Sub-project ID-097
Program Based Research Grant (PBRG)

Sub-project Completion Report

on

Livelihood Improvement of Farmers through Integrated Farming System Research and Development of Drought and Rainfed Ecosystem

Sub-project Duration
October 2019 to December 2022

Coordinating Organization
Planning & Evaluation Division
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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New Airport Road, Farmgate, Dhaka-1215, Bangladesh
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On-Farm Research Division
Bangladesh Agricultural Research Institute

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Bangladesh Livestock Research Institute

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Abbreviation and Acronyms

AEZ	:	Agro Ecological Zone
Aug.	:	August
Avg.	:	Average
B	:	Boron
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BRRI	:	Bangladesh Rice Research Institute
BLRI	:	Bangladesh Livestock Research Institute
BSRI	:	Bangladesh Sugarcrop Research Institute
BCR	:	Benefit Cost Ratio
BCRDV	:	Baby Chick Ranikhet Disease Vaccine
BQ	:	Black Quarter
BMD	:	Bangladesh Meteorological Division
BWDB	:	Bangladesh Water Development Board
BMDA	:	Barind Multipurpose Development Authotity
CC	:	Component Crop
Co-PI	:	Co-Principal Investigator
cm	:	Centimeter
CP	:	Cropping Pattern
CSO	:	Chief Scientific Officer
DAE	:	Department of Agricultural Extension
DP	:	Duck Plague
DLS	:	Department of Livestock Services
DLO	:	District Livestock Officer
DAS	:	Days After Sowing
DAT	:	Days After Transplant
Dec	:	Decimal
Dec.		December
E	:	East
EP	:	Existing Pattern
Feb.	:	February
FGD	:	Focus Group Discussion
FYM	:	Farm Yard Manure
FMD	:	Foot and Mouth Disease
FRG	:	Fertilizer Recommendation Guide
FSR	:	Farming Systems Research
FSRD	:	Farming System Research and Development
FSRDP	:	Farming System Research and Development program
g	:	Gram

GR	:	Gross Return
GM	:	Gross Margin
HBT	:	High Barind Tract
HL	:	High Land
HS	:	Hemorrhagic Septicemia
HYV	:	High Yielding Variety
ha	:	Hectare
IPM	:	Integrated Pest Management
IP	:	Improved Pattern
Jan.	:	January
K	:	Potash
Kg	:	Kilogram
Km	:	Kilometer
LBT	:	Level Barind Tract
LSP	:	Local Service Provider
LER	:	Land Equivalent Ratio
MBCR	:	Marginal Benefit Cost Ratio
MC	:	Main Crop
MHL	:	Medium High Land
MLL	:	Medium Low Land
mm	:	Millimeter
MoP	:	Muriate of Potash
NATP	:	National Agricultural Technology Project
NARS	:	National Agricultural Research System
N	:	North
Nov.	:	November
N	:	Nitrogen
No.	:	Number
OFRD	:	On-Farm Research Division
ORC	:	Oilseeds Research Center
Oct.	:	October
PIU	:	Project Implementation Unit
PBRG	:	Programme Based Research Grant
PPR	:	Peste Des Petits Ruminants
P	:	Phosphorus
PA	:	Preference Analysis
PI	:	Principal Investigator
PRA	:	Participatory Rural Appraisal
PSO	:	Principal Scientific Officer
REY	:	Rice Equivalent Yield

RDV	:	Ranikhet Disease Vaccine
Sep.	:	September
SDG	:	Sustainable Development Goal
S	:	Sulphur
SA	:	Scientific Assistant
SO	:	Scientific Officer
SSO	:	Senior Scientific Officer
t/ha, t ha^{-1}	:	Ton per hectare
T. Aman	:	Transplanted Aman
Temp.	:	Temperature
TSP	:	Triple Super Phosphate
TEY	:	Tobacco Equivalent Yield
TVC	:	Total Variable Cost
Tk.	:	Taka
WPGM	:	Whole Pattern Gross Margin
WPREY	:	Whole Pattern Rice Equivalent Yield
Zn	:	Zinc

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Executive Summary

A combination of high temperature, low and erratic annual rainfall and soil moisture deficiencies causing drought and rainfed ecosystem, having a devastating impact on agricultural production and thus a threat for small-scale farmers. Rainfed areas are mostly covered by Sylhet and Bandarban district of Bangladesh. While there are different production alternatives, farmers have a limited set of resources. Due to the growing human population and shrinking agricultural land, a holistic approach to technology generation and packaging is essential to achieve this result through maximizing the complementary interactions among the different farming enterprises/production system and the biophysical and socio-economic environment. It is vital to utilize an integrated strategy to manage all of the resources of poor farm households. With these views, the PBRG sub-project was undertaken to develop integrated farming technologies, fine-tune the technologies generated by NARS institutes, integrate component technologies with efficient use of farm resources and thereby improve family income and livelihoods. The integrated farming programs were initiated under the coordinated sub-project on 'Livelihood Improvement of Farmers through Integrated Farming System Research and Development of Drought and Rainfed Ecosystem'. The sub-project have been implemented by Bangladesh Agricultural research institute (BARI) and Bangladesh Livestock Research Institute (BLRI) with the coordination of Bangladesh Agricultural Research Council (BARC). The sub-project started from October 2019 at six Farming system Research and Development (FSRD) sites of BARI and BLRI continued up to December, 2022.The Farming Systems Research and Development (FSRD) sites are of Basantapur (Rajshahi), Amnura (Chapainawabganj), Chanduria (Rajshahi), Jiarokhi (Kushtia), Kamalbazar (Sylhet) and Naikhongchari (Bandarban). In each site, two villages have been considered for FSRD activities. A total of seventy two (72) household were selected from all sites, with twelve household (12) from each site. The household comprising of four from each of marginal, small and medium farmers group considering homestead vegetables, fruits, field crops, livestock and poultry, fisheries and off-farm component of farming system. Farmer's need-based technologies were intervened among the small, marginal, and medium-sized resource-poor farmers based on the PRA and baseline survey data.

Inception workshop, program planning workshop, coordination meeting and progress review workshops were organized by BARC component as per sub-project proposal. BARC in collaboration with an agricultural economist developed a structured questionnaire for baseline survey for all sites and survey report published. Training on FSRD technologies were also organized in two batches of 60 Scientist and Scientific Assistant. Several field visits were organized by BARC to monitor the progress of FSRD activities at farmers' level. A training manual with 18 lecture notes related to FSRD was prepared and distributed among the trainees. Annual Review Workshop, Project Completion Workshop and Technology Packaging Workshop were also organized.

BARI brought all existing components under improved technological intervention towards increased income. At the FSRD sites of Basantapur, Amnura, Chanduria, Jiarokhi, and Kamalbazar, the average homestead size was 0.05, 0.05, 0.04, 0.13, and 0.07 ha, respectively. In the homestead component, the average vegetables production was 645 kg per homestead after intervention (AI), which was only 45 kg before intervention (BI) which is 659% more. After intervention (AI), the average vegetables consumption was 209 g $head^{-1}day^{-1}$, which was 465% higher than BI. The average fruits production per homestead was 389 kg, which was only 108 kg during BI due to improper management. The average consumption of fruit was also increased significantly (Avg. 197%) during AI compared to BI due to motivational work. Existing fruit tree management and new plantation have had a positive influence on households, around 1186 fruit trees have been brought under pest management, and a total of 4312 saplings of various fruits have been distributed among the cooperate farmer over the locations. Women's participation in agricultural activities has increased facilitating gender equity. In case of field crops, farmers achieved higher yields and economic returns from their alternative or improved cropping pattern, due to improved variety (s) and better management practices. The improved cropping pattern increased rice equivalent yield by 45-235% over the existing pattern. At irrigated Barind, Mustard (BARI Sarisha-14 and 17)- Boro (BRRI dhan81) and T. Aman rice (BRRI dhan49) is recommended and Lentil, (BARI Masur-8) -Fallow-T. Aman rice (BRRI dhan51) can

be a potential cropping pattern for the rainfed Barind area. Similarly, Mustard (BARI Sarisha-18)-T. Aus (BRRI dhan82)-T. Aman (BRRI dhan87) for level Barind tract; Lentil (BARI Masur-8)-Sesame (BARI Til-4) -T. Aman (BRRI dhan75) for High Ganges River Floodplain (Kushtia) and Potato (BARI Alu-41)-T. Aus (BRRI dhan65)-T. Aman rice (BRRI dhan57) for Eastern Surma Kushiyara Floodplain (Sylhet) can be recommended for higher productively. BARI Hybrid Tomato-11 produced a higher fruit yield (38 t ha^{-1}) with gross margin (Tk. 1470000 ha^{-1}). Furthermore, BARI Masur-8 and BARI Sarisha-17 are gaining popularity due to their high financial returns. In case of livestock sector, the frequency of major cattle diseases (Anthrax, FMD, and BQ) went below 3-5% through vaccination. Cattle fattening programs created interest among the farmers due to remarkable gain of cattle body weight (45-55%) and with higher gross margin was recorded (Tk. 25000 $cattle^{-1}$). Goat rearing was found promising because of low rearing cost and high profit within short period. In poultry system, Sonali breed, duck and pigeon rearing in the homestead created a good impact among the farm family as a good source of income and child nutrition. After vaccination, poultry mortality is reduced to 2-5%. Moreover, the production and use of farm yard manure (FYM) is continuing among farm families. Green fodder (Napier grass) production continues at the homestead pond bank, roadside, and fallow land and created a good impact among the farm families. Seasonal fish culture with carp polyculture in seasonal pond was found promising than monoculture. Carp polyculture gave a satisfactory fish production (95-4285 kg $Pond^{-1}$) with gross margin (Tk. 8000-15000 $pond^{-1}$) at farmer's level. From different types of off-farm activities (e.g. weaving kantha. sewing cloths, making handicraft, grocery shop and pulling van/rickshaw etc.) farmers also earned some extra money (25000-Tk. 35000 $household^{-1}$). Among the different production components, field crop sector gave maximum gross margin (65083 - Tk. 460195 $farm^{-1}$) but gross margin increased maximum at homestead vegetables production sector (321-2421%), After intervention gross margin $farm^{-1}$ was increased 68, 88, 58, 52 and 26%, respectively compared to before intervention at Basantapur, Amnura, Chanduria, Jiarokhi and Kamalbazar FSRD sites through integrated farming (homestead, field crop, livestock, fishery, off-farm). Field days are organized on homestead gardening. mustard and T. Aus rice production which created a great impact in the locality. A local service provider (LSP) was intimately involved in the mechanization process. On a custom employment basis, the LSP provided seeding services for crops under the conservation agriculture system. FSRD operations, adopting an integrated farming program at FSRD sites has created an opportunity toward livelihood improvement of resource-poor farmers.

BLRI conducted a baseline survey on individual households. On the basis of farmer's existing practices, their needs and choices, several alternatives of technologies of crops, cropping pattern, livestock, fisheries, agroforestry, off-farm activities and other components were employed with active participation of the farmers for lively hood improvement. After intervention of the improved technologies, the average vegetables production was increased 85%. Using of improved technologies and judicious time management enhanced the remarkable increment of vegetables production in homestead area. The average vegetables intake farm $family^{-1}$ $year^{-1}$ was 320 kg after intervention which was only 200 kg farm $family^{-1}$ $year^{-1}$ before intervention. The vegetables intake increased 60% $household^{-1}$ $year^{-1}$. After implementation of the program, the fruits production and intake were increased 40% and 28%, respectively $household^{-1}$. After intervention farmers received 76% higher gross margin compared to before intervention from fruit production. Two improved cropping pattern; Cucumber-T. Aman-Brinjal and Fodder-Fodder-Fodder were tested against existing cropping pattern. Higher REY and MBCR was found from Cucumber-T. Aman-Brinjal cropping pattern. A total of 2683 different type of fruit saplings were distributed among the cooperator farmers and the survival rate ranges from 75-95%. Cattle fattening enterprise were profitable and the amount of gross margin from cattle fattening was calculated Tk. 20000 per cattle. From goat rearing, average gross margin Tk. 21866 earned $household^{-1}$. Average gross margin Tk. 41000 farm $family^{-1}$ was found from sheep rearing. Poultry birds rearing in household is very profitable enterprise. Farmers earned average gross margin from hilly chicken, duck, turkey and pigeon 3016, 5530, 4900 and Tk. 3900, respectively. After vaccination of poultry birds and major livestock species mortality reduced which was recorded 1.2% for poultry and 1.34% for major livestock species. Average gross margin from mixed fish and monosex tilapia culture was found Tk. 131405 $pond^{-1}$ and Tk. 16950 $pond^{-1}$ while it was Tk. 82500 and Tk. 8000 before intervention. Average income from off-farm activities increased 181% after intervention. Before

intervention of the sub project, an average per farm gross margin was Tk. 92271 whereas it was Tk. 198674 after intervention and the increment of gross margin after intervention was 115% compared to before intervention.

The sub-project have demonstrated and established effective ways of maximizing farm productivity through dissemination and adoption of farming systems technologies with efficient use of farm resources in drought and rainfed ecosystem. An interdisciplinary, inter institutional, coordinated climate resilience result based research was executed to address the complex nature of drought and its impact, such as drought resistant crops and its variety, low water requiring crops and its variety, short duration drought escaping crops, goat, sheep, chicken, duck, pigeon rearing, fish culture at seasonal and perennial ponds following carp polyculture system, fruit and vegetables sapling production at nursery, postharvest and processing, seed preservation, and off farm activities, which improve livelihood as well as food security.

Key words: Homestead production system. Cropping system, Farming system, Farm productivity, BCR, MBCR, REY, Sonali chicken, Turkey, Fish poly culture, Food security, Goyeshpur model, Barind model, Homestead model, Integrated farming Drough & Rainfed, Ecosystem and Llivelihood.

PBRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the PBRG sub-project: Livelihood Improvement of Farmers through Integrated Farming System Research and Development of Drought and Rainfed Ecosystem.

2. Implementing organizations

Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.
Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka.

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4. Sub-project budget (Tk.)

4.1 Total (in Tk. as approved) : 1,75,00000.00
4.2 Latest Revised : 2,65,50,000.00

5. Duration of the sub-project

5.1 Start date (based on LoA signed): 15th October, 2019
5.2 End date: 29 December 2022

6. Background of the sub-project

Bangladesh is a predominantly agricultural country. Livelihood of most people, particularly in rural area, depends largely on agriculture. The area under crop production is anticipated to be 8.44 million ha. Drought-prone areas are largely found in Bangladesh's northwestern region (the high Barind tract of Rajshahi, Chapainawabganj, and Kushtia), as well as the rainfed areas of Sylhet and Bandarban (Brammer, 1987). A combination of high temperature, low and erratic annual rainfall and soil moisture deficiencies, causing drought and rainfed ecosystem, have a devastating impact on agricultural production and threaten small scale farmers. During the rabi, pre-kharif, and kharif seasons, an estimated 5.97 million ha of cultivated land is affected by drought, with 1.22 million ha experiencing severe to very severe drought, primarily in the northwestern districts of Chapainawabganj, Naogaon, Rajshahi, Natore, Rangpur, Dinajpur, Joypurhat, Pabna, Bogura, Chuadanga, and Kushtia (Habiba *et. al.*, 2011) .

The high Barind tract (HBT) of north-west Rajshahi division stands apart from other regions of the country due to terraced land, high temperature; and low and erratic annual rainfall (1200 mm ± 300). The soil of this area is compact, low fertile, limited soil moisture storage and acidic in nature (Ali *et al.*, 2018). In addition, the HBT contains no rivers or water bodies. In comparison to other sections of the country, vegetation is also sparse. As a result, the HBT is recognized as drought prone area of Bangladesh. The main crop and backbone of the rural economy is T. Aman rice. Drought can reduce rice production by 45-70 percent in extreme cases. Due to the short monsoon and weak water holding capacity of soil, the land remains fallow in the rabi and kharif-1 seasons after the harvest of T. Aman rice. Non-rice crops and Boro rice have recently taken the position immediate after harvesting of T. Aman rice in the BMDA commanded region (Ali *et al.*, 2018). Irrigated Boro crops may be harmed if the water table drops due to excessive groundwater pumping and lack of rain at such a stressful period. Considering the situation of these areas low-water-demanding crops such as pluses, oilseeds, wheat, and potatoes production have been given preference in the fallow land during the rabi season. On the other hand, the Barind area's homestead land is still unutilized. As a result, there is a severe lack of vegetables in these areas. To meet up vegetables and fruit requirement, there is a scope to bring homestead area, as well as fallow land under cultivation of vegetables and fruits. Every home has a pond, but they do not cultivate fish in a scientific way rather follow the traditional fish culture method. The majority of the livestock are sick and broken health due to worms and lack of fodder. Livestock productivity could be increased by using proper technologies related to livestock rearing (Such as vaccination, deworming, feeding etc).

Greater Kushtia belongs to Agro Ecological Zone (AEZ) 10, 11 and 12. In this region terminal drought occurs frequently in T. Aman crop (BARC, 2018). The main crops of this area are aus rice, aman rice, boro rice, wheat, onion, maize, pulses, oil seed and vegetables. Various types of fruits namely mango, jackfruit, banana, guava, litchi, lime and papaya are also grown here. There is a scope of year-round vegetables production in the homestead area as well as field since the land type is high and medium high which could play a significant role in reducing malnutrition and increasing farmer’s income. Cattle, Black Bengal Goat, especial type of sheep (garol) and chicken are predominant in livestock and poultry production system. Farmers of Kushtia region have been growing fodder crops in their fallow land for beef fattening and milk production. Farmers earn some additional income from selling of excess fodder grown in their fallow land, which is readily sold in the local market of Kushtia. Fish culture is also practiced in perennial ponds and seasonal water bodies.

Almost 95-98% area of Sylhet belongs to AEZ 20 (Surma Kushiyara Floodplain). The region occupies the

eastern part of the country where the rain starts earlier and usually heavier than any other region of Bangladesh. According to last 30 years observation, late season drought in mid-September to October, coinciding with flowering and grain filling stage of aman rice occurs more frequently mainly due to the early withdrawal of rainfall. As a result, yield of aman rice reduce drastically and sometimes damaged completely. The soils are generally heavy silty clay loams and clays with small areas of loam soils. The top soils dry quickly at the end of the rainy season. So, it is not possible to grow field crops during rabi season. The dominant cropping pattern of this area is Fallow-T. Aus-T. Aman. Homestead vegetables, fruit production, cultivation of high yielding nutritious vegetables and fruit in the fallow land could play a significant role in reducing malnutrition. Cattle, goat, chicken and duck are dominated in livestock and poultry production system. Just after harvesting of T. Aman, cattle are set freed to graze in the crop land.

Naikhongchari is an Upazila under Bandarban district of the Chattogram Hill Tracts region. The region is dominated by tribal people. The topography of the land is characterized by undulated hills (50%) and plain lands (50%). Agriculture is practicing in the area with traditional system. Productivity is very much low. There is a scope for establishment of mixed fruit orchard in this region. Livestock producing system is not satisfactory due to local breed and traditional management practices. Availability of large forest and grazing area with adequate production of natural bio-mass forages, grasses, weeds and legumes, there exists a prospect for improving goat, sheep and cattle production in the region. Since family system is mainly women dominated and women are directly involved in livestock production, livestock is visualized as the most prospective and dependable sector to ensure women participation and income generation. Small lake and seasonal water bodies are used for fish culture.

In general drought not only impact on yield of standing crops but also hamper fisheries production since the ponds become dry due to the lack of water. Animal may suffer from shortage of forage and drinking water. It becomes difficult for the trees to survive with drought. Farm laborers could lose their job due to reduction in crop productivity as a result employment opportunities based on agriculture decreases.

Under these circumstances, it is important to develop robust technologies and disseminate the technologies among the stakeholder that could help to overcome the potential impact of drought sustainability. An interdisciplinary, inter institutional, coordinate results based research program is necessary to address the complex nature of drought, and its impact on productivity. For this region, a sub-project was undertaken entitled "Livelihood Improvement of Farmers through Integrated Farming System Research and Development of Drought and Rainfed Ecosystem" funded by NATP Phase-2, BARC during October 2019 to December 2022.

7. Sub-project general objective:

To develop better understanding of changing nature of drought in view of climate change, risk and vulnerability associated with drought and its impact on agriculture, food security, economy and livelihood and its potential impact in the future.

8. Sub-project specific objectives

BARC Component

i) To coordinate, planning, monitoring and evaluate the Farming Systems Research and Development activities within involved organizations by BARC.

ii) To strengthen linkage with the stakeholders in terms of FSRD activities.

BARI Component

i) To maximize the farm productivity and efficient utilization of drought & rainfed ecosystem

ii) To integrate component technologies (crops, livestock, fisheries, agro-forestry and homestead gardening, etc.) for improving farm practices and establish linkage with different stakeholders.

iii) To create awareness about modern agricultural technologies among the participating farmers.

iv) To improve family income and livelihood through empowering woman in farm activities.

BLRI Component

i) To maximize the farm productivity with efficient use of farm resources in the rainfed ecosystem.

ii) To create awareness about modern Agricultural Technology (ies) among the participating farmers.

iii) To improve family income and livelihood of the drought prone area

9. Implementing locations

Implementing locations were selected based on climatic, edaphic, social, vegetation and economic conditions of the regions. The following sites were selected to conduct the research activities of the sub-project.

FSRD site Basantapur, Rajshahi

Two villages named Baslitala and Udpur under Godagari upazila of Rajshahi district were considered for FSRD activities under the Basantapur site (24° 26' 57" N; 88° 26' 12" E). Basantapur has a distance of fourteen km from the upazila head quarter and is located on the east side of AEZ-26 (Figure 9.1).

FSRD site Amnura, Chapainawabganj

In Chapainawabganj, Amnura has a distance of sixteen km from the sadar head quarter and is located on the east side (AEZ-26). Two villages namely Laxmipur and Bohoroil under Nachole upazila (24° 44' 14 N; 88° 26' 9 E) of ChapaiNawabgonj were considered as FSRD activities. The two villages were adjacent to FSRD site, Amnura (Figure 9.2).

FSRD site Chanduria, Rajshahi

The Integrated Farming System Research and Development for Livelihood Improvement in the drought and rainfed ecosystem project site named Chanduria, Rajshahi is located on the east site of Tanore upazila (AEZ-26)(24° 35' 21N; 88° 34' 34 E). The site is 6 km away from upazila head quarter. Ratul and Deutola villages were considered as project activities village (Figure 9.3).

Figure 9.1 FSRD site Basantapur, Rajshahi

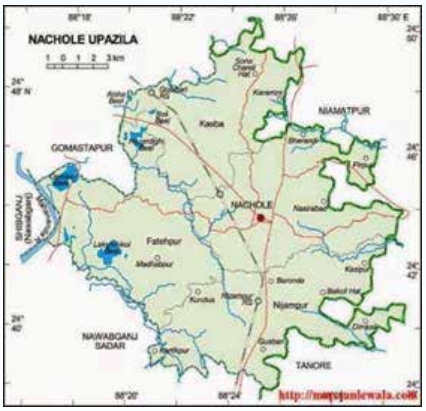

Figure 9.2 FSRD site Amnura, Chapainawabganj

Figure 9.3 FSRD site, Chanduria, Rajshahi

FSRD site Jiarokhi, Kushtia

The FSRD site Jiarokhi is situated at the two villages namely Boria and Belghoria under Kushtia sadar Upazila of Kushtia district. It is twelve km away from the district headquarter and located on the east side (23°53'60.00 N 89°07'59.88" E). Most of the land in these villages is under AEZ-11 (Figure 9.4).

FSRD site Kamalbazar, Sylhet

The Kamalbazar FSRD site is located under Dakshin Surma Upazila in Sylhet district. It is eleven km away from the district headquarter and located at the east side 24°81′ N and 91°90′ E. Most of the land in these villages is under Eastern Surma Kushiyara Floodplain (AEZ# 20). The FSRD activities were done in two villages namely Guptergoan and Laxmibasa (Figure 9.5).

FSRD Site Naikhongchari, Bandarban

Naikhongchari is located at 21.4167°N 92.1833°E. It has 6,882 households and a total area of 463.61 km2. Population Total 49465; male 26029, female 23436; Muslim 36766, Hindu 530, Buddhist 254, Christian 11523 and others 392. Indigenous communities such as Chakma, Marma, Murang, Tabjhong belong to this Upazila. Two villages (Khamar Chak Para and Chakdala) were selected for conducting the study (Figure 9.6).

Figure 9.4 FSRD site Jiarokhi, Kushtia

Figure 9.5 FSRD site Kamalbazar, Sylhet

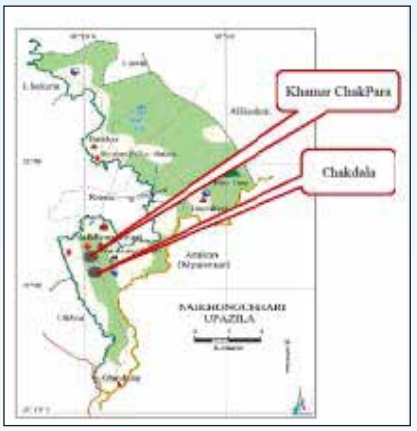

Figure 9.6 FSRD site Naikhongchari, Bandarban

10. Methodology in brief

The Farming Systems Research and Development Programme (FSRDP) have been working with slightly modified methodology of the Asian Farming Systems Network, the successor of the Asian Cropping Systems Network. The modification has been made to adopt and make it more applicable to Bangladesh condition. For the successful implementation of the sub-project, integrated farming systems research and development program, the following methods were considered:

Specific Methodology

The integrated farming research and development activities were executed at drought and rainfed ecosystem at six FSRD sites of two implementing institutes (BARI and BLRI) with the coordination of BARC during October 2019 to December 2022 for improving livelihood of rural households through generation and adoption of Farming System Technologies especially integrated farming technologies and the technologies generated by NARS institutes. The selected FSRD sites of two NARS institutes are presented in Table 10.1.

Table 10.1 Project locations/sites

SL	Implementing organization	District	Upazila	FSRD Site
1.	OFRD, BARI, Barind station, Rajshahi	Rajshahi	Godagari	Basantapur
2.	OFRD, BARI, Barind station, Rajshahi	Chapainawabganj	Chapainawabganj Sadar	Amnura
3.	OFRD, BARI, Shyampur, Rajshahi	Rajshahi	Tanore	Chanduria
4.	OFRD, BARI, Kushtia	Kushtia	Sadar	Jiarokhi
5.	OFRD, BARI, Sylhet	Sylhet	South Surma	Kamalbazar
6.	BLRI, Naikhongchari, Bandarban	Bandarban	Naikhongchari	Naikhongchari

The program was executed in a participatory approach, where critical inputs and technological suggestions were provided by BARI and BLRI personnel and other commodities were used from farmer's own sources. Based on farmer's traditional practices, their needs and choices, several alternatives of technologies of crops, livestock, fisheries, off-farm activities and other components were incorporated with active participation of the farmers. According to the aim of the sub-project resource poor marginal, small and medium farmers having major components of farming (crop, livestock, fishery, agroforestry, off-farm etc.,) and sizeable homestead under single ownership were targeted. Twelve farm households from two villages were selected at each site. Thus a total seventy two (72) farm households were selected from six FSRD sites considering twelve (12) from each site (Table 10.2).

Table 10. 2 Categorical information of selected farmers at different FSRD sites

FSRD site	Categories	No. of Farmer	Avg. family size (no.)	Avg. crop land area (ha)	Avg. homestead area (ha)	Avg. pond area (ha)
Basantapur,Rajshahi	Marginal	4	5.00	0.48	0.044	0.020
	Small	4	4.00	0.88	0.050	0.024
	Medium	4	5.75	1.38	0.044	0.052
Amnura Chapainawabganj	Marginal	4	6.00	0.37	0.032	0.021
	Small	4	4.50	0.87	0.048	0.020
	Medium	4	5.25	1.95	0.074	0.035
Chanduria Rajshahi	Marginal	4	5.60	0.12	0.028	0.028
	Small	4	6.20	0.37	0.040	0.037
	Medium	4	4.00	1.35	0.048	0.06
Jiarokhi, Kushtia	Marginal	4	6.50	0.19	0.11	0.025
	Small	4	4.66	0.58	0.13	0.05
	Medium	4	5.0	1.05	0.16	0.05
Kamalbazar, Sylhet	Marginal	4	4.00	0.06	0.06	0.021
	Small	4	4.38	0.45	0.064	0.048
	Medium	4	5.33	1.12	0.08	0.08
Naikhongchari Bandarban	Marginal	4	5.50	0.44	0.043	0.00
	Small	4	5.38	0.96	0.06	0.032
	Medium	4	5.75	1.26	0.045	0.031

Training program was arranged to buildup farmers capacity and to develop awareness regarding nutrition and crop production. An individual household survey (Benchmark survey) was carried out before starting the sub-project activities. The detail information regarding livelihoods pattern were documented. Total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year was accounted by detail households' case study with intensive visit and cross examinations for authentication of the data before intervention. Based on the potentials, suitable technological options were addressed to the farmers and accordingly farmers selected suitable technologies adjusting with their need for livelihood improvement.

Year-round vegetables production followed by respective location-wise model in each homestead, existing fruit tree management and new fruit saplings plantation, crops and cropping system improvement through improve cropping pattern development and promising variety piloting, goat, sheep, chicken, duck, pigeon rearing, cattle fattening, vaccination of poultry and livestock, green fodder production, fish culture and some off-farm activities were identified as their major potential area.

During the implementation period of the sub-project activities, site working group meeting and field visit was done. FSRD site team facilitated the cooperator farmers through technological intervention to maximize the productivity of the each and every component. However, season-wise (Rabi=October-March, Kharif I=April-June and Kharif II=July-September) data on production, farm level utilization with disposal pattern, possible integration among the components, economic return focusing income and expenditure and other socio-economic information were collected and tabulated accordingly.

10.1 Homestead Production System

Homestead production system is widely used all over the world and is a very important option for food and nutrition security. Homestead production system is a well-established land use systems where different vegetables and trees are grown following different developed models adjacent to their dwelling house irrespective of the operational holding size. A judicious mix of vegetables and fruit production suited to the given agro-climatic conditions not only supplement the income of the farmers but also help in increasing the family labour employment. The farm wastes are better recycled for productive purposes in such integrated system. Homestead production system improves the resources of poor farmers and also meets several socio-economic, nutritional and ecological conditions which contribute to their better living and sustainability (Singh *et al.*, 2012). Low input cost, stable yield every year, application of simple technology, and intensive management practices are the main features in homestead production system.

10.1.1 Year-round vegetables and fruit production at homestead

A homestead is an area of farmer togetherness with the land around of a farm house. The area under a homestead is a valuable asset of a resource poor farm household that is suitable for vegetables, crops and fruits production.

On the basis of farmers' choice, agro-ecological suitability, nutritional aspects, market demand and existing resources of the farm households BARI developed different vegetables production models and some cases modification of BARI developed models were used for year round vegetables and fruits production in the homestead area.

On the basis of farmers' choice, agro-ecological suitability and human nutrition requirement, the fruits saplings were supplied and plantation was done in the homestead area and nearby homestead area. Some sole fruit orchard with mango and some mixed fruit garden with Mango, Guava and Malta were established. Irrigation, fertilization, pest control and other management of new and existing fruit trees were undertaken in this program. The fallow and un-utilized homestead areas were brought under exploited scientifically in considering time and space. The recommended seed rate, plant spacing, fertilizer dozes and sowing dates were followed for all crops accordingly in all niches. Vegetables from different beds and niches were harvested according to their maturity and the recorded data were converted into average. The production values were calculated with the local market price for all crops.

However, different models those were followed for year round vegetables and fruit production in homestead area in different farming system research and development (FSRD) sites under drought and rainfed ecosystem are given below:

10.1.1.1 Year-round vegetables and fruit production in homestead area at different FSRD sites of BARI component

FSRD site Basantapur, Chanduria and Amnura

Modified Barind model was followed at Basantapur and Chanduria FSRD sites of Rajshahi, and Amnura FSRD site of Chapainawabganj to produce year round vegetables and fruit in the homestead area (Table 10.3)

Table 10.3 Barind model (modified) followed at three sites, Basantapur & Chanduria, Rajshahi, and Amnura, Chapainawabganj

SI No.	Spaces	Cropping patterns		
		Rabi	Kharif-I	Kharif-II
1.	Open sunny place			
	Bed 1	Brinjal	Kangkong	Kangkong
	Bed 2	Spinach-Spinach	Indian spinach	Red amaranth
	Bed 3	Radish-Red amaranth	Stem amaranth (Katua data)	Green Shak
	Bed 4	Cabbage	Onion	Red amaranth/Jute leaves
	Bed 5	Cauliflower-Red amaranth	Okra	Red amaranth/Jute leaves
2.	Fence	-	Bitter gourd, yard long bean	Sponge gourd
3.	Trellis	Country bean, bottle gourd	Pointed gourd, snake gourd, ridge gourd	Sponge gourd
4.	Roof	Country bean, Bottle gourd	Sweet gourd, White gourd	White gourd
5.	Tree support	-	White gourd, Potato yam, Sponge gourd	Sponge gourd
6	Partial shady place	Coriander leaf	Turmeric, Aroids	Turmeric, Aroids
7.	Homestead boundary/back yard	Plantain banana, Papaya and Drumstick	Plantain banana Papaya Drumstick	Plantain banana Papaya Drumstick
8.	Pond/ ditch banks and slope	Bottle gourd	Snake gourd, Bitter gourd	-
9.	Others	-	Fodder crops, Chewing type sugarcane	Fodder crops, Chewing type sugarcane

FSRD site Jiarokhi, Kushtia

Goyeshpur model was used at the FSRD site Jiarokhi, Kushtia to produce year round vegetables and fruit in the homestead area (Table 10.4)

Table 10.4 Goyeshpur model at FSRD site Jiarokhi, Kushtia

Niche/space		Cropping patterns		
		Rabi	Kharif-I	Kharif-II
1. Open sunny place	Bed-1	Radish	Stem amaranth	Indian spinach
	Bed-2	Cabbage	Brinjal	Red amaranth
	Bed-3	Tomato	Spinach	Okra
2. Fence		Bitter gourd	Yard long bean	Bitter gourd
3. Trellis		Bottle gourd	Sweet gourd	Sweet gourd
4. Roof		Bottle gourd	Wax gourd	Wax gourd
5. Tree support		Bitter gourd	Ridge gourd	Sponge gourd
		Potato yam	Snake gourd, Potato yam	Potato yam
		Country bean	Yard long bean	Yard long bean/Country bean

Niche/space	Cropping patterns		
	Rabi	Kharif-I	Kharif-II
6. Partial shady area	Elephant foot yam		
	Leaf aroid (moulavi kachu)		
	Turmeric		
	Perennial chilli		
7. Marshy land	Pani kachu (Latiraj)		
8. Homestead boundary	Papaya (3-5 plant)		
	Guava (1-2 plant)		
	Lemon (1-2 plant)		
9. Back yard /waste land	Drumstick (1-2 tree)		
	Banana		

FSRD site Kamalbazar, Sylhet

Golapgonj model was used at the FSRD site Kamalbazar, Sylhet to produce year round vegetables and fruit in the homestead area (Table 10.5)

Table 10.5 Golapgonj model at FSRD site Kamalbazar, Sylhet

Sl. No.	Niches/space		Year-round homestead vegetables and fruits pattern		
			Rabi	Kharif-I	Kharif-II
1	Open sunny place	Bed-1	Radish/Indian Spinach	Indian Spinach	Kangkong
		Bed-2	Radish/Tomato	Red amaranth/Okra	Indian Spinach
		Bed-3	Bush bean	Kangkong	Brinjal
		Bed-4	Coriander / Red amaranth	Coriander	Amaranth
2	Roof		Country bean/Bottle gourd	Ash gourd	-
3	Trellis		Country Bean/Bottle gourd	Shake gourd	Ridge gourd
4	Fences/Boundary wall		Bitter gourd	Bitter gourd	-
5	Tree support		-	Ridge gourd	Ridge gourd
6	Partially shady land		Bilati Coriander	Turmeric/Ginger	Turmeric/Ginger
7	Boundery		Papaya	Papaya	Papaya
8	Marshy land		Water aroid (Kalakachu), Aroid (BARI Panikachu-1)		
9	Backyard		Papaya, Banana, Guava, Mango, Lemon, Sugarcane, Satkora, Malta		

10.1.1.2 Year-round vegetables and fruit production in homestead area at FSRD site Naikhongchari, Bandarban of BLRI component

Modified Khagrachari model was used for vegetables and fruit production in homestead area at the FSRD site Naikhongchari, Bandarban (Table 10.6)

Table10.6 Modified Khagrachari model for vegetables and fruit production in homestead area at FSRD site Naikhongchari, Bandarban

Sl. No.	Spaces	Bed	Cropping patterns		
			Rabi	Kharif-I	Kharif-II
1.	Open sunny place	a.	Radish	Stem amaranth	Fallow
		b.	Cauliflower	Brinjal	Fallow
2.	Roof	a.	Bottle gourd	Wax gourd	-
		b	Bitter gourd	Ridge gourd	-
3.	Trellis	a.	Bottle gourd	Sweet gourd	-
4.	Tree support	a.	Bitter gourd	Ridge gourd	Sponge gourd
		b.	Ridge gourd	Snake gourd	Testle gourd
		c.	Yard long bean	Cucumber	Bitter gourd

Sl. No.	Spaces	Bed	Cropping patterns		
			Rabi	Kharif-I	Kharif-II
5.	Partial shade area	a	Perennial chilli		
		b	Turmeric		
		c	Leaf aroid (Moulavikachu)		
6.	Marshy land	a.	Water spinach	Aroid (BARI Panikachu-1)	
7.	Fence	a.	Yard long bean	Bitter gourd	Bitter gourd
8.	Homestead boundary	a.	Papaya		
		b.	Mango		
		c.	Lemon		
		d.	Dragon fruit		
9.	Back yard/waste land	a.	Banana		
		b.	Lemon		

10.2 Crops and Cropping System

10.2.1 Improvement or development of cropping pattern

10.2.1.1 Improvement or development of cropping pattern at different FSRD sites of BARI component

Cropping patterns that formerly dominant were investigated for improvement or replaced by more profitable cropping patterns. Two cropping patterns were explored for development at each FSRD site in drought and rainfed ecosystem to boost crop productivity (Table 10.7).

