base on herbivore (cattle) effects on broadleaf forests dynamics Outcome: Grazing effects on broadleaf forests consolidated	Non-infrastructure	Rimchu, Punakha	July 2008	June 2013	RC Bajo	RNR-RC Jakar, DFO Wangdue; DzFO
Social Forestry							
Community Forestry	Impact: Soil conservation measures in community forestry integrated Outcome: Soil erosion in community forestry reduced	Non-infrastructure	Dagana	July 2008	June 2013	RC Bajo	DzFO, Farmers, Soils (Bajo)
Private forestry	Impact: Policy makers informed on private forestry interests Outcome: Farmers interests on private forests documented	Non-infrastructure	West central region	July 2008	June 2013	RC Bajo	DzFO, Farmers, DoF
Agroforestry	Impact: Increased MPTS domestication and propagation by farmers Outcome: MPTS domestication and propagation consolidated	Non-infrastructure	West central region	July 2008	June 2013	RC Bajo	DzFO, Farmers, DoF
Non-Wood Forest Products							
Resource inventory	Impact: NWFP domestication and propagation technology available to farmers Outcome: NWFP distribution, uses and availability assessed	Non-infrastructure		July 2008	June 2013	RC Bajo	DzFO, Farmers
Bamboo and Cane	Impact: Farmers adopt bamboo propagation technology Outcome: Domestication and propagation technology of selected bamboo species	Non-infrastructure	Jala, Dagana, Tsirang	July 2008	June 2013	RC Bajo	DzFO, Farmers

	promoted						
Forest protection							
Pest and Diseases	Impact: Pests/diseases outbreak incidences reduced Outcome: Nursery pest and diseases control methods identified	Non-infrastructure	Tsirang, Dagana	July 2008	June 2013	RC Bajo	DzFO, CFMG

Annexure 10c: Monitoring and Evaluation of Forestry Research program

Result level	Indicators	Baseline	Target	Data source	Reporting frequency	Responsibility	Report to
Bluepine stand productivity and stability improved	Increased volume/ha/year and stability			Research results, coordination workshop reports	Every 3 years	RCs, DFO, Wangdue	CoRRB DoF
Grazing effects on broadleaf forests consolidated	Data analyzed/reported according to species	Fence promotes regeneration	1	Research results, coordination workshop reports	Once in five years	RCs, DFO, Wangdue	CoRRB DoF
Soil conservation measures in community forestry integrated	Techniques tested and applied in community forests	Nil	1	Research reports, field visits, learning by doing demonstration	Once	RCs , DzFO,CFMG	CoRRB
Farmers interests on private forestry documented	Technical reports	Nil	1	Research reports, coordination workshop reports	Once	RCs , DzFO	CoRRB DoF
MPTS domestication and propagation consolidated	Additional pamphlets	6 MPTS pamphlets	5	Centre's publication, extension offices	Once	RCs	CoRRB DzFO
NWFP distribution, uses and availability assessed	Reports	Methods (CF manuals)	1	Research reports	Once	RCs , DzFO	CoRRB,DoF
Domestication and propagation of selected bamboo species promoted	Pamphlets developed and distributed to farmers	1	3	Research reports	Once	RCs , DzFO, Farmers	CoRRB
Nursery pest and diseases control methods	Reports distributed and applied by nursery growers	Reports on general pest/diseases	1	Research reports/booklets	Once	RCs , DzFO, CFMG	CoRRB