Table 10.7 Activities for improvement or development of cropping pattern under drought and rainfed ecosystem of BARI component

Location	Observation	Improved cropping pattern			Existing cropping pattern		
Basantapur Rajshahi	Cropping Pattern-I						
	Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
	Variety	BARI Sarisha-17	BRRI dhan81	BRRI dhan49	BRRI dhan28	-	Sharwna
	Date of sowing/ Transplanting	3-6 Nov.	05-10 Feb.	12-15 July	26-31 Jan.	-	23-26 July
	Seed rate (kg ha^{-1})	7.5	50	40	60	-	50
	Spacing (cm)	Broadcast	20 × 15	20 × 15	20 × 15	-	20 ×15
	Fertilizer dose (N-P-K-S-Zn-B, kg ha^{-1})	90-22-45-27-2-1.5	100-15-37-12-0-0	86-13-15-10-0-0	120-20-35-13-0-0	-	80-12-25-10-0-0
	Date of harvesting	1-3 Feb.	9-12 May	25-28 Oct.	1-4 May	-	20-25 Nov.
	Field duration (days)	90-92	91-93	108-111	95-100	-	120-125
	Turnaround time (days)	5-8	5-7	62-65	66-68	-	85-88
	Cropping Pattern-I1						
	Crop	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman
	Variety	BARI Gom-30	BARI Til-4	BRRI dhan51	BARI Gom-28	-	Sharwna
	Date of sowing/ Transplanting	20-22 Nov.	29-30 March	12-15 July	5-7 Dec.	-	20-25 July
	Seed rate (kg ha^{-1})	120	7.5	40	150	-	50
	Spacing (cm)	20 × Cont. (Strip tillage)	Broadcast	20 × 15	Broadcast	-	20 × 15
	Fertilizer dose (N-P-K-S-Zn-B, kg ha^{-1})	103-25-41-27-2-1.5	60-15-37-12-0-0	86-13-15-10-0-0	90-20-41-27-0-0	-	80-12-25-10-0-0
	Date of harvesting	20-23 March	20-22 June	10-12 Nov.	3-5 April	-	22-25 Nov.
	Field duration (days)	120-124	90-100	123-125	123	-	130-132
	Turnaround time (days)	10-12	6-7	22	6		113

Location	Observation	Improved cropping pattern			Existing cropping pattern		
Amnura Chapainawabganj	Cropping pattern-I						
	Crop	Wheat	Mungbean	T. Aman	Wheat	Fallow	T. Aman
	Variety	BARI Gom-30	BARI Mung-6	BRRI dhan51	BARI Gom-28	-	Sharwna
	Date of sowing/ Transplanting	18-20 Nov.	25-28 March	22-26 July	3-5 Dec.	-	25-28 July
	Seed rate (kg ha^{-1})	120	35	40	150	-	50
	Spacing (cm)	20 × Cont. (Strip tillage)	Broadcast	20 × 15	Broadcast	-	20 × 15
	Fertilizer dose (N-P-K-S-Zn-B, kg ha^{-1})	100-25-40-27-2-1.5	20-20-20-0-0-0	86-13-15-10-0-0	88-20-40-25-0-0	-	80-12-25-10-0-0
	Date of harvesting	18-22 Mar.	05-15 June	12-15 Nov.	4-5 April	-	20-25 Nov.
	Field duration (days)	120	75	120	122	-	120
	Turnaround time (days)	11	7	37	42	-	81
	Cropping pattern-II						
	Crop	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
	Variety	BARI Masur-8	-	BRRI dhan51	-	-	Sharwna
	Date of sowing/ Transplanting	20-21 Nov.	-	15-20 July	-	-	23-25 July
	Seed rate (kg ha^{-1})	50	-	40	-	-	50
	Spacing (cm)	Broadcast	-	20 × 15	-	-	20 × 15
	Fertilizer dose (N-P-K-S-Zn-B, kg ha^{-1})	20-20-20—0-0-1	-	86-13-15-10-0-0	-	-	80-12-25-10-0-0
	Date of harvesting	08-10 Mar.	-	5-7 Nov.	-	-	20-24 Nov.
	Field duration (days)	110	-	112	-	-	123
	Turnaround time (days)			128			242
Chanduria Rajshahi	Cropping pattern-I						
	Crop	Lentil	Maize	T. Aman	Fallow	Boro	T. Aman
	Variety	BARI Masur-8	Laltir 339	BRRI dhan87	-	BRRI dhan28	Sharwna
	Date of sowing/ Transplanting	20 Nov.	05 April	25 July	-	25-28 Feb.	20-25 July
	Seed rate (kg ha^{-1})	35	25	35	-	35	35
	Spacing (cm)	Broadcast	60 × 20	20 × 15	-	20 × 15	20 × 15
	Fertilizer dose (N-P-K-S-Zn-B, kg.ha^{-1})	18-30-25-18-1-1	152-52-74-26-2.5-1.2	90-10-25-12-1-0	-	120-15-60-13-3-0	96-18-28-8-0-0
	Date of harvesting	15-17 March	15-17 July	30-31 Oct.	-	20-23 June	7-10 Nov.
	Field duration (days)	117	102	98	-	117	111
	Turnaround time (days)	19	20	09	-	108	29
	Cropping pattern-II						
	Crop	Mustard	T. Aus	T. Aman	Fallow	Boro	T. Aman
	Variety	BARI Sarisha-18	BRRI dhan82	BRRI dhan87	-	BRRI dhan28	Sharwna
	Date of sowing/ Transplanting	11-13 Nov.	16-17 March	27-29 June	-	25-28 Feb.	20-25 July
	Seed rate (kg ha^{-1})	07	35	35	-	35	35
	Spacing (cm)	Broadcast	20 × 15	20 × 15	-	20 × 15	20 × 15
	Fertilizer dose (N-P-K-S-Zn-B, kg ha^{-1})	126-35-46-29-2.5-2	76-11-38-6.4-0-0	90-10-25-12-1-0	-	120-15-60-13-3-0	96-18-28-8-0-0
	Date of harvesting	21-23 Feb.	15-17 June	07-09 Oct.	-	20-23 June	7-10 Nov.
	Field duration (days)	103	92	102	-	117	111
	Turnaround time (days)	34	23	11	-	108	29

Location	Observation	Improved cropping pattern			Existing cropping pattern		
Jiarokhi Kushtia	Cropping pattern-I						
	Crop	Lentil	Sesame	T. Aman	Lentil	Sesame	T. Aman
	Variety	BARI Masur-8	BARI Til-4	BRRI dhan75	BARI Masur-6	Local	BRRI dhan39
	Date of sowing/ Transplanting	23-25 Nov.	22-25 March	3-4 Aug.	20-24 Nov.	12-15 March	30-35 July
	Seed rate (kg ha^{-1})	30	7	22	35	8	30
	Spacing (cm)	Broadcast	Broadcast	20 × 15	Broadcast	Broadcast	20 × 15
	Fertilizer dose (N-P-K-S-Zn-B, kg.ha^{-1})	21-17-17.5-9.36-0-1	55-28-22.5-19-1.8-1.7	115-27-44-13-1-0	20-17-17.5-9-0-1	50-25-20-15-0-0	115-27-44-13-1-0
	Date of harvesting	15-17 March	16-18 July	30-31 Oct.	7-9 March	15-17 July	03-05 Nov.
	Field duration (days)	112	114	87	103	120	93
	Turnaround time (days)	16	7	18	21	8	10
	Cropping pattern-II						
	Crop	Onion	Sweet gourd	T. Aman	Onion	Sweet gourd	T. Aman
	Variety	BARI Piaj-4	Local hybrid	BRRI dhan75	Local	Local hybrid	BRRI dhan39
	Date of sowing/ Transplanting	05-07 Dec.	26-28 January	20-22 July	06-10 Dec.	26-28 January	25-28 July
	Seed rate (kg ha^{-1})	7.5	6.0	30	7.5	6.0	30
	Spacing (cm)	25 line	300 × 300	20 ×15	25 line	300 × 300	20 × 15
	Fertilizer dose (N-P-K-S-Zn-B, kg ha^{-1})	110-52-75-20-1-0.5	80-80-75-18-3.5-1.7	115-27-44-13-2.5-0	110-52-75-20-1-0.5	80-80-75-18-3.5-1.7	115-27-44-13-2.5-0
	Date of harvesting	28 March	05 May-05 July	10 Nov. 2020	28 March	05 May-05 July	14 Nov.
	Field duration (days)	113	100-120	110	112	100-130	109
	Turnaround time (days)	20	-	15	20	-	20
Kamalbazar Sylhet	Cropping pattern-I						
	Crop	Potato	T. Aus	T. Aman	Fallow	T. Aus	T. Aman
	Variety	BARI Alu-41	BRRI dhan65	BRRI dhan57	-	BR26	BRRI dhan33
	Date of sowing/ Transplanting	22-11-19	25-04-19	31-07-19	-	17-04-19	03-08-19
	Seed rate (kg ha^{-1})	1500	26	26	-	26	26
	Spacing (cm)	45 × 15	20 × 15	20 × 15	-	20 × 15	20 × 15
	Fertilizer dose (N-P-K-S-Zn-B, kg ha^{-1})	115-30-175-22-4-2	134-53-83-60-0-0	150-53-83-60-0-0	-	134-53-83-60 -0-0	165-60-105-86-0-0
	Date of harvesting	27-02-20	28-07-19	01-11-19	-	30-07-19	17-11-19
	Field duration (days)	98	93	90	-	103	104
	Turnaround time (days)	56	4	21	-	5	150
	Cropping pattern-II						
	Crop	Mustard	T. Aus	T. Aman	Mustard	T. Aus	T. Aman
	Variety	BARI Sarisha-14	BRRI dhan65	BRRI dhan57	Tori-7	BR26	BRRI dhan33
	Date of sowing/ Transplanting	15-11-20	23-04-20	02-08-20	29-11-19	16-04-20	01-08-20
	Seed rate (kg ha^{-1})	7.5	26	26	7.5	26	26
	Spacing (cm)	Broadcast	20 x 15	20 x 15	-	20 x 15	20 x 15
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	115-30-43-27-18-1.7	134-53-83-60-0-0	150-53-83-60-0-0	115-30-43-27-18-1.7	134-53-83-60-0-0	165-60-105-86-0-0
	Date of harvesting	10-02-21	27-07-20	03-11-20	08-02-21	25-07-20	18-11-20
	Field duration (days)	85	94	91	76	105	108
	Turnaround time (days)	72	6	12	61	4	11

10.2.1.2 Improvement or development of cropping pattern at FSRD site Naikhongchari, Bandarban of BLRI component

To increase cropping intensity the existing cropping pattern needed to improve by inclusion of one or two crops in the hill tracts areas. All field operations and management practices were closely monitored and data were recorded accordingly. However, to increase crop productivity in FSRD site, Naikhongchari two cropping patterns were tested. Following improved cropping patterns were practiced against farmer's existing pattern (Table 10.8 & 10.9).

Table 10.8 Improved and existing cropping pattern-I of BLRI component

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Cucumber	T. Aman	Brinjal	Fallow	T. Aman (Local)	Fallow
Variety	Green king Commercial Hybrid (Lal Teer)	BRRI dhan49	Commercial hybrid (Metal)	-	Local	-
Date of sowing/ Transplanting	7-10 June	02-05 Sept.	05-10 Jan.	-	25-30 July	-
Seed rate (kg ha^{-1})	4	50	0.40	-	50	-
Spacing	1.0 m × 1.0 m	20 cm × 15 cm	45 cm × 75 cm	-	Line showing	-
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	115-34-40-24-2-1	135-20-60-18-4-0	80-22-35-1-0-0	-	115-19-60-17-2-0	-
Date of harvesting (range)	10-30 Aug.	25-29 Nov.	15 March-30 May	-	15-25 Dec.	-

Table 10.9 Improved and existing Cropping pattern-II of BLRI component

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Fodder	Fodder	Fodder	Tobacco	Fallow	Fallow
Variety	Napier	Napier	Napier	HYV	-	-
Date of sowing/ Transplanting	16-20 July	-	-	25-30 Oct.	-	-
Seed kg ha^{-1}/ No. of cutting ha^{-1}	24710	-	24710	7.5	-	-
Spacing	0.5 m × 0.5 m	0.5 m × 0.5 m	0.5 m × 0.5 m	75 cm × 50 cm	-	-
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	120-50-110-24-4-2	135-20-60-18-4-0	80-22-35-1-0-0	125-300-250-0-0-0	-	-
Date of harvesting (range)	2-3 times harvest in a season	2-3 times harvest in a season	2-3 times harvest in a season	15-28 March	-	-

10.2.2 On-farm verification/production program

10.2.2.1 On-farm verification/production program at different FSRD sites of BARI component

Bangladesh Agricultural Research Institute and other NARS Institutes have developed a large number of modern varieties of different crops, those are high yielding as well as short in duration. To identify the suitable crops and varieties, on-farm verification trials were conducted during the years of 2019-2020 and 2020–2021 with different types of crops, e.g., mustard, potato, tomato, wheat, mungbean, sesame, lentil, barley, okra, radish, etc., (Table 10.10). The identified suitable varieties were brought under production programs at each location in the following years. The details of crop management are given below:

Table 10.10 Different operations conducted for production program on different crops and their varieties at different FSRD sites of BARI during the years of 2019 to 2022

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Basantapur Rajshahi	**Year-I: 2019-2020**					
	Lentil	BARI Masur-8	6	1.5	20-23 Nov. 2019	12-13 Mar. 2020
	Chickpea	BARI Chola-5	6	1	16 Nov. 2019	20-22 Mar. 2020
	Summer Tomato	BARI Hybrid Tomato-8	1	10 dec.	6 July 2020	31 Aug. to 15 Oct. 2020
	Mustard	BARI Sarisha-17	7	2.0	1-5 Nov. 2019	2-3 Feb. 2020
		BARI Sarisha-14	03	1.0	2-5 Nov. 2019	28-30 Jan. 2020
	Potato	BARI Alu-7	1	0.13	30 Nov. 2019	8 Mar. 2020
		BARI Alu-25				
		BARI Alu-36				
		BARI Alu-41				
		BARI Alu-46				
	Year-II: 2020-2021					
	Lentil	BARI Masur-8	8	3.0	17-21 Nov. 2020	08-11 Mar. 2021
	Chickpea	BARI Chola-5	7	2.0	7-11 Nov. 2020	22-25 Mar. 2021
	Mustard	BARI Sarisha-17	12	3.0	1-5 Nov. 2020	2-3 Feb. 2021
		BARI Sarisha-14	03	1.0	2-5 Nov. 2020	28-30 Jan. 2021
	Tomato	BARI Hybrid Tomato-11	2	0.15	26-28 July 2021	01 Oct-23 Dec. 2021
	Potato	BARI Alu-7	1	0.13	25 Nov. 2020	8 Mar. 2021
		BARI Alu-25				
		BARI Alu-36				
		BARI Alu-41				
		BARI Alu-46				
	Year-III: 2021-2022					
	Lentil	BARI Masur-8	7	3.0	22-28 Nov. 2021	10-12 Mar. 2022
	Chickpea	BARI Chola-5	8	3.0	22-30 Nov. 2021	25-28 Mar. 2022
	Wheat	BARI Gom-30	4	1.0	27-30 Nov. 2021	20-22 Mar. 2022
	Mustard	BARI Sarisha-18	6	2	30-31 Oct. 2021	15-16 Feb. 2022
		BARI Sarisha-17	10	4.0	4-5 Nov. 2021	2-5 Feb. 2022
		BARI Sarisha-15	4	1.0	1-2 Nov. 2021	3-4 Feb. 2022
		BARI Sarisha-14	14	5.0	1-5 Nov. 2021	28-31 Jan. 2022
	Potato	BARI Alu-7	1	0.13	28-30 Nov. 2021	8-15 Mar. 2022
		BARI Alu-25				
		BARI Alu-36				
		BARI Alu-41				
		BARI Alu-46				
Amnura Chapainawabganj	**Year-I: 2019-2020**					
	Lentil	BARI Masur-8	5	1.0	20-22 Nov. 2019	10-12 Mar. 2020
	Chickpea	BARI Chola-5	6	1.5	20-22 Nov. 2019	26-28 Mar. 2020
	Mustard	BARI Sarisha-14	7	1.5	10-12 Nov. 2019	4-5 Feb. 2020
	Year-II: 2020-2021					
	Lentil	BARI Masur-8	8	2.0	15-18 Nov. 2020	10-12 Mar. 2021
	Chickpea	BARI Chola-5	9	2.0	17-20 Nov. 2020	27-28 Mar. 2021
	Mustard	BARI Sarisha-17	8	2.0	10-12 Nov. 2020	10-12 Feb. 2021
		BARI Sarisha-14	10	2.0	07-10 Nov. 2020	3-8 Feb. 2021
	Year-III: 2021-2022					
	Lentil	BARI Masur-8	9	2.0	24-26 Nov. 2021	10-12 Mar. 2020
	Chickpea	BARI Chola-5	5	1.2	16-20 Nov. 2021	20-22 Mar. 2020
	Mustard	BARI Sarisha-17	10	2.3	15-18 Nov. 2021	10-12 Feb. 2021
		BARI Sarisha-14	12	2.5	10-12 Nov. 2021	3-8 Feb. 2021

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Chanduria Rajshahi	**Year-I: 2019-2020**					
	Lentil	BARI Masur-8	06	01	15-20 Nov. 2019	10-15 Mar. 2020
	Wheat	BARI Gom-30	08	1.33	20-21 Nov. 2019	02-03 Mar. 2020
	Sesame	BARI Til-4	2	0.267	20 Mar. 2020	25 June 2020
	T. Aus rice	BRRI dhan82	1	0.267	20 May 2020	18 Aug. 2020
	Potato	BARI Alu-7	05	0.13	30 Nov. 2019	03-04 Mar. 2020
		BARI Alu-37	05	0.13	30 Nov. 2019	03-04 Mar. 2020
		BARI Alu-40	05	0.13	30 Nov. 2019	03-04 Mar. 2020
	Mustard	BARI Sarisha-11	06	80 m^2	30 Nov. 2019	14-16 Mar. 2020
		BARI Sarisha-14	45	7.33	10-15 Nov. 2019	10-17 Feb. 2020
		BARI Sarisha-16	06	80 m^2	30 Nov. 2019	14-16 Mar. 2020
		BARI Sarisha-18	06	80 m^2	30 Nov. 2019	14-16 Mar. 2020
	Year-II: 2020-2021					
	Mustard	BARI Sarisha-14	15	2.5	15-20 Nov. 2020	7-10 Feb. 2021
		BARI Sarisha-11	05	0.5	20-22 Nov. 2020	15-20 Mar. 2021
		BARI Sarisha-16	05	0.5	20-25 Nov. 2020	10-15 Mar. 2021
		BARI Sarisha-18	05	0.5	18-21 Nov. 2020	12-15 Mar. 2021
	Wheat	BARI Gom-30	06	1.2	25-28 Nov. 2020	18-20 Mar. 2021
		BARI Gom-33	05	2.5	25-30 Nov. 2020	25-28 Mar. 2021
	Sesame	BARI Til-4	04	0.8	15-20 Mar. 2020	25-30 June 2021
	Lentil	BARI Masur-8	05	0.5	20-25 Nov. 2020	20-22 Mar. 2021
	Potato	BARI Alu-7	06	0.5	28-30 Nov. 2020	01-03 Mar. 2021
		BARI Alu-37	06	0.5	25-30 Nov. 2020	01-04 Mar. 2021
		BARI Alu-40	03	0.5	24-28 Nov. 2020	01-04 Mar. 2021
	Year-III: 2021-2022					
	Mustard	BARI Sarisha-14	05	1.153	1-20 Nov. 2021	21 Jan. to 26 Feb. 2022
		BARI Sarisha-17	01	0.133	03 Nov. 2021	21 Jan. 2022
		BARI Sarisha-18	03	0.346	13-25 Nov. 2021	22 Feb.-16 Mar. 2022
	Potato	BARI Alu-35	01	0.133	22-26 Nov. 2021	20-25 Feb. 2022
		BARI Alu-37	02	0.293	04-05 Dec. 2021	20-21 Mar. 2022
		BARI Alu-57	01	0.133	04 Dec. 2021	21 Mar. 2022
		BARI Alu-73	04	0.406	01 -02 Dec. 2021	15-21 Mar. 2022
	Lentil	BARI Masur-8	02	0.267	5 Nov. 2021	15-16 Mar. 2022
Jiarokhi, Kushtia	**Year-I: 2019-2020**					
	Lentil	BARI Masur-8	4	0.91	25 Nov. 2019	25-27 Feb. 2020
	Mustard	BARI Sarisha-18	4	1.00	22 Nov. 2019	20-25 Feb. 2020
	Potato	BARI Alu-7	3	1.00	05 Dec. 2019	12-15 Mar. 2020
		BARI Alu-53	5	0.50	05 Dec. 2019	10-15 Mar. 2020
	Year-II: 2020-2021					
	Lentil	BARI Masur-8	2	0.50	27-29 Nov. 2020	26-28 Feb. 2021
	Mustard	BARI Sarisha-18	5	1.00	20-22 Nov. 2020	15-20 Feb., 2021
	Potato	BARI Alu-7	2	0.45	01-05 Dec. 2020	05-08 Mar. 2021
		BARI Alu-53	3	0.50	03-07 Dec. 2020	10-15 Mar. 2021
	Year-III: 2021-2022					
	Lentil	BARI Masur-8	2	0.65	22-25 Nov. 2021	25-28 Feb. 2022
	Mustard	BARI Sarisha-18	4	1.00	18-20 Nov. 2021	15-20 Feb. 2022
	Potato	BARI Alu-53	2	0.50	01-05 Dec. 2021	03-08 Mar. 2022
	Sunflower	BARI Surjomukhi-3	5	.12	05-10 Dec. 2021	08-12 Mar. 2022
Kamalbazar Sylhet	**Year-I: 2019-2020**					
	Tomato	BARI Hybrid Tomato-5	2	0.3	10-15 Oct. 2019	27 Dec. 2019 to 30 Jan. 2020
	Potato	BARI Alu-41	6	2.0	25-30 Nov. 2019	26-28 Feb. 2020
		BARI Alu-46	6	2.5	16-20 Nov. 2019	25- 28 Feb. 2020
		BARI Alu-53	4	1.5	19-20 Nov. 2019	24-28 Feb. 2020
	Mustard	BARI Sarisha -14	3	0.6	14-16 Nov. 2019	16-18 Feb. 2020
	Sunflower	BARI Surjomukhi-2	4	0.5	02-09 Dec. 2019	02-06 Feb. 2020
		BARI Surjomukhi-3	4	0.7	05-10 Dec. 2019	06-12 Feb. 2020

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
	Year-II: 2020-2021					
	Tomato	BARI Hybrid Tomato-5	2	0.3	06-10 Sep. 2020	02-05 Mar. 2021
	Potato	BARI Alu-41	3	0.5	03-05 Dec. 2020	06-09 Mar. 2021
		BARI Alu-46	5	1.5	07-09 Dec. 2020	08-10 Mar. 2021
		BARI Alu-53	6	1.7	06-10 Dec. 2020	08-12 Mar. 2021
	Mustard	BARI Sarisha-14	5	0.7	15-17 Nov. 2020	12-15 Feb. 2021
		BARI Sarisha -17	4	1.2	16-20 Nov. 2020	8-10 Feb. 2021
	Bottle gourd	BARI Lau-4	4	0.4	28-30 Apr. 2020	26 July 2020 to 30 Aug. 2021
	Country bean	BARI Sheem-6	3	0.4	26-29 Sep. 2020	17 Dec. 2020 to 01 Jan. 2021
	Year-III: 2021-2022					
	Tomato	BARI Hybrid Tomato-5	2	0.4	05-10 Dec. 2021	22 Feb. to 28 Mar. 2022
	Potato	BARI Alu-41	6	1.0	08-12 Dec. 2021	22-28 Feb. 2022
		BARI Alu-46	4	0.7	10-17 Nov. 2021	18-24 Feb. 2022
		BARI Alu-53	5	0.8	12-15 Nov. 2021	16-19 Feb. 2022
	Mustard	BARI Sarisha -14	6	1.2	15-20 Nov. 2021	7-10 Feb. 2022
		BARI Sharisa-18	5	0.8	17-21 Nov. 2021	14-17 Feb. 2022
	Bottle gourd	BARI Lau-4	3	0.5	28-31Oct. 2021	05 Jan.- 28 Feb. 2022
	Brinjal	BARI Begun-12	2	0.3	24 Oct. 2021	15 Jan. to 20 Feb. 2022

* Year I= Oct. 2019-Sep. 2020; Year II= Oct. 2020-Sep. 2021; Year III= Oct. 2021-May 2022

10.2.2.2 Production program at FSRD site Naikhongchari, Bandarban of BLRI component

To identify the suitable crops and varieties, on-farm verification trial was conducted during years of 2020-21 and 2021-2022 with different types of crops e.g., Potato, Maize, Cowpea, Kidney bean, Cucumber, Brinjal, Sweet gourd etc,. (Table 10.11). The details of crop management practices are given below:

Table 10.11 Different operations conducted for production program of different crops at FSRD site Naikhongchari, Bandarban during 2021 to 2022

Year	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Year-II	Potato	Local	5	0.18	25-30 Dec. 2020	20-25 March 2021
	Maize	Commercial hybrid (Hira-104)	5	0.14	28-30 Dec. 2020	18-20 April 2021
	Cowpea	Local	1	0.03	25-30 Dec. 2020	25-29 March 2021
	Kidney bean	Local	1	0.024	25-30 Dec. 2020	15 Feb-20 March 2021
Year-III	Potato	Local	9	0.32	25-30 Dec. 2021	20-25 March 2022
	Maize	Commercial hybrid (Hira-104)	9	0.35	28-30 Dec. 2021	25-30 April 2022
	Cowpea	Local	8	0.29	28-30 Dec. 2021	3- 10 April 2022
	Kidney bean	Local	7	0.13	25-30 Dec. 2021	18 Feb-24 March 2022
	Cucumber	Commercial Hybrid (Lal teer)	2	0.09	1-5 Jan. 2022	15 April – 12 May 2022
	Brinjal	Commercial Hybrid (Lal teer)	2	0.065	6-10 Jan. 2022	20 April – 30 June 2022
	Sweet gourd	Commercial Hybrid (Lal teer)	2	0.05	7-10 Jan. 2022	10 April – 15 May 2022

* Year II= Oct. 2020-Sep. 2021; Year III= Oct. 2021-May 2022

10.3 Livestock Component

Livestock rearing in Bangladesh is an integral agricultural activity among most rural households, particularly landless, marginal and small landholders. It has significant positive impact on equity in terms of income, employment and poverty reduction in rural areas (Rahman *et. al.*, 2020). Livestock sector constitutes about 17 percent of agricultural gross domestic product and provides nutritionally rich food to many people in both rural and urban areas of Bangladesh (BBS, 2015). Different empirical evidence shows that livestock rearing has a positive impact on equity of income and employment for resource-poor rural households (Ali, 2007; Birthal & Ali, 2005; Birthal & Singh, 1995, Rao *et al.*, 2003; Singh & Hazell, 1993). Component wise livestock activities were under taken as:

10.3.1 Livestock activities at different FSRD sites of BARI component

Livestock operations are profitable enterprise, and their success is largely determined by good feeding, care, and management. Almost all cooperative farmers used to raise their animals using traditional methods. During 2019 to 2022, improved cattle rearing system was implemented in several FSRD sites, which included deworming, vaccination, adequate housing, a balanced ration, and sufficient health care. Broad spectrum anthelmintic were used to deworm livestock, particularly cattle, sheep, goats, and other poultry species, according to recommendations for body weight and age. Vitamin A, D, and E-containing injections were also given to cattle after deworming. Cattle mortality could be reduced if they were properly vaccinated against four primary diseases.

The Anthrax vaccine, Foot and Mouth Disease (FMD) vaccine, Black Quarter (BQ) vaccine, and Hemorrhagic Septicemia (HS) vaccine were all applied according to the recommended schedule in the vaccinated group. In some regions, cattle fattening and calf rearing activities were also continued.

Cowdung, in addition to cattle products, is a significant by-product for integrated farming, and farmers were encouraged to use it for the manufacture of farmyard manure (FYM), as well as other homestead waste, rather than utilizing it as fuel. The green fodder Napier grass was found as a good and profitable crop to grow on the farmhouse and its adjacent areas, particularly along the pond bank. Farmers were urged to use FYM after each grass cut. It was introduced to farmers as part of a campaign to help them produce it for cow feed.

Poultry farming is a popular practice in rural areas of Bangladesh's. Chicken rearing is highly frequent across a variety of species. Because it contains comparatively high protein and low-fat percentages, as well as vitamins and minerals, chicken egg is considered a complete food, and chicken meat is regarded a very healthy food. In addition, as compared to pork and beef, it has fewer religious limitations. Poultry disease is the most common difficulty that poultry farmers confront when raising chickens. Only effective immunization can reduce poultry mortality. This program was undertaken in the farmer's field to minimize the mortality rate and investigate the efficiency of chicken vaccine at the farmer's level. During the project's duration, a large number of poultry birds were vaccinated. BCRDV, RDV, Fowl pox, Fowl cholera, and Duck plague vaccinations were given to the vaccinated group according to the prescribed schedule. The facilitator team kept in touch with them on a regular basis to offer advice on how to handle their challenges.

10.3.2 Livestock activities at FSRD site Naikhongchari, Bandarban of BLRI component

As livestock is an integral part of a farm family and an important component of Farming System Research and Development program, cattle fattening, hilly chicken rearing, duck rearing, turkey rearing, pigeon rearing, goat and sheep rearing program was conducted in the FSRD site. To reduce mortality rate of cattle, goat, sheep, chicken, duck, turkey and pigeon vaccination program was done as per recommended vaccination schedule. Enhancing supply of quality feed for cattle BLRI developed high yielding Napier fodder production program was also under taken during 2019-2022.

10.4 Fisheries Component

10.4.1 Fisheries activities at different FSRD sites of BARI component

Improved fish farming technology has the potential to enhance farmers income and livelihood. However, the main impediment to the viability of fish farming in a pond at the homestead area is poor management. At the different FSRD sites, carp polyculture program was implemented in seasonal ponds with the goal of increasing farmer's income and alleviating rural people's protein deficiency. At first, seasonal ponds were selected from two project villages, weeds and wild fishes were removed from the ponds using both physical and chemical methods, lime was applied at a rate of one kg per decimal, as well as the pond was prepared for stocking fingerlings with organic manure (cow dung). The size, species, pond depth, feed availability, and other factors have influence fingerling stocking density. However, in this carp polyculture system, silver carp, rohu, mrigal, grass carp, katla and sorputi was stocked based on their feeding behavior (surface, column and bottom feeder) at the rate of 20-30 fingerlings/decimal. Farmers mostly applied home-made feed using rice and wheat bran, mustard oil cake, salt and molasses to reduce the production cost and utilize the by products whereas lime and fingerlings were supported from the program. The fish feed formula, periodic checking and suggestions for the cure of fish disease and water quality problems was provided by the project personnel on a regular basis.

10.4.2 Fisheries activities at FSRD site Naikhongchari, Bandarban of BLRI component

Improper management is the major hindrance against profitability of fish culture in pond under farmers household. The mixed culture of rohu, katla and monosex tilapia and monoculture with monosex tilapia in seasonal and perennial, ponds were undertaken at the FSRD site with the objectives of increasing farmer's income and reducing protein deficiency of rural people. Proper management is the key factor for getting higher profit from fish culture in pond. During fish culture period following activities were done chronologically.

Pond selection: The success of fish farming depends largely on pond selection, pond preparation and management. The ponds were made free from weeds. Farmers were suggested not to keep large trees on the banks of the pond and remove fallen leaves from the ponds. The location of the pond was close to the homestead for the suitability of overall management.

Pond preparation: The ponds were well prepared before stocking the fingerlings. For suitable physical growth of the fish species, it was ensured that the required amount of natural food was produced in the pond. The various stages in the preparation of the pond were- control of aquatic weeds, control of giant fish and unwanted animals, application of lime and fertilizer etc.

Lime application: Lime application was essential to decontaminate soil and water in ponds, to destroy fish disease germs and parasites, to increase immunity and calcium in water and to increase the productivity of ponds. The soil pH was maintained 6.4 to 7.2 and thus, lime @ 2 kg per decimal area was applied before release the fingerlings in ponds.

Stocking density: The success of fish farming mainly depend on the right level of fingerlings stocks based on water and soil quality as well as fingerlings size, species, pond depth and feed availability (Miah, *et al.*, 1997). In case of mixed culture, fingerlings having the size of 2-5 inches (5-12.5 cm) were released at the number of Rohu 2-5, Katla 2-5, and Monosex tilapia 150-200 per decimal. In case of monoculture, 2 inches (5 cm) size fingerlings of monosex tilapia were released 200-250 number per decimal of water body.

Fertilizer and manure management: After stocking of fingerlings in the pond, fertilizers were applied regularly on weekly basis. In this case organic manure (cow dung) was applied in the pond at the rate of 1 kg every 15 days. In addition, 40 g urea and 20 g TSP was mixed with 30 times water in a container, soaked for at least 12 hours and sprayed all over the pond during the sun days.

Supplementary food: Supplementary food was provided for the rapid physical growth of the fishes. From the day after release of fish, supplementary food was applied every morning and afternoon at the rate of 5-6% of the total body weight of the stored fish. For every 20 kg of fish, at least 1 kg of food was applied.

Once every 15 days or every 1 month, some fishes were caught by pulling the net and the average weight was taken out and subsequently fed in proportion to the total weight. For low-cost management, wheat husk or rice husk at the rate of 50 gm in 1st month, 100 gm in 2nd month, 180 gm in 3rd month, 220 gm in 4th month, 270 gm in 5th month and 300 gm in 6th monts were given. For making supplementary food, fishmeal 10%, rice husk 53%, mustard oil 30.50%, vitamin and mineral mixture 0.5% and molasses 6% were mixed and fed to the fingerlings (Miah, *et al.*, 1993).

10.5. Off-Farm Activities

10.5.1 Off-farm activities at different FSRD sites of BARI component

Off-farm (non-farm) income refers to the portion of farm household income that comes from sources other than the farm, such as non-farm wages and salaries, pensions, and interest income. Since the last three decades or more, there has been mounting evidence that small-holder farm households in developing nations rarely rely solely on agriculture, but rather maintain a diverse income portfolio that includes off-farm activities (Barrett *et al.*, 2001).

Off-farm activities were being pursued by several farm families, particularly the women. In their leisure time, some farmers created small food businesses and mastered weaving katha and machine stitching. Commercial cooking is also done by men in some circumstances. During their spare time, ladies worked on Kumra bora, Pilo covers, rope crafts, plastic balls, and other crafts, while men worked on basket weaving and van/rickshaw pulling.