Annexure 11a: Livestock Research Program Matrix for 10 FYP

Result level	Indicator description	Baseline indicator	FYP targets	Link to Vision 2020, MDG, sector and other thematic goals and Target
Impact 1 (long term results) Reduction in the proportion of rural households living below poverty line	Research and technology innovation contribute to increased ourput per animal	23.2% of Bhutanese live below poverty line at Nu. 1096.94 per persons per month **(PAR, 2007)**	Three fold increase in rural income of farmers by 2013 (Bhutan 2020)	Increase household income, improve livelihood and maximize GNH
Outcome 1 (mid term results) • Increase in production of dairy, meat and egg production by 20-25% • Value of income from livestock to rural household increased from 22% to 25% • Per capita availability of milk is increased from 172g/day to 200g/day • 90% of animal genetic resources characterized	Increase in crossbred livestock populations Improved way of rearing livestock demonstrated No. of alternate feed and fodder resources adopted by farmers	Milk: 19927 mt, pork : 1649mt, beef: 547 mt, chicken: 151 mt, egg: 5397163 nos **(DoL, 2007)** Livestock ensures 22% of rural income **(RNR census, 2000)** Per capita milk availability is 12g/day **(ICIMOD,2002)** 50% of AnGR characterized **(RC Jakar, 2008)**	3 technologies for enriching cereal by products/ crop residues developed 2 non conventional feed formulations developed 2 reproductive management technlologies (estrus synchromnization and mobile AI adopted)	Food security and income generation (GNH pillar I) Environmental conservation (GNH pillar II)
Output 1 (short term results) 3 technologies for enriching cereal by-products/residues developed 2 non -conventional feed formulation developed 1 winter feed package developed 2 legumes in orchard system developed 2 cereal-legume intercropping systems developed 2 reproductive management technologies (Mobile AI and Estrus synchronization0 developed	Technology to improve production No. of feed and fodder varieties released for extension use	Existing: 1 (urea treatment of straw) Existing: None Existing: 3 (oat, fodder beet, swede) Existing: 1 (fodder peanut in orange orchard) Existing: 1 (AI)	As in the outputs	GNH pillar 1, GNH pillar 2

1 fast growing goat breed, 1 egg type and 1 broiler type poultry strain identified 1 basis for genetic improvement of cattle established (cattle ID, Recording) 1 basis for Yak eco-tourism initiated 1 organic agriculture system studied		Existing: goat (only local) improved (none), chicken/broiler: 1 each Existing: none or not effective Existing: no data		

Annexure 12b: Subprogram, project and other details of Livestock Research for 10FYP

Sub-program/ project	Impact/output/outcome	Program/ project type	Geographical coverage/ Beneficiaries	Start date	End date	Lead agency	Collaborating agencies
Component 1: Pastoral systems	1 community based yak eco-tourism ventures initiated 2 rangeland management practices recommended 1 winter feed package developed 1 estrus synchronization and AI trail implemented 1 yak products processing technology introduced	Non infrastructure	4 pockets (Dhur, Soe yaksa, merak-Sakten and Sephu) involving 30-40 farmers Final beneficiaries (13,000yak herders)	2008	2013	RC Jakar	RCs (Yusipang, Bajo, wengkhar) DoL
Component 2: Dry land systems	2 cereal residues/by-products enriching technologies developed (e.g. feed blocks) 1 cereal residue enriching technology developed 1 legume-cereal intercropping system developed 1 reproductive technology (estrus synchronization) applied 1 basis for breed improvement (cattle identification and recording) initiated	Non-infrastructure	Farmers involved in dryland (112774 acres) Tsiri/pangshing (71164 acres) cultivation (86.9% & 47.5% Bhutanese population respectively)	2008	2013	RC Yusipang	RCs NFFDP Extension
Component 3: Wetland	2 cereal residues/by-products enriching	Non infrastructure	Farmers involved in	2008	2013	RC Bajo	RCs NFFDP

systems	technologies developed (e.g. feed blocks) 1 cereal residue enriching technology developed 1 legume-cereal intercropping system developed 1 reproductive technology (estrus synchronization) applied 1 basis for breed improvement (cattle identification and recording) initiated		paddy (58.9% of Bhutanese population) in 54019 acres of land				Extension
Component 4: Orchard systems	2 legume fodder for orchard system developed		About 28% of Bhutanese population; 21250 acres of orchard systems	2008	2013	RC Wengkhar	RCs
Component 5: Feed and Fodder biotechnology	2 cereal crop residues/by-products enriching technology developed		About 77.5% of Bhutanese population who own cattle Nationwide application	2008	2013	NFFDP	RCs

Sub program 2: Meat

Sub-program/ project	Impact/output/outcome	Program/ project type	Geographical coverage/ Beneficiaries	Start date	End date	Lead agency	Collaborating agencies
Project 1: small ruminants (goat)							
Component 1: wetland Component 2: Dry land Component 3: Orchard system	1 fast growing goat developed	Non infrastructure	Goat rearing areas farmers (15.7% of Bhutanese population) in sarpang, Tsirang, Samtse, Chukha, Dagana Districts	2008	2013	RNR RCS Bhur	RNR RSC Tsirang
Project 2: Poul;try (Chicken & Duck)							
Component 1: Feed and fodder biotechnology	1 alternative economical feed formulation developed with available local resources 1 appropriate broiler	Non infrastructure	Broiler enterprise interested farmers in Tsirang, Dagana,	2009	2013	NFFDP RC Jakar	RCs Poultry Farms

	strain for Bhutan identified		sarpang, Samtse, S/jongkhar districts and periurban areas of Bhutan				
Project 4: Pork							
Component 1 Feed and fodder biotechnology	1 alternative economical feed formulation developed with available local resources 1 appropriate broiler strain for Bhutan identified	Non infrastructure	About 37% of Bhutanses population in Tsirang, Dagana, Sarpang, Samtse S/jongkhar districts and periurban areas of Bhutan	2009	2013	NFFDP RC Jakar	RCs Pig farms