10.5.2 Off-farm activities at FSRD site Naikhongchari, Bandarban of BLRI component

Off-farm (non-farm) income refers to the portion of farm household income obtained off the farm, including nonfarm wages and salaries, pensions, and interest income earned by farm families. Some farm families' especially the women were engaged with off-farm activities. In Naikhongchari site katha sewing, plastic bag making and bamboo basket making off farm activities were practiced.

10.6 Deployed of Local Service Provider (LSP)

Two farmers from the area were chosen as Local Service Providers (LSP) to improve the execution of farming activities and expand the scope of automation. The LSPs were chosen based on their level of knowledge, eagerness, technological understanding and distribution capability, local and social acceptance, and other factors. They received training from BARI-FMPE, which was supported by the KGF initiative.

10.7 Integration Among Different Components/sub-sectors of Agriculture

Integrated farming encompasses a variety of businesses, including home gardening with vegetables and fruits, crops and cropping systems, dairy, poultry, and fisheries, among others, all of which are interconnected. The waste and end product of one business could be utilized as inputs in another. Dairy waste, such as dung, urine, and garbage, is used to make FYM, which is utilized as an input in cropping systems. The straw from the crops is utilized as food for the cattle, which are intimately linked. Furthermore, careful use of farm resources can help keep the environment clean while lowering production costs. The impact of one component on other components is an important factor in integrated farming for long-term sustainability.

11. Results and discussion

11.1 Homestead Production System

11.1.1 Year-round vegetables and fruits production in homestead area during the years of 2019 to 2022

Sustainable, safe and nutritious food productions are the major challenges for worldwide food security that meets dietary requirements and food preferences for existence of an active and healthy life (Shaheb *et. al.*, 2014). The objectives of year round vegetables and fruits production were to utilize homestead resources in scientific method for producing fresh vegetables and fruits over space and time and to meet up the food and nutritional security of the farm household.

11.1.1.1 Year-round vegetables and fruits production in homestead area at different FSRD sites of BARI component

FSRD Site: Basantapur, Rajshahi

Vegetables production: During 2019-2022, the "Barind Model" was used to implement a vegetables production program in the homestead area at the FSRD site in Basantapur, Rajshahi. The three-year average annual vegetables production was shown to be much larger after intervention (841 kg homestead^{-1}) than before intervention (99 kg homestead^{-1}) (Table 11.3). After intervention, vegetables production was 749% higher compared to before intervention. Using all the niches of the homestead, updated technologies, and smart time management could help to increase vegetables production in the homestead area. After intervention, overall annual vegetables production was 784, 836, and 902 kg homestead^{-1} in Year-I, Year- II, and Year-III, respectively (Table 11.2). On the roof and homestead boundary, creeping type vegetables (country bean, sponge gourd and ash gourd) were customarily grown. The highest amount of vegetables (414.67 kg homestead^{-1}) was produced from open sunny place that was about 50% of total production (Table 11.2). Unfortunately, it remained fallow until the sub-project's operations intervened. The second highest vegetables production was found on the roof (110.67 kg homestead^{-1}) and third on trellis (85.33 kg homestead^{-1}). Rabi season had the the highest yield (374 kg homestead^{-1}), followed by Kharif-1 (237.67 kg homestead^{-1}) and Kharif-2 (221 kg homestead^{-1}) in terms of cropping season (Table 11.1). During the Rabi season, weather conditions were generally suitable which resulted enhanced vegetables production.

Picture11.1 Vegetables production at homestead area of FSRD site, Basantapur, Rajshahi

Utilization of vegetables: With the cooperation of the co-operator farmers, the disposal pattern of various vegetables grown in the homestead area was periodically recorded. It was observed that after intervention, the disposal pattern of vegetables changed. After intervention, the average vegetables intake per farm family increased by 508% compared to before intervention (Table 11.3). The consumption of vegetables by farm family members increased dramatically. During the study period, averege distribution and selling of vegetables were 105.67 kg and 218 kg homestead^{-1}, respectively after intervention. Increased vegetables production enabled farm families to distribute more vegetables to their relatives and neighbors, which helped in strengthening their bonds as well as earning money from more vegetables sale. More vegetables production and subsequent consumption, distribution, and sale were aided by greater exploitation of homestead area and optimum management by effective farm family labor.

Picture11.2 Vegetables utilization pattern of FSRD site, Basantapur, Rajshahi

Fruits production: Pruning, pest management, fertilizer, and irrigation were used to manage rapidly growing fruit trees (Papaya, Lemon, and Banana) as well as existing fruit trees (Mango, Coconut and Wood Apple). Fruit production has expanded significantly since the introduction of established and modern technologies in the homestead. When compared to farmers' practice (135 kg homestead^{-1}), modern technologies resulted in a higher quantity of average fruit production (455 kg homestead^{-1}) (Table 11.3). Fruit yield increased by 237% after intervention compared to before intervention. Fruit production increased sequentially in each year after intervention which reached 425, 462, and 478 kg homestead^{-1}, in the Year-I, Year-1I, and Year-III, respectively (Table 11.2). The use of new technologies in fruit production, such as balanced fertilizer and pest management, has resulted in a rational rise in production.

The highest average fruit production (296 kg homestead^{-1}) was found in Kharif-1 season followed by Kharif-2 season (112.67 kg homestead^{-1}) and the lowest (46.33 kg homestead^{-1}) in Rabi season (Table 11.1). Mangoes were harvested in June, resulting in the highest yield of fruit in the Kharif-1 season due to mango is harvested in June. Rabi is a slow season for fruit production but a minor number of fruits were produced during Rabi season.

Picture11.3 Fruits (coconut) production of FSRD site Basantapur, Rajshahi

Utilization of fruits: The disposal pattern of fruits grown in the homestead area was meticulously recorded. From the total produced fruit, farm families consumed most of the fruits amounted 274.33 kg household^{-1}, selling was 129.33 kg household^{-1}, and distribution was 51.33 kg household^{-1} (Table 11.3). Both intake and sold value of fruit were higher than before the sub-project's involvement.

Income from vegetables and fruits: After intervention, the average gross return, total variable cost, and gross margin from vegetables in a homestead were 16653, 2255, and Tk.14398, respectively (Table 11.3). The increase in gross margin from homestead vegetables production after intervention was found 873% higher than before intervention. After intervention, the average gross return, total variable cost, and gross margin from fruit production homestead^{-1} were 9100, 1217, and Tk.7883, respectively. The gross margin increased by 232% from fruit sector (Table 11.3).

Table 11.1 Seasonwise vegetables and fruits production per homestead area during 2019 to 2022 at FSRD Site, Basantapur, Rajshahi

Niches/production unit	Production in Rabi season (Kg)				Production in Kharif-1 season (Kg)				Production in Kharif-2 season (Kg)			
	October- March				April-June				July-September			
	Yea- I	Year- II	Year- III	Total avg.	Year- I	Year- II	Year- III	Total avg.	Year- I	Year- II	Year- III	Total avg.
Open sunny place	198	215	219	210.67	97	112	102	103.67	101	95	105	100.33
Roof	54	55	69	59.33	11	17	26	18.00	25	29	36	30.00
Trellis	36	25	29	30.00	32	19	26	25.67	22	27	40	29.67
Fence	10	11	14	11.67	21	17	14	17.33	10	18	21	16.33
Tree support	21	16	14	17.00	14	20	18	17.33	8	14	16	12.67
Marshy land	6	12	16	11.33	8	11	0	6.33	0	0	0	0.00
Backyard	14	17	11	14.00	21	16	30	22.33	17	13	19	16.33
Partially shady place	0	0	0	0.00	12	16	21	16.33	0	0	0	0.00
House boundary	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
Pond bank	14	15	31	20.00	14	6	12	10.67	18	16	13	15.67
Total vegetables production	353	366	403	374.00	230	234	249	237.67	201	212	250	221.00
Total fruits production	35	56	48	46.33	275	301	312	296.00	115	105	118	112.67
Total production (vegetables +fruits)	388	422	451	420.33	505	535	561	533.67	316	317	368	333.67

* Year I= Oct. 2019-Sep. 2020; Year II= Oct. 2020-Sep. 2021; Year III= Oct. 2021-Sep. 2022

Table 11.2 Yearwise vegetables and fruits production at homestead during 2019- 2022 (Per homestead) at FSRD Site, Basantapur, Rajshahi

Niches/production unit	Production (Kg)			
	Year- I	Year- II	Year-III	Avg. of total
Open sunny place	396	422	426	414.67
Roof	90	111	131	110.67
Trellis	90	71	95	85.33
Fence	41	46	49	45.33
Tree support	43	50	48	47.00
Marshy land	14	37	16	22.33
Backyard	52	46	60	52.67
Partially shady place	12	16	21	16.33
House boundary	0	0	0	0.00
Pond bank	46	37	56	46.33
Total vegetables production	784	836	902	840.67
Total fruits	425	462	478	455.00
Total production vegetables +fruits)	1209	1274	1380	1287.67

* Year- I = Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

Table 11.3 Vegetables & fruits production, utilization pattern and income before and after intervention during 2019 to 2022 at FSRD Site, Basantapur, Rajshahi

Description	Before intervention		After intervention							
	Vegetables	Fruit	Vegetables				Fruits			
			Year I	Year II	Year III	Avg. three years	Year I	Year II	Year III	Avg. three years
Consumption (Kg)	85	95	486	511	554	517.00	255	288	280	274.33
Distribution (Kg)	14	40	106	99	112	105.67	50	44	60	51.33
Selling (Kg)	0	0	192	226	236	218.00	120	130	138	129.33
Total production (Kg)	99	135	784	836	902	840.67	425	462	478	455.00
Gross return (Tk.)	1980	2700	15680	16240	18040	16653.33	8500	9240	9560	9100.00
Total variable cost (Tk.)	500	325	2125	2140	2500	2255.00	1050	1250	1350	1216.67
Gross margin (Tk.)	1480	2375	13555	14100	15540	14398.33	7450	7990	8210	7883.33

*Year- I = Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

FSRD site: Amnura, Chapainawabganj

Vegetables production: Following the Barind model, available and utilizable production niches of the homestead areas were brought under cultivation with the specified vegetables and fruits. In the Barind model, nine niches were used to use fallow and under-utilized homestead areas scientifically, considering time and space. Vegetables production has expanded greatly in the homestead after the implementation of proven and improved technology during 2019 and 2022. The average annual vegetables yield after intervention with better technology (658 kg homestead^{-1}) was much higher than before intervention (85 kg homestead^{-1}) (Table 11.6). After intervention, vegetables production increased by 674% compared to before intervention. The Kharif season is always a bleak time for vegetables production, with seasonal

drought havoc on crops. After intervention, the highest amount of vegetables 270 kg homestead^{-1} was produced in the Rabi season, followed by 196 kg homestead^{-1} in Kharif-2 season (Table 11.4). The lowest production (193 kg homestead^{-1}) was found in Kharif-I season. The significant increment in vegetables production in the homestead area might be attributed to the use of upgraded technology and careful time management.

Picture11.4 Vegetables production of FSRD site, Amnura, Chapainawabganj

Utilization of vegetables: With the help of co-operator farmers, the disposal pattern of various vegetables grown in the homestead area was periodically recorded. The findings revealed that after intervention, the utilization pattern of vegetables changed (Table 11.6). During the study period, the average annual household vegetables intake per farm family was 439 kg after program intervention that was only 68 kg before intervention. After intervention, the annual distribution of vegetables was 67 kg, and the annual sale of vegetables was 152 kg. Increased vegetables production prompted farm families to give out more produce to their relatives and neighbors, which might help them strengthen their bonds while also helping them make more money from selling of additional vegetables.

Picture11.5 Vegetables utilization of FSRD site, Amnura, Chapainawabganj

Fruits production: Fast-growing fruit trees including guava, papaya, lemon, ber, and banana, as well as existing fruit trees like mango, jackfruit, coconut, and wood apple, were managed with pruning, pest management, fertilization, and irrigation. After intervention with modern technology in the homestead area, fruit yield increased by 236%. Using advanced technology fruit production was 424 kg homestead^{-1} which was 126 kg homestead^{-1} before intervention (Table 11.6). The least amount of fruits was produced during Rabi season (42 kg homestead^{-1}), which might be due to a shortage of Rabi (winter) fruit species and varieties. After intervention, average fruit production in Khari-1 and Kharif-2 was 271 and 111 kg homestead^{-1}, respectively (Table 11.4).

Picture11.6 Fruit Production of FSRD site Amnura Chapainawabganj

Utilization of fruits: The pattern of disposal of various fruits produced in the homestead area was meticulously documented. The average annual fruit intake per farm family was 257 kg after intervention that was 90 kg before intervention. Fruit intake was increased by 186% after intervention (Table 11.6). Average annual fruit distribution and selling was 60 kg and 119 kg, respectively after the program intervention. Farm families were encouraged to share their surplus fruit among relatives and neighbors, but farmers were more interested in selling to make money.

Picture11.7 Fruit (Mango) utilization pattern of FSRD site, Amnura, Chapainawabganj

Income from vegetables and fruits: Gross return, total variable cost, and gross margin were calculated 14203, 2468, and Tk. 11735, respectively, after the intervention from the homestead vegetables production. The increment in gross margin from homestead vegetables production was 763% after intervention (Table 11.6). In case of the fruit production, after the program's intervention, the gross return per farm was Tk. 9938, with a gross margin of Tk. 8412. The gross margin increased by 311% after intervention from fruit production at homestead (Table 11.6).

Table 11.4 Seasonwise vegetables and fruits production per homestead area during 2019 to 2022 at FSRD site, Amnura, Chapainawabganj

Niches/production unit	Production in Rabi season (Kg)				Production in Kharif-1 season (Kg)				Production in Kharif-2 season (Kg)			
	October- March				April-June				July-September			
	Year-I	Year-II	Year-III	Total Avg.	Year -I	Year-II	Year-III	Total Avg.	Year -I	Year -II	Year - III	Total Avg.
Open sunny place	116	127	139	127.33	76	92	101	89.67	91	98	119	102.67
Roof	49	53	47	49.67	15	9	18	14.00	21	24	31	25.33
Trellis	30	27	43	33.33	26	20	14	20.00	19	24	12	18.33
Fence	0	0	0	0.00	06	9	04	6.33	08	7	13	9.33
Tree support	12	8	21	13.67	13	13	17	14.33	06	11	09	8.67
Marshy land	7	7	0	4.67	6	5	11	7.33	02	0	09	3.67
Backyard	16	19	24	19.67	18	13	9	13.33	18	9	13	13.33
Partially shady place	0	0	0	0.00	10	12	6	9.33	0	0	08	2.67
Pond bank	14	22	28	21.33	13	20	23	18.67	16	8	12	12.00
Total vegetables production	*244*	263	302	269.67	183	193	203	193.00	180	181	226	195.67
Total fruits production	32	44	49	41.67	250	273	289	270.67	110	95	129	111.33
Total production (vegetables +fruits)	276	307	351	311.33	433	466	492	463.67	290	314	355	319.67

* Year I= Oct. 2019-Sep. 2020; Year II= Oct. 2020-Sep. 2021; Year III= Oct. 2021-Sep. 2022

Table 11.5 Yearwise vegetables and fruits production at homestead during 2019- 2022 (Per homestead) at FSRD site, Amnura, Chapainawabganj

Niches/production unit	Production (Kg)			
	Year- I	Year- II	Year- III	Avg. of total
Open sunny place	283	317	359	319.67
Roof	85	86	96	89.00
Trellis	75	71	69	71.67
Fence	14	16	17	15.67
Tree support	31	32	47	36.67
Marshy land	15	12	20	15.67
Backyard	52	41	46	46.33
Partially shady place	10	12	1 4	12.00
Pond bank	43	50	63	52.00
Total vegetables production	607	637	731	658.33
Total fruits production	392	412	467	423.67
Total production (vegetables + fruits)	999	1087	1198	1094.67

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

Table 11.6 Vegetables & fruits production, utilization pattern and income before and after intervention during 2019 to 2022 at FSRD site Amnura, Chapainawabganj

Description	Before intervention		After intervention							
	Vegetables	Fruit	Vegetables				Fruits			
			Year- I	Year- II	Yea- III	Avg. three years	Year- I	Year- II	Year- III	Avg. three years
Consumption (Kg)	68	90	421	435	461	439	235	275	262	257
Distribution (Kg)	17	36	65	67	69	67	46	55	80	60
Selling (Kg)	0	0	121	135	201	152	111	120	125	119
Total production (Kg)	85	126	607	637	731	658	392	412	467	424
Gross return (Tk.)	1760	2520	13200	14220	15190	14203	7840	10300	11675	9938
Total variable cost (Tk.)	400	475	1950	2580	2875	2468	1380	1590	1610	1527
Gross margin (Tk.)	1360	2045	11245	11640	12315	11735	6460	8710	10065	8412

* Year I= Oct. 2019-Sep. 2020; Year II= Oct. 2020-Sep. 2021; Year III= Oct. 2021-Sep. 2022

FSRD Site: Chanduria, Rajshahi

Vegetables production: The vegetables cultivation program at homestead area was carried out at the Farming Systems Research and Development (FSRD) site following the "Barind Model" using the available and utilizable production niches of the homestead areas during 2019-2022. With the consideration

Picture11.8 Vegetables production at FSRD site, Chanduria, Rajshahi

of time and space, the fallow and under-utilized homestead areas were utilized scientifically. In the production system at Chanduria, Rajshahi, nine niches were utilized (Table 11.7). After intervention of improved technologies, vegetables production was increased significantly, and the most remarkable change was observed in open sunny place (Table 11.8). Among the three seasons, highest average production (261 kg homestead^{-1}) was found in Rabi season followed by Kharif-1 (196 kg homestead^{-1}) and Kharif-2 (196 kg homestead^{-1}). Highest amount of vegetables production was found in the Rabi season due to prevailing favorable weather. The total vegetables production was 624, 641 and 693 kg homestead^{-1} during the Year-I, Year- II and Year- III, respectively (Table 11.8). Among the different niches, the highest production 349 kg homestead^{-1} was found from open sunny place that was 53% increase of total production followed by backyard (113 kg homestead^{-1}). Average increment of vegetables production after intervention was 545 kg homestead^{-1} which is 505% higher than before intervention (Table 11.9). Vegetables production in homestead area was remarkably might be due to effectively use of different production niches, improved technologies, and judicious management.

Utilization of vegetables: Utilization of homestead produced vegetables in the means of consumption, distribution and sold was recorded regularly with the help of the co-operator farmers. From the results it was found that disposal pattern of vegetables varied from year to year (Table 11.9). Before intervention, vegetables consumption, distribution and selling was 72 kg, 14 kg and 22 kg, respectively whereas after intervention, it was increased remarkably (Consumption: 391 kg, distribution: 66 kg and selling: 195 kg). The average vegetables intake per year per farm family was increased by 443% after program intervention. The better utilization of homestead area with optimum management by effective farm family labor can be

achieved for optimum vegetables production and subsequent consumption, distribution and sold. Surplus vegetables produced in homestead area helped the farmers to earn more cash money from more selling of vegetables. Increased production of vegetables encouraged the farm families to distribute relatively more vegetables to their relatives and neighbor, which might be helpful to increase their inter-relationship.

Fruits production: Improved production technologies like pruning, pest management, judicious and balanced fertilization, and irrigation in quick growing fruit trees (Guava, Papaya, Lemon, Ber and Banana) along with other existing fruit trees (Mango, Jackfruit, Coconut) were provided in the existing homestead garden. By using of improved technologies, fruits production was increased tremendously. Performances of fruit production in the homestead are presented in the Table 11.7 where indicated that, maximum fruits were

Picture11.9 Fruit production at FSRD site, Chanduria, Rajshahi

produced during Kharif-1 season (267 kg homestead^{-1}) and minimum in Rabi season (49 kg homestead^{-1}). It is due to less availability of Rabi (winter) fruits species and HYV varieties, which needs to introduce more winter fruiting fruit trees like Ber, Guava, Malta. After intervention, fruits yield has also increased significantly. The total fruit production was found 390, 405 and 511 kg homestead^{-1} in the Year-I, Year- II and Year - III, respectively (Table 11.8). Increasing trend was found in case of fruit production. The average three years of fruit production was 435 kg homestead^{-1} which was 140% higher over before intervention (181 kg homestead^{-1}).

Utilization of fruits: Disposal pattern (consumption, distribution and selling) of fruits were varied in the year to year (Table 11.9). It is observed that the higher production of fruit resulted the higher consumption. Before intervention, fruits consumption, distribution and selling were 92, 35 and 54 kg, respectively whereas after intervention, it was 165, 53, and 217 kg, respectively. After intervention, the fruits consumption per year per farm family was 147, 155 and 194 kg, in the Year-I, Year- II and Year- III, respectively. Disposal pattern of all items were found to be increasing trend. Thus, it is concluded that, consumption ratio both in vegetables and fruits was increased year to year.

Income from vegetables and fruits: After intervention average gross return, total variable cost, and gross margin of vegetables were 11794, 1965 and Tk. 9829, respectively while it was 1728, 216 and Tk. 1512, respectively before intervention. In case of fruits, gross return, total variable cost, and gross margin were 15672, 1223 and Tk. 14449, respectively after intervention, whereas it was 6516, 162 and Tk. 2754, respectively before intervention (Table 11.9). The increment in gross margin after intervention was 469% higher than that of before intervention (vegetables+Fruit).

Table 11.7 Round the year vegetables and fruits production from different niches of homestead during the years of 2019-2022 at the FSRD site, Chanduria, Rajshahi

Niches/production unit	Production in Rabi season (kg)				Production in Kharif-1 season (kg)				Production in Kharif-2 season (kg)			
	October- March				April-June				July-September			
	Year- I	Year-II	Year-III	Total Avg.	Year- I	Year-II	Year-III	Total Avg.	Year- I	Year-II	Year-III	Total Avg.
Open sunny place	134	141	146	140	108	113	115	112	93	98	100	97
Roof	24	24	26	25	0	0	0	0	17	17	20	18
Trellis	42	42	44	43	24	24	26	25	15	15	16	15
Fence	2	2	2	2	6	6	8	7	0	0	0	0

Niches/production unit	Production in Rabi season (kg)				Production in Kharif-1 season (kg)				Production in Kharif-2 season (kg)			
	October- March				April-June				July-September			
	Year- I	Year- II	Year- III	Total Avg.	Year- I	Year- II	Year- III	Total Avg.	Year- I	Year- II	Year- III	Total Avg.
Tree support	0	0	0	0	0	0	0	0	7	7	10	8
Backyard	28	25	31	28	43	40	45	43	42	40	45	42
Partially shady place	20	20	25	22	3	3	5	4	4	4	5	4
Pond bank	0	3	2	2	0	3	4	2	0	2	3	2
Others (Marshy land)	0	0	0	0	3	3	5	4	9	9	10	9
Total vegetables production	250	257	276	261	187	192	208	196	187	192	209	196
Total fruits production	28	58	61	49	301	201	300	267	61	146	150	119
Total production (vegetables +fruits)	278	315	337	310	488	393	508	463	248	338	359	315

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

Table 11.8 Yearwise vegetables and fruits production from different niches of homestead during the years of 2019-2022 at the FSRD site, Chanduria, Rajshahi

Niches/production unit	Production (kg)			
	Year- I	Year- II	Year- III	Avg. of total
Open sunny place	335	352	361	349
Roof	41	41	46	43
Trellis	81	81	86	83
Fence	8	8	10	9
Tree support	7	7	10	8
Backyard	113	105	121	113
Partially shady place	27	27	35	30
Pond bank	0	8	9	6
Others (Marshy land)	12	12	15	13
Total vegetables production	624	641	693	653
Total fruits production	390	405	511	435
Total production (vegetables +fruits)	1014	1046	1204	1088

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

Table 11.9 Vegetables and fruits production, utilization pattern and cost and returan before and after intervention during the years of 2019-2022 at the FSRD site, Chanduria, Rajshahi

Description	Before intervention		After intervention							
			Vegetables				Fruits			
	Vegetables	Fruit	Year - I	Year- II	Year-III	Avg. three years	Year- I	Year- II	Year-III	Avg. three years
Consumption (kg)	72	92	373	385	416	391	147	155	194	165
Distribution (kg)	14	35	74	55	69	66	51	48	61	53
Selling (kg)	22	54	177	201	208	195	192	202	256	217

Description	Before intervention		After intervention							
			Vegetables				Fruits			
	Vegetables	Fruit	Year - I	Year- II	Year-III	Avg. three years	Year- I	Year- II	Year-III	Avg. three years
Total production (kg)	108	181	624	641	693	653	390	405	511	435
Gross return (Tk.)	1728	6516	9984	11538	13860	11794	14040	14580	18396	15672
Total variable cost (Tk.)	216	162	1872	1923	2100	1965	1170	1000	1500	1223
Gross margin (Tk.)	1512	2754	8112	9615	11760	9829	12870	13580	16896	14449

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

FSRD Site: Jiarokhi, Kushtia

Picture11.10 Vegetables production at FSRD site Jiarokhi, Kushtia

Vegetables production: Using Goyeshpur Model, available and utilizable production niches in homestead areas were brought under cultivation with the specified vegetables. The fallow and under-utilized homestead areas were used scientifically in terms of time and space. In the Goyeshpur Model, seven niches were used in the production system. Vegetables production was increased dramatically since the introduction of established and enhanced technology in the household. The highest average vegetables production was found in Kharif-1 season (297 kg homestead^{-1}) followed by Kharif-2 (253 kg homestead^{-1}) and the lowest (204 kg homestead^{-1}) was found in Rabi seasons (Table 11.10). After intervention, vegetables production increased by 621% (Table 11.12). The remarkable increment of vegetables production in homestead area might be enhanced by using improved technologies and judicious time management.

Utilization of vegetables: The data of utilization pattern of various vegetables produced in the homestead area was kept regularly with the help of co-operator farmers. It was observed that utilization pattern of vegetables varied depending on the total amount of vegetables produced (Table 11.12). After intervention, the average vegetables intake per farm family per year was 522 kg which was only 100 kg farm famil^{-1} year^{-1} before intervention. Vegetables intake farm family^{-1} year^{-1} was increased by 422% after intervention of the sub-project activities. A five member's farm family's vegetables intake was dramatically enhanced, which was 286 g head^{-1} day^{-1}. After intervention the annual distribution of vegetables was 62 kg, and the annual sale of vegetables was 150 kg. Increased vegetables production enabled farm families to give out more vegetables to their relatives and neighbors, which might help them in strengthen their bonds while also allowing them to earn more money by selling more vegetables. For optimal vegetables production and subsequent intake, distribution, and sale, improved exploitation of homestead area combined with optimum management by effective farm family labor can be attained.

Fruits production: Pruning, pest management, fertilization, and irrigation were used to manage fast-growing fruit trees (guava, papaya, lemon, ber and banana) as well as existing fruit trees (mango, jack fruit, coconut, wood apple and pummelo). Fruit production has been expanded dramatically since the introduction of established and enhanced technologies in the household. The highest average fruit production (73 kg homestead^{-1}) was found in Kharif-2 season, followed by Kharif-1 season (65 kg homestead^{-1}) and the lowest (53 kg homestead^{-1}) in Rabi season (Table 11.10). During the Rabi season, less fruits were produced, which is owing to a lack of Rabi (winter) fruit species, so scientists should focus on developing more winter fruit varieties. Fruit production was increased by 1180%, after program

intervention compared to before intervention (Table 11.12). The use of better technologies in fruit production, such as judicious fertilizer use, has greatly increased productivity.

Utilization of fruits: The disposal pattern of various fruits produced in the homestead area was meticulously recorded. The average annual fruit intake per farm family was found 40 kg after program intervention but it was only 15 kg before intervention. The increment of fruit production was 177 kg household^{-1} after intervention (Table 11.12). After intervention, annual fruit distribution was 13 kg, and annual fruit sales were 138 kg. Increased fruit production encouraged farm families to share with their relatives and neighbors, while farmers were more interested in selling to make a profit.

Income from vegetables and fruits: After intervention, from the vegetables production average gross return per farm was recorded as Tk. 16160 with the average gross margin Tk. 10327 which was only Tk. 2040 and Tk. 1040, respectively before intervention. From the fruits sector, after intervention, average gross return per farm was recorded as Tk. 5750 with the average gross margin of Tk. 4750 which was only Tk. 300 before intervention (Table 11.12).

Table 11.10 Round the year vegetables and fruits production from different niches of homestead during the years of 2019-2022 at FSRD Site, Jiarokhi, Kushtia

Niches/production unit	Production in Rabi season (kg)				Production in Kharif-1 season (kg)				Production in Kharif-2 season (kg)			
	October- March				April-June				July-September			
	Year -I	Year -II	Year - III	Total Avg.	Year- I	Year- II	Year- III	Total Avg.	Year -I	Year- II	Year- III	Total Avg.
Open sunny place	40	50	54	48	132	140	148	140	72	78	80	77
Roof	32	35	37	35	20	26	30	25	55	65	70	63
Trellis	40	42	48	43	15	20	24	20	18	22	26	22
Fence	25	30	32	29	18	24	22	21	12	15	20	16
Tree support	5	8	10	8	20	20	24	21	15	18	20	18
Marshy land	0	0	0	0	10	15	18	14	12	14	12	13
Backyard	8	10	14	11	5	8	10	8	4	16	15	12
Partially shady place	4	6	10	7	7	6	10	8	8	11	12	10
House boundary	10	12	15	12	8	10	14	11	8	10	14	11
Pond bank	8	10	14	11	7	12	14	11	8	13	12	11
Total (vegetable)	172	203	234	204	242	281	314	297	212	262	281	253
Fruits	45	52	63	53	50	57	88	65	65	70	85	73
Total (vegetables +fruit)	217	255	297	257	292	388	402	362	277	332	366	326

* Year I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

Table 11.11 Yearwise vegetables and fruits production from different niches of homestead during 2019-2022 at FSRD Site, Jiarokhi, Kushtia

Niches/production unit	Production (Kg)			
	Year- I	Year- II	Year- III	Avg. of total
Open sunny place	244	268	282	265
Roof	107	126	137	123
Trellis	73	84	98	85
Fence	55	69	74	66
Tree support	40	46	54	47
Marshy land	22	29	30	27
Backyard	17	34	39	30
Partially shady place	19	23	32	25
House boundary	26	32	43	34
Pond bank	23	35	37	32
Total vegetables production	626	746	829	734
Total fruits production	160	195	220	192
Total production (vegetables +fruits)	786	941	1046	924

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

Table 11.12 Vegetables and fruits production, utilization pattern and cost and return before and after intervention during the years of 2019-2022 at FSRD Site, Jiarokhi, Kushtia

Description	Before intervention		After intervention							
	Vegetables	Fruit	Vegetables				Fruits			
			Year- I	Year- II	Year- III	Avg. three years	Year- I	Year- II	Year- III	Avg. three years
Consumption (kg)	100	15	450	525	590	522	30	40	50	40
Distribution (kg)	12	0	36	71	79	62	10	15	15	13
Selling (kg)	0	0	140	150	160	150	120	140	155	138
Total production (kg)	112	15	626	746	829	734	160	195	220	192
Gross return (Tk.)	2040	300	14000	16700	17800	16160	4800	5850	6600	5750
Variable cost (Tk.)	1000	0	6000	6000	6500	5833	800	1000	1200	1000
Gross margin (Tk.)	1040	300	8000	10700	11300	10327	4000	4850	5400	4750

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

FSRD Site: Kamalbazar, Sylhet

Vegetables production: Following the Golapgonj Model, several niches of the homestead areas were brought under cultivation with the specified vegetables. In terms of time and space, the fallow and under-utilized homestead areas were used scientifically. In the Golapgonj Model, nine niches were used in the production system. Vegetables production has been increased dramatically in the homestead after the use of proven and alternative methods.

Picture11.11 Vegetables production at FSRD site, Kamalbazar, Sylhet

It was observed that the average vegetables production was (154 kg homestead^{-1}) in Rabi season followed by Kharif-I (107 kg homestead^{-1}) and Kharif-II (69 kg homestead^{-1}) season (Table 11.13). Kharif-II season was a relatively dull season for vegetables production, with periodic rainfall affecting most of the crops. Before the intervention, vegetables production per family was found 21 kg which increase to 329 kg after the intervention of sub-project activities (Table 11.15). Using alternative technologies with time management, the substantial increase in vegetables production was found in the homestead area.

Utilization of vegetables: The findings revealed that the pattern of vegetables disposal varied depending on the total amount of vegetables produced (Table 11.15). The average vegetables intake per year per farm family was 121 kg after program intervention whereas intake was only 15 kg per farm family per year before program intervention. Vegetables intake by a number of 5 member's farm family was increased remarkably and it was on an average 153 g head^{-1} day^{-1}. After intervention, the distribution of vegetables per year was recorded 35 kg and sell of vegetables per year was 174 kg. Increased vegetables production enabled farm families to give out more vegetables to their relatives and neighbors, which might help them to strengthen their bonds while also allowing them to earn more money by selling more vegetables. For optimal vegetables production and subsequent intake, distribution, and sale, improved exploitation of homestead area combined with optimum management by effective farm family labor can be attained.

Fruits production: Pruning, pest management, fertilization, and irrigation were used to manage fast-growing fruit trees (guava, papaya, lemon, ber, banana, coconut and malta) as well as existing fruit trees (mango, jack fruit and pummelo). Fruit production has been increased dramatically in the homestead with the implementation of proven and alternative methods. The highest amount of average fruits production was found in Kharif-II season (169 kg homestead^{-1}) followed by Kharif-I season (167 kg homestead^{-1}) and Rabi season (114 kg homestead^{-1}), which was more or less the reverse scenario of vegetables production (Table 11.13). This is owing to a lack of Rabi (winter) fruit varieties and kinds, which scientists should give more focus on developing more winter fruit varieties. The use of alternative technology in fruit production, such as prudent fertilizer control, has greatly enhanced productivity.

Utilization of fruits: The disposal pattern of various fruits produced in the homestead area was meticulously recorded. The average annual fruit intake per farm family was found 280 kg after program intervention which was 50 kg before intervention (Table 11.15). After the program's implementation, the annual distribution of fruits was 72 kg, and the annual sale of fruits was 83 kg. Increased fruit output encouraged farm families to share with their relatives and neighbors, but farmers were more interested in consuming and selling to make money.

Income: After intervention, from the vegetables production average gross return per farm was recorded as Tk. 10642 with the average gross margin of Tk. 6808 which was only Tk. 420 and Tk. 270, respectively before intervention. From the fruits sector, after program intervention, average gross return per farm was recorded as Tk. 35493 with the average gross margin of Tk. 25927 which was only Tk. 6720 and Tk. 5220, respectively before intervention (Table 11.15).