Sub program 3: Egg **Project 1: poultry (Chicken & Duck)**							
Poultry (Chicken & Duck)	1 alternative economical feed formulation from locally available ingredients developed 1 additional egg type poultry strain introduced	Non infrastructure	About 65.5% of Bhutanese population whi are engaged in backyard poultry enterprise	2009	2013	NFFDP	

Sub program 4: Honey **Project 1: Apiculture (Bees)**							
Component 1 Orchard systems	1 innovative technology in hiving local *Apis cerena* bees developed 3 community based honey villages established	Non infrastructure	Farmers in southern districts of Sarpang, Tsirang, Dagana, Samtse,Cjukha	2009	2013	RNR-RSC Bhur	RNR RSC Darla, Tsirang BeKAB

Sub program 5: Animal Energy **Project 1: Draft Power (cattle, horse,yak)**							
Component 1 Integrated systems	1 community based breeding program for nublang and horse initiated 1 yak related eco-tourism venture initiated 1 project for embryo transfer in Nublang secured	Non infrastructure	Farmers in rural areas without access to motor roads, tourism sector	2009	2013	NBC	RCs Nublang farm Horse breeding farm

Annexure 13c: Monitoring and Evaluation of Livestock Research program

Result level	Indicators	Baseline	Target	Data source	Frequency/training	Responsibility	Report to
Impact 1 (long term results) Reduction in the proportion of rural households living below poverty line	Research and technology innovation contribute to increased ourput per animal	23.2% of Bhutanese live below poverty line at Nu. 1096.94 per persons per month **(PAR, 2007)**	Three fold increase in rural income of farmers by 2013 (Bhutan 2020)	Annual Centre Report Program Report	Annual, Twice in a financial year	RCs	CoRRB
Outcome 1 (mid term results) • Increase in production of dairy, meat and egg production by 20-25% • Value of income from livestock to rural household increased from 22% to 25% • Per capita availability of milk is increased from 172g/day to 200g/day • 90% of animal genetic resources characterized	Increase in crossbred livestock populations Improved way of rearing livestock demonstrated No. of alternate feed and fodder resources adopted by farmers	Milk: 19927 mt, pork : 1649mt, beef: 547 mt, chicken: 151 mt, egg: 5397163 nos **(DoL, 2007)** Livestock ensures 22% of rural income **(RNR census, 2000)** Per capita milk availability is 12g/day **(ICIMOD,2002)** 50% of AnGR characterized **(RC Jakar, 2008)**	3 technologies for enriching cereal by products/ crop residues developed 2 non conventional feed formulations developed 2 reproductive management technlologies (estrus synchromnization and mobile AI adopted)	Annual Centre Report Program Report	Annual Twice in a financial year	RCs	CoRRB
Output 1 (short term results) 3 technologies for enriching cereal by-products/residues developed 2 non -conventional feed formulation developed 1 winter feed package developed 2 legumes in orchard system developed 2 cereal-legume intercropping systems developed 2 reproductive management technologies (Mobile AI and Estrus synchronization0 developed 1 fast growing goat breed, 1 egg type and 1 broiler type poultry strain identified	Technology to improve production No. of feed and fodder varieties released for extension use	Existing: 1 (urea treatment of straw) Existing: None Existing: 3 (oat, fodder beet, swede) Existing: 1 (fodder peanut in orange orchard) Existing: 1 (AI) Existing: goat (only local) improved (none), chicken/broiler: 1 each Existing: none or not effective Existing: no data	As in the outputs	Annual Centre Report Program Report	Annual Twice in a financial year	RCs	CoRRB

1 basis for genetic improvement of cattle established (cattle ID, Recording) 1 basis for Yak eco-tourism initiated 1 organic agriculture system studied							