Table 11.13 Round the year vegetables and fruits production from different niches of homestead during 2019 to 2022 at FSRD Site, Kamalbazar, Sylhet

Niches/production unit	Production in Rabi season (kg)				Production in Kharif-I season (kg)				Production in Kharif-II season (kg)			
	October – March				April – June				July - September			
	Year-I	Yea-II	Year-III	Total avg.	Yea- I	Year-II	Year-III	Total avg.	Year-I	Year-II	Year-III	Total avg.
Open Sunny place	56	105	112	91	17	42	55	38	12	33	34	26.3
Roof	12	27	29	22.7	13	22	24	19.7	1	4	15	6.7
Trellis	10	17	21	16	11	17	19	15.7	5	9	11	8.3
Fence	0	2	4	2	4	7	11	7.3	2	5	6	4.3
Tree support	0	0	0	0	2	5	6	4.3	0	4	9	4.3
Marshy land	0	3	6	3	0	0	0	0	2	8	11	7
Backyard	8	17	19	14.7	11	16	21	16	4	9	9	7.7
Partially shady place	0	6	7	4.3	4	6	7	5.7	2	4	8	4.7
Total vegetables production	86	177	198	153.7	63	115	143	107	28	76	103	69
Total fruits production	55	136	150	113.7	77	195	230	167.3	85	210	213	169.3
Total production (vegetables + fruits)	141	313	348	267.3	140	310	373	274.3	113	286	316	238.3

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

Table 11.14 Yearwise vegetables and fruits production from different niches of homestead during 2019 to 2022 at FSRD Site, Kamalbazar, Sylhet

Niches/production unit	Production (Kg)			
	Year- I	Year- II	Year- III	Avg. of total
Open Sunny land	86	180	201	155.7
Roof	26	53	68	49
Trellis	26	43	51	40
Fence	06	14	21	13.7
Tree support	02	09	14	8.3
Marshy land	02	11	17	10
Backyard	23	42	49	38
Partially shady place	06	16	22	14.7
Total vegetables production	177	368	443	329.3
Total fruits production	217	541	573	443.7
Total production (vegetables + fruits)	394	909	1016	773

* Year- I= Oct. 2019-Sep. 2020; Yea- II= Oct. 2020-Sep. 2021; Year -III= Oct. 2021-Sep. 2022

Table 11.15 Vegetables and fruits production, utilization pattern and cost and return before and after intervention during 2019 to 2022 at FSRD Site, Kamalbazar, Sylhet

Description	Before intervention		After intervention							
	Vegetables	Fruit	Vegetables				Fruits			
			Year- I	Year- II	Year -III	Avg. three years	Year- I	Year-II	Year-III	Avg. three years
Consumption (Kg)	15	50	80	130	152	121	170	335	360	280
Distribution (Kg)	6	24	27	36	42	35	30	91	95	72
Selling (Kg)	0	10	70	202	249	174	17	115	118	83
Total production (Kg)	21	84	177	368	443	329	217	541	573	444
Gross return (Tk.)	420	6720	3540	12880	15505	10642	17360	43280	45840	35493
Total variable cost (Tk.)	150	1500	1500	4500	5500	3833	7000	10500	11200	9567
Gross margin (Tk.)	270	5220	2040	8380	10005	6808	10360	32780	34640	25927

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-Sep. 2022

11.1.1.2 Year-round vegetables and fruits production in homestead area at FSRD site Naikhongchari, Bandarban of BLRI component

Before intervention, the different niches of a homestead area were not used properly for production purpose. Farmers successively learned to use these niches with the technical help after intervention. The production from different niches after intervention is given in Table 11.16. After intervention, vegetables production homestead^{-1} from different niches were estimated 431 kg, 522 and 229 kg respectively in the 1st, 2nd and 3rd year respectively (Table 11.17).

Vegetables production: The vegetables cultivation program at homestead area was carried out for three consecutive years at FSRD site, following the "Modified Khagrachhari Model" from October 2019 to May 2022 (Table 11.16). From the results, it was found that the highest amount of vegetables produced from trellis (251 Kg) and lowest amount of vegetables from backyard (23 Kg). It was also observed that, the vegetables production was maximum in Rabi season (148, 192 and 229 kg homestead^{-1} in 1st, 2nd and 3rd year, respectively) followed by Kharif-2 season (Table 11.16). After intervention of the improved technologies, the average vegetables production was increased 85% compared to before intervention of the program (Table 11.18). Using of improved technologies and judicious time management for vegetables production might be enhanced the remarkable increment of vegetables production in homestead area.

Table 11.16 Year-round vegetables and fruits production from different niches at FSRD Site, Naikhongchari during 2019-2022

Niches/production unit	Production in Rabi season (kg)				Production in Kharif-1 season (kg)				Production in Kharif-2 season (kg)			
	October- March				April-June				July-September			
	Year-I	Year-II	Year-III	Total Avg.	Year- I	Year- II	Year- III	Total Avg.	Year- I	Year-II	Year- III	Total Avg.
Open sunny place	20	25	30	30	18	22	0	20	20	25	0	22.5
Roof	18	23	28	27.6	12	10	0	11	15	18	0	16.5
Trellis	45	56	62	65.2	17	21	0	19	30	20	0	25
Fence	18	28	37	33.2	13	18	0	15.5	12	15	0	13.5
Tree support	11	9	13	13.2	9	12	0	10.5	10	13	0	11.5
Marshy land	9	12	9	12	20	15	0	17.5	25	18	0	21.5
Backyard	0	3	4	2.8	4	6	0	5	2	4	0	3
Partially shady place	15	28	35	31.2	25	42	0	33.5	22	39	0	30.5
House boundary	12	8	11	12.4	16	11	0	13.5	13	21	0	17
Total vegetables production	148	192	229	227.6	134	157	0	145.5	149	173	0	161
Total fruits production	36			12	82		0	41	72		0	36

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.12 Vegetables production in homestead area at FSRD Site, Naikhongchari, Bandarban

Utilization of vegetables: The disposal pattern of different vegetables produced in the homestead area was recorded regularly through the help of the co-operator farmers (Table 11.18). The average vegetables intake per year farm family was 320 kg after program intervention and the increment was 60%, whereas intake was only 200 kg per farm family per year before program intervention. After intervention, the average distribution of vegetables per year was recorded as 43 kg and average sell was 110 kg. Increased production of vegetables encouraged the farm families to distribute relatively more vegetables to their relatives and neighbor, which might be helpful to increase their relationship and also helped them to earn more money from more selling of vegetables. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetables production and subsequent intake, distribution and sell.

Fruits production: Season and year wise fruits production are presented in the Table 11.16 and 11.17. Among the three season the highest amount of fruits were produced in kharif-I season followed by kharif-II and rabi those were 82, 72 and 36 Kg homestead^{-1}, respectively (Table 11.16). On the other hand highest amount of fruits were produced in year II and lowest in year III those were 94 and 56 Kg homestead^{-1}, respectively (Table 11.17). Maximum fruits were produced during Kharif-I and Karif-II season and minimum fruits during Rabi season due to less availability fruits species and variety in this season. In this regard, scientists should give more emphasis to develop more winter fruits varieties. After implementation of the program, the fruits productions were increased 40% compared to before intervention of the program (Table 11.18)

Picture 11.13 Homestead fruit production at FSRD site Naikhongchari, Bandarban

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely in three consecutive years. The three years average fruit intake per year per farm family was 64 kg after program intervention, whereas it was only 50 kg before intervention and the 28% increment was mainly due to increment of total production and motivation (Table 11.18). After intervention, the average distribution of fruits per year was recorded as 8 kg household^{-1} and sale of fruits per year was 19 kg household^{-1}. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested to sell for getting some cash money.

Income from homestead vegetables and fruits production: After intervention of homestead production system, gross return from vegetables production were 6465, 8613 and Tk. 4466 and gross margin were estimated 5205, 6833 and Tk. 3490 per household in 1st , 2nd and 3rd year, respectively. The average gross margin was 175% higher after intervention compared to before intervention (Table 11.18). In case of fruits sector, after intervention, gross return per household from homestead production was recorded as Tk. 1786, 2350 and 1554 in 1st , 2nd and 3rd year, respectively. The gross margin per household from homestead fruits production was found Tk. 1426, 1880 and 1254, respectively in 1st, 2nd and 3rd year. After intervention farmers received 76% higher gross margin compared to before intervention.

Table 11.17 Yearwise vegetables and fruits production at homestead during 2019- 2022 (Per homestead) at FSRD site, Naikhongchari

Niches/production unit	Production (Kg)				
	Year- I	Year- II	Year- III	Total	Avg. of 3 yrs
Open sunny place	58	72	30	160	64
Roof	45	51	28	124	49.6
Trellis	92	97	62	251	100.4
Fence	43	61	37	141	56.4
Tree support	30	34	13	77	30.8
Marshy land	54	45	9	108	43.2

Niches/production unit	Production (Kg)				
	Year- I	Year- II	Year- III	Total	Avg. of 3 yrs
Backyard	6	13	4	23	9.2
Partially shady place	62	109	35	206	82.4
House boundary	41	40	11	92	36.8
Total vegetables production	431	522	229	1182	472.8
Total fruits production	76	94	56	226	91

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.18 Vegetables and fruits production, utilization pattern and income before and after intervention during 2019 to 2022 at FSRD site, Naikhongchari, Bandarban

Description	Before intervention		After intervention							
	Vegetables	Fruit	Vegetables				Fruits			
			Yea- I	Year- II	Year- III	Avg. three years	Year- I	Year- II	Year- III	Avg. three years
Consumption (Kg)	200	50	300	350	150	320	55	65	40	64
Distribution (Kg)	27	4	40	48	20	43	6	9	4	8
Selling (Kg)	29	11	91	124	59	110	15	20	12	19
Total production (Kg)	256	65	431	522	229	473	76	94	56	91
Gross return (Tk.)	2816	1300	6465	8613	4465.5	7817	1786	2350	1554	2276
Variable cost (Tk.)	560	265	1260	1780	976	1606	360	470	300	452
Gross margin (Tk.)	2256	1035	5205	6833	3489.5	6211	1426	1880	1254	1824

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Yea- III= Oct. 2021-May 2022

11.1.2 Family labor utilization pattern in homestead production system during the years of 2019 to 2022

11.1.2.1 Family labor utilization pattern in homestead production at different FSRD sites of BARI component

The homestead production system gave an opportunity for women's employment and empowerment. It was revealed that women had a good involvement in seed and seedling production and planting, intercultural operation, harvesting and marketing of vegetables and fruits (Table 11.19). It is revealed that women are coming forward and participating more in the income generation system. Hard work activities were mostly done by the male workers. Children also help the men and women in production systems, especially in soft-working areas. However, cooking (98%) was done by women. Only 2% of the cooking work was done by men and children when the housewife was sick or absent. So, it was found that homestead gardening has created a good opportunity to utilize the unused labor of women and children properly.

Picture11.14 Family labor utilization pattern at FSRD site, Basantapur, Rajshahi

Table 11.19 Family labor utilization pattern (average) for homestead vegetables and fruits production at five FSRD sites of BARI

Work area	Men (%)	Women (%)	Children (%)
Land preparation	81	17	2
Seed/seedling production	53	41	6
Sowing/planting	50	43	7
Intercultural operation	37	55	8
Harvesting	27	64	9
Marketing	70	28	2
Cooking	1	98	1

11.1.2.2 Family labor utilization pattern in homestead production at FSRD site Naikhongchari, Bandarban of BLRI component

Man played significant role in land preparation, intercultural operation, seedlings and marketing that contributed 71, 65, 63 and 60%, respectively of total labour utilization in homestead production system (Table 11.20). Woman contributed 95% in cooking. Women also contributed significant role in harvesting, sowing/planting, marketing and seedling. Contribution of children in labour supply for homestead production ranged 2-5% in harvesting, cooking, land preparation, sowing and intercultural operations.

Table 11.20 Family labor utilization pattern for homestead production system at FSRD site Naikhongchari, Bandarban

Work area	Men (%)	Women (%)	Children (%)
Land preparation	71	25	4
Seed/seedling	63	37	0
Sowing/planting	50	45	5
Intercultural operations	65	30	5
Harvesting	18	80	2
Marketing	60	40	0
Cooking	2	95	3

Picture 11.15 Family labour utilization pattern at FSRD Site Naikhongchari, Bandarban

11.1.3 Plantation and management of fruit tree during 2019-2022

Cultivation of fruit crops plays an important role in the prosperity of any nation. It is generally stated that the standard of living of the people can be judged by per capita production and consumption of fruits. Fruits are found to be a rich source of vitamins and minerals. Importance of fruits in human diet is well recognized. Man cannot live on cereals alone. Fruit growing have economic and nutritional advantages.

From a unit area of land more yield is realized from fruit crops than any of the agronomic crops. To increase nutrient intake from fruits sector, it needs to increase the number of quality fruit plants in the homestead.

11.1.3.1 Plantation of fruit trees at different FSRD sites of BARI component

FSRD site: Basantapur, Rajshahi

Sapling/seedling distribution: The number and quality of fruits plants in the homestead should be raised to increase nutrient intake from the fruits sector. A variety of high-quality fruit and other saplings, such as mango, guava, papaya, malta, sugarcane, and drumstick, were delivered to the homestead. In addition, in the crop land, a mango orchard was established. Total number of saplings of various fruit plants that were distributed is presented in the Table 11.21. Total number of supplied saplings of different fruits, drumstick and sugarcane settling were 1166. The saplings are in good condition and survival rate ranges from 80-96%.

Picture11.16 Sapling distribution of fruit tree at FSRD site, Basantapur, Rajshahi

Table 11.21 Number of fruits and other saplings distributed among the farmers at FSRD site, Basantapur, Rajshahi during 2020-2021

Sl. No	Types of fruits sapling	Variety	Number			Survival rate (%)
			Year- I	Year- II	Total	
1	Mango	BARI Aam-4	100	80	180	96
3	Guava	BARI Peyara-2	24	24	48	90
4	Malta	BARI Malta-1	24	24	48	90
6	Papaya	BARI Papaya-1	120	240	360	80
8	Drumstick	Local	60	40	100	85
9	Sugarcane	BSRI Akh 42 (Rangbilash)	250	180	430	90
		Total	578	588	1166	80-96

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021

FSRD site: Amnura, Chapainawabganj

To improve nutritional intake from the fruits sector, the number and quality of fruits plants in the home must be raised. A variety of fruit saplings, including mango, guava, papaya, malta, moringa, and sugarcane, were delivered to the household. Total number of saplings of various fruits plants that were delivered is presented in the Table 11.22. In addition, a mango orchard was established nearby homestead. FSRD team also offer professional assistance to farmers for better fruit tree management, including fertilizer, irrigation, and insect and disease control. Total number of supplied saplings of different fruits and sugarcane settling were 1162. The saplings are in good condition and survival rate ranges from 80-95%.

Table 11.22 Number of fruits and other saplings distributed among the farmers at Amnura, Chapainawabganj during 2020-2021

Sl. No	Types of fruits sapling	Variety	Number		Total	Survival rate (%)
			Year- I	Year- II		
1	Mango	BARI Aam-4	130	86	216	95
3	Guava	BARI Peyara-2	24	24	48	90
4	Malta	BARI Malta-1	24	24	48	90
6	Papaya	BARI Papaya-1	120	180	300	80
8	Moringa	Local	60	60	120	80
9	Sugarcane	BSRI Akh 42 (Rangbilash)	250	180	430	90
Total			608	554	1162	80-95

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021

FSRD Site: Chanduria, Rajshahi

For increasing nutrient intake of famers from fruits sector, the number and quality of fruits plant in the homestead needs to be increased. Twelve species/varieties of nine fruit and other sapling were distributed among the target farmers of FSRD Site Chanduria, Rajshahi (Table 11.23). Chewing type sugarcane namely BSRI Akh 42 (Rangbilash) was also distributed among the farmers. Total number of distributed saplings was 816 and mortality rate ranged from 2-10%.

Picture11.17 Sapling distribution of fruit tree at FSRD site, Chanduria, Rajshahi

Table 11.23 Number of fruits and other saplings distributed among the farmers at FSRD Site, Chanduria, Rajshahi during the years of 2020 to 2021

Sl. No	Types of fruits sapling	Variety	Number			Mortality rate (%)
			Year-I	Year- II	Total	
1	Mango	BARI Aam-3	36	36	72	5
		BARI Aam-4	24	24	48	5
		BARI Aam-11	24	24	48	5
2	Guava	BARI Peyara-2	24	24	48	10
3	Malta	BARI Malta-1	24	24	48	5
4	Papaya	Local	108	108	216	10
5	Lemon	BARI Lebu-2	15	15	30	2
6	Bay Leaves	BARI Tejpata-1	12	12	24	2
7	Dragon fruit	BARI Dragon Fruit-1	15	15	30	2
8	Pummelo	BARI Batabilebu-3	15	15	30	2
9	Sugarcane	BSRI Akh 42 (Rangbilash)	106	80	150	5
Total			403	377	744	2-10

* Year- I= Oct 2019-Sep .2020; Year- II= Oct 2020-Sep.2021

FSRD Site: Jiarokhi, Kushtia

A variety of fruit saplings, including mango, guava, papaya, Malta, drumstick and sugarcane were delivered to the household. Total number of various fruits saplings that were delivered is presented in the Table 11.24. In addition, a mango orchard was established nearby homestead. The project personnel offer professional assistance to farmers for better fruit tree management, including fertilizer, irrigation, and insect and disease control. Total number of supplied saplings of different fruits and sugarcane settling were 1078. The saplings are in good condition and mortality rate ranges from 1-5%.

Table 11.24 Number of fruits and other saplings distributed at FSRD Site, Jiarokhi, Kushtia during the years of 2020 to 2021

Sl. No	Type of fruits sapling	Variety	Number			Mortality rate (%)
			Year- I	Year- II	Total	
1	Mango	BARI Aam-4	75	85	160	2
2	Litchi	BARI Litchi-3	16	10	26	3
3	Guava	Thai-10	103	70	173	5
4	Malta	BARI Malta-1	12	10	22	2
5	Lime	Thai	4	3	7	1
6	Papaya	Local	36	40	76	3
7	Dragon fruit	BARI Dragon Fruit-1	26	50	76	0
8	Ber	Commercial cultivar (Ball shundori)	112	105	217	3
9	Drumstick	Local	26	20	46	4
10	Sugarcane	BSRI Akh 42 (Rangbilash)	130	145	275	0
Total			540	538	1078	0-5

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021

FSRD Site: Kamalbazar, Sylhet

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. Based on this viewpoint, a few different fruit saplings (mango, litchi, satkara, jara lebu, litchi, malta, papaya, sugarcane, and bettle nut) were distributed to the households of farming system area. The supplied total number of saplings of different fruits plants and sugarcane sets are shown in Table 11.25. Furthermore, two Malta and one Jara lebu orchards were established in nearby homestead. FSRD team also provided technical support to the farmer for better management of supplied fruit saplings such as fertilization, irrigation and disease pest control. Total number of supplied saplings of different fruits and sugarcane settling were 1570. The saplings are in good condition and survival rate ranges from 80-100%.

Table 11.25 Number of fruits and other saplings distributed at FSRD site, Kamalbazar, South Surma, Sylhet during the years of 2020-2021

Sl. No	Types of fruit saplings	Variety	Yearwise number of saplings distributed			Survival rate (%)
			Year- I	Year –II	Total	
1	Mango	BARI Aam-3	24	36	60	90
2	Litchi	BARI Litchi-3	20	48	68	85
3	Guava	BARI Peyara-2	60	100	160	95
4	Malta	BARI Malta-1	140	200	340	90
5	Papaya	Local	60	30	90	92
6	Satkora	BARI Satkora-1	60	80	140	95
7	Jara lebu	BARI Jaralebu-1	80	160	280	98
8	Bettle nut	Local	60	200	260	100
9	Sugarcane	BSRI Akh 42	24	48	72	80
10	Bilimbi	BARI Bilimbi-1	60	40	100	90
			588	942	1570	80-100

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021

11.1.3.2 Plantation of fruit trees in homestead area at FSRD site Naikhongchari, Bandarban of BLRI component

To increase nutrient intake from fruits sector, it needs to increase the number of quality fruit plants in the homestead. From this view, a number of different quality fruit saplings of BARI developed and locally popular varieties were supplied. Total 2683 different types of fruit saplings were supplied among the cooperator farmers during 2020-2021 (Table 11.26). Saplings are in good condition and survival rate ranges from 70-95%. Technical support (fertilization, irrigation, insect and disease control etc.,) was provided to the farmer for better management of fruit trees.

Table 11.26 Fruit saplings distribution at FSRD site Naikhongchari, Bandarban during 2020 - 2021

Sl. No.	Types of fruit saplings	Variety Name	Number			Survival rate (%)
			Year-I	Year-II	Total	
1	Papaya	Red lady (Hybrid)	406	371	777	70
2	Mango	Renguish (Local)	120	100	220	85
		Harivangha	50	60	110	87
		BARI Aam-3	20	50	70	81
		BARI Aam -4	31	49	80	83
3	Lemon	BARI Lebu-1(seedless)	398	414	812	76
4	Malta	BARI Malta-1	174	162	336	78
5	Dragon Fruit	BARI Dragon Fruit-1	138	140	278	95
Total			1337	1346	2683	Range: 70-95

* Year- I= Oct .2019- Sep. 2020; Year- II= Oct. 2020- Sep. 2021

Picture 11.18 Fruit saplings distribution at FSRD site Naikhongchari, Bandarban

11.1.3.3 Management of fruit trees for increasing fruits production in homestead area at different FSRD sites of BARI during the years of 2019 to 2022

Pest management of fruit tree: Fruit trees, which are abundant in the homestead region, are the best source of human sustenance. Pests were shown to be the primary hindrance to appropriate edible fruit production in most cases, which inhibits farmers from planting fruit trees in their homestead. However, a basic technology (two-time pesticide and fungal sprays, once just before flower blooming and once at pea-size fruit stage) can help with domestic fruit output. Pesticide spraying activities at each FSRD site were conducted safely. A total of 1186 fruits trees were sprayed with insecticide and pesticide, with mango trees accounting for the most (388). Across the location, in total the highest number (594) of fruit trees were sprayed with different

Picture11.19 Pest management activities of fruit tree at FSRD site, Basantapur, Rajshahi

pesticides, where the maximum fruit trees were papaya (216) and mango (168) at FSRD site Chanduria, Rajshahi (Table 11.27).

Table 11.27 Number of fruit trees sprayed for hopper and other pest control at different FSRD sites of BARI during the year of 2019-2022

FSRD site	Mango	Guava	Malta	Papaya	Coconut	Others*	Total
Basantapur, Rajshahi	100	35	45	60	20	40	300
Amnura, Chapainawabganj	120	26	30	70	8	38	292
Chanduria, Rajshahi	168	48	48	216	10	104	594
Total	388	109	123	346	38	182	1186

11.2 Crops and Cropping System

11.2.1 Improvement of cropping pattern (CP) during 2019-2022

The crops and cropping system in rainfed ecosystem were performed with a view to develop improved cropping pattern as well as to increase crop productivity by introducing new technology or variety. Following crops and cropping systems were practiced in different FSRD sites, during 2019-2022.

11.2.1.1 Improvement of cropping pattern (CP) at different FSRD sites of BARI component

FSRD Site: Basantapur, Rajshahi

Cropping pattern-I

Improved Pattern (IP): Mustard (var. BARI Sarisha-17)-Boro (var. BRRI dhan81)-T. Aman (var. BRRI dhan49)

Existing Pattern (EP): Boro (var. BRRI dhan28) -Fallow-T. Aman (var. Sharwna)

The yield performance, cost and return of the improved pattern (Mustard-Boro-T. Aman rice) against existing pattern (Boro-Fallow- T. Aman rice) are presented in Table 11.28, 11.29 and 11.30. Average rice equivalent yield (REY) of IP was 14.48 t ha^{-1} against 9.65 t ha^{-1} in EP (Table 11.30). The increment of REY in IP was 50% over EP due to the introduction of new crop, modern variety, and improved crop management practices. The average gross margin of IP was Tk. 219210 ha^{-1} while Tk. 131690 ha^{-1} in EP. On an average, MBCR of IP was 3.85 over EP. A similar trend was observed in Year-I and Year-II.

Mustard

Boro rice

T. Aman rice

Picture11.20 Alternative cropping pattern at FSRD site, Basantapur, Rajshahi

Table 11.28 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Sarisha-17	BRRI dhan81	BRRI dhan49	BRRI dhan28	-	Sharwna
Seed/grain yield (t ha^{-1})	1.65	5.60	4.76	5.32	-	4.32
Stover/straw (t ha^{-1})	3.38	6.22	5.80	5.96	-	5.56
Rice equivalent yield (t ha^{-1})	3.71	5.60	4.76	5.32	-	4.32
Whole pattern Rice equivalent yield (t ha^{-1})	14.07			9.64		

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Sarisha-17	BRRI dhan81	BRRI dhan49	BRRI dhan28	-	Sharwna
Gross return (Tk. ha^{-1})	74250	118220	106800	112360	-	86720
Variable cost (Tk. ha^{-1})	30750	47550	40250	47100	-	41500
Gross margin (Tk. ha^{-1})	43500	70670	66550	65260	-	45220
Total gross return (Tk. ha^{-1})	299270			199080		
Total variable cost (Tk. ha^{-1})	118550			88600		
Total gross margin (Tk. ha^{-1})	180720			110480		
MBCR	3.34					

*Output price (Tk.kg^{-1}). Mustard: 45.00, rice grain: 20, rice straw: 1.00

Table 11.29 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Sarisha-17	BRRI dhan81	BRRI dhan49	BRRI dhan28	-	Sharwna
Seed/grain yield (t ha^{-1})	1.70	5.75	4.88	5.38	-	4.28
Stover/straw (t ha^{-1})	3.42	6.18	5.87	6.02	-	5.58
Rice equivalent yield (t ha^{-1})	4.25	5.75	4.88	5.38	-	4.28
Whole pattern Rice equivalent yield (t ha^{-1})	14.88			9.66		
Gross return (Tk. ha^{-1})	110500	143750	122000	134500	-	107000
Variable cost (Tk. ha^{-1})	30750	47550	40250	47100	-	41500
Gross margin (Tk. ha^{-1})	79750	96200	81750	87400	-	65500
Total gross return (Tk. ha^{-1})	376250			241500		
Total variable cost (Tk. ha^{-1})	118370			88600		
Total gross margin (Tk. ha^{-1})	257700			152900		
MBCR	4.35					

*Output price (Tk./kg): Improved and existing: Mustard: 65.00, rice: 25.00, rice straw: 1.00

Table 11.30 Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2019-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Sarisha-17	BRRI dhan81	BRRI dhan49	BRRI dhan28	-	Sharwna
Seed/grain yield (t ha^{-1})	1.68	5.68	4.82	5.35	-	4.30
Stover/straw (t ha^{-1})	3.40	6.20	5.84	5.99	-	5.57
Rice equivalent yield (t ha^{-1})	3.98	5.68	4.82	5.35	-	4.30
Whole pattern Rice equivalent yield (t ha^{-1})	14.48			9.65		
Gross return (Tk. ha^{-1})	92375	130985	114400	123430	-	96860
Variable cost (Tk. ha^{-1})	30750	47550	40250	47100	-	41500
Gross margin (Tk. ha^{-1})	61625	83435	74150	76330	-	55360
Total gross return (Tk. ha^{-1})	337760			220290		
Total variable cost (Tk. ha^{-1})	118460			88600		
Total gross margin (Tk. ha^{-1})	219210			131690		
MBCR	3.85					

Cropping pattern-II

Improved Pattern (IP): Wheat (var. BARI Gom-30)-Sesame (var. BARI Til-4)-T. Aman (var. BRRI dhan51)

Existing Pattern (EP): Wheat (var. BARI Gom-28)-Fallow-T. Aman (var. Sharwna)

The yield performance, cost and return of the improved pattern; Wheat (BARI Gom-30)-Sesame (BARI Til-4)-T. Aman (BRRI dhan51) against existing pattern Wheat (BARI Gom-28)-Fallow-T. Aman (Sharwna) is presented in Table 11.31, 11.32, and 11.33.

The EP was Wheat-Fallow-T. Aman rice while sesame being added to the IP. Varietal improvement was also carried out in IP. Average REY in IP was found to be 12.87 t ha^{-1}, while the value in EP was 8.87. The productivity increase was 45 percent. The increased output was primarily due to the addition of another crop, improved variety, and better management practices. Productivity and economic performance were similar. In IP, the gross margin was Tk. 153465 ha^{-1}, whereas in EP, it was Tk. 111485 ha^{-1}. The MBCR in IP was 1.97.

Wheat Sesame T. Aman rice

Picture11.21 Alternative cropping pattern at FSRD site, Basantapur, Rajshahi

Table 11.31 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Til-4	BRRI dhan51	BARI Gom-28	-	Sharwna
Seed/grain yield (t ha^{-1})	4.30	1.10	5.28	3.70	-	4.86
Stover/straw (t ha^{-1})	5.80	2.11	6.10	5.12	-	6.01
Rice equivalent yield (t ha^{-1})	4.83	2.75	5.28	3.70	-	4.86
Whole pattern Rice equivalent yield (t ha^{-1})	12.86			9.02		
Gross return (Tk. ha^{-1})	96750	55000	111610	83250	-	103210
Variable cost (Tk. ha^{-1})	35625	33750	40250	34600	-	39250
Gross margin (Tk. ha^{-1})	61125	21250	71360	50650	-	63960
Total gross return (Tk. ha^{-1})	263360			186460		
Total variable cost (Tk. ha^{-1})	109625			73850		
Total gross margin (Tk. ha^{-1})	153735			114610		
MBCR	2.14					

*Output price (Tk. kg^{-1}): Wheat: 22.50, Sesame: 50, rice grain: 20, rice straw: 1.00

Table 11.32 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2020-2021

Observation	**Improved cropping pattern**			**Existing cropping pattern**		
Crop	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Til-4	BRRI dhan51	BARI Gom-28	-	Sharwna
Seed/grain yield (t ha^{-1})	4.12	1.25	5.12	3.46	-	4.82
Stover/straw (t ha^{-1})	5.78	2.32	6.18	5.22	-	5.96

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Til-4	BRRI dhan51	BARI Gom-28	-	Sharwna
Rice equivalent yield (t ha^{-1})	4.63	3.12	5.12	3.89	-	4.82
Whole pattern Rice equivalent yield (t ha^{-1})	12.87			8.71		
Gross return (Tk. ha^{-1})	92700	62500	107620	77850	-	102360
Variable cost (Tk. ha^{-1})	35625	33750	40250	34600	-	39250
Gross margin (Tk. ha^{-1})	57075	28750	67370	43250	-	63110
Total gross return (Tk. ha^{-1})	262820			180210		
Total variable cost (Tk. ha^{-1})	109625			73850		
Total gross margin (Tk. ha^{-1})	153195			108360		
MBCR	1.80					

*Output price (Tk. kg^{-1}): Wheat: 22.50, Sesame: 50, rice grain: 20, rice straw: 1.00

Table 11.33 Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2019-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Til-4	BRRI dhan51	BARI Gom-28	-	Sharwna
Seed/grain yield (t ha^{-1})	4.21	1.18	5.20	3.58	-	4.84
Stover/straw (t ha^{-1})	5.79	2.22	6.14	5.17	-	5.99
Rice equivalent yield (t ha^{-1})	4.73	2.94	5.20	3.80	-	4.84
Whole pattern Rice equivalent yield (t ha^{-1})	12.87			8.87		
Gross return (Tk. ha^{-1})	94725.00	58750.00	109615.00	80550.00	-	102785.00
Variable cost (Tk. ha^{-1})	35625.00	33750.00	40250.00	34600.00	-	39250.00
Gross margin (Tk. ha^{-1})	59100.00	25000.00	69365.00	46950.00	-	63535.00
Total gross return (Tk. ha^{-1})	263090.00			183335.00		
Total variable cost (Tk. ha^{-1})	109625.00			73850.00		
Total gross margin (Tk. ha^{-1})	153465.00			111485.00		
MBCR	1.97					

FSRD site: Amnura, Chapainawabganj

Cropping pattern-I

Improved Pattern (IP): Wheat (var. BARI Gom-30)-Mungbean (var. BARI Mung-6)-T. Aman (var. BRRI dhan51)

Existing Pattern (EP): Wheat (var. BARI Gom-28)-Fallow-T. Aman rice (var. Sharwna)

The yield performance, cost and return of the improved pattern; Wheat (BARI Gom-30)-Mungbean (BARI Mung-6)-T. Aman (BRRI Dhan51) against existing pattern Wheat (BARI Gom-28)-Fallow-T. Aman rice (Sharwna) is presented in Tables 11.34, 11.35, and 11.36.

The EP was Wheat-Fallow-T. Aman rice, while mungbean crop being added to the IP. Mungbean produced seed as well as brown manure, which is beneficial to soil management. Varietal improvement was also carried out in IP. The pattern average REY in IP was found to be 12.58 t ha^{-1}, while the value in EP (8.58 t ha^{-1}). The increase in productivity was 47% due to the addition of another crop, improved varietals, and better management. Economic performance was similar to productivity. The gross margin in IP was Tk. 159107 ha^{-1} and it was Tk. 95810 ha^{-1} in EP. The MBCR in IP was 3.47 over EP.

Wheat Mungbean T. Aman rice

Picture 11.22 Alternative cropping pattern at FSRD site, Amnura, Chapainawabganj

Table 11.34 Yield and economic analysis of improved and existing cropping pattern at the FSRD site Amnura, Chapainawabganj during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Mung	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Mung-6	BRRI dhan51	BARI Gom-28	-	Sharwna
Seed/grain yield (t ha^{-1})	4.15	1.2	5.15	3.80	-	4.32
Stover/straw (t ha^{-1})	5.78	3.0	6.05	5.05	-	5.56
Rice equivalent yield (t ha^{-1})	4.66	3.0	5.15	4.27	-	4.32
Whole pattern Rice equivalent yield (t ha^{-1})	12.81			8.59		
Gross return (Tk. ha^{-1})	93375	60000	115100	85500	-	86720
Variable cost (Tk. ha^{-1})	35125	26250	39780	34500	-	41500
Gross margin (Tk. ha^{-1})	58250	33750	75320	51000	-	45220
Total gross return (Tk. ha^{-1})	268475			172220		
Total variable cost (Tk. ha^{-1})	101155			76000		
Total gross margin (Tk. ha^{-1})	167320			96220		
MBCR	3.82					

*Output price (Tk. kg^{-1}): Wheat: 22.50, Mung: 50, rice grain: 20, rice straw: 1.00

Table 11.35 Yield and economic analysis of improved and existing cropping pattern at the FSRD site Amnura, Chapainawabganj during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Mung	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Mung-6	BRRI dhan51	BARI Gom-28	-	Sharwna
Seed/grain yield (t ha^{-1})	3.90	1.18	5.01	3.62	-	4.50
Stover/straw (t ha^{-1})	5.46	3.3	6.05	5.05	-	5.56
Rice equivalent yield (t ha^{-1})	4.39	2.95	5.01	4.07	-	4.50
Whole pattern Rice equivalent yield (t ha^{-1})	12.35			8.57		
Gross return (Tk. ha^{-1})	87800	59000	106250	81400	-	90000
Variable cost (Tk. ha^{-1})	38125	24250	39780	34500	-	41500
Gross margin (Tk. ha^{-1})	58250	33750	75320	46900	-	48500
Total gross return (Tk. ha^{-1})	253050			171400		
Total variable cost (Tk. ha^{-1})	102155			76000		
Total gross margin (Tk. ha^{-1})	150895			95400		
MBCR	3.12					

*Output price (Tk./kg): Wheat: 22.50, Mung: 50, rice grain: 20, rice straw: 1.00

Table 11.36 Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site Amnura, Chapainawabganj during 2019-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Mung	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Mung-6	BRRI dhan51	BARI Gom-28	-	Sharwna
Seed/grain yield (t ha^{-1})	4.025	1.19	5.08	3.71	-	4.41
Stover/straw (t ha^{-1})	5.62	3.15	6.05	5.05	-	5.56
Rice equivalent yield (t ha^{-1})	4.525	2.975	5.08	4.17	-	4.41
Whole pattern Rice equivalent yield (t ha^{-1})	12.58			8.58		
Gross return (Tk. ha^{-1})	90587.5	59500	110675	83450	-	88360
Variable cost (Tk. ha^{-1})	36625	25250	39780	34500	-	41500
Gross margin (Tk. ha^{-1})	58250	33750	75320	48950	-	46860
Total gross return (Tk. ha^{-1})	260762			171810		
Total variable cost (Tk. ha^{-1})	101655			76000		
Total gross margin (Tk. ha^{-1})	159107			95810		
MBCR	3.47					

Cropping pattern-II

Improved Pattern (IP): Lentil (var. BARI Masur-8)-Fallow-T. Aman (var. BRRI dhan51)

Existing Pattern (EP): Fallow-Fallow-T. Aman rice (var. Sharwna)

The average annual yield and economic performance of IP and EP were presented in Table 11.37, 11.38, 11.39. Amnura is a severely drought prone area. So, a substantial area was under the Fallow-Fallow-T. Aman rice cropping pattern. The sub-project is trying to introduce a low water consuming crop like lentil. The result indicated that the pattern average REY in IP was 11.85 t ha^{-1} while the value in EP was 4.89 t ha^{-1}. The increment in productivity was substantial with value (142%). The yield advantage was mainly due to the inclusion of lentil in the existing cropping sequence as well as the high monetary return from lentil and improved management. The economic performance was similar to productivity. The gross margin in IP was Tk. 163075 ha^{-1} while Tk. 67605 ha^{-1} in EP. The MBCR in IP was 3.80 over EP.