Annexure 14a: Farming Systems Research Program Matrix for 10FYP

Result level	Indicator description	Baseline indicator	FYP targets	Link to
Impact: Package of technologies generated	No. of technologies	10	22 additional by 2013	DoA/MoA 10FYP target s
Outcome 1: Sustainable soil fertility management technologies generated	No. of technologies	8	10 more	
Output 1.1: Improved nutrient management technologies for field crops	No. of technologies	5 technologies	2 technologies	
Output 1.2: Improved nutrient management technologies for horticulture crops	No. of technologies	Nil	2 technologies	
Output 1.3: Sustainable land management technologies	No. of technologies	2-3 technologies?	2 technologies	
Output 1.4: Information on organic soil nutrient management available	No. of pamphlets/leaflets	Nil	4 relevant pamphlets/leaflets	
Outcome 2: Improved water management practices identified	No. of management practices	3	?	
Output 2.1: Improved understanding on watershed management	No. of studies	3 component studied	2 additional	
Output 2.2: Irrigation system management study conducted	No. of schemes	4	5 more	
Output 2.3: Improved water use efficiency	Crop productivity per unit of water used	Nil	10% increase	
Output 2.4: Reliable water supply	No. of farm households	20 households	30 households	
Outcome 3: Integrated Pest Management technologies generated	No. of technologies	1	14 more by 2013	
Output 3.1: Improved insect pest management technologies identified	No. of technologies	Nil	4 technologies	
Output 3.2: Disease management technologies identified	No. of technologies	1 for maize	4 technologies identified	
Output 3.3: Weed management in rice and potato identified	No. of technologies	Nil	2 technologies identified	
Output 3.4: Information on organic pest/disease management available	No. of pamphlets/leaflets	Nil	4 pamphlets/leaflets	
Outcome 4: Increased understanding of socio-economic aspects of rural livelihood	No. of documentations	15 Nos.	10	
Output 4.1: Production economics documented	No. of studies	4 Nos.	4 studies	
Output 4.2: Diagnostic studies conducted	No. of studies	4 Nos.	3 studies	
Output 4.3: Impact assessment conducted	No. of documents	2 Nos.	2 studies	

Output 4.4: Gender studies conducted	No. of studies	Nil	3 studies	

Annexure 15b: Subprogram, project and other details of Farming Systems Research Project for 10FYP

Sub-program/ project	Impact/output/ outcome	Program/ Project type	Coverage/ Beneficiaries	Date		Lead agency	Collaborating agencies
				Start	End		
1. Soil							
1.1 Plant nutrient management for FCs	Impact: Increased/stabilize crop production Outcome: Improved nutrient management technologies	Non-infrastructure	Punakha, Tsirang	July 2008	June 2013	RC Bajo	NSSC, Dzongkhags
1.2 Plant nutrient management for Horticulture Crop	Impact: Increased/stabilize crop production Outcome: Improved nutrient management technologies	Non-infrastructure	Tsirang, Dagana	July 2008	June 2013	RC Bajo	NSSC, Dzongkhags
1.3 Land management	Impact: Increased/stabilized crop production Outcome: Sustainable land management technologies	Non-infrastructure	Tsirang, Dagana	July 2008	June 2013	RC Bajo	NSSC, Dzongkhags
1.4 Soil fertility technology for organic farming	Impact: Increased understanding on organic farming. Outcome: Information on organic soil nutrient management available	Non-infrastructure	Gasa, On-station	July 2008	June 2013	RC Bajo	NOP, Gasa
2. Water							
2.1 Watershed management	Impact: Improved water resource management Outcome: Improved understanding on watershed management	Both	2 WSs	July 2008	June 2013	RC Bajo	Dzongkhags
2.2 Irrigation System Management	Impact: Improved irrigation system management Outcome: Increased understanding on irrigation system management	Both	WCR	July 2008	June 2013	RC Bajo	Dzongkhags
2.3 On-farm water management	Impact: Increased crop production Outcome: Improved water use efficiency	Both	5 HH per Dzongkhag	July 2008	June 2013	RC Bajo	Dzongkhags
2.4 Water harvesting	Impact: Improved crop production Outcome: Reliable	Both	30 HH	July 2008	June 2013	RC Bajo	Dzongkhags