Lentil T. Aman rice

Picture11.23 Alternative cropping pattern at FSRD site, Amnura, Chapainawabganj

Table 11.37 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Amnura, Chapainawabganj during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
Variety	BARI Masur-8	-	BRRI dhan51	-	-	Sharwna
Seed/grain yield (t ha^{-1})	1.92	-	5.10	-	-	4.95
Stover/straw (t ha^{-1})	-	-	6.10	-	-	6.15
Rice equivalent yield (t ha^{-1})	7.20	-	5.10	-	-	4.95
Whole pattern Rice equivalent yield (t ha^{-1})	12.30			4.95		
Gross return (Tk. ha^{-1})	124800	-	114200	-	-	111300

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
Variety	BARI Masur-8	-	BRRI dhan51	-	-	Sharwna
Variable cost (Tk. ha^{-1})	33750	-	39750	-	-	39250
Gross margin (Tk. ha^{-1})	91050	-	74450	-	-	72050
Total gross return (Tk. ha^{-1})	239000			111300		
Total variable cost (Tk. ha^{-1})	73500			39250		
Total gross margin (Tk. ha^{-1})	165500			72050		
MBCR	3.73					

*Output price (Tk. kg^{-1}): Lentil seed: 65, rice grain: 20, rice straw: 1.00

Table 11.38 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Amnura, Chapainawabganj during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
Variety	BARI Masur-8	-	BRRI dhan51	-	-	Sharwna
Seed/grain yield (t ha^{-1})	1.88	-	5.28	-	-	4.82
Stover/straw (t ha^{-1})	-	-	6.35	-	-	6.01
Rice equivalent yield (t ha^{-1})	6.11	-	5.28	-	-	4.82
Whole pattern Rice equivalent yield (t ha^{-1})	11.39			4.82		
Gross return (Tk. ha^{-1})	122200	-	111950	-	-	102410
Variable cost (Tk. ha^{-1})	33750	-	39750	-	-	39250
Gross margin (Tk. ha^{-1})	88450	-	72200	-	-	63160
Total gross return (Tk. ha^{-1})	234150			102410		
Total variable cost (Tk. ha^{-1})	73500			39250		
Total gross margin (Tk. ha^{-1})	160650			63160		
MBCR	3.87					

*Output price (Tk. kg^{-1}): Lentil seed: 65, rice grain: 20, rice straw: 1.00

Table 11.39 Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site, Amnura, Chapainawabganj during 2019-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
Variety	BARI Masur-8	-	BRRI dhan51	-	-	Sharwna
Seed/grain yield (t ha^{-1})	1.90	-	5.19	-	-	4.89
Stover/straw (t ha^{-1})	-	-	6.23	-	-	6.08
Rice equivalent yield (t ha^{-1})	6.66	-	5.19	-	-	4.89
Whole pattern Rice equivalent yield (t ha^{-1})	11.85			4.89		
Gross return (Tk. ha^{-1})	123500	-	113075	-	-	106855
Variable cost (Tk. ha^{-1})	33750	-	39750	-	-	39250
Gross margin (Tk. ha^{-1})	89750	-	73325	-	-	67605
Total gross return (Tk. ha^{-1})	236575			106855		
Total variable cost (Tk. ha^{-1})	73500			39250		
Total gross margin (Tk. ha^{-1})	163075			67605		
MBCR	3.80					

FSRD Site: Chanduria, Rajshahi

Cropping pattern-I

Improved cropping pattern (IP): Lentil (var. BARI Masur-8)-Maize (var. Laltir339)- T. Aman (var. BRRI dhan87)

Existing cropping pattern (EP): Fallow- Boro (var. BRRI dhan28) - T. Aman (var. Sharwna)

Agronomic and economic performances of improved cropping pattern against existing cropping pattern are presented in Table 11.40 and 11.41. In the IP, three crops were accommodated against double cropping existing pattern. In addition, hybrid maize was included in IP which has high yield potentiality. Considering all the component crops, the REY of IP was 16.26 and 23.82 t ha^{-1} $yr.^{-1}$ which was about 58.48% and 140.12% higher against EP (10.26 and 9.92 t ha^{-1} yr^{-1}). Higher rice equivalent yield indicates higher productivity and efficiency of the IP. It was observed from Table 11.42 that on an average, improved cropping pattern produced higher gross margin Tk. 293048 ha^{-1} against EP (GM: Tk. 103135 ha^{-1}) which was about 184.12% higher than that of existing cropping pattern in two consecutive years. The average marginal benefit cost ratio (MBCR) was obtained 7.26 which were further indicated the superiority to improved cropping pattern over existing pattern.


Lentil


Maize


T. Aman rice

Picture11.24 Alternative cropping pattern at FSRD site, Chanduria, Rajshahi

Table 11.40 Yield and economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop and variety	Lentil (BARI Masur-8)	Maize (Laltir 339)	T. Aman (BRRI dhan87)	Fallow	Boro (BRRI dhan28)	T. Aman (Sharwna)
Seed /grain Yield (t ha^{-1})	2.07	7.02	5.2	-	5.68	5.05
Straw yield (t ha^{-1})	2.25	6.83	5.75	-	6.21	5.78
Rice equivalent yield (t ha^{-1})	5.83	4.48	5.95	-	4.46	5.80
Whole pattern Rice equivalent yield (t ha^{-1})	16.26			10.26		
Gross return (Tk. ha^{-1})	157500	120905	160525	-	120340	156580
Total variable cost (Tk. ha^{-1})	37810	77200	48950	-	85200	49150
Gross margin (Tk. ha^{-1})	119690	43705	111575	-	35140	107430
Whole pattern gross return (Tk. ha^{-1})	438930			276920		
Whole pattern total variable cost (Tk. ha^{-1})	163960			134350		
Whole pattern gross margin (Tk. ha^{-1})	274970			142570		
MBCR	5.47					

*Price of output (Tk. kg^{-1}): T. Aman: 27, straw 3.5, Lentil seed: 75.00, Maize grain: 16.25 and stover: 1, Boro rice: 19 and straw: 2

Table 11.41 Yield and economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop and variety	Lentil (BARI Masur-8)	Maize (Laltir 339)	T. Aman (BRRI dhan87)	Fallow	Boro (BRRI dhan28)	T. Aman (Sharwna)
Seed /grain yield (t ha^{-1})	2.28	9.96	5.41	-	4.95	3.65
Straw yield (t ha^{-1})	2.35	6.72	6.05	-	5.65	5.05
Rice equivalent yield (t ha^{-1})	9.00	8.8	6.02	-	5.76	4.16

Observation	Improved cropping pattern			Existing cropping pattern		
Crop and variety	Lentil (BARI Masur-8)	Maize (Laltir 339)	T. Aman (BRRI dhan87)	Fallow	Boro (BRRI dhan28)	T. Aman (Sharwna)
Whole pattern Rice equivalent yield (t ha^{-1})	23.82			9.92		
Gross return (Tk. $hā^{1}$)	180190	176040	120300	-	115250	83100
Total variable cost (Tk. $hā^{1}$)	39550	78305	47550	-	84500	50150
Gross margin (Tk. $hā^{1}$)	140640	97735	72750	-	30750	32950
Whole pattern gross return (Tk. ha^{-1})	476530			198350		
Whole pattern total variable cost (Tk. ha^{-1})	165405			134650		
Whole pattern gross margin (Tk. ha^{-1})	311125			63700		
MBCR	9.05					

*Price of output (Tk. kg^{-1}): T. Aman- 20, straw- 2, Lentil seed- 78.00, Maize grain- 17 and stover- 1, Boro rice- 21 and straw- 2.

Table 11.42 Average yield and economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2019-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop and variety	Lentil (BARI Masur-8)	Maize (Laltir 339)	T. Aman (BRRI dhan87)	Fallow	Boro (BRRI dhan28)	T. Aman (Sharwna)
Seed /grain yield (t ha^{-1})	2.18	8.49	5.31	-	5.32	4.35
Straw yield (t ha^{-1})	2.3	6.78	5.9	-	5.93	5.42
Rice equivalent yield (t ha^{-1})	7.42	6.64	5.99	-	5.11	4.98
Whole pattern Rice equivalent yield (t ha^{-1})	20.04			10.09		
Gross return (Tk. $hā^{1}$)	168845	148473	140413	-	117795	119840
Total variable cost (Tk. $hā^{1}$)	38680	77753	48250	-	84850	25075
Gross margin (Tk. $hā^{1}$)	130165	70720	92163	-	32945	16475
Gross return (Tk. ha^{-1})	457730			237635		
Total variable cost (Tk. ha^{-1})	164683			134500		
Whole pattern Gross margin (Tk. ha^{-1})	293048			103135		
MBCR	7.26					

Cropping pattern-II

Improved cropping pattern (IP): Mustard (var. BARI Sarisha-18)-T. Aus (var. BRRI dhan82)- T. Aman (var. BRRI dhan87)

Existing cropping pattern (EP): Fallow- Boro (var. BRRI dhan28)- T. Aman (var. Sharwna)

Agronomic and economic performance of improved cropping pattern against existing cropping pattern is presented in Table 11.43 and 11.44. In the IP, semi-long duration mustard var. was included, and the EP was remained fallow at that time. The BARI Sarisha-18 yielded 1.92 t ha^{-1} in Year-I. However, considering whole pattern REY of IP was 13.06 and 18.89 t ha^{-1} yr^{-1} which was about 25% and 84% higher against existing cropping pattern (10.45 and 10.27 t ha^{-1} yr^{-1}). Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was observed that improved cropping pattern produced higher gross margin on an average Tk. 207087 ha^{-1} against EP Tk. 109180 ha^{-1} which was 89.67% higher than existing cropping pattern in two consecutive years. The average marginal benefit cost ratio (MBCR) was obtained 3.91 which further indicated the superiority to improved cropping pattern over existing pattern.

Mustard T. Aus rice T. Aman rice

Picture11.25 Alternative cropping pattern at FSRD site, Chanduria, Rajshahi

Table 11.43 Yield and economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2019-2020

Parameter	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Fallow	Boro	T. Aman
Variety	BARI Sarisha-18	BRRI dhan82	BRRI dhan87	-	BRRI dhan28	Sharwna
Seed /grain yield (t ha $^{-1}$)	1.92	4.76	5.1	-	5.68	5.01
Straw yield (t ha^{-1})	3.5	5.10	5.34	-	5.81	5.31
Rice equivalent yield (t ha^{-1})	3.62	3.65	5.79	-	4.75	5.7
Whole pattern Rice equivalent yield (t ha^{-1})	13.06			10.45		
Gross return (Tk. ha^{-1})	97750	98430	156390	-	119540	153860
Total variable cost (Tk. ha^{-1})	52976	57550	48910	-	85100	49100
Gross margin (Tk. ha^{-1})	44774	40880	107480	-	34440	104755
Gross return (Tk. ha^{-1})	352570			273395		
Total variable cost (Tk. ha^{-1})	159436			134200		
Whole pattern Gross margin (Tk. ha^{-1})	193134			139200		
MBCR	3.14					

*Price of output (Tk. kg-^{1}): T. Aman: 27, straw 3.5, Mustrad seed: 50.00, straw 0.5, T. Aus rice: 18.00 and straw: 2.5, Boro rice: 19 and straw: 2

Table 11.44 Yield and economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2020-2021

Parameter	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Fallow	Boro	T. Aman
Variety	BARI Sarisha-18	BRRI dhan82	BRRI dhan87	-	BRRI dhan28	Sharwna
Seed /grain yield (t ha $^{-1}$)	2.23	4.85	5.37	-	4.90	3.65
Straw yield (t ha^{-1})	3.4	5.05	5.15	-	5.61	5.12
Rice equivalent yield (t ha^{-1})	7.89	5.11	5.89		5.73	4.54
Whole pattern Rice equivalent yield (t ha^{-1})	18.89			10.27		
Gross return (Tk. ha^{-1})	157800	102250	117700	-	114120	83240
Total variable cost (Tk. ha^{-1})	50576	56550	49584	-	78100	40100
Gross margin (Tk. ha^{-1})	107224	45700	68116	-	36020	43140
Whole pattern gross return (Tk. ha^{-1})	377750			197360		
Whole pattern total variable cost (Tk. ha^{-1})	156710			118200		
Whole pattern gross margin (Tk. ha^{-1})	221040			79160		
MBCR	4.68					

*Price of output (Tk. kg-^{1}): T. Aman- 20, straw- 2, Mustard seed- 70.00, straw- 0.5, T. Aus Rice-19.00 and straw- 2, Boro rice- 21 and straw- 2

Table 11.45 Average yield and economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2019-2021

Parameter	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T.Aus	T. Aman	Fallow	Boro	T.Aman
Variety	BARI Sarisha-18	BRRI dhan82	BRRI dhan87	-	BRRI dhan28	Sharwna
Seed /grain yield (t ha^{-1})	2.08	4.81	5.24	-	5.29	4.33
Straw yield (t ha^{-1})	3.45	5.08	5.25	-	5.71	5.22
Rice equivalent yield (t ha^{-1})	5.76	4.38	5.84	-	5.24	5.12
Whole pattern rice equivalent yield (t ha^{-1})	15.98			10.36		
Gross return (Tk. ha^{-1})	127775	100340	137045	-	116830	118550
Total variable cost (Tk. ha^{-1})	51776	57050	49247	-	81600	44600
Gross margin (Tk. ha^{-1})	75999	43290	87798	-	35230	73950
Whole pattern gross return (Tk. ha^{-1})	365160			235380		
Whole pattern total variable cost (Tk. ha^{-1})	158073			126200		
Whole pattern gross margin (Tk. ha^{-1})	207087			109180		
MBCR	3.91					

FSRD Site: Jiarokhi, Kushtia

Cropping pattern-I

Improved cropping pattern (IP): Lentil (var. BARI Masur-8)-Sesame (var. BARI Til-4)- T. Aman rice (var. BRRI dhan75)

Existing cropping pattern (EP): Lentil (var. BARI Masur-6)-Sesame (var. Local)-T. Aman rice (var. BRRI dhan39)

Yearwise yield and economic analysis and two years average yield and economic information of improved and existing cropping pattern at the FSRD site, Jiarokhi, Kushtia during 2019-2021 are presented in Table 11.46, 11.47, and 11.48. It was found that, newly released varieties from NARS institutes performed better than that of farmer's existing varieties. It was observed that the average yield of BARI Masur-8, BARI Til-4 and BRRI dhan75 were higher in improved cropping pattern against the yield of BARI Masur-6, Sesame (local) and BRRI dhan39 those were used in the existing cropping pattern. In both the year the whole pattern rice equivalent yield in improved cropping pattern was higher (15.15 and 15.69 t ha^{-1}) than existing cropping pattern (13.03 & 13.57 t ha^{-1}). Estimated MBCR were 16.66 and 8.65 over existing cropping pattern in the year 2019-2020 and 2020-2021, respectively. The calculated two-year average whole pattern REY was 15.42 t ha^{-1} in improved cropping pattern while it was 13.30 t ha^{-1} in existing pattern. The improved cropping pattern gave 15.94% higher whole pattern REY than that of existing pattern. Whole pattern gross margin was Tk. 329890 ha^{-1} in improved cropping pattern which was Tk. 267796 ha^{-1} in existing pattern. The average MBCR in improved pattern was 12.66 over existing pattern (Table 11.48).

Table 11.46 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Jiarokhi, Kushtia during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Sesame	T. Aman	Lentil	Sesame	T. Aman
Variety	BARI Masur-8	BARI Til-4	BRRI dhan75	BARI Masur-6	Local	BRRI dhan39
Seed/grain yield (t ha^{-1})	2.29	1.51	5.55	1.80	1.10	5.50
Stover/straw yield (t ha^{-1})	1.91	2.04	4.39	1.20	1.10	4.85
Rice equivalent yield (t ha^{-1})	5.83	2.81	6.51	4.51	1.96	6.56

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Sesame	T. Aman	Lentil	Sesame	T. Aman
Variety	BARI Masur-8	BARI Til-4	BRRI dhan75	BARI Masur-6	Local	BRRI dhan39
Whole pattern rice equivalent yield (t ha^{-1})	15.15			13.03		
Gross return (Tk. ha^{-1})	186265	89780	208330	144300	62700	209950
Variable cost (Tk. ha^{-1})	41912	40150	80200	40000	38015	80200
Gross margin (Tk. ha^{-1})	144353	49630	128130	104300	24685	129750
Total Gross return (Tk. ha^{-1})	484375			416950		
Total variable cost (Tk. ha^{-1})	162262			158215		
Total gross margin (Tk. ha^{-1})	322113			258735		
MBCR	16.66					

*Output price (Tk.kg^{-1}): Lentil seed- 75.50, Stover-7.00, Sesame seed- 50.00, Rice-32.00, Rice straw- 7.00

Table 11.47 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Jiarokhi, Kushtia during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Sesame	T. Aman	Lentil	Sesame	T. Aman
Variety	BARI Masur-8	BARI Til-4	BRRI dhan75	BARI Masur-6	Local	BRRI dhan39
Seed/grain yield (t ha^{-1})	2.05	1.68	5.65	1.49	1.42	5.45
Stover/straw yield (t ha^{-1})	1.40	1.72	4.46	1.36	1.59	4.55
Rice equivalent yield (t ha^{-1})	5.35	3.73	6.61	3.96	3.18	6.43
Whole pattern Rice equivalent yield (t ha^{-1})	15.69			13.57		
Gross return (Tk. ha^{-1})	173800	121240	214845	128720	92300	208975
Variable cost (Tk. ha^{-1})	45320	41250	85650	41250	40750	82270
Gross margin (Tk. ha^{-1})	128480	79990	129195	87470	51550	126705
Total gross return (Tk. ha^{-1})	509885			441125		
Total variable cost (Tk. ha^{-1})	172220			164270		
Total gross margin (Tk. ha^{-1})	337665			276855		
MBCR	8.65					

*Output price (Tk.kg^{-1}): Lentil seed: 80.00, Stover=7.00, Sesame seed: 65.00, Rice: 32.50, Rice straw: 7.00

Table 11.48 Average yield and economic analysis of improved and existing cropping pattern at the FSRD site, Jiarokhi, Kushtia during 2019-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Sesame	T. Aman	Lentil	Sesame	T. Aman
Variety	BARI Masur-8	BARI Til-4	BRRI dhan75	BARI Masur-6	Local	BRRI dhan39
Seed/grain yield (t ha^{-1})	2.17	1.60	5.60	1.65	1.26	5.48
Stover/straw yield (t ha^{-1})	1.66	1.88	4.43	1.28	1.35	4.70
Rice equivalent yield (t ha^{-1})	5.59	3.27	6.56	4.23	2.57	6.5
Whole pattern rice equivalent yield (t ha^{-1})	15.42			13.30		
Gross return (Tk. ha^{-1})	180033	105510	211588	136510	83065	209463
Variable cost (Tk. ha^{-1})	43616	40700	82925	40625	39383	81235
Gross margin (Tk. ha^{-1})	136417	64810	128663	95885	43683	128228
Total gross return (Tk. ha^{-1})	497131			429038		
Total variable cost (Tk. ha^{-1})	167241			161243		
Total gross margin (Tk. ha^{-1})	329890			267796		
MBCR	12.66					



Lentil Sesame T. Aman rice

Picture11.26 Alternative cropping pattern at FSRD site, Jiarokhi, Kushtia

Cropping pattern-II

Improved cropping pattern (IP): Onion (var. BARI Piaj-4)-Sweet gourd (var. Local hybrid)-T. Aman rice (var. BRRI dhan75)

Existing cropping pattern (EP): Onion (var. Local)-Sweet gourd (var. Local hybrid)-T. Aman rice (var. BRRI dhan39)

Year wise yield and economic analysis and two years average yield and economic information of improved and existing cropping pattern at the FSRD site, Jiarokhi, Kushtia during 2019-2021 are presented in Table 11.49, 11.50, and 11.51. It was found that, newly released varieties from NARS institutes performed better than that of farmer's existing varieties. It was observed that the average yield of BARI Piaj-4, Sweet gourd (Local hybrid) and BRRI dhan75 were higher in improved cropping pattern against the yield of Onion (Local) and BRRI dhan39 those were used in the existing cropping pattern. In both the year the whole pattern rice equivalent yield in improved cropping pattern was higher (38.77 & 33.86 t ha^{-1}) than existing cropping pattern (31.65 & 29.61 t ha^{-1}). Estimated MBCR were 5.79 and 8.51 over existing cropping pattern in the year 2019-2020 and 2020-2021, respectively.

The calculated two-year average whole pattern REY was 36.32 t ha^{-1} in improved cropping pattern while it was 30.63 t ha^{-1} in existing pattern. The improved cropping pattern gave 18.58% higher whole pattern REY than that of existing pattern. Whole pattern gross margin was Tk. 805015 ha^{-1} in improved cropping pattern which was Tk. 648348 ha^{-1} in existing pattern. The average MBCR in improved pattern was 7.15 over existing pattern.

Table 11.49 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Jiarokhi, Kushtia during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Onion	Sweet gourd	T. Aman	Onion	Sweet gourd	T. Aman
Variety	BARI Piaj-4	(Local hybrid)	BRRI dhan75	Local	(Local hybrid)	BRRI dhan39
Seed/grain/bulb yield (t ha^{-1})	20.08	19.00	5.70	15.07	18.00	5.45
Stover/straw yield (t ha^{-1})	-	-	4.48	-	-	4.40
Rice equivalent yield (t ha^{-1})	26.21	5.85	6.66	19.71	5.54	6.40
Whole pattern REY (t ha^{-1})	38.77			31.65		
Gross return (Tk. ha^{-1})	853400	190000	216610	640475	180000	207925
Variable cost (Tk. ha^{-1})	227250	49750	80585	201830	44184	71571
Gross margin (Tk. ha^{-1})	626150	140250	136025	438645	135816	136354
Total gross return (Tk. ha^{-1})	1260010			1028400		
Total variable cost (Tk. ha^{-1})	357585			317585		
Total gross margin (Tk. ha^{-1})	902425			710815		
MBCR	5.79					

*Output price (Tk./kg): Improved and existing: Onion: 42.50, Sweet gourd=10, Rice: 32.50, Rice straw: 7.00

Table 11.50 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Jiarokhi, Kushtia during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Onion	Sweet gourd	T. Aman	Onion	Sweet gourd	T. Aman
Variety	BARI Piaj-4	(Local hybrid)	BRRI dhan75	Local	(Local hybrid)	BRRI dhan39
Seed/grain/bulb yield (t ha^{-1})	20.65	22.50	5.55	18.05	17.80	5.42
Stover/straw yield (t ha^{-1})	-	-	4.35	-	-	4.45
Rice equivalent yield (t ha^{-1})	19.06	8.31	6.49	16.66	6.57	6.38
Whole pattern REY (t ha^{-1})	33.86			29.61		
Gross return (Tk. ha^{-1})	619500	270000	210825	541500	213600	207300
Variable cost (Tk. ha^{-1})	255350	52720	84650	245320	48350	82850
Gross margin (Tk. ha^{-1})	364150	217280	126175	296180	165250	124450
Total gross return (Tk. ha^{-1})	1100325			962400		
Total variable cost (Tk. ha^{-1})	392720			376520		
Total gross margin (Tk. ha^{-1})	707605			585880		
MBCR	8.51					

*Output price (Tk./kg). Improved and existing: Onion: 30.00, Sweet gourd=12.00, Rice: 32.50, Rice straw: 7.00

Table 11.51 Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site, Jiarokhi, Kushtia during 2019-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Onion	Sweet gourd	T. Aman	Onion	Sweet gourd	T. Aman
Variety	BARI Piaj-4	(Local hybrid)	BRRI dhan75	Local	(Local hybrid)	BRRI dhan39
Seed/grain/bulb yield (t ha^{-1})	20.37	20.75	5.63	16.56	17.90	5.44
Stover/straw yield (t ha^{-1})	-	-	4.42	-	-	4.43
Rice equivalent yield (t ha^{-1})	22.66	7.08	6.58	18.19	6.05	6.39
Whole pattern REY (t ha^{-1})	36.32			30.63		
Gross return (Tk. ha^{-1})	736450	230000	213718	590988	196800	207613
Variable cost (Tk. ha^{-1})	241300	51235	82618	223575	46267	77211
Gross margin (Tk. ha^{-1})	495150	178765	131100	367413	150533	130402
Total gross return (Tk. ha^{-1})	1180168			995401		
Total variable cost (Tk. ha^{-1})	375153			347053		
Total gross margin (Tk. ha^{-1})	805015			648348		
MBCR	7.15					

Onion Sweet gourd T. Aman rice

Picture11.27 Alternative cropping pattern at FSRD site, Jiarokhi, Kushtia

FSRD Site: Kamalbazar, Sylhet

Cropping pattern-I

Improved cropping pattern (IP): Potato (var. BARI Alu-41)-T. Aus (var. BRRI dhan65)-T. Aman (var. BRRI dhan57)

Existing cropping pattern (EP): Fallow-T. Aus (var. BR26)-T. Aman (var. BRRI dhan33)

Yearwise yield and economic analysis and two years average yield and economic information of improved and existing cropping pattern at the FSRD site, Kamalbazar, Sylhet during 2019-2021 are presented in Table 11.52, 11.53 and 11.54. It was found that, newly released varieties from NARS institutes performed better. In both the year the whole pattern rice equivalent yield in improved cropping pattern was higher (24.36 t ha^{-1} & 32.58 t ha^{-1}) than existing cropping pattern (7.23 t ha^{-1} & 9.77 t ha^{-1}). Estimated MBCR were 2.24 and 2.8 over existing cropping pattern in 2019-2020 and 2020-2021, respectively.

It is clear from the result that all the crop varieties used in improved cropping pattern performed better than those used in existing pattern. The calculated two-year average, whole pattern REY was 28.48 t ha^{-1} in improved cropping pattern while it was 8.51 t ha^{-1} in existing pattern. The improved cropping pattern gave 234.67% higher whole pattern REY than that of existing pattern due to introduction of potato in improved pattern during fallow period. Whole pattern gross margin was Tk. 395590 ha^{-1} in improved cropping pattern which was Tk. 90120 ha^{-1} in existing pattern. The average MBCR in improved pattern was 2.52 over existing pattern.

Table 11.52 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Kamalbazar, Sylhet during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Potato	T. Aus	T. Aman	Fallow	T. Aus	T. Aman
Variety	BARI Alu-41	BRRI dhan65	BRRI dhan57	-	BR26	BRRI dhan33
Seed/grain yield (t ha^{-1})	25.95	3.58	3.80	-	2.60	3.40
Straw yield (t ha^{-1})	0	3.97	4.80	-	3.20	4.50
REY	15.57	4.22	4.57	-	3.11	4.12
Whole pattern REY	24.36			7.23		
Gross return (Tk. ha^{-1})	389250	105380	114200	-	77800	103000
Total variable cost (Tk. ha^{-1})	184250	54540	64870	-	49080	63700
Gross margin (Tk. ha^{-1})	205000	50840	49330	-	28720	39300
Total gross return (Tk. ha^{-1})	608830			180800		
Total variable cost (Tk. ha^{-1})	303660			112780		
Total Gross margin (Tk. ha^{-1})	305170			68020		
MBCR	2.24					

* Output price (Tk. kg^{-1}): Potato- 15.00; Rice Straw- 4.00; Rice- 25.00

Table 11.53 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Kamalbazar, Sylhet during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Potato	T. Aus	T. Aman	Fallow	T. Aus	T. Aman
Variety	BARI Alu-41	BRRI dhan65	BRRI dhan57	-	BR26	BRRI dhan33
Seed/grain yield (t ha^{-1})	36.45	4.04	5.00	-	3.60	4.20
Straw yield (t ha^{-1})	0	4.43	6.00	-	4.20	5.30
REY	21.87	4.75	5.96	-	4.72	5.05
Whole pattern REY	32.58			9.77		
Gross return (Tk. ha^{-1})	546750	118720	149000	-	106800	126200
Total variable cost (Tk. ha^{-1})	196750	59940	71770	-	51580	69200
Gross margin (Tk. ha^{-1})	350000	58780	77230	-	55220	57000
Total gross return (Tk. ha^{-1})	814470			233000		
Total variable cost (Tk. ha^{-1})	328460			120780		
Total Gross margin (Tk. ha^{-1})	486010			112220		
MBCR	2.8					

* Output price (Tk. kg^{-1}) Potato: 15.00, Rice Straw: 4.00, Rice: 25.00

Table 11.54 Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site, Kamalbazar, Sylhet during 2019-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Potato	T. Aus	T. Aman	Fallow	T. Aus	T. Aman
Variety	BARI Alu-41	BRRI dhan65	BRRI dhan57	-	BR26	BRRI dhan33
Seed/grain yield (t ha^{-1})	31.2	3.81	4.4	-	3.10	3.80
Straw yield (t ha^{-1})	0	4.2	5.4	-	3.7	4.9
REY	18.72	4.49	5.27	-	3.92	4.59
Whole pattern REY	28.48			8.51		
Gross return (Tk. ha^{-1})	468000	112050	131600	-	92300	114600
Total variable cost (Tk. ha^{-1})	190500	57240	68320	-	50330	66450
Gross margin (Tk. ha^{-1})	277500	54810	63280	-	41970	48150
Total gross return (Tk. ha^{-1})	711650			206900		
Total variable cost (Tk. ha^{-1})	316060			116780		
Total Gross margin (Tk. ha^{-1})	395590			90120		
MBCR	2.52					

Unit price (Tk. kg^{-1}) Potato: 15.00, Rice Straw: 4.00, Rice: 25.00

Potato T. Aus rice T. Aman rice

Picture11.28 Alternative cropping pattern at FSRD site, Kamalbazar, Sylhet

Cropping pattern-II

Improved cropping pattern (IP): Mustard (var. BARI Sarisha-14)-T. Aus (var. BRRI dhan65)-T. Aman (var. BRRI dhan57)

Existing cropping pattern (EP): Mustard (var. Tori-7)-T. Aus (var. BR26)-T. Aman (var. BRRI dhan33)

Year wise yield and economic analysis and two years average yield and economic information of improved and existing cropping pattern at the FSRD site, Kamalbazar, Sylhet during 2019-2021 are presented in Table 11.55, 11.56, and 11.57. It was found that, newly released varieties from NARS institutes performed better than that of farmer's existing varieties. It was observed that the average yield of BARI Sarisha-14, BRRI dhan65 and BRRI dhan57 were higher in improved cropping pattern against the yield of Mustard (Tori-7), BR26 and BRRI dhan33 those were used in the existing cropping pattern. In both the year the whole pattern rice equivalent yield in improved cropping pattern was higher (17.13 & 13.73 t ha^{-1}) than existing cropping pattern (14.71 & 10.56 t ha^{-1}). Estimated MBCR were 4.98 and 6.08 over existing cropping pattern in the year 2019-2020 and 2020-2021, respectively.

The calculated two-year average whole pattern REY was 15.43 t ha^{-1} in improved cropping pattern while it was 12.64 t ha^{-1} in existing pattern. The improved cropping pattern gave 22.07% higher whole pattern REY than that of existing pattern. Whole pattern gross margin was Tk. 179220 ha^{-1} in improved cropping pattern which was Tk. 111950 ha^{-1} in existing pattern. The average MBCR in improved pattern was 5.53 over existing pattern.

Table 11.55 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Kamalbazar, Sylhet during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Mustard	T. Aus	T. Aman
Variety	BARI Sarisha-14	BRRI dhan65	BRRI dhan57	Tori-7	BR26	BRRI dhan33
Seed/grain yield (t ha^{-1})	1.59	4.52	5.19	1.06	3.86	4.49
Straw yield (t ha^{-1})	1.61	5.72	6.04	1.22	5.00	5.40
REY	5.53	5.44	6.16	3.7	5.66	5.35
Whole pattern REY	17.13			14.71		
Gross return (Tk. ha^{-1})	138370	135880	153910	92540	116500	133850
Total variable cost (Tk. ha^{-1})	61020	73800	85623	51489	70580	81250
Gross margin (Tk. ha^{-1})	77350	62080	68287	41051	45920	52600
Total gross return (Tk. ha^{-1})	428160			342890		
Total variable cost (Tk. ha^{-1})	220443			203319		
Total Gross margin (Tk ha^{-1})	207717			139571		
MBCR	4.98					

* Output price (Tk. kg^{-1}) Mustard seed: 85.00, Mustard straw: 2.00, Rice straw: 4.00, Rice: 25.00

Table 11.56 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Kamalbazar, Sylhet during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Mustard	T. Aus	T. Aman
Variety	BARI Sarisha-14	BRRI dhan65	BRRI dhan57	Tori-7	BR26	BRRI dhan33
Seed/grain yield (t ha^{-1})	1.19	3.88	4.11	0.82	3.06	3.29
Straw yield (t ha^{-1})	1.21	5.08	4.96	0.98	4.20	4.20
REY	4.14	4.69	4.9	2.87	3.73	3.96
Total REY	13.73			10.56		
Gross return (Tk. ha^{-1})	103570	117320	122590	71660	93300	99050
Total variable cost (Tk. ha^{-1})	50180	68200	74377	46511	62420	70750
Gross margin (Tk. ha^{-1})	53390	49120	48213	25149	30880	28300
Total gross return (Tk. ha^{-1})	343480			264010		
Total variable cost (Tk. ha^{-1})	192757			179681		
Total Gross margin (Tk. ha^{-1})	150723			84329		
MBCR	6.08					

*Output price (Tk. kg^{-1}) Mustard seed: 85.00, Mustard straw: 2.00, Rice straw: 4.00, Rice: 25.00

Table 11.57 Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site, Kamalbazar, Sylhet during 2019-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Mustard	T. Aus	T. Aman
Variety	BARI Sarisha-14	BRRI dhan65	BRRI dhan57	Tori-7	BR26	BRRI dhan33
Seed/grain yield (t ha^{-1})	1.39	4.20	4.65	0.94	3.46	3.89
Straw yield (t ha^{-1})	1.41	5.4	5.5	1.10	4.6	4.8
REY	4.84	5.06	5.53	3.28	4.7	4.66
Total REY	15.43			12.64		
Gross return (Tk. ha^{-1})	120970	126600	138250	82100	104900	116450
Total variable cost (Tk. ha^{-1})	55600	71000	80000	49000	66500	76000
Gross margin (Tk. ha^{-1})	65370	55600	58250	33100	38400	40450
Total gross return (Tk. ha^{-1})	385820			303450		
Total variable cost (Tk. ha^{-1})	206600			191500		
Total Gross margin (Tk. ha^{-1})	179220			111950		
MBCR	5.53					

Unit price (Tk. kg^{-1}) Mustard: 85.00, Mustard straw: 2.00, Rice straw: 4.00, Rice: 25.00

Mustard

T. Aus rice

T. Aman rice

Picture11.29 Alternative cropping pattern at FSRD site, Kamalbazar, Sylhet

11.2.1.2 Improvement of cropping pattern (CP) at FSRD site Naikhongchari, Bandarban of BLRI component

For improvement of cropping pattern, two cropping patterns were developed at FSRD site Naikhongchari, Bandarban.

Cropping pattern-I

Improved Cropping Pattern: Cucumber -T. Aman -Brinjal

Existing Cropping Pattern: Fallow-T. Aman - Fallow

Crop yield and economic performances of the tested croping pattern (Cucumber-T. Aman-Brinjal) against existing pattern (Fallow-T. Aman (Local)-Fallow) during 2020-2021 and 2021-2022 are presented in Table 11.58 and Table 11.59. In 2020-2021, the whole pattern rice equivalent yield (REY) was found 72.23 and 5.43 t ha^{-1} with the whole pattern gross margin 910750 and Tk. 50550 ha^{-1} in improved and existing cropping pattern, respectively (Table 11.58). In 2021- 2022, the whole pattern rice equivalent yield (REY) was found 84.15 and 5.9 t ha^{-1} with the whole pattern gross margin 1148750 and Tk. 38250 ha^{-1} in improved and existing cropping pattern, respectively (Table 11.59). The MBCR in improved pattern was found 2.06 and 2.34 over existing pattern during 2020-2021 and 2021-2022. Use of modern T. Aman rice variety instead of local T. Aman rice variety and inclusion of extra crop (cucumber and brinjal) including improve crop management technologies were triggered the higher REY in improved cropping pattern.

Average yield and cost return of improved and existing cropping pattern for the year of 2020-2021 and 2021-2022 are presented in the Table 11.60. The average whole pattern rice equivalent yield (REY) was 78.19 and 5.67 t ha^{-1} with the average whole pattern gross margin 1029750 and Tk. 44400 ha^{-1} in improved and existing cropping pattern, respectively (Table 11.60). The MBCR in improved pattern was found 2.2 over existing pattern during 2020-2022.

So, Cucumber-T. Aman-Brinjal cropping pattern may be a new way of increasing household income of the farmers of FSRD site Naikhongchari, Bandarban.