	water supply						
3. IPM							
3.1 Insect Pest Management	Impact: Increased crop production Outcome: Improved insect pest management technologies identified	Non-infrastructure	Tsirang Wangdue Dagana	July 2008	June 2013	RC Bajo	NPPC, Dzongkhags
3.2 Disease Management	Impact: Increased crop production Outcome: Disease management technologies identified	Non-infrastructure	Tsirang, Dagana	July 2008	June 2013	RC Bajo	NPPC, Dzongkhags
3.3 Weed Management	Impact: Increased crop production Outcome: Weed management technology in rice and potato identified	Non-infrastructure	Wangdue Punakha	July 2008	June 2013	RC Bajo	NPPC, RCs Dzongkhags
3.4 Organic pest & disease management	Impact: Increased understanding on organic farming Outcome: Information on organic pest/disease management available	Non-infrastructure	Gasa	July 2008	June 2013	RC Bajo	NOP, Gasa
4. SE							
4.1 Production economics	Impact: Increased understanding on farm production economics Outcome: Production economics documented	Non-infrastructure	WCR	July 2008	June 2013	RC Bajo	PPD, Dzongkhags
4.2 Diagnostic studies	Impact: Better understanding of the rural livelihood system Outcome: Diagnostic studies	Non-infrastructure	3 sites	July 2008	June 2013	RC Bajo	Dzongkhags
4.3 Adoption/ impact assessment	Impact: Increased understanding on the adoption of RNR technologies Outcome: Impact assessment of new technologies	Non-infrastructure	WCR	July 2008	June 2013	RC Bajo	Dzongkhags
4.4 Gender studies in NRM	Impact: Better understanding on gender participation in NRM Outcome: Gender studies conducted	Non-infrastructure	3 study sites	July 2008	June 2013	RC Bajo	Dzongkhags

Annexure 16c: Monitoring and Evaluation of Farming Systems Research Program

Result level	Indicators	Baseline	Target	Data source	Reporting frequency	Responsibility	Report to
Package of technologies generated	No. of technologies	10	22 additional by 2013	RC records	Annually	RCs,	CoRRB
Sustainable soil fertility management technologies generated	No. of technologies	8	10 more		Annually	RCs	CoRRB
Improved water management practices identified	No. of management practices	3	?	RC records	Annually	RCs	CoRRB
Integrated Pest Management technologies generated	No. of technologies	1	14 more by 2013	RC records	Annually	RCs,	CoRRB
Increased understanding of socio-economic aspects of rural livelihood	No. of documentations	15 Nos.	10	RC records	Annually	RCs	CoRRB

Annexure 17a: Regional Research Communication Program Matrix for 10FYP

Result level	Indicator description	Baseline indicator	FYP targets	Link to MoA Target
Impact: Increased Adoption of Technology	No of technology adopted	NA	One technology per sector	DoA/MoA 10th FYP
Outcome 1: Research Technology Disseminated	No of Publications/Demonstrations/Field days/	25	10 % increase	
Output 1.1 Training Conducted	No of Trainings	6	10	
Output 1.2: Information Corner Set up	No of extension centres	NA	10sites	
Output 1.3: Workshop/meeting conducted	No of Meetings/ Workshop	5	5	
Output 1.4 Research extension Linkages Improved	No of meetings/workshops	5	5	
Output 1.5 Research Technology Packaged	No of Publication	25	20	
Output 1.5 VERCON link maintained	No of querries replied	NA	100	
Outcome 2: Farmers Group Formed	No of Groups formed	7	5	
Output :2.1 Awareness created	No of awareness campaign	NA	5	
Output 2.2 Group Bylaws formed	No of Bylaws	7	5	
Output 2.3 Group Visits/evaluation	No of reports	NA	7	
Outcome 3: Extension Methodology Studied	No of Report	NA	2	
Output :3.1 Research Outreach Program study done	No of studies/sites studied	5	7	
Output :3.2 Technology Park made functional	No of functional parks		8	
Outcome 3: Data base set up in RNR-RC	Regional database	none	1	

Output 3.1 Regional Information compiled	No of Database	non	1	
Output 3.2 Library Updated	Record	NA	1	

Annexure 18b: Subprogram, project and other details of Research Communication Sector for 10FYP

Subprogram/project	Impact/output/outcome	Program/ Project type	Geographical coverage/ Beneficiaries	Date		Agency(ies)	
				Start	End	Lead	Collaborators
1.1 Research Communication							
1.1 Research Communication	**Impact 1**:More new technology adopted by farmers **Outcome 2**: Research Information disseminated to the EAs and farmers **Output 2.1** Research outputs converted into extension materials (leaflet, pamphlets, posters and booklets) **Output 1.54** Research Newsletters published **Output 1.55** Farmers visit conducted at the centre **Output 1.55** Extension agents get advice through VERCON website	Non infrastructure	West Central/Nation wide	July 08'	June 2013'	RC	CoRRB, Dzongkhag
1.2 Training	**Impact 1.21:** More Farmers Adopt New Technologies **Outcome 1.22** Farmers become knowledgeable of the new released technology **Output 1.23**Extension Agents trained on new technology **Output 1.24**: Farmers trained on new technology and group concept **Output 1.25 :** NFE/School teachers(School Agriculture) trained on new proven technologies	Non infrastructure	West Central/Nation wide				MoA
1.3 Set Up Information Library in few selected Extension Centres	**Impact 1.31:** More Farmers Adopt New Technology **Outcome 1.32** Extension personnel posses all	Non infrastructure	West Central/Nation wide				NSSC,AMC,NHPC,AMMS, NPPC, NMC,DoA, MoA,

	required information as a back up at the centre to deal with farmer's day to day problem. **Output 1.33**List of required information gathered **Output 1.34**: Information compiled and published and distributed						Dzongkhag
1.4 Research Extension Linkage developed	**Impact 1.41:**More Farmers Adopt New technologies **Outcome 1.42** Location specific and suitable technology developed **Output 1. 43** Extension Issues and Opportunities discussed and research program planned **Output 1.44** Research and extension annual collaborative work-plan developed :	Non infrastructure	West Central/Nation wide				DoA,MoA Dzongkhag
1.5 Extension Methodology Research	**Impact 1.51:**More Farmers Adopt New technologies **Outcome 1.52** New Extension Methodology identified **Output 1. 53** Conduct Research Outreach program **Output 1.54** Develop Fully functional Technology Park	Non infrastructure	West Central/Nation wide				DoA, MoA, Dzongkhags
1.6. Information Management	**Impact 1.51:**More Farmers Adopt New technologies **Outcome 1.52** Regional Database established **Output 1. 53** Collection of required regional data **Output 1.54** Develop a regional databank for regional planning **Output 1.54** Maintain and update the regional library	Non infrastructure	West Central/Nation wide				MoA, Dzongkhags

Annexure 19c: Monitoring and Evaluation of Research Communication Unit

Result Level	Indicator Description	Baseline indicator	Target	Data source	Reporting frequency	Respon sibility	Report to
Increased Adoption of Technology	No of technology adopted	NA	1 technol ogy per sector	Annual Report/Digital compendium	Twice in the 10th plan period	RC, Dzongk hag	CoRRB, DoA
Research Technology Disseminated	No of Publications/Demonstratio ns/Field days/	25	10 % increas e	Annual Report	Annual	RC	CoRRB
Training Conducted	No of Trainings	6	10	Annual Report	Annual	RC	CoRRB
Information Corner Set up	No of extension centres	NA	10sites	Annual Report	Annual	RC	CoRRB
Workshop/meeting conducted	No of Meetings/ Workshop	5	5	Annual Report	Annual	RC	CoRRB
Research extension Linkages Improved	No of meetings/workshops	5	5	Annual Report	Annual	RC	CoRRB
Research Technology Packaged	No of Publication	25	20	Annual Report	Annual	RC	CoRRB
VERCON website managed at RC	No of queries and answers	NA	100	ICS/Annual report	Annual		
Farmers Group Formed	No of Groups formed	7	5	Annual Report	Annual	RC	CoRRB
Awareness created	No of awareness campaign	NA	5	Annual Report	Annual	RC	CoRRB
Group Bylaws formed	No of Bylaws	7	5	Annual Report	Annual	RC	CoRRB
Group Visits/evaluation	No of reports	NA	7	Annual Report	Annual	RC	CoRRB
Extension Methodology Studied	No of Report	NA	2	RC, Report	Twice in the planned period	RC	CoRRB
Research Outreach Program study done	No of studies/sites studied	5	7	Annual Report	Annual	RC	CoRRB
Technology Park made functional	No of functional parks		8	Annual Report	Annual	RC	CoRRB
Regional Information compiled	Regional database	none	1	Annual Report	Annual	RC	CoRRB
Data base set up in RNR-RC	No of Database	non	1	Annual Report	Annual	RC	CoRRB
Library Updated	Record	NA	1	Annual Report	Annual	RC	CoRRB