Table 11.58 Yield and economic analysis of improved and existing cropping pattern at FSRD site Naikhongchari, Bandarban during 2020- 2021

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	T. Aman	Fallow	Cucumber	T. Aman	Brinjal
Variety	-	Local variety	-	Green king (Lal Teer)	BRRI dhan49	Commercial hybrid (Metal seed)
Seed/grain yield (t/ha)	.	3.02	-	32.0	4.03	50.25
Straw yield (t/ha)	-	4.00	-		4.00	

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	T. Aman	Fallow	Cucumber	T. Aman	Brinjal
Variety	-	Local variety	-	Green king (Lal Teer)	BRRI dhan49	Commercial hybrid (Metal seed)
Rice equivalent yield (t ha^{-1})	-	5.43	-	25.6	6.43	40.2
Whole pattern Rice equivalent yield (t ha^{-1})	5.43			72.23		
Total gross return (Tk. ha^{-1})	135750			1805750		
Total variable cost (Tk. ha^{-1})	85200			895000		
Gross margin (Tk. ha^{-1})	50550			910750		
MBCR	2.06					

* Output Price (Tk. kg^{-1}): Cucumber-20, Brinjal-20, T. Aman rice- 25, Straw-15

Table 11.59 Yield and economic analysis of improved and existing cropping pattern at FSRD site Naikhongchari, Bandarban during 2021- 2022

Observation	**Existing cropping pattern**			**Improved cropping pattern**		
Crop	Fallow	T. Aman	Fallow	Cucumber	T. Aman	Brinjal
Variety	-	Local variety	-	Green king (Lal Teer)	BRRI dhan49	Commercial hybrid (Metal seed)
Seed/grain yield (t/ha)	-	3.50	-	31.25	4.25	50.0
Straw yield (t/ha)	-	4.00	-	-	4.0	-
Rice equivalent yield (t ha^{-1})	-	5.9	-	27.5	6.65	50.0
Whole pattern Rice equivalent yield (t ha^{-1})	5.9			84.15		
Total gross return (Tk. ha^{-1})	166250			2103750		
Total variable cost (Tk. ha^{-1})	128000			955000		
Gross margin (Tk. ha^{-1})	38250			1148750		
MBCR	2.34					

* Output Price (Tk. kg^{-1}): Cucumber-22, Brinjal-25, T. Aman rice- 25, Straw-15

Table 11.60 Average yield and eeconomic analysis of improved and existing cropping pattern at FSRD site Naikhongchari, Bandarban during 2020-2022

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	T. Aman	Fallow	Cucumber	T. Aman	Brinjal
Variety	-	Local variety	-	Green king (Lal Teer)	BRRI dhan49	Commercial hybrid (Metal seed)
Seed/grain yield (t/ha)	-	3.26	-	31.62	4.14	50.12
Straw yield(t/ha)	-	4.00	-	-	4.00	-
Rice equivalent yield (t ha^{-1})	-	5.67	-	26.55	6.54	45.10
Whole pattern Rice equivalent yield (t ha^{-1})	5.67			78.19		
Total gross return (Tk. ha^{-1})	151000			1954750		
Total variable cost (Tk. ha^{-1})	106600			925000		
Gross margin (Tk. ha^{-1})	44400			1029750		
MBCR	2.20					

Cucumber T. Aman rice Brinjal

Picture 11.30 Improved cropping pattern at FSRD site Naikhongchari, Bandarban

Cropping pattern-II

Existing cropping pattern: Tobacco-Fallow-Fallow

Improved cropping pattern: Fodder (var. BLRI HYV Napier)-Fodder (var. BLRI HYV Napier)-Fodder (var. BLRI HYV Napier)

Crop yield and economic performances of the tested pattern (Fodder-Fodder-Fodder) against existing pattern (Tobacco-Fallow -Fallow) during 2020-2021 and 2021-2022 are presented in the Table 11.61 and Table 11.62. In 2020-2021, the whole pattern tobacco equivalent yield (TEY) was 3.87 and 3.03 t ha^{-1} with the whole pattern gross margin Tk. 248200 ha^{-1} and Tk. 185000 ha^{-1} in improved and existing cropping pattern, respectively (Table 11.61). In 2021-2022, the whole pattern tobacco equivalent yield (TEY) was found 3.88 and 3.19 t ha^{-1} with the whole pattern gross margin Tk. 262580 and 201100 ha^{-1} in improved and existing cropping pattern, respectively (Table 11.62). The MBCR in improved pattern was found 2.17 and 2.75 over existing pattern during 2020-2021 and 2021-2022. Inclusion of HYV fodder throughout the year and improve management of fodder crop were triggered the higher TEY in improved cropping pattern.

Average yield and economic performance of the improved and existing cropping pattern for the year of 2020-2021 and 2021-2022 are presented in the Table 11.63. The average whole pattern tobacco equivalent yield (TEY) was 3.88 and 3.11 t ha^{-1} with the average whole pattern gross margin Tk. 255390 ha^{-1} and Tk. 193050 ha^{-1} in improved and existing cropping pattern, respectively (Table 11.63). The MBCR in improved pattern was found 2.46 over existing pattern during 2020-2022.

Table 11.61 Yield and economic analysis of improved and existing cropping pattern at FSRD site Naikhongchari, Bandarban during 2020- 2021

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Tobacco	Fallow	Fallow	Fodder	Fodder	Fodder
Variety	HYV	-	-	BLRI HYV Napier	BLRI HYV Napier	BLRI HYV Napier
Yield (t ha^{-1})	2.75	-	-	56.28	60.32	63.8
Straw yield/ stick (t ha^{-1})	3.25	-	-	-	-	-
Tobacco equivalent yield (t ha^{-1})	3.03	-	-	1.21	1.29	1.37
Whole pattern Tobacco equivalent yield (t ha^{-1})	3.03			3.87		
Gross return (Tk. ha^{-1})	424000			541200		
Total variable cost (Tk. ha^{-1})	239000			293000		
Gross margin (Tk. ha^{-1})	185000			248200		
MBCR	2.17					

* Output Price (Tk. kg^{-1}): Tobacco-140, Straw-12, fodder -3

Table 11.62 Yield and economic analysis of improved and existing cropping pattern at FSRD site Naikhongchari, Bandarban during 2021- 2022

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Tobacco	Fallow	Fallow	Fodder	Fodder	Fodder
Variety	HYV	-	-	BLRI HYV Napier	BLRI HYV Napier	BLRI HYV Napier
Yield (t ha^{-1})	2.90	-	-	56.39	60.79	63.78
Straw yield/ stick (t ha^{-1})	3.35	-	-	-	-	-
Tobacco equivalent yield (t ha^{-1})	3.19	-	-	1.21	1.3	1.37
Whole pattern Tobacco equivalent yield (t ha^{-1})	3.19			3.88		
Gross return (Tk. ha^{-1})	446200			542880		
Total variable cost (Tk. ha^{-1})	245100			280300		
Gross margin (Tk. ha^{-1})	201100			262580		
MBCR	2.75					

- Output Price (Tk. kg^{-1}): Tobacco-140, Straw-12, fodder -3

Table 11.63 Average yield and eeconomic analysis of improved and existing cropping pattern at FSRD site, Naikhongchari, Bandarban during 2020-2022

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Tobacco	Fallow	Fallow	Fodder	Fodder	Fodder
Variety	HYV	-	-	BLRI HYV Napier	BLRI HYV Napier	BLRI HYV Napier
Yield (t ha^{-1})	2.83	-	-	56.28	60.32	63.8
Straw yield/ stick (t ha^{-1})	3.3	-	-	-	-	-
Tobacco equivalent yield (t ha^{-1})	3.11	-	-	1.21	1.3	1.37
Whole pattern Tobacco equivalent yield (t ha^{-1})	3.11			3.88		
Gross return (Tk. ha^{-1})	435100			542040		
Total variable cost (Tk. ha^{-1})	242050			286650		
Gross margin (Tk. ha^{-1})	193050			255390		
MBCR	2.46					

Napier grass

Picture 11.31 Improved cropping pattern at FSRD site Naikhongchari, Bandarban

11.2.2 On-farm verification/Production program

11.2.2.1 On-farm verification/Production program at different FSRD sites of BARI component

On-farm verification trials with modern varieties of cereals, oilseed, pulses, vegetables, spices and tuber crops at different FSRD sites during the years of 2019 to 2022 is given below.

FSRD Site: Basantapur, Rajshahi

The yield, cost and return of On-farm verification trials on different crops and varieties are presented in Tables 11.64 and 11.65.

Crop varieties are tested over a period of one to three years. It was observed that, results from each year as well as the average of all years mustard var. BARI Sarisha-18 produced the highest seed yield (1.80 t ha^{-1}) with gross margin (Tk. 97500 ha^{-1}) followed by BARI Sarisha-17 (1.71 t ha^{-1}); BARI Sarisha-14 (1.67 t ha^{-1}) and the lowest (1.55 t ha^{-1}) from BARI Sarisha-15. In case of summer hybrid tomatoes, BARI Hybrid Tomato-8 and BARI Hybrid Tomato-11 yielded fruit 18.50 and 38.0 t ha^{-1}, respectively. Farmers are happy about the performance of BARI Hybrid Tomato-11 for its yield and monetary benefit. Potato is not normally grown by farmers in Godagari Upazilla due to soil conditions. In the Barind area, On-farm trial was conducted with five popular and recently developed potato varieties. Highest tuber yield (26.58 t ha^{-1}) was found from BARI Alu-7 followed by BARI Alu-41 (25.56 t ha^{-1}), BARI Alu-46 (25.56 t ha^{-1}), BARI Alu-36 (24.73 t ha^{-1}) and the lowest yield (21.83 t ha^{-1}) from BARI Alu-25. A production program on BARI Masur-8 was conducted in the Barind area during 2019-2020. The average seed yield of BARI Masur-8 was found 1.78 t with gross margin Tk. 95417 ha^{-1}. Farmers in this area very much impressed having higher seed yield of BARI Masur-8 and good amount of seed was stored by the farmers for growing in the next year.

Lentil Chickpea Tomato Mustard

Picture11.32 Production program of BARI released variety at FSRD site, Basantapur, Rajshahi

Table 11.64 Yield, cost and return of different crops at the FSRD Site, Basantapur, Rajshahi during 2019-2022

Variety	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Year - I (2019-2020)				
BARI Masur-8	1.95	136500	33750	102750
BARI Chola-5	1.52	91200	28500	62700
BARI Hybrid Tomato-8	18.50	1110000	587500	522500
BARI Sarisha-17	1.65	82500	40250	42250
BARI Sarisha-14	1.60	80000	40250	39750
BARI Alu-7	26.00	312000	158000	154000
BARI Alu-25	21.00	252000	158000	94000
BARI Alu-36	24.50	294000	158000	136000
BARI Alu-41	25.23	302760	158000	144760
BARI Alu-46	24.60	295200	158000	137200
Year - II (2020-2021)				
BARI Masur-8	1.90	133000	34750	98250
BARI Chola-5	1.55	100750	29500	71250
BARI Sarisha-17	1.75	.09375	40250	69125
BARI Sarisha-14	1.65	103125	40250	62875
BARI Hybrid Tomato-11	38.0	2280000	810000	1470000
BARI Alu-7	26.75	321000	158000	163000

Variety	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Year - II (2020-2021)				
BARI Alu-25	22.00	264000	158000	106000
BARI Alu-36	24.75	297000	158000	139000
BARI Alu-41	25.25	303000	158000	145000
BARI Alu-46	25.78	309360	158000	151360
Year- III (2021-2022)				
BARI Masur-8	1.50	120000	34750	85250
BARI Chola-5	1.45	108750	29500	79250
BARI Gom-30	3.20	96000	44000	52000
BARI Sarisha-18	1.80	139500	42000	97500
BARI Sarisha-17	1.72	129000	40250	88750
BARI Sarisha-15	1.55	112500	40250	72250
BARI Sarisha-14	1.65	123750	40250	83500
BARI Alu-7	27.00	324000	158000	166000
BARI Alu-25	22.50	270000	158000	112000
BARI Alu-36	24.95	299400	158000	141400
BARI Alu-41	26.20	314400	158000	156400
BARI Alu-46	26.30	315600	158000	157600

* Year- I= Oct 2019-Sep .2020; Year - II= Oct 2020-Sep.2021; Year- III= Oct 2021-May 2022

Table 11.65 Average yield, cost and return of crops at the FSRD Site Basantapur, Rajshahi during 2019-2022

Variety	Yield (t ha^{-1})	Gross return (Tk.ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk.ha^{-1})
BARI Masur-8	1.78	129833	34416	95417
BARI Chola-5	1.51	100233	29166	71067
BARI Gom-30	3.20	96000	44000	52000
BARI Sarisha-18	1.80	139500	42000	97500
BARI Sarisha-17	1.71	112500	40250	72250
BARI Sarisha-15	1.55	106958.	40250	66708
BARI Sarisha-14	1.67	104375	40250	64125
BARI Hybrid Tomato-8	18.50	1110000	587500	522500
BARI Hybrid Tomato-11	38.0	2280000	810000	1470000
BARI Alu-7	26.58	319000	158000	161000
BARI Alu-25	21.83	262000	158000	104000
BARI Alu-36	24.73	296800	158000	138800
BARI Alu-41	25.56	306720	158000	148720
BARI Alu-46	25.56	306720	158000	148720

* Year- I= Oct 2019-Sep .2020; Year - II= Oct 2020-Sep.2021; Year- III= Oct 2021-May 2022

Ave. price (Tk. kg^{-1}): BARI Masur-8: 73; BARI Chola-5: 66; BARI Gom-30: 30; BARI Sarisha-18: 77.5: BARI Sarisha-17: 66; BARI Sarisha-15: 69: BARI Sarisha-14: 63: BARI Hybrid Tomato-8: 60; BARI Hybrid Tomato-11: 60: BARI Alu-7: 12; BARI Alu-25: 12; BARI Alu-36:12; BARI Alu-41: 12; BARI Alu-46: 12.

FSRD site: Amnura, Chapainawabganj

Yearwise and average yield, cost and return of production programs on different crops and varieties are presented in Tables 11.66 and 11.67. In case of mustard, it was observed that, mustard var. BARI Sarisha-14 seed yield (1.57 t ha^{-1}) and BARI Sarisha-17 seed yield (1.66 t ha^{-1}) performed better. Farmers in the area very much impressed having the higher seed yield of BARI Sarisha-14 and BARI Sarisha-17 and good amount of seeds was stored by the farmers for growing in the next year.

Lentil var BARI Masur-8 produced a good seed yield (1.76 t ha^{-1}) among the other varieties of lentil, and farmers are keen interested about this variety because of the good market price. Chickpea is a traditional crop in the High Barind region where var. BARI Chola-5 is now well-known in the Barind area. The chickpea variety BARI Chola-5 produced 1.58 t ha^{-1} seed yield with gross margin (Tk. 78917 ha^{-1}) under production program in the farmer's field.

Lentil Chickpea Mustard

Picture11.33 Production program of BARI released variety at FSRD site Amnura, Chapainawabganj

Table 11.66 Yield, cost and return of crops at the FSRD site Amnura, Chapainawabganj during 2019-2022

Variety	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Year - I (2019-2020)				
BARI Masur-8	1.76	123200	33750	89450
BARI Chola-5	1.55	100750	28500	72250
BARI Sarisha-14	1.50	67500	30750	36750
Year - II (2020-2021)				
BARI Masur-8	1.82	127400	34750	92650
BARI Chola-5	1.65	107250	29500	77750
BARI Sarisha-17	1.60	100000	40250	59750
BARI Sarisha-14	1.55	96875	40250	56625
Year - III (2021-2022)				
BARI Masur-8	1.70	136000	34750	101250
BARI Chola-5	1.55	116250	29500	86750
BARI Sarisha-17	1.72	129000	40250	88750
BARI Sarisha-14	1.65	123750	40250	83500

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.67 Average yield, cost and return of crops at the FSRD site Amnura, Chapainawabganj during 2019-2022

Variety	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Masur-8	1.76	128867	34417	94450
BARI Chola-5	1.58	108083	29167	78917
BARI Sarisha-17	1.66	114500	40250	74250
BARI Sarisha-14	1.57	96042	37083	58958

Ave. price (Tk. kg^{-1}): BARI Masur-8: 73; BARI Chola-5: 68; BARI Sarisha-17: 69; BARI Sarisha-14: 61:

FSRD site, Chanduria, Rajshahi

Yearwise and average yield and economic performance of different crops under production program or on-farm verification trail are presented in the Table 11.68 and Table 11.69. The trials of different crop varieties were conducted for one to three years. It was observed that, among the short duration mustard varieties BARI Sarisha-17 gave the highest seed yield (1.45 t ha^{-1}) with gross margin (Tk. 79085 ha^{-1}) followed by BARI Sarisha-14. BARI Sarisha-18 is a semi-long duration and good quality edible oil producing variety. This variety yielded 1.93 t ha^{-1}. Among the mustards varieties BARI Sarisha-16 gave the maximum seed yield (2.01t ha^{-1}) with gross margin Tk. 49285 ha^{-1}. The grain yield of BARI Gom-30 was better than BARI Gom-33. Among the tested potato varieties, BARI Alu-57 gave the highest tuber yield (35.30 t ha^{-1}) followed by BARI Alu-40 (34.77 t ha^{-1}) and the lowest yield (22.50 t ha^{-1}) was found from BARI Alu-73. Among the all varieties BARI Alu-40 gave the highest gross margin (Tk. 244290 ha^{-1}) for its higher market price. The seed yield of BARI Masur-8 was found 1.82 t with gross margin of Tk. 101633 ha^{-1}. Farmers of the locality chose the variety for its high yield potential and good market price.

Mustard

Wheat

Lentil

Til

Rice

Potato

Picture11.34 Production program of BARI released variety at FSRD site Chanduria, Rajshahi

Table 11.68 Yield, cost and return of crops at the FSRD Site Chanduria, Rajshahi during 2019-2022

Variety	Yield (t ha^{-1})	Gross return (Tk.ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Year- I (2019-2020)				
BARI Masur-8	1.93	144750	37700	107050
BARI Sarisha-11	2.02	102250	52985	49265
BARI Sarisha-14	1.42	95850	36515	59335
BARI Sarisha-16	2.04	104315	52985	51330
BARI Sarisha-18	1.91	96800	52985	43815
BARI Gom-30	4.2	100800	48175	62625
BARI Til-4	1.10	66000	25000	41000
BRRI dhan82	3.30	116250	81750	34500
BARI Alu-7	31.32	375840	172950	202890
BARI Alu-37	32.35	388200	172950	215250
BARI Alu-40	35.42	425040	172950	252090
Year- II (2020-2021)				
BARI Masur-8	1.81	135750	37700	98050
BARI Sarisha-11	1.95	98706	52985	45721
BARI Sarisha-14	1.38	93150	36515	56635
BARI Sarisha-16	1.98	100225	52985	47240
BARI Sarisha-18	1.95	98706	52985	45721
BARI Gom-30	4.1	98400	48175	60225
BARI Gom-33	4.01	88750	38765	49985
BARI Til-4	1.20	72000	25000	47000
BARI Alu-7	30.35	364200	172950	191250
BARI Alu-37	31.56	381000	172950	208050
BARI Alu-40	34.12	409440	172950	236490
Year- III (2021-2022)				
BARI Masur-8	1.73	138000	38200	99800
BARI Sarisha-14	1.27	101600	36915	64685
BARI Sarisha-17	1.45	116000	36915	79085
BARI Sarisha-18	2.02	161600	36915	124685
BARI Alu-35	34.5	414000	260250	153750
BARI Alu-37	32.2	386400	260250	126150
BARI Alu-57	35.3	317700	260250	57450
BARI Alu-73	22.5	270000	260250	9750

* Year- I = Oct 2019-Sep .2020; Year- II= Oct 2020-Sep.2021; Year- III= Oct 2021-May 2022

Table 11.69 Average yield, cost and return of crops at the FSRD Site Chanduria, Rajshahi during 2019-2022

Variety	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{1-})	Gross margin (Tk. ha^{-1})
BARI Masur-8	1.82	139500	37867	101633
BARI Sarisha-11	1.99	100478	52985	47493
BARI Sarisha-14	1.36	96867	36648	60218
BARI Sarisha-16	2.01	102270	52985	49285
BARI Sarisha-17	1.45	116000	36915	79085
BARI Sarisha-18	1.93	97753	52985	44768
BARI Gom-30	4.15	99600	48175	61425
BARI Gom-33	4.01	88750	38765	49985
BARI Til-4	1.15	69000	25000	44000
BRRI dhan 82	3.30	116250	81750	34500
BARI Alu-7	30.84	370020	172950	197070
BARI Alu-35	34.50	414000	260250	153750
BARI Alu-37	32.04	385200	202050	183150
BARI Alu-40	34.77	417240	172950	244290
BARI Alu-57	35.30	317700	260250	57450
BARI Alu-73	22.50	270000	260250	9750

Ave. price (Tk. kg^{-1}): BARI Masur-8: 77; BARI Sarisha-11: 50; BARI Sarisha-14: 71; BARI Sarisha-16: 51; BARI Sarisha-17: 80; BARI Sarisha-18: 51; BARI Gom-30: 24; BARI Gom-33: 22; BARI Til-4: 60; BRRI dhan82: 35; BARI Alu-7: 12; BARI Alu-35: 12; BARI Alu-37:12; BARI Alu-40: 12; BARI Alu-57: 9; BARI Alu-73: 12

FSRD Site: Jiarokhi, Kushtia

Yearwise and average yield and economic performance of different crops under production program or on-farm verification trials are presented in the Tables 11.70 and 11.71.

The results revealed that in case of mustard var. BARI Sarisha-18 gave seed yield 1.72 t ha^{-1} which performed better than local varieties and farmers also chose for next year's cultivation. Among the lentil, BARI Masur-8 gave a good seed yield (2.12 t ha^{-1}) and farmers are more interested in cultivating this variety due to higher market price. The tuber yield of BARI Alu-7 and BARI Alu-53 were 22.19 and 25.05 t ha^{-1}, respectively. Under the production program, yield and gross margin 3.20 t ha^{-1} and Tk.162696 ha^{-1} were found from sunflower var. BARI Surjomukhi-3.

Table 11.70 Yield, cost and return of crops at the FSRD Site Jiarokhi, Kushtia during 2019-2022

Variety	Yield (tha^{-1})	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Year - I (2019-2020)				
BARI Masur-8	2.17	177025	41912	135113
BARI Sarisha-18	1.68	148000	42360	105640
BARI Alu-7	21.78	217800	139680	78120
BARI Alu-53	24.40	244000	139680	104320
Year- II (2020-2021)				
BARI Masur-8	2.05	153750	43250	110500
BARI Sarisha-18	1.75	148750	44265	104485
BARI Alu-7	22.60	226000	145000	81800
BARI Alu-53	25.75	257500	146350	111150
Year- III (2021-2022)				
BARI Masur-8	2.15	182750	47520	135230
BARI Sarisha-18	1.72	152000	43750	108250
BARI Alu-53	25.05	250500	147820	102680
BARI Surjomukhi-3	3.20	260800	98104	162696

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.71 Average yield, cost and return of crops at the FSRD Site Jiarokhi, Kushtia during 2019-2022

Variety	Yield (t ha^{-1})	Gross return (Tk.ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Masur-8	2.12	171175	44227	126948
BARI Sarisha-18	1.72	149583	43458	106125
BARI Alu-7	22.19	221900	142340	79560
BARI Alu-53	25.07	250667	144617	106050
BARI Surjomukhi-3	3.20	260800	98104	162696

Ave. price (Tk. kg^{-1}): BARI Masur-8: 81; BARI Sarisha-18: 87; BARI Alu-7: 10; BARI Alu-53: 10; BARI Surjomukhi-3: 82

Mustard Lentil Sunflower Potato

Picture11.35 Production program of BARI released variety at FSRD site Jiarokhi, Kushtia

FSRD Site: Kamalbazar, Sylhet

On-farm verification and production program on different crops (tomato, potato, mustard, sunflower, bottle gourd, country bean and brinjal) was conducted at the FSRD site, Kamalbazar, Sylhet for three years. Results of each year and their average are presented in the Table 11.72 and 11.73. The results revealed that in case of potato var. BARI Alu-46 gave the highest avg. tuber yield (32.70 t ha^{-1}) followed by BARI Alu-41 (30.40 t ha^{-1}) and the lowest (27.03 t ha^{-1}) from var. BARI Alu-53. Among the potato varieties BARI Alu-46 showed high gross margin of Tk. 271197 ha^{-1}. Tomato is a high value crop where var. BARI Hybrid Tomato-5 was selected due to its good shelf life and earliness. The BARI Hybrid Tomato-5 contributed fruit yield of 52.80 t ha^{-1} with the gross margin Tk. 384567 ha^{-1}. The mustard var. BARI Sarisha-17 (1.62 t ha^{-1}) and BARI Sarisha-14 (1.45 t ha^{-1}) performed better than that of BARI Sarisha-18 (1.39 t ha^{-1}). The short duration mustard varieties can contribute to meet up the edible oil deficit partially. In case of Sunflower, var. BARI Surjomukhi-3 (2.12 t ha^{-1}) performed better than BARI Surjomukhi-2 (1.90 t ha^{-1}). Furthermore, the BARI Surjomukhi-3 is a dwarf variety and less chance to lodge. Among the other vegetables bottle gourd var. the BARI Lau-4, country bean var. BARI Sheem-6 and brinjal var. BARI Begun-12 yielded 66.05, 17.50 and 48.40 t ha^{-1}, respectively. Among them var. BARI Begun-12 newly released variety, gave the highest gross return (Tk. 1452000 ha^{-1}) and gross margin (Tk. 1255950 ha^{-1}). Farmers showed positive response towards the variety of BARI Begun-12 for next year cultivation.

Table 11.72 Yield, cost and return of crops at FSRD site, Kamalbazar during 2019 to 2022

Variety	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Year- I (2019-2020)				
BARI Hybrid Tomato-5	52.7	527000	210800	316200
BARI Alu-41	30.4	453000	192560	260440
BARI Alu-46	32.2	462250	124900	237350
BARI Alu-53	25.4	338582	135430	203150
BARI Sarisha-14	1.38	117300	46920	70300
BARI Surjomukhi-2	1.9	133000	85255	47745
BARI Surjomukhi-3	2.12	148400	86300	62100
Year -II (2020-2021)				
BARI Hybrid Tomato-5	55.8	558400	170000	388400
BARI Alu-41	29.6	394568	157828	236740
BARI Alu-46	35.2	528000	197300	330700
BARI Alu-53	27.8	417000	193000	224000
BARI Sarisha-14	1.44	122400	81420	40980

Variety	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Sarisha-17	1.62	137700	84680	53020
BARI Lau-4	68.4	640470	256180	384280
BARI Sheem-6	17.5	525000	173620	351380
Year- III (2021-2022)				
BARI Hybrid Tomato-5	49.9	748500	299400	449100
BARI Alu-41	31.2	415890	166360	249540
BARI Alu-46	30.7	409230	163690	245540
BARI Alu-53	27.9	371910	148760	223150
BARI Sarisha-14	1.52	114000	45600	68400
BARI Sarisha-18	1.39	104250	41700	62550
BARI Lau-4	63.7	596460	238580	357870
BARI Begun-12	48.4	1452000	196050	1255950

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.73 Average yield, cost and return of crops at FSRD site, Kamalbazar during 2019 to 2022

Variety	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Hybrid Tomato-5	52.80	611300	226733	384567
BARI Alu-41	30.40	421153	172249	248907
BARI Alu-46	32.70	466494	161963	271197
BARI Alu-53	27.03	375831	159063	216767
BARI Sarisha-14	1.45	117900	57980	59893
BARI Sarisha-17	1.62	137700	84680	53020
BARI Sarisha-18	1.39	104250	41700	62550
BARI Surjomukhi-2	1.90	133000	85255	47745
BARI Surjomukhi-3	2.12	148400	86300	62100
BARI Lau-4	66.05	618465	247380	371075
BARI Sheem-6	17.50	525000	173620	351380
BARI Begun-12	48.40	1452000	196050	1255950

Ave. price (Tk. kg^{-1}): BARI Hybrid Tomato-5: 12; BARI Alu-41: 14; BARI Alu-46: 14; BARI Alu-53: 14; BARI Sarisha-14: 81; BARI Sarisha-17: 85; BARI Sarisha-18: 75; BARI Surjomukhi-2: 70 ; BARI Surjomukhi-3: 70; BARI Lau-4: 9; BARI Sheem-6: 30; BARI Begun-12:30.

Brinjal

Tomato

Bottle gourd

Picture11.36 Production program of BARI released variety at FSRD site Kamalbazar, Sylhet

11.2.2.2 Production program at FSRD site Naikhongchari, Bandarban of BLRI component

The average performance of crops is considered in economic analysis of the crop production. It is mentionable here that most of the farmers used local variety in their production system in the FSRD site Naikhongchari. The farmers are more interested in cultivating local varieties because of comparative less risk in production process of local varieties compared to HYV. So, an attempt was under taken to introduce farmers with HYV varieties through production program of different crops. The yield, cost and return of different crops are presented in the Table 11.74.

Potato: Local variety of potato was used in the farmer's field for production program. The average tuber yield of potato was 5.06 t ha^{-1} during the two consecutive years. The gross return, total variable cost and gross margin were calculated Tk. 151950, Tk. 65300 and Tk. 86650 ha^{-1}, respectively. The benefit cost ratio (BCR) was 2.33 which indicated that this technology is economically profitable.

Maize: Commercial hybrid variety (Hira-104) was used in maize production. The average grain yield of maize was 5.80 t ha^{-1} during the two consecutive years. The gross return, total variable cost and gross margin were calculated Tk. 145125, Tk. 60500 and Tk. 84625 ha^{-1}, respectively. The benefit cost ratio (BCR) was 2.40 which indicated that this technology is profitable.

Cowpea: Local variety was used in cowpea production. The average yield of cowpea was 1.48 t ha^{-1} during the two consecutive years. The gross return, total variable cost and gross margin were calculated Tk. 133650, Tk. 45300 and Tk. 88350 ha^{-1}, respectively. The benefit cost ratio (BCR) was 2.95 which indicated that this technology is profitable.

Kidney bean: The average yield of Kidney bean was 2.22 t ha^{-1} during the two consecutive years. The gross return, total variable cost and gross margin were calculated 200250, 52300 and Tk. 147950 ha^{-1}, respectively. The benefit cost ratio (BCR) was 3.83 which indicated that this technology is profitable.

Cucumber: Commercial Hybrid (Lal teer) variety was used in cucumber production. The field was monitored regularly. The yield data was recorded after every harvest period and yield was multiplied with market price for calculating gross margin. Data on variable costs was also recorded properly. The average fruit yield of cucumber was 9.88 t ha^{-1}. The gross return, total variable cost and gross margin were calculated Tk. 247000, Tk. 135000 and Tk. 112000 ha^{-1}, respectively. The benefit cost ratio (BCR) was 1.83 which indicated that this technology is profitable.

Brinjal: Commercial Hybrid (Lal teer) variety was used in brinjal production. The average fruit yield of brinjal was 11.11 t ha^{-1}. The gross return, total variable cost and gross margin were calculated 333450, 175700 and Tk. 157750 ha^{-1}, respectively. The benefit cost ratio (BCR) was 1.90 which indicated that this technology is profitable.

Sweetgourd: Commercial Hybrid (Lal teer) variety was used in sweet gourd production. The average fruit yield of sweet gourd was 12.10 t ha^{-1}. The gross return, total variable cost and gross margin were calculated 266760, 125000 and Tk. 141760 ha^{-1}, respectively. The benefit cost ratio (BCR) was 2.13 which indicated that this technology is profitable.

Table 11.74 Performance of different crops under production program at FSRD site, Naikhongchari, Bandarban during 2019-2022

Crop	Variety	Yield (t ha^{-1})			GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})	BCR
		Year-II	Year-III	Avg.				
Potato	Local	4.94	5.19	5.06	151950	65300	86650	2.33
Maize	Hira-104	6.18	5.43	5.80	145125	60500	84625	2.40
Cowpea	Local	1.24	1.73	1.48	133650	45300	88350	2.95
Kidney bean	Local	1.98	2.47	2.22	200250	52300	147950	3.83
Cucumber	Lal teer hybrid	-	9.88	9.88	247000	135000	112000	1.83
Brinjal	Lal teer	-	11.11	11.11	333450	175700	157750	1.90
Sweetgourd	Lal teer		12.10	12.10	266760	125000	141760	2.13

* Year II= Oct 2020-Sep.2021; Year- III= Oct 2021-May 2022

Ave. price (Tk. kg^{-1}): Potato - 30; Maize-25; Cowpea-90; Kidney bean-90; Cucumber-25; Brinjal-30; Sweetgourd-22.

Kidney bean

Potato

Picture 11.37 Production program at FSRD site Naikhongchari, Bandarban

11.3 Livestock System

More than 70 per cent of rural households are engaged in livestock related production and business in which smallholders and many landless households are engaged. Livestock is an important sub-sector of Bangladesh agriculture. Livestock and poultry sector can generate high-quality food products such as meat, egg, milk, cheese, etc. The Government of Bangladesh has given top priority to livestock development for milk, meat and egg production, and to create employment and generate income for the rural poor.

Animal diseases are the most important constraints to livestock development in Bangladesh which causes half of the death of all livestock population. Only proper vaccination can reduce the mortality rate of Livestock and poultry. To increase production and reduce mortality of livestock different program like cattle fattening, hilly chicken rearing, turkey rearing, duck rearing, pigeon rearing, goat/sheep rearing, poultry vaccination, goat vaccination, cattle vaccination, program was conducted at the FSRD sites.

11.3.1 Cattle, goat and sheep vaccination program

Animal disease control through vaccination is the most cost-effective way to reduce disease incidence and minimize economic losses.

11.3.1.1 Cattle, goat and sheep vaccination program at different FSRD sites of BARI component

FSRD Site: Basantapur, Rajshahi

Vaccination technology was found to be easy to adopt with minimal cost involvement. The information on the number of livestock under the vaccination program, name of the vaccine applied to the selected cattle and goat are presented in the Table 11.75. The total number of livestock brought under the vaccination program was 1110 at the FSRD Site, Basantapur, Rajshahi. It was found that before vaccination the mortality rate was higher (15%) but after vaccination of cattle and goat, all of the diseases frequency reduced drastically, and the mortality rate was around 2-3%.

Picture11.38 Cattle vaccination at FSRD site, Basantapur, Rajshahi

Table 11.75 Mortality information of goat and cattle before and after vaccination against major diseases at FSRD Site, Basantapur, Rajshahi during 2019 to 2022

Year of vaccination	Name of the vaccines	No. of animal vaccinated		Mortality rate (%)	
		Goat	Cattle	Before vaccination	After vaccination
Year- I	Anthrax, FMD, BQ, PPR	100	257	15	3
Year- II	Anthrax, FMD, BQ, PPR	110	268		3
Year- III	Anthrax, FMD, BQ, PPR	105	270		2
Total		315	795	Avg. 15	Range: 2-3; Avg: 2.5

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD site: Amnura, Chapainawabganj

Number of livestock under vaccination program i.e., vaccine applied to the selected cattle and goat are presented in Table 11.76. A total of 1290 cattle and 410 goats were vaccinated. Frequency of diseases (18%) was found higher before vaccination, but after vaccination, all of the diseases frequency reduced to 2-4%.

Picture11.39 Cattle vaccination at FSRD site, Amnura, Chapainawabganj

Table 11.76 Mortality information of goat and cattle before and after vaccination against major diseases at FSRD site, Amnura, Chapainawabganj during 2019 to 2022

Year of vaccination	Name of the vaccines	No. of animal vaccinated		Mortality rate (%)	
		Goat	Cattle	Before vaccination	After vaccination
Year- I	Anthrax, FMD, BQ, HS, PPR	105	365	18	4
Year- II	Anthrax, FMD, BQ, PPR	150	450		3
Year- III	Anthrax, FMD, BQ, PPR	155	475		2
Total		410	1290	Avg. 18	Range: 2-4; Avg: 3

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD site: Chanduria, Rajshahi

The number of livestock vaccinated, name of the vaccines used for the selected livestock and the percentage of mortality are presented in the Table 11.77. In the FSRD site Chanduria, Rajshahi, a total of 334 livestock were brought under vaccination. It was showed that before vaccination, the frequency of various diseases was higher (22%) whereas after vaccination, the frequency of all diseases decreased to 4-5% and the majority of the treated animals were free of Anthrax, BQ, HS, and FMD.

Table 11.77 Mortality information of goat, sheep and cattle before and after vaccination against major diseases at FSRD Site, Chanduria, Rajshahi during 2019 to 2022

Year of vaccination	Name of the vaccines	No. of animal vaccinated			Mortality rate rate (%)	
		Goat	Sheep	Cattle	Before vaccination	After vaccination
Year- I	Anthrax, BQ, HS, FMD	20	08	80	21	04
Year- II	Anthrax, BQ, HS, FMD	17	07	82	23	05
Year- III	FMD	32	09	80	22	05
Total		68	24	242	Avg. 22	Range: 4-5; Avg: 4.6

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Jiarokhi, Kushtia

The number of livestock vaccinated, the name of the vaccine used on the selected livestock, and the percentage of mortality are presented in the Table Table 11.78. At the FSRD site, Jiarokhi, Kushtia, a total of 175 livestock were brought under vaccination. Anthrax was found major Livestock disease in the FSRD site. Before vaccination, the frequency of Anthrax was higher and the mortality rate was 10% while after vaccination, the disease Anthrax occurrence reduced, and the mortality rate decreased into 2-4% range.

Picture11.40 Cattle vaccination at FSRD site, Jiarokhi, Kushtia

Table 11.78 Mortality information of livestock before and after vaccination against major disease (Anthrax) at FSRD Site Jiarokhi, Kushtia during 2019 to 2022

Year of vaccination	Name of the vaccine	No. of animal vaccinated			Mortality rate (%)	
		Goat	Buffalo	Cattle	Before vaccination	After vaccination
Year- I	Anthrax	20	10	30	10	4
Year- II	Anthrax	25	12	35		3
Year - III	Anthrax	15	8	20		2
Total		60	30	85	Avg. 10	Range: 2-4; Avg.: 3

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Kamalbazar, Sylhet

Number of livestock under vaccination program, name of the vaccine applied to the selected livestock and percentage of mortality are presented in Table 11.79. Total 230 livestock were brought under vaccination program in the FSRD Site, Kamalbazar, Sylhet. It was observed that, before vaccination, the diseases (Anthrax and FMD) occurrence frequency was higher with mortality rate 7-10% while after vaccination of livestock, all of the diseases frequency reduced as well as mortality rate decreased to 2-3% and most of the treated animals were free from Anthrax and FMD.

Picture11.41 Cattle vaccination at FSRD site, Kamalbazar, Sylhet

Table 11.79 Mortality information of goat, sheep and cattle before and after vaccination against major diseases at FSRD Site Kamalbazar, Sylhet during 2019-2022

Year of vaccination	Name of the vaccines	No. of animal vaccinated			Mortality rate (%)	
		Goat	Sheep	Cattle	Before vaccination	After vaccination
Year- I	Anthrax, FMD	25	10	30	10	3
Year- II	Anthrax, paraclear	30	12	35	8	3
Year- III	Anthrax, paraclear FMD	36	12	40	7	2
Total		91	34	105	Range : 7-10 Avg.: 8.2	Range: 2-3 Avg.: 2.7

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

11.3.1.2 Cattle, goat and sheep vaccination program at FSRD site Naikhongchari, Bandarban of BLRI component

The major livestock species (Cattle, goat and Sheep) were vaccinated against major diseases such as PPR and FMD at FSRD site, Naikhongchari, Bandarban during October 2019- May 2022. It was found that before vaccination mortality of livestock was 7.67% due to different diseases. After vaccination, occurrence frequencies all of the diseases reduced drastically and mortality rate was recorded 1.34% (Table 11.80).

Table 11.80 Mortality information of goat, sheep and cattle before and after vaccination against major diseases at FSRD site, Naikhongchari, Bandarban during 2019- 2022

Year of vaccination	Name of the vaccines	No. of animal vaccinated			Mortality rate (%)	
		Goat	Sheep	Cattle	Before vaccination	After vaccination
Year- I	PPR	110	70	-	10	2
	FMD	-	-	40		
Year- II	PPR	130	80	-	8	1
	FMD	-	-	35		
Year -III	PPR	100	100	-	5	1
	FMD	-	-	50		
Total		340	250	125	Avg.=7.67	Range: 1-2; Avg.=1.34

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.42 Livestock vaccination at FSRD site Naikhongchari, Bandarban

11.3.2 Poultry vaccination

Vaccination protects the welfare of farm animals by preventing or reducing disease and can help safeguard our food produced from animals. Poultry vaccines are widely applied to prevent and control contagious poultry diseases and thus increasing production.

11.3.2.1 Poultry vaccination at different FSRD sites of BARI component

FSRD site: Basantapur, Rajshahi

Several poultry vaccination program was carried out at the FSRD site Basantapur, Rajshahi during 2019-2022. The number of poultry in the vaccination program, the name of the vaccines and the mortality rate are presented in the Table 11.81. A total of 1276 chicken and 166 ducks were vaccinated. Among the cooperative farmers, it was found that before vaccination, mortality rate (25%) of poultry bird owing to several diseases but after vaccination mortality rate ranged from 4-6%.

Picture11.43 Poultry vaccination program at FSRD site, Basantapur, Rajshahi

Table 11.81 Mortality information of poultry birds before and after vaccination against major diseases at FSRD Site, Basantapur, Rajshahi during 2019 to 2022

Year of vaccination	Name of the vaccines	No. of poultry birds vaccinated		Mortalit rate (%)	
		Chicken	Duck	Before vaccination	After vaccination
Year- I	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	398	46	25	6
Year- II	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	412	55		5
Year-III	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	466	65		4
Total		1276	166	Avg. 25	Range: 4-6; Avg: 5

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD site: Amnura, Chapainawabganj

Several poultry vaccination program was carried out at the FSRD site Amnura, Chapainawabganj during 2019-2022. The number of poultry in the vaccination program, name of the vaccines and the mortality rate are presented in the Table 11.82. A total of 1299 chicken and 188 ducks were vaccinated. Among the cooperative farmers, mortality rate of poultry was higher before vaccination (22%). Mortality rate of poultry reduced after vaccination that was ranged from 3-7% (Table 11.82).

Picture11.44 Poultry vaccination program at FSRD site, Amnura, Chapainawabganj

Table 11.82 Mortality information of poultry birds before and after vaccination against major diseases at FSRD site, Amnura, Chapainawabganj during 2019 to 2022

Year of vaccination	Name of the vaccines	No. of poultry birds vaccinated		Mortality rate (%)	
		Chicken	Duck	Before vaccination	After vaccination
Year -I	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	386	50	22	7
Year- II	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	447	68		6
Year- III	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	466	70		3
Total		1299	188	Avg. 22	Range : 3-7; Avg: 5

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD site: Chanduria, Rajshahi

Poultry vaccinations program was carried out at the FSRD site Chanduria, Rajshahi during 2019-2022. The number of poultry in the vaccination program, the name of the vaccine and the mortality rate are presented in the Table 11.83. A total of 1244 chicken and 162 ducks were vaccinated. Before vaccination program, among the cooperative farmers, the mortality percentage of poultry birds against various diseases was higher (17%). All infections were dramatically decreased after vaccination of poultry birds, with a mortality rate ranged from 4-5% (Table 11.83).

Picture11.45 Poultry vaccination program at FSRD site, Chanduria, Rajshahi

Table 11.83 Mortality information of poultry birds before and after vaccination against major diseases at FSRD Site, Chanduria, Rajshahi during 2019 to 2022

Year of vaccination	Name of the vaccines	No. of poultry birds vaccinated		Mortality rate (%)	
		Chicken (Sonali)	Duck (Khaki Campbell)	Before vaccination	After vaccination
Year- I	BCRDV, RDV and Duck plague	374	47	17	04
Year- II	BCRDV, RDV and Duck plague	445	55	17	04
Year- III	BCRDV, RDV and Duck plague	325	60	17	05
Total		1244	162	Avg. 17	Range: 4-5; Avg: 4.33

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Jiarokhi, Kushtia

The number of poultry in the vaccination program, name of the vaccines and mortality rate are presented in the Table 11.84. A total of 455 chicken and 195 ducks were vaccinated. Among the cooperative farmers, the mortality percentage of poultry birds against various diseases was recorded before vaccination (20%). All diseases were drastically decreased after vaccination of poultry birds, with a mortality rate ranged from 4-6% (Table 11.84).

Picture11.46 Poultry vaccination program at FSRD site, Jiarokhi, Kushtia

Table 11.84 Mortality information of poultry birds before and after vaccination against major diseases at FSRD Site, Jiarokhi, Kushtia during 2019 to 2022

Year of vaccination	Name of the vaccines	No. of poultry birds vaccinated		Mortality rate (%)	
		Chicken	Duck	Before vaccination	After vaccination
Year- I	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	140	60	20	6
Year- II	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	150	70		5
Year- III	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	165	65		4
Total		455	195	Avg. 20	Range: 4-6; Avg: 5

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Kamalbazar, Sylhet

Vaccination program of poultry birds was conducted at FSRD Site, Kamalbazar, Sylhet during 2019 to 2022. The number of poultry under vaccination program, name of the vaccine applied to the selected poultry birds and mortality rate are presented in the Table 11.85. The total number of vaccinated chickens was 734 and duck was 397. Mortality percentage of poultry birds against different diseases was recorded among the cooperative farmers. The mortality of poultry birds due to different diseases was higher (20%) before vaccianation. After vaccination of poultry, all of the diseases reduced drastically, and mortality rate ranged 3-7%.

Picture11.47 Poultry vaccination program at FSRD site, Kamalbazar, Sylhet

Table 11.85 Mortality information of poultry birds before and after vaccination against major diseases at FSRD Site, Kamalbazar, Sylhet during 2019-2022

Year of vaccination	Name of the vaccines	No. of poultry birds vaccinated		Mortality rate (%)	
		Chicken	Duck	Before vaccination	After vaccination
Year- I	BCRDV Duck plague	170	120	28	7
Year- II	RDV Duck plague	294	135	18	6
Year- III	BCRDV, RDV Duck plague	270	142	15	3
Total		734	397	Range: 15-28: Avg : 20	Range :3-7 Avg: 5

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

11.3.2.2 Poultry vaccination at FSRD site Naikhongchari, Bandarban of BLRI component

A total number of 994 poultry birds were vaccinated at FSRD site, Naikhongchari, Bandarban during 2019-2022 of which 904 and 90 were chicken and duck, respectively. The poultry birds were vaccinated as (BCRDV, RDV, and Duck plague) against major diseases. It was found that, average mortality rate before vaccination was 14% but after vaccination of birds all of the diseases occurrence frequency reduced drastically and mortality rate ranged from 1-2% (Table 11.86).

Table 11.86 Mortality (%) of poultry birds before and after vaccination against major diseases at FSRD site, Naikhongchari, Bandarban during October 2019-May 2022

Year of vaccination	Name of the vaccines	No. of poultry birds vaccinated		Mortality rate (%)	
		Chicken	Duck	Before vaccination	After vaccination
Year- I	BCRDV and RDV	432	-	15	2
	Duck plague	-	36		
Year- II	BCRDV and RDV	232	-	14	2
	Duck plague	-	24		
Year- III	BCRDV and RDV	240	-	13	1
	Duck plague	-	30		
Total		904	90	Avg.= 14	Range : 1-2; Avg.= 1.67

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.48 Poultry vaccination at FSRD site Naikhongchari, Bandarban

11.3.3 Cattle fattening

Cattle of Bangladesh are an integral part of the agricultural farming and agribusiness system. Cattle fattening for beef production is an emerging sector for employment and income generation for the rural poor, especially landless, destitute and divorced women. Cattle fattening is an effective tool for poverty alleviation of the rural poor in Bangladesh. One of the advantages of the cattle fattening in the rural areas is

that farmers use locally available cattle feed resources (Ahmed *et al*., 2010). In recent years the women farmers of Bangladesh have been involved and sustained beef fattening program in rural areas of the country.

11.3.3.1 Cattle fattening at different FSRD sites of BARI component

FSRD Site: Basantapur, Rajshahi

Cattle fattening program was implemented at the FSRD site, Basantapur, Rajshahi during 2019 to 2022. Adequate green roughage and balanced concentrate feed were supplied under this program along with routine de-warming and vaccination. It was found that the body weight of cattle increased due to the fattening program. After six month of rearing, farmer received gross margin 26000, 25000 and Tk. 28600, respectively in the Year-I, Year-II and Year-III. Each farmer earned average gross margin of Tk. 26533 from cattle fattening (Table 11.87).

Picture11.49 Cattle fattening program at FSRD site, Basantapur, Rajshahi

Table 11.87 Performance of cattle fattening programme during 2019-2022 at the FSRD Site, Basantapur, Rajshahi (Per family)

Description of item	Year- I	Year- II	Year- III
No. of farmer	2	2	2
No. of cattle selected	2	2	2
No. cattle per farmer	1	1	1
Age of cattle (month)	12	13	12
Avg. wt. of cattle during distribution period (kg)	85	102	98
Avg. procurement price per cattle (Tk.)	38875	47000	45600
Rearing period (month)	6	6	6
Avg. body wt. (Kg) of cattle in selling period	190	211	208
Avg. price of cattle (Tk.)	80000	88000	93600
Gross income (Tk.) from alive cattle (sale + consumption+ distribution)	80000	88000	93600
Total variable cost (market value of calf/cattle + fed cost + health management cost)	54000	63000	65000
Gross Margin in Tk. (Gross income –Total variable cost)	26000	25000	28600
Average gross margin in Tk.	26533		

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD site: Amnura, Chapainawabganj

Cattle were dewormed and vaccinated under the fattening program and supplied balanced ration. It was found that body weight of cattle under the program, increased rapidly. Each farmer earned average gross margin of Tk. 33900 from cattle fattening after six months of rearing (Table 11.88).

Picture11.50 Cattle fattening program at FSRD site, Amnura, Chapainawabganj

Table 11.88 Performance of cattle fattening programme during 2019-2022 at the FSRD site, Amnura, Chapainawabganj (Per family)

Description of item	Year- I	Year- II	Year- III
No. of farmer	2	3	2
No. of cattle selected	2	3	2
No. cattle per farmer	1	1	1
Age of cattle (month)	12	13	12
Avg. wt. of cattle during distribution period (kg)	85	96	98
Avg. procurement price per cattle (Tk.)	38400	41000	44000
Rearing period (month)	6	6	6
Avg. body wt. (Kg) of cattle in selling period	211	220	208
Avg. price of cattle (Tk.)	88600	95000	93600
Gross income (Tk.) from alive cattle (sale + consumption + distribution)	88600	95000	93600
Total variable cost (market value of calf/cattle + fed cost + health management cost)	55000	59500	61000
Gross Margin in Tk. (Gross income –Total variable cost)	33600	35500	32600
Average gross margin in Tk.	33900		

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD site: Chanduria, Rajshahi

Cattle fattening program was performed at the FSRD site in Chanduria, Rajshahi during 2019 - 2022. This initiative was implemented with green grasses and Urea Molasses Straw (UMS). After six months rearing, farmers received gross margin 11400, 9300 and Tk. 14580, respectively in the Year-I, Year-II and Year-III. Each farmer earned average gross margin Tk. 11760 from cattle fattening which was 114% higher before intervention (Table 11.89).

Picture11.51 Cattle fattening program at FSRD site, Chanduria, Rajshahi

Table 11.89 Performance of cattle fattening programme during 2019-2022 at the FSRD site, Chanduria, Rajshahi (Per family)

Description of item	Before intervention	After intervention		
		Year - I	Year - II	Year-III
No. of farmer	06	06	10	11
No. of cattle reared	08	06	10	11
Age of cattle (month)	32	20	20	22
Avg. wt. of cattle during first feed distribution period (kg)	99	87	83	92
Avg. estimated price per cattle before rearing time (Tk.)	44000	37000	35500	41000
Rearing period (month)	12	06	06	06
Avg. body wt. (Kg) of cattle in selling period	125	132	128	141

Description of item	Before intervention	After intervention		
		Year - I	Year - II	Year-III
Gross income from alive cattle (Tk.)	53000	62900	59000	71500
Total variable cost (market value of calf/cattle + fed cost + health management cost)	47500	51500	49700	56920
Gross Margin (Tk.)	5500	11400	9300	14580
Average gross margin in Tk.	5500	11760		

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Jiarokhi, Kushtia

Cattle fattening program was implemented in FSRD Site, Jiarokhi, Kushtia during 2019 to 2022. Adequate green roughage and balanced concentrate feed were supplied under this program along with routine de-worming and vaccination. It was found that body weight of cattle increased due to fattening program. Each farmer earned average gross margin Tk. 28000 from cattle fattening (Table 11.90).

Picture11.52 Cattle fattening program at FSRD site, Jiarokhi, Kushtia

Table 11.90 Performance of cattle fattening program during 2019-2022 at the FSRD Site, Jiarokhi, Kushtia (Per family)

Description of item	Year- I	Year -II	Year- III
No. of cattle	2	2	2
Age of cattle (month)	15	16	14
Avg. wt. of cattle (kg)	70	75	70
Rearing period (month)	10	11	7
Avg. body wt. (Kg) of cattle in selling period	125	130	0
Avg. price of cattle (Tk.)	62500	66000	0
Gross income (Tk.)	62500	66000	0
Total variable cost (market value of calf/cattle + fed cost + health management cost)	35000	37500	42300
Gross Margin in Tk. (Gross income –Total variable cost)	27500	28500	0
Average gross margin in Tk.	28000		

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

11.3.3.2 Cattle fattening at FSRD site Naikhongchari, Bandarban of BLRI component

Cattle fattening program was started at December 2021 and continued up to May 2022. Two farmers were selected for cattle fattening program. One 24-30 month aged bull was selected from each farmer for fattening program. Under cattle fattening program bull was dewormed, vaccinated and supplied balance and improved feed. Initial body weight of the cattle was 155 kg while after 6 months of rearing body weight gained 210 kg due to deworming, vaccination and supplying of balance and improved feed, gross margin was calculated Tk. 20000 from cattle fattening program (Table 11.91). Results showed that small scale cattle fattening enterprise were profitable.

Figure 11.53 Cattle fattening program at FRSD site Naikhongchari, Bandarban

Table 11.91 Performance of cattle fattening programme at the FSRD site Naikhongchari, Bandarban

Description of item	Year III
No. of farmer	1
No. of cattle distributed	1
No. cattle farmer distributed	2
Age of cattle (month)	24-30
Avg. wt. of cattle during distribution period (kg)	150-175
Avg. procurement price per cattle (Tk.)	50000-60000
Rearing period (month)	6
Avg. body wt. (Kg) of cattle in selling period	200-220
Avg. price of cattle (Tk.)	80000-95000
Gross income (Tk.) from alive cattle (sale + consumption+ distribution)	90000
Total variable cost (market value of calf/cattle + fed cost + health management cost)	70000
Gross Margin in Tk. (Gross income –Total variable cost)	20000

Year- III: Oct. 2021-May 2022

11.3.4 Goat rearing

Goat rearing is an integral part of many farming systems in Bangladesh. The goat is probably the only animal which in Bangladesh is managed for multiple end uses: meat, hides, milk and manure. It provides one of the main sources of income for the farmers of Bangladesh. It is a major contributor of protein and fat and often the goat enterprise can help farmers to overcome an unforeseen crisis, which demands immediate finance. Cash income from the goat is utilized in different sub-sectors of the farm.

11.3.4.1 Goat rearing at different FSRD sites of BARI component

FSRD Site: Basantapur, Rajshahi

At the FSRD site in Basantapur, Rajshahi, two farmers willingly reared male goats as part of a fattening program. Five goats were raised by one farmer, while three were raised by another. As an upgraded technology, the FSRD team created a bamboo slot. The technology protected them from a variety of ailments, and their goat growth accelerated. On an average the goat's initial body weight was 10.0 kg while after ten months the goats reached a weight of 24.0 kg, resulting in a gross margin of Tk. 6700 each goat, and a total of Tk. 26800 for the rearing of four goats. (Table 11.92)

Table 11.92 Performance of goat rearing at FSRD Site, Basantapur, Rajshahi during the years of 2020 to 2021

Description of Items	Information
Number of farmers	2
Number of goats reared	4
Date of supplied	September 2020
Age of goat during distribution	5-6 months
Initial body wt. goat^{-1} (kg)	10 Kg
Procurement price goat^{-1} (Tk.)	5000
No of goat survive	4
Wt. gained/goat after 10 months	14 kg
Gross return (Tk.) goat^{-1}	13500
Total variable cost (Tk.) goat^{-1}	6800
Gross margin (Tk.) goat^{-1}	6700
Total Gross Margin (Tk.) per farmer for 4 goat rearing	26800

* Year- II= Oct. 2020-Sep. 2021

FSRD Site: Chanduria, Rajshahi

Four farmers reared male and female goats willingly under fattening program at FSRD site, Chanduria, Rajshahi. Each farmer reared one goat. The technology protected them from different diseases and goat growth enhanced rapidly. Survival rate was 100%. After 6-10 months rearing, the goat weight was increased. On an average, gross margin was found Tk. 2750 from each goat and accordingly all farmer earned Tk. 11000 for rearing of 4 goats (Table 11.93).

Table 11.93 Performance of goat rearing at FSRD Site, Chanduria, Rajshahi during the years of 2019 to 2022

Description of Items	Information
Number of farmers	4
Number of goats	4
Procurement price goat^{-1} (Tk.)	3750
No. of goat survive	4
Gross return (Tk.) goat^{-1}	7250
Total variable cost (Tk.) goat^{-1}	4500
Gross margin (Tk.) goat^{-1}	2750
Total Gross Margin (Tk.) for 4 farmer from 4 goat rearing	11000

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

11.3.4.2 Goat rearing at FSRD site Naikhongchari, Bandarban of BLRI component

Performances of distributed goat in farmers' households are presented in Table 11.94. Eighteen to twenty four months aged goats were distributed among the 6 farmers during in the first year (October 2019-Sep 2020). Average initial body weight of distributed goats was 10-12 kg. From one household, a total of 10 kids were borne during October 2019-May 2022. Average gross margin 6000, 23600 and Tk. 36000 were found in the 1st, 2nd and 3rd year, respectively. It was observed that goat rearing is very much profitable. Farmers were very enthusiastic in adopting this program and also like to continue this program.

Table 11.94 Performance of goat rearing programme during 2019-2022 at the FSRD site Naikhongchari, Bandarban (Per family)

Description of item	Year- I	Year- II	Year- III
No. of farmer	6	6	2
No. of goat distributed	14	14	3
No. goat /farmer distributed	1-2	2	1-2
Age of goat (month)	18-24	26	12-18

Description of item	Year- I	Year- II	Year- III
Avg. wt. during distribution period (kg)	10-12	14.5	14-15
Avg. procurement price per goat (Tk.)	7000	7000	7000
Rearing period (month)	12	18	6
Total kids born (No.)	2	4	4
Value of alive kids (Tk.)	7000	14000	14000
Avg. price of alive kid (Tk.)	3500	3500	3500
Income (Tk.) from alive goat (sale + consumption + distribution)	8000	12000	15000
Gross income in Tk. (Kids + adult goat)	21000	42000	56000
Total variable cost (Purchase value of goat + fed cost + health management cost)	15000	18400	20000
Gross Margin in Tk. (Gross income –Toal variable cost)	6000	23600	36000

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.54 Goat rearing at FSRD site Naikhongchari, Bandarban

11.3.4.3 Sheep rearing in farmer's household at FSRD site Naikhongchari, Bandarban

The sheep play a very important role in the rural economy of Bangladesh by providing a source of employment, women empowerment and the tool for poverty alleviation. Among the small ruminants, native sheep are important for production of meat in Bangladesh.

Performances of distributed sheep in farmer's households are presented in the Table 11.95. Twelve months aged sheep were distributed among the 6 farmers during October 2020-May 2021. Average initial body weights of distributed sheep were 16.5 kg. In October 2021-May 2022, after six month of rearing average body weight gained 7.0 kg. From 6 households, a total of 18 lambs were born during October 2021-May 2022. Average gross margin Tk. 41000 farm family^{-1} was found during October 2021-May 2022. Some sheep had second progeny and some had first. Farmers were very enthusiastic in adopting this program and also like to continue this program.

Table 11.95 Performance of sheep rearing programme during 2019-2022 at FSRD site, Naikhongchari, Bandarban (per family)

Description of item	Year- I	Year- II	Year -III
No. of farmer	6	6	6
No. of sheep distributed	18	18	18
No. sheep /farmer distributed	3	3	3
Age of sheep (month)	18-24	24	12
Avg. wt. during distribution period (kg)	12-14	16.5	16.5
Avg. procurement price per sheep (Tk.)	6000	6000	6000

Description of item	Year- I	Year- II	Year -III
Rearing period (month)	12	18	30
Total lamb born (No.)	3	4	6
Value of alive lamb (Tk.)	9000	12000	18000
Avg. price of alive lamb (Tk.)	3000	3000	3000
Income (Tk.) from alive sheep (sale + consumption + distribution)	10000	15000	20000
Gross income in Tk. (lamb + adult goat/sheep)	27000	54000	72000
Total variable cost (Purchase value of sheep + fed cost + health management cost)	20000	19400	25000
Gross Margin in Tk. (Gross income – Total variable cost)	7000	34600	47000

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.55 Sheep rearing at FSRD site Naikhongchari, Bandarban

11.3.5 Performance of chicken rearing

11.3.5.1 Performance of chicken rearing at different FSRD sites of BARI component

FSRD Site: Basantapur, Rajshahi

At the FSRD site Basantapur, Rajshahi, Sonali chicken rearing program was implemented. Ten farmers in the hamlet were chosen for poultry production, and each received about 13 Sonali chicks per year from a regional farm (male to female ratio is 1:10). All Sonali chicken, as well as local chickens, were vaccinated as per recommendation of Department of Livestock Service (DLS). The initial body weight of each bird was 0.37-0.52 kg. In the first, second, and third years, a total of 1385, 1125, and 1280 eggs were produced, respectively with gross income per household Tk. 14887, 12850, 14090, and gross margin Tk. 9287, 7700, 8590, respectively (Table 11.96). Farmers showed their interest in rearing of Sonali chicken due to their growth and number of egg production.

Picture11.56 Sonali chicken rearing program at FSRD site, Basantapur, Rajshahi

Table 11.96 Performance of Sonali chicken rearing during 2019-2022 at the FSRD Site, Basantapur, Rajshahi

Description of item	Year- I	Year- II	Year- III
No. of farmer	12	8	10
No. of bird distributed	192	96	120

Description of item	Year- I	Year- II	Year- III
No. bird /farmer distributed	16	12	12
Age of bird (month)	2	3	3
Avg. wt. of bird during distribution period (kg)	0.37	0.51	0.52
Avg. procurement price per bird (Tk.)	100	120	125
Rearing period (month)	9	8	8
Total egg production (No.)	1385	1125	1280
Income (Tk.) from egg (sale + consumption+ distribution)	10387	9000	10240
Avg. price of bird (Tk.)	300	350	350
Income (Tk.) from alive bird (sale + consumption+ distribution)	4500	3850	3850
Gross income in Tk. (Egg + bird)	14887	12850	14090
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost)	5600	5150	5500
Gross Margin in Tk. (Gross income –Total variable cost)	9287	7700	8590

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

A comparison between before and after intervention in income from egg and bird are shown in the Table 11.97. Before intervention, gross income from egg was Tk. 688 and from bird it was Tk. 1450 which turned into Tk. 10104 from egg and Tk. 4020 from bird after intervention. Gross income from chicken was increased by 561%.

Table 11.97 Comparative income information (before intervention and after intervention) from chicken rearing at the FSRD Site, Basantapur, Rajshahi (Per family)

Description of item	Before intervention		After intervention		Increment over before intervention		% Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg								
Sale	50	400	740	5920	690	5520	1380	1380
Consumption	36	288	490	3920	454	3632	1261	1261
Distribution	-	-	33	264	33	264		
Gross income from egg	86	688	1263	10104	1177	9416	1369	1369
Bird								
Sale	2	580	8	2680	6	2100	300	362
Consumption	3	870	4	1340	1	470	33	54
Distribution	-	-	-	-	-	-	-	-
Gross income from bird	5	1450	12	4020	7	2570	140	177
Gross income from Chicken (Egg + bird)	5	2138	15	14124	10	11986	200	561

FSRD site: Amnura, Chapainawabganj

Sonali chicken rearing program was initiated at the FSRD site: Amnura, Chapainawabganj. Ten farmers were chosen for Sonali chicken rearing, and each farmer received nearly 13 Sonali chicks per year (male to female ratio is 1:10) purchased from a regional poultry farm. All purchased Sonali chickens, along with local birds, were vaccinated as per the recommended schedule. The initial body weight was 0.37–0.52 kg per bird. The total number of eggs was produced 1405, 1150, and 1300 in the first, second, and third years, respectively with gross income per family Tk. 15740, 13050, and 14250 and gross margin Tk. 10140, 7900, and 8750 in the first, second, and third years, respectively (Table 11.98).

Picture11.57 Sonali chicken rearing program at FSRD site, Amnura, Chapainawabganj

Table 11.98 Performance of Sonali chicken rearing during 2019-2022 at the FSRD site, Amnura, Chapainawabganj (Per family)

Description of item	Year- I	Year- II	Year- III
No. of farmer	12	8	10
No. of bird distributed	192	96	120
No. bird /farmer distributed	16	12	12
Age of bird (month)	2	3	3
Avg. wt. of bird during distribution period (kg)	0.37	0.51	0.52
Avg. procurement price per bird (Tk.)	100	120	125
Rearing period (month)	9	8	8
Total egg production (No.)	1405	1150	1300
Income (Tk.) from egg (sale + consumption+ distribution)	11240	9200	10400
Avg. price of bird (Tk.)	300	350	350
Income (Tk.) from alive bird (sale + consumption+ distribution)	4500	3850	3850
Gross income in Tk. (Egg + bird)	15740	13050	14250
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost)	5600	5150	5500
Gross Margin in Tk. (Gross income –Total variable cost)	10140	7900	8750

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

A comparison between before and after intervention in income from egg and bird are shown in Table 11.99. Before intervention, income from egg was Tk. 1200 while from bird Tk. 1740 which turned into Tk. 10280 from egg and Tk. 4020 from bird after intervention. Gross income from chicken was increased by 386%.

Table 11.99 Comparative income information (before intervention and after intervention) from chicken rearing at the FSRD site, Amnura, Chapainawabganj (Per family)

Description of item	Before intervention		After intervention		Increment over before intervention		% Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg								
Sale	100	800	800	6400	700	5600	700	700
Consumption	50	400	400	3200	350	2800	700	700
Distribution	-	-	85	680	85	680		

Description of item	Before intervention		After intervention		Increment over before intervention		% Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Gross income from egg	150	1200	1285	10280	1135	9080	757	757
Bird								
Sale	2	580	8	2680	6	2100	300	362
Consumption	4	1160	4	1340	0	0	0	0
Distribution	-	-	-	-	-	-		
Gross income from bird	6	1740	12	4020	6	2280	100	131
Gross income from Chicken (Egg + bird)	6	2940	12	14300	6	11360	100	386

FSRD site: Chanduria, Rajshahi

To implement chicken rearing program at the FSRD site, Chanduria, Rajshahi twelve farmers were selected from two villages. Average 19 numbers of Sonali chicks were supplied each farmer every year (ratio between male and female was 1:10) which was purchased from regional government poultry farm. All purchased Sonali chicken along with local birds was vaccinated as per recommended schedule. The initial body weight was 0.29 kg per bird. Avg. 1042 number eggs were produced from each family. On an average, it was found that after intervention, gross income and gross margin per family was Tk.17550 and Tk. 15050, respectively (Table 11.100) which is higher than that of before intervention (Gross income: Tk. 2960 and Gross margin: Tk. 2360 family^{-1}).

Picture11.58 Sonali chicken rearing program at FSRD site, Chanduria, Rajshahi

Table 11.100 Performance of Sonali and Improved local chicken rearing programme during 2019-2022 at the FSRD site, Chanduria, Rajshahi

Description of item	Before intervention (local)	After intervention			
		Year- I	Year- II	Year- III	Avg.
No. of farmer	12	12	12	12	12
Total no. of bird distributed	72	216	240	216	224
Avg. no. of bird distributed /family	-	18	20	18	19
Age of bird (month)	2.5	2.5	02	2.5	2.3
Avg. wt. of bird during distribution period (kg)	-	0.30	0.25	0.31	0.29
Avg. procurement price per bird (Tk.)	200	140	120	200	153
Rearing period (month)	12	04	06	06	5.3
Total egg production (No./family)	56	1075	1189	862	1042
Income from egg (sale + consumption+ distribution) (Tk./family)	560	10750	11890	8625	10422

Description of item	Before intervention (local)	After intervention			
		Year- I	Year- II	Year- III	Avg.
Avg. price of bird (Tk.)	400	450	460	485	465
Income from alive bird (sale + consumption+ distribution) (Tk./family)	2400	6750	7360	7275	
Gross income in Tk. (Egg + bird)	2960	17500	19250	15900	17550
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost) (Tk./family)	600	2500	3500	1500	2500
Gross Margin (Tk. family^{-1})	2360	15000	15750	14400	15050

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Comparison between before and after intervention in income from egg and bird are shown in (Table 11.101). Before intervention, gross income from egg was Tk. 560 and from bird was Tk. 2400 which turned into Tk. 10420 from egg and Tk.7200 from bird after intervention. Gross income from chicken rearing was increased by 495%.

Table 11.101 Comparative income information (before intervention and after intervention) from chicken rearing at the FSRD site, Chanduria, Rajshahi

Description of item	Before intervention		After intervention		Increment over before intervention		% of Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg	56	560	1042	10420	986	9860	1761	1761
Sale	20	200	715	7150	695	6950	3475	3475
Consumption	36	360	327	3270	291	2910	808	808
Distribution	-	-	-	-	-	-	-	-
Gross income from egg	56	560	1042	10420	986	1120	1761	200
Bird	6	2400	16	7200	10	4800	167	200
Sale	4	1600	12	5400	08	3800	200	236
Consumption	2	800	04	1800	02	1000	100	125
Distribution	-	-	-	-	-	-	-	-
Gross income from bird	06	2400	16	7200	10	4800	167	200
Gross income from chicken rearing (Egg + bird)	06	2960	16	17620	10	14660	167	495

FSRD Site: Jiarokhi, Kushtia

Twelve farmers in the hamlet were chosen for poultry rearing, and each was given an average of ten Sonali chicks per year (male to female ratio is 1:10). All Sonali chicken and local birds were vaccinated according to the approved schedule. The initial body weight of each bird was 0.50-0.55 kg. In the first, second, and third years, the total number of eggs was produced 750, 650, and 700, respectively while gross income per farm was Tk. 39696, 34684, 37324, and gross margin was Tk. 18096, 17404, 17884, respectively (Table 11.102).

Picture11.59 Sonali chicken rearing program at FSRD site, Jiarokhi, Kushtia

Table 11.102 Performance of Sonali chicken rearing program during 2019-2022 at the FSRD site, Jiarokhi, Kushtia (Per family)

Description of item	Year- I	Year- II	Year- III
No. of farmer	12	12	12
No. of bird distributed	120	96	108
No. bird /farmer distributed	10	8	9
Age of bird (month)	1	1	1
Avg. wt. of bird during distribution period (kg)	0.50	0.55	0.50
Avg. procurement price per bird (Tk.)	130	135	140
Rearing period (month)	6	6	6
Total egg production (No.)	750	650	700
Income (Tk.) from egg (sale + consumption+ distribution)	6000	5200	5600
Avg. price of bird (Tk.)	312	324	308
Income (Tk.) from alive bird (sale + consumption + distribution)	33692	29484	31724
Gross income in Tk. (Egg + bird)	39696	34684	37324
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost)	21600	17280	19440
Gross Margin in Tk. (Gross income –Total variable cost)	18096	17404	17884

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Comparison between before and after intervention in income from egg and bird are shown in Table 11.103. Before intervention, income from egg was Tk. 2700 and from bird was Tk. 14000 which turned into Tk. 6750 from egg and Tk. 35568 from bird after intervention.

Table 11.103 Comparative income information (before intervention and after intervention) from chicken rearing at the FSRD site, Jiarokhi, Kushtia (Per family)

Description of item	Before intervention		After intervention		Increment over before intervention		% Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg	300	2700	750	6750	450	4050	150	150
Sale	100	900	400	3600	300	2700	300	300
Consumption	200	1800	300	2700	100	900	50	50
Distribution	0	0	50	450	50	450	100	100
Gross income from egg	300	2700	750	6750	450	4050	150	150
Bird	50	6500	120	15600	70	9100	140	140

Description of item	Before intervention		After intervention		Increment over before intervention		% Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Sale	30	8400	60	18720	30	10320	100	123
Consumption	20	5600	44	13728	24	8128	120	145
Distribution	0	0	10	3120	10	3120	100	100
Total income from bird	50	14000	114	35568	64	19968	128	143

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Kamalbazar, Sylhet

Sonali chicken rearing program was conducted at two households. On an average, 50 birds were supplied to each farmer in every year with maintaining the male and female ratio of 1:10, which was purchased from nearby recognized poultry farm. All purchased Sonali chicken along with local birds was vaccinated as per recommended schedule. The initial body weight was 0.25 kg per bird. Total number of eggs was produced 2562, 4480, 5039 in first, second and third year, respectively while gross income per family was Tk. 58744, 88160, 103668 and gross margin was Tk. 35246, 52896, 62200, respectively (Table 11.104).

Picture11.60 Sonali chicken rearing program at FSRD site, Kamalbazar, Sylhet

Table 11.104 Performance of Sonali chicken rearing programme during 2019-2022 at FSRD Site, Kamalbazar, Sylhet during 2019-2022

Description of Item	Year- I	Year- II	Year- III
Numbers of farmers	1	2	3
No of birds distributed	70	86	108
No of birds/farmers distributed	70	43	36
Age of bird (month)	1	1	1
Avg. wt. of bird during distributed period (Kg)	0.25	0.25	0.25
Avg. procurement price per bird (Tk.)	130	130	130
Rearing period (month)	8	8	8
Total egg production (No.)	2562	4480	5039
Income (Tk.) from egg (sale + consumption + distribution)	30744	53760	60468
Avg. price of bird (Tk.)	400	400	400
Income (Tk.) from alive bird (sale + consumption + distribution)	28000	34400	43200
Gross income in Tk. (egg + bird)	58744	88160	103668
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost)	23498	35264	41467
Gross margin in Tk. (Gross income – Total variable cost)	35246	52896	62200

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Comparison between before and after intervention in income from egg and bird are shown in Table 11.105. Before intervention, gross income from egg was Tk. 30744 and from bird was Tk. 28000 which turned into Tk. 53760 from egg and Tk. 34400 from bird after intervention.

Table 11.105 Comparative income information (before intervention and after intervention) from chicken rearing at FSRD Site, Kamalbazar, Sylhet during 2019-2022

Description of Item	Before intervention		After intervention		Increment over before intervention		% Of increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg								
Sale	1767	21204	3449	41388	1682	20184	95	95
Consumption	695	8340	900	10800	205	2460	29	29
Distribution	100	1200	131	1572	31	372	31	31
Gross income from egg	2562	30744	4480	53760	559	23016	22	22
Bird								
Sale	55	22000	63	25200	8	3200	15	15
Consumption	13	5200	21	8400	8	3200	62	62
Distribution	2	800	2	800	0	0	0	0
Gross income from bird	70	28000	86	34400	16	6400	23	23

11.3.5.2 Performance of hilly chicken rearing at FSRD site Naikhongchari, Bandarban of BLRI component

Several types of indigenous chicken are found in Bangladesh. Hilly chicken are native birds found in hilly areas of the Chittagong region and reared for local consumption and its egg and meat has a unique taste, is regarded as a delicacy, and is popular among consumers in Bangladesh (Talukder *et. al.*, 2016). Indigenous chickens are characterized as dual purpose birds due to their ability to supply both meat and eggs for human consumption. Indigenous chicken is always considered to be better than commercial broilers in term of carcass composition due to its low fat content (Ganabadi *et al.*, 2009). The production potentialities of hilly chicken are relatively higher than that of other native chickens of Bangladesh (Khan *et al.*, 2007).

Hilly Chicken farming is more profitable for its higher growth rate and market price. There is a high demand of hilly chicken's meat in the markets, especially in the restaurants of hilly areas. Hilly chicken rearing was introduced among the cooperative farmers at FSRD site, Nakhongchari, Bandarban, during 2019-2022. One hundred twenty (120) day old hilly chicks were distributed among the twelve farmers (each farmer having 10) and their survival rate was almost 96.67%. Average initial weight during distribution was 45 g. It was observed that total variable cost for 1st, 2nd and 3rd year was Tk. 2700, 3000 and 3500, respectively while gross margin was Tk. 350, 3950 and 4750, respectively (Table 11.106). The increase of gross margin mainly due to genetically improved breed, adequate feed supplement and proper management. Farmers showed their interest in rearing hilly chicken for their faster growth and soft meat.

Table 11.106 Performance of Hilly chicken rearing programme during 2019-2022 at FSRD site, Naikhongchari, Bandarban (per family)

Description of item	Year- I	Year -II	Year -III
No. of farmer	12	12	12
No. of bird distributed	120	120	120
No. bird /farmer distributed	10	10	10
Age of bird (month)	Day old	Day old	Day old
Avg. wt. of bird during distribution period (kg)	45 g	45 g	45 g
Avg. procurement price per bird (Tk.)	250	250	250
Rearing period (month)	2.2	12	12
Total egg production (No.)	5	155	360

Description of item	Year- I	Year -II	Year -III
Income (Tk.) from egg (sale + consumption+ distribution)	50	2000	4000
Avg. price of bird (Tk.)	300	300	300
Income (Tk.) from alive bird (sale + consumption+ distribution)	2000	3000	6000
Gross income in Tk. (Egg + bird)	3050	6950	8250
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost)	2700	3000	3500
Gross Margin in Tk. (Gross income –Total variable cost)	350	3950	4750

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.61 Hilly chicken rearing at FSRD site Naikhongchari, Bandarban

11.3.6 Performance of duck rearing

Duck is one of most common poultry species which have a significant economic importance. Ducks are considered as second most important poultry species after chicken in Bangladesh mainly rear for egg and meat purpose (Ahmed *et. al.*, 2021). Duck rearing is an integral part of poultry production in Bangladesh. Duck keeping is one of the possible means of breaking out poverty trap of resource-poor farm families in low income countries (Pym *et al.*, 2002). Ducks are considered to be the most important asset and source of income for ultra-poor rural women of Bangladesh. Small scale duck farming has not only been proved to be a beneficial occupation for small, marginal and landless farmers, but also a potential source of self-employment for the youth and distress women (Jabber, 2004).

11.3.6.1 Performance of duck rearing at different FSRD sites of BARI component

FSRD site: Basantapur, Rajshahi

Two farmers were selected for duck rearing in their homestead. The average egg laid by the duck 120-210 no. month^{-1} household^{-1} (Table 11.107). Consumption of egg was 60-65 numbers after starting the duck rearing. Monthly income was calculated about 1800-Tk. 2000 month^{-1} household^{-1}.

Picture11.62 Duck rearing program at FSRD site Basantapur, Rajshahi

Table 11.107 Performance of improved duck breed (Khaki Campbell) after 12 months of rearing at FSRD Site Basantapur, Rajshahi during the years of 2020 - 2021

Name of Farmer	No. of ducks survived at present	Body wt. after 6 months (kg)	Production of egg month^{-1}	Consumption of eggs month^{-1}		Monthly income (Tk.)
				Before	After	
Rony	9	1.1	180	0	60	1800
Al-Amin	10	1.12	200	0	65	2000
Average	9	1.11	190	0	62	1900

FSRD site: Chanduria, Rajshahi

Six farmers were selected for duck rearing in their homestead. The average egg production was found to be 260 household^{-1} (Table 11.108). Consumption of egg was 55 numbers month^{-1} household^{-1} after starting the duck rearing. Income was calculated about Tk. 4350 household^{-1}.

Picture11.63 Duck rearing program at FSRD site Chanduria, Rajshahi

Table 11.108 Performance of improved duck breed (Khaki Campbell) after 9 months of rearing at FSRD Site Chanduria, Rajshahi during the years 2020 - 2021

No. of duck farmer	No. of ducks per household	Duck rearing month	Avg. no. of egg Production (household $^{-1}$)	Consumption of eggs month^{-1}		Income in Tk. (household $^{-1}$)
				Before	After	
6	5	9	260	0	55	4350

FSRD site: Kamalbazar, Sylhet

Two farmers were selected for duck rearing in their homestead. The average egg laid by the duck 230-242 no. month^{-1} household^{-1} (Table 11.109). Consumption of egg was 84-120 numbers during the period of duck rearing. Monthly income was calculated about 4650-Tk. 7920 month^{-1} household^{-1}.

Picture11.64 Duck rearing program at FSRD site Kamalbazar, Sylhet

Table 11.109 Performance of improved breed of duck (Khaki Campbell) after 8 months of rearing at FSRD site, Kamalbazar during the years of March 2020 to November 2020

Name of Farmer	No. of ducks survived at present	Body wt. after 8 months (kg)	Production of egg month^{-1}	Consumption of eggs month^{-1}		Monthly income (Tk.)
				Before	After	
Ibrahim	30	2.34	230	0	84	7920
Anser Ali	25	2.54	242	0	120	4650
Average	27.50	2.44	236	0	144	6285

11.3.6.2 Performance of duck rearing at FSRD site Naikhongchari, Bandarban of BLRI component

During October 2019-May 2022, twenty five Khaki Campbell ducks were supplied among 5 farmers and their survival rate was almost 100%. Initial body weight of duckling during distribution time was 60 g. Average number egg production was 315. Gross margin from duck rearing were obtained Tk. 4200, Tk. 5800 and Tk. 6600 per family during 1st, 2nd and 3rd year, respectively (Table 11.110). Farmers were highly interested because duck rearing is very easy and profitable. Farm family expressed their satisfaction on fulfillment the aesthetic need and as well as bear the expenditure of their child education.

Table 11.110 Performances of Khaki Campbell ducks in farmers' household at FSRD site, Naikhongchari, Bandarban during October 2019-May 2022 (per family)

Description of item	Year - I	Year - II	Year - III
No. of farmer	5		
No. of bird distributed	25		
No. bird /farmer distributed	5		
Age of bird (month)	Day old		
Avg. wt. of bird during distribution period (kg)	60 g		
Avg. procurement price per bird (Tk.)	80		
Rearing period (month)	12	12	12
Total egg production (No.)	270	320	360
Income (Tk.) from egg (sale + consumption+ distribution)	2700	3200	3600
Avg. price of bird (Tk.)	500	500	500
Income (Tk.) from alive bird (sale + consumption+ distribution)	3500	4700	5500
Gross income in Tk. (Egg + bird)	6200	7500	8500
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost)	2000	2100	2500
Gross Margin in Tk. (Gross income –Total variable cost)	4200	5800	6600

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.65 Duck rearing at FSRD Site, Naikhongchari, Bandarban

11.3.7 Performance of pigeon rearing

Pigeon rearing is considered as a ready cash source of income during hard time and creates employment opportunities for villagers especially for poor women and educated unemployed youth (Hanoun *et. al.*, 2008).

The weather and vast areas of crop field along with housing premises of Bangladesh are suitable for pigeon farming. The contribution of pigeon has not yet been considered in livestock sub-sector. Comparatively low investment, less care, less feed and housing cost involved, easy and economic husbandry practices, short reproduction cycle and less disease occurrence are observed for pigeon farming. Hence profitable pigeon farming may be an easy and reliable source of employment opportunity, way of family labour utilization and cash income.

11.3.7.1 Performance of pigeon rearing at FSRD site Basantapur, Rajshahi of BARI component

On an average, each farmer had five pairs of pigeon. The pigeon gave one pair of squabs in each 2 months. So on an average, farmer earned Tk. 2600 from rearing of pigeon (Table 11.111).

Table 11.111 Performance of pigeon in farmers household at FSRD Site Basantapur, Rajshahi during 2019-2022

No of pigeon/family	Average body wt. (g)	No. of squab born	No. of pigeon died	No. of squab intake	Sale (No.)	Income (Tk.)
10	400	30	04	14	12	2600

11.3.7.2 Performance of pigeon rearing at FSRD site Naikhongchari, Bandarban of BLRI component

Under pigeon rearing program 12 pairs of pigeons were given among six selected farmers for increasing income and nutrition of the farm family. Two pairs of pigeons were given to each farmer. The pigeon gave squab after two months of rearing. The routine works of vaccination are being followed regularly such as BCRDV, RDV and natural feeds are being fed. The number of pigeons was increased rapidly. Every month the pigeon produced squab. After 6 month of rearing, average eight pairs of squab were found per family. Gross margin from pigeon were obtained Tk. 2500, Tk. 2900 and Tk. 6300 per family during 1st, 2nd and 3rd year, respectively (Table 11.112).

From the findings it shows that pigeon rearing is require less initial investment and provides high income with additional employment generation, opportunity for family labour utilization during their leisure time and way of earning quick cash income.

Table 11.112 Performance of pigeon in farmers' household at FSRD site, Naikhongchari, Bandarban during October 2019-May 2022 (per family)

Description of item	Year- I	Year- II	Year- III
No. of farmer	6		
No. of bird distributed (pair)	12		
No. bird /farmer distributed (pair)	2		
Age of bird (month)	2		
Avg. wt. of bird during distribution period (kg)	0.300		
Avg. procurement price per pair bird (Tk.)	300		
Rearing period (month)	12	12	12
Total no. of squab born (pair)	6	8	10
Income (Tk.) from squab (sale + consumption+ distribution)	1800	2400	3000
Avg. price of pair bird (Tk.)	1000	1000	1000
Income (Tk.) from alive bird (sale + consumption+ distribution)	4000	4700	5500

Description of item	Year- I	Year- II	Year- III
Gross income in Tk. (squab + bird)	5800	7100	8500
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost)	1500	1800	2200
Gross Margin in Tk. (Gross income –Total variable cost)	2500	2900	6300

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.66 Pigeon rearing at FSRD Site, Naikhongchari, Bandarban

11.3.8 Performance of turkey rearing at FSRD Site Naikhongchari, Bandarban

Poultry rearing in rural Bangladesh has been carried on for a long time with ducks and chickens. Turkey rearing has been introduced very recently in Bangladesh. Turkey birds mainly eat grasses and vegetables. As a result, farmers do not have to depend only on market's feed. Besides, it can be kept in open areas, not like the poultry farm. Average Performances of Turkey in farmers' household at FSRD site, Naikhongchari, Bandarban during 2019- 2022 are presented in Table 11.113.

Thirty-six (36) Turkey chicks were distributed among the six farmers. The routine works of vaccination were followed regularly such as BCRDV, RDV and natural feeds (grass, and vegetables) were provided as food. Some household gave commercial market food as supplemental feed. After 4-6 months' age female birds have been started laying eggs. Egg production and body weight gained was monitored regularly. At about 6-8 month's duration Turkey birds gained commercial weight and ready to sale. Technical supports (feeding, vaccination and necessary treatment) and advices were also given to the farmer. Initial body weight chick-1 of Turkey during distribution was 56 g. Average number egg production was 310. Gross margin from turkey rearing were obtained 4200, 5000 and Tk. 5500 per family during 1st, 2nd and 3rd year, respectively. Farmers were highly interested to include this new intervention in their existing farming system because turkey rearing under scavenging system was very easy and profitable.

Table 11.113 Performances of turkey in farmers' household at FSRD site, Naikhongchari, Bandarban during October 2019-May 2022 (per family)

Description of item	Year- I	Year- II	Year- III
No. of farmer	6		
No. of bird distributed	36		
No. bird /farmer distributed	6		
Age of bird (month)	Day old		
Avg. wt. of bird during distribution period (kg)	56 g		
Avg. procurement price per bird (Tk.)	300		
Rearing period (month)	12	12	12
Total egg production (No.)	280	300	350

Description of item	Year- I	Year- II	Year- III
Income (Tk.) from egg (sale + consumption+ distribution)	2800	3000	3500
Avg. price of bird (Tk.)	600	600	600
Income (Tk.) from alive bird (sale + consumption+ distribution)	3600	4500	5000
Gross income in Tk. (Egg + bird)	6400	7500	8500
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost)	2200	2500	3000
Gross Margin in Tk. (Gross income –Total variable cost)	4200	5000	5500

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.67 Turkey rearing at FSRD Site, Naikhongchari, Bandarban

11.3.9 Improvement of cattle health through deworming at FSRD site Naikhongchari, Bandarban of BLRI component

Average body weight gain, milk production and lactation period after deworming are presented in the Table11.114. It was observed that deworming is an easy process to adopt with minimum cost. After deworming, the milking rate per day and body weight of cattle gaining observed promisingly. It was found that, before deworming the frequency of disease incidence was higher whereas after dewormed the average body weight, disease incidence, lactation yield and the lactation period increased over the controlled cows. A total of 850 cattle were dewormed. It was observed that body weight gained (130 and 135g), milk production (2.6 and 2.7 L/day) and lactation period (230 and 240 day) was increased by Dewormed+Vitamin ADE injection and only dewormed cattle respectively, where as non-treated cattle showed lower performance.

Table 11.114 Average body weight gain, milk production and lactation period after different treatment at FSRD site Naikhongchari, Bandarban during 2019 to 2022

Treatment	No. of animal	Avg. Body wt. gain/day/animal (g)	Avg. lactation yield (L/day)	Avg. lactation period (day)
Controlled Cattle	50	82	1.6	210
Dewormed Cattle	650	130	2.6	230
Dewormed + Vitamin ADE injection treated Cattle	150	135	2.7	240

11.3.10 Performance of Napier grass cultivation

Fodder is one of the most important components of the crop-livestock-manure-soil nutrient cycle of the agricultural system. Fodder should be high-quality and nutrient-rich. High-quality fodders are not only essential for higher livestock productivity but also play an important role in the addition of nitrogen content of animal dung. Napier grass is popular among farmers due to its high dry matter potential, ease of propagation, cultivation and harvest. Farmers can earn extra profits by cultivating the grass on their fallow homesteads, roadside places, mango and litchi orchards and abandoned lands also to make best use of land without hampering regular crop farming on cultivable lands. Green Napier grass has more vitamins than dry paddy straws and meets nutrition and enhances disease resistance capacity of domestic animals like cows, goats and sheep for their healthier growth along side increasing production of meat and milk.

11.3.10.1 Performance of Napier grass cultivation at FSRD site Basantapur, Rajshahi of BARI component

The production of Napier grass was 80 and 68 t ha^{-1} and the average gross margin was calculated Tk. 38000 and 2800 ha^{-1} in the year 2020-2021 and 2021-2022, respectively (Table 11.115). The average green fodder yield was 74 t ha^{-1} and average gross margin was Tk. 33000 ha^{-1}.

Table 11.115 Average performance of Napier grass production at FSRD site Basantapur, Rajshahi

Year	No. of harvesting	Green fodder yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
2020-21	17	80	80000	42000	38000
2021-22	14	68	68000	40000	28000
Av.	16	74	74000	41000	33000

11.3.10.2 Performance of Napier grass cultivation at FSRD site Naikhongchari, Bandarban of BLRI component

Green fodder production in the nearby homestead area might be a promising technology for maintaining farmers own cattle as well as earing cash money. From these views, BLRI-developed HYV Napier grass production was started farmer's nearby homestead. Production program on Napier grass cultivation conducted during October 2019-May 2022. Nine farmers were selected for Napier grass cultivation. The total land area was 52 decimals. The land area ranges from 3-15 decimal. BLRI-developed HYV Napier fodder was distributed among the nine farmers. The performances of Napier grass are presented in the Table 11.116. Total production of green fodder was found 6570 kg, 7455 kg, 8215 kg during 1st, 2nd and 3rd year, respectively from 52 decimal of land while gross margin from cultivation of Napier grass were obtained 19710, 22365 and Tk. 24650, respectively.

Picture 11.68 Fodder production at FSRD site Naikhongchari, Bandarban

Table 11.116 Performance of Napier grass at FSRD Site, Naikhongchari, Bandarban during 2019-2022

Year	Number of farmers	Yield kg 52 dec.$^{-1}$	Price per kg (Tk.)	Variable cost (Tk.)	Gross return (Tk.)	Gross margin (Tk.)
Year- I	9	6570	3.0	5500	25210	19710
Year- II	9	7455	3.0	5000	27365	22365
Year- III	9	8215	3.0	4500	29150	24650

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

11.3.11 Performance of Farmyard Manure production at different FSRD sites of BARI component

FSRD Site: Basantapur, Rajshahi

Farmyard manure was producing by using cowdung and homestead wastage at the homestead area during 2019-2022. The average production of FYM per homestead was 1050 kg and the gross margin was equivalent to Tk.1400 homestead^{-1} (Table 11.117).

Picture11.69 Farmyard Manure production program at FSRD site Basantapur, Rajshahi

Table 11.117 Average performance of compost production and utilization per year per homestead at FSRD Site Basantapur, Rajshahi

Intervention	Total production (kg homestead^{-1})	Use of compost (kg farmer^{-1})	Distribution (kg farmer^{-1})	Sale (kg farmer^{-1})	Value of compost per year (Tk. homestead^{-1})	TVC in Tk. (homestead^{-1})	GM in Tk. (homestead^{-1})
Before	320	320	0	0	640	200	440
After	1050	720	0	330	2100	700	1400

FSRD site: Chanduria, Rajshahi

Farmyard manure was producing by using cow dung and homestead wastage at the homestead area during 2019-2022. The average production of FYM per homestead was 800 kg and the gross margin was equivalent to Tk.1000 homestead^{-1} (Table 11.118).

Picture11.70 Farmyard manure production program at FSRD site Chanduria, Rajshahi

Table 11.118 Average performance of compost production and utilization per year per homestead at FSRD site Chanduria, Rajshahi

Intervention	Total producetion (kg homestead^{-1})	Use of compost (kg farmer^{-1})	Distribution (kg farmer^{-1})	Value of compost produce per year (Tk. homestead^{-1})	TVC in Tk. homestead^{-1})	GM in Tk. (homestead^{-1})
Before	0	0	0	0	0	0
After	800	650	150	1200	200	1000

11.4 Fisheries Production System

Fish play a crucial role in the Bangladeshi diet, providing more than 60% of animal source food, representing a crucial source of micro-nutrients, and possessing an extremely strong cultural attachment. Fish farming has been proved a profitable and attractive business comparing to the rice or other agricultural cultivations.

11.4.1. Maximization of farmers' income through carp polyculture technique at different FSRD sites of BARI component

FSRD Site: Basantapur, Rajshahi

Carp polyculture program was conducted at 9 ponds of the cooperator farmer's homestead area in 2019-20 and 10 ponds in 2020-21 and 2021-22. Average area of the ponds, number of fingerlings released and their weight, total number of fishes at the harvest and survival rate are presented in the Table 11.119. Average pond size was 6.5 decimal and 1.60 meters in depth. The survival rate of carp fishes in polyculture system was found to be 80-85%.

Picture11.71 Carp fish polyculture at FSRD site Basantapur, Rajshahi

Average performance of individual carp species are presented in the Table 11.120. Average weight of silver carp was 1156 g after 180 days from stocking whereas maximum body weight increase was found from Rohu (673%). Fish production, cost, and return analysis are presented in the Table 11.121. After intervention, the average fish production was 119 kg pond^{-1} with a gross margin of Tk. 10102 pond^{-1}. Farmers consumed a portion of the total production, gave it to relatives, and sold it on the local market. Farmers sold the majority of the fish (50%), consumed approximately 42%, and distributed around 8% of the fish to their neighbors, family, and well-wishers (Table 11.122). Farmers benefited from the carp polyculture system, and they expressed an increased interest in carp polyculture farming.

Table 11.119 Performance of fish farming (carp polyculture) at FSRD Site Basantapur, Rajshahi during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year I	6.5 and 1.60	22.50 kg and 170 nos.	130.00	850	116 kg and 136 no.	80
Year II	6.5 and 1.60	23.00 kg and 165 nos.	135.00	870	126 kg and 144 no.	85
Year III	6.5 and 1.60	23.00 kg and 172 nos.	133.00	860	120 kg and 141 no.	82
Average	6.5 and 1.60	22.83 kg and 169 nos.	132.67	860	119 kg and 140 no.	82

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.120 Average performance of individual carp species under polyculture system at FSRD site, Basantapur, Rajshahi during 2019 to 2022

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase over initial (%)
Silver carp	21.5	208	39.5	1156	456
Rohu	14.8	97	32.0	750	673
Mrigal	16.5	93	31.0	675	626
Average	17.60	133	34.0	860	547

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.121 Fish production and income before and after intervention at FSRD site, Basantapur, Rajshahi during 2019 to 2022

Description	Production before intervention (kg)		Production after intervention (kg)				
			Production (kg pond^{-1})				Average production (kg ha^{-1})
	pond^{-1}	ha^{-1}	Year I	Year II	Year III	Average	
Total production (kg)	28	1064	110	126	122	119	4522
Gross return (Tk.)	3360	127680	13200	16380	15860	15147	575573
Total cost (Tk.)	1150	43700	4525	5240	5370	5045	191710
Gross margin (Tk.)	2210	83980	8675	11140	10490	10102	383863

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table.11.122 Utilization pattern of fishes before and after intervention at FSRD site, Basantapur, Rajshahi during 2019 to 2022

Description	Before intervention (kg pond^{-1})	After intervention (kg pond^{-1})				
		Year- I	Year- II	Year- III	Average	Average (%)
Consumption (kg)	22	50	52	48	50	42
Distribution (kg)	6	8	10	9	9	8
Selling (kg)	-	52	64	65	60	50
Total production (kg)	28	110	126	122	119	100

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Amnura, Chapainawabganj

Data on pond area, fingerlings number and weight, final total amount and number of fish, and survival rate are presented in the Table 11.123. Eight ponds were chosen for carp fish polyculture where average pond size was 5 decimals and depth 1.50 meters. The average survival rate of carp fishes was 78-85%. Average performance of individual carp species are presented in the Table 11.124. Average weight of silver carp was 946 g after 180 days from stocking whereas maximum body weight increase was found from Mrigal (598%). The production of fishes and economic analysis are presented in the Table 11.125. Average fish production was 95 kg pond^{-1} with gross margin of Tk. 7772 Pond^{-1}. Among the total production of fish, farmers consumed 57, sold 33 and distributed 10% to their neighbor's, relatives and well-wishers (Table 11.126). The marginal farmers were benefitted by carp polyculture system, and they showed further interest for farming of carp polyculture.

Picture11.72 Carp fish polyculture at FSRD site Amnura, Chapainawabganj

Table 11.123 Performance of fish farming (carp polyculture) at FSRD site, Amnura, Chapainawabganj during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year -I	5.0 and 1.50	17.50 kg and 150 nos.	117.00	755	93 kg and 123 nos.	82
Year- II	5.0 and 1.50	17.00 kg and 155 nos.	112.00	748	90 kg and 121 nos.	78
Year- III	5.0 and 1.50	18.00 kg and 160 nos.	113.00	760	103 kg and 136 nos.	85
Average	5.0 and 1.50	17.50 kg and 155 nos.	114.00	754	95 kg and 127 nos.	82

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.124 Average performance of individual carp species under polyculture system at FSRD site, Amnura, Chapainawabganj during 2019 to 2022

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase over initial (%)
Silver carp	16	160	37.0	946	491
Rohu	13.5	95	30.0	650	584
Mrigal	14.2	96	32.0	670	598
Average	14.5	117	33.0	755	545

Table 11.125 Fish production and income before and after intervention at FSRD site, Amnura, Chapapinawabganj during 2019 to 2022

Description	Production before intervention (kg)		Production after intervention (kg)				
			Production (kg pond^{-1})				Average production (kg ha^{-1})
	pond^{-1}	ha^{-1}	Year I	Year II	Year III	Average	
Total production (kg)	20	988	93	90	103	95	4693
Gross return (Tk.)	2400	118560	11160	11700	13390	12083	596917
Total cost (Tk.)	1000	49400	4125	4240	4570	4312	212996
Gross margin (Tk.)	1400	69160	7035	7460	8820	7772	383921

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.126 Utilization pattern of fishes before and after intervention at FSRD site, Amnura, Chapapinawabganj during 2019 to 2022

Description	Before intervention (kg pond^{-1})	After intervention (kg pond^{-1})				
		Year I	Year II	Year III	Average	Average (%)
Consumption (kg)	16	50	55	58	54	57
Distribution (kg)	4	9	12	10	10	10
Selling (kg)	-	34	23	35	31	33
Total production (kg)	20	93	90	103	95	100

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Chanduria, Rajshahi

Carp fish polyculture technology was implemented on six seasonal ponds at the FSRD site Chanduria, Rajshahi. The average size of the ponds was 6 decimal and depth of water was 1.5 m (Table 11.127). After 7 days of pond preparation, fingerlings were acclimatized in pond water and released in the pond. The average initial weight of fingerlings (89 g), final average weight (795 g), total amount and number of fingerlings (100 kg and 123) and survival rate (84.6%) are shown in Table 11.127. Average body weight

was increased by 917% over initial body weight after 180 days from stocking (Table 11.128). It was observed that, average production of fishes after intervention were 100 kg pond^{-1} with an average gross margin of Tk. 9775 pond^{-1} (Table 11.129). Among the average total production, farmers consumed, distributed to relatives, and sell their products in local market. It was observed that, farmers sold most of the fish (65%), consumed about 28% and distributed about 7% to their neighbors, relatives and well-wishers of the produced fish (Table 11.130). The farmers benefitted by carp polyculture system, and they showed their interest in farming of carp polyculture.

Picture11.73 Carp fish polyculture at FSRD site Chanduria, Rajshahi

Table 11.127 Performance of carp polyculture fish farming at FSRD site, Chanduria, Rajshahi during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year- I	6 and 1.5	14 kg and 164 nos.	87	980	125 kg and 128 nos.	78
Year- II	6 and 1.5	15 kg and 171 nos.	90	830	120 kg and 145 nos.	84.8
Year- III	6 and 1.5	10 kg and 114 nos.	89	575	55 kg and 96 nos.	84
Average	6 and 1.5	13 kg and 150 nos.	89	795	100 kg and 123 nos.	84.6

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.128 Average performance of individual carp species under polyculture system at FSRD site Chanduria, Rajshahi during 2019 to 2022

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase over initial (%)
Silver carp	16.0	110	38	1030.0	836
Catla	13.0	100	29	875.0	775
Rohu	12.8	85	33	812.5	856
Mrigal	14.0	70	34	807.5	1054
Grass carp	13.0	80	30	1000.0	1150
Average	13.8	89	33	905.0	917

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.129 Fish production and income before and after intervention at FSRD site, Chanduria, Rajshahi during 2019 to 2022

Description	Production before intervention (kg)		Production after intervention				
			Production (kg pond^{-1})				Average production (kg ha^{-1})
	pond^{-1}	ha^{-1}	Year I	Year II	Year III (3 months)	Average	
Total production (kg)	60	2470	125	120	55	100	4117
Gross return (Tk.)	10500	432250	21875	19200	10450	17175	707037
Total cost (Tk.)	4150	170842	10500	8500	3200	7400	304633
Gross margin (Tk.)	6350	261408	11375	10700	7250	9775	402404

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.130 Utilization pattern of fishes before and after intervention at FSRD site, Chanduria, Rajshahi during 2019 to 2022

Description	Before intervention (kg pond^{-1})	After intervention (kg pond^{-1})			
		Year I	Year II	Year III	Average
Consumption (kg)	16	35	32	17	28
Distribution (kg)	4	9	8	4	7
Selling (kg)	40	81	80	34	65
Total production (kg)	60	125	120	55	100

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Jiarokhi, Kushtia

Picture11.74 Carp fish polyculture at FSRD site Jiarokhi, Kushtia

Six seasonal ponds were chosen for carp polyculture program at the FSRD site Jiarokhi, Kushtia. The average pond size was 21 decimal and depth was 1.52 m (Table 11.131). Fingerlings were released into the pond after 7 days of pond preparation and acclimatization with pond water. The average initial weight of fingerlings was 73 g. At the harvesting period, average weight of fish was 845 g, total amount of fish was 200 kg , number of fishes was 236 and the survival rate was 77% (Table11.131). Information on average performance of individual carp species are presented in the Table 11.132. Individual average weight of silver carp and sorputi was 1000 gm after 180 days from stocking whereas maximum body weight increase was found from silver carp (900%). The average fish production after intervention was 200 kg pond^{-1} with an average gross margin of Tk. 28800 pond^{-1} (Table 11.133). Farmers sold the majority of the fish they produced (62%), consumed approximately 27%, and dispersed around 11% to their neighbors, family, and well-wishers (Table 11.134). Farmers benefited from the carp polyculture method, and they expressed interest in carp polyculture system.

Table 11.131 Performance of carp polyculture fish farming at FSRD site, Jiarokhi, Kushtia during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year- I	21 and 3.50	20.00 kg and 286 nos.	70.00	750	161 kg and 215 nos.	75
Year- II	21 and 3.50	22.50 kg and 306 nos.	73.50	885	209 kg and 236 nos.	77
Year -III	21 and 3.50	24.50 kg and 325 nos.	75.50	900	231 kg and 257 nos.	79
Average	21 and 3.50	22.33 kg and 306 nos.	73.00	845	200 kg and 236 nos.	77

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.132 Average performance of individual carp species under polyculture system at FSRD site, Jiarokhi, Kushtia during 2019 to 2022

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase over initial (%)
Silver carp	13.2	100	39.8	1000	900
Catla	10	110	30	750	582
Rohu	10	120	31	800	567
Mrigal	12	110	31.6	900	718
Sorputi	12.5	120	27	1000	733
Average	11.54	112	32	890	700

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.133 Fish production and income before and after intervention at FSRD site, Jiarokhi, Kushtia during 2019 to 2022

Description	Production before intervention (kg)		Production after intervention				
			Production (kg pond^{-1})				Average production (kg ha^{-1})
	pond^{-1}	ha^{-1}	Year I	Year II	Year III	Average	
Total production (kg)	30	353	161	209	231	200	2354
Gross return (Tk.)	2700	31770	28980	37620	41580	36000	423720
Total cost (Tk.)	1000	11770	6500	7200	7900	7200	84744
Gross margin (Tk.)	1700	20000	22480	30420	33680	28800	338976

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.134 Utilization pattern of fishes before and after intervention at FSRD site, Jiarokhi, Kushtia during 2019 to 2022

Description	Before intervention (kg pond^{-1})	After intervention (kg pond^{-1})				
		Year I	Year II	Year III	Average	Average %
Consumption (kg)	10	50	52	60	54	27
Distribution (kg)	5	20	21	24	22	11
Selling (kg)	15	91	136	147	125	62
Total production (kg)	30	161	209	231	200	100

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

FSRD Site: Kamalbazar, Sylhet

At the FSRD site, Kamalbazar, Sylhet a program of carp polyculture in seasonal ponds was implemented with the goals of increasing farmer income and alleviating rural people's protein deficiency. Under this program, 8 selected farmers from two villages received fish fingerlings. The growth of fish was measured every 15 days with periodic checks. Weeds and wild fish were removed from the pond for fish cultivation, and the pond was limed at a rate of 1 kg decimal^{-1}, as well as prepared for stocking with organic manure (cow dung) at a rate of 3 kg decimal^{-1}.

Picture11.75 Carp fish polyculture at FSRD site Kamalbazar, Sylhet

Average size of the ponds was 20 decimals with 1.5 m depth. The result revealed that average survival rate was 79%. Average production and fish number pond^{-1} was found 347 kg and 395 number, respectively at harvesting period (Table 11.135). Performance of individual carp species are presented in the Table 11.136. Maximum average weight (1020 gm) and body weight increase (1033%) after 180 days were found from silver carp. Total production and economic analysis are presented in Table 11.137. It was observed that total production was 347 kg pond^{-1} with the gross margin of Tk. 22880. Farmers sold most of the fish (46%), consumed 40% and distributed 14% of total produced fish (Table 11.138). The farmers were benefitted by carp polyculture system, and they showed interest for farming of carp polyculture.

Table 11.135 Performance of carp polyculture fish farming at FSRD site, Kamalbazar, Sylhet, during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year- I	20 dec &1.5m	40.5 kg and 479 nos.	84.6	877	340 kg and 388 nos.	81

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year- II	20 dec &1.5m	44 kg and 568 nos.	78.2	890	390 kg and 438 nos.	77
Year- III	20 dec &1.5m	38 kg and 472 nos.	81	830	310 kg and 373 nos.	79
Average	20 dec &1.5m	41 kg and 506 nos.	82	866	347 kg and 395 nos.	79

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.136 Average performance of individual carp species under polyculture system at FSRD site, Kamalbazar, Sylhet, during 2019 to 2022

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase over initial (%)
Silver carp	13	90	31.8	1020	1033
Catla	10	85	24	815	859
Mrigal	12	70	27	760	986
Average	12	82	27	865	959

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.137 Fish production and income before and after intervention at FSRD site, Kamalbazar, Sylhet, during 2019 to 2022

Description	Production before intervention (kg)		Production after intervention				
			Production (kg pond^{-1})				Average production (kg ha^{-1})
	Pond^{-1}	ha^{-1}	Year I	Year II	Year III	Average	
Total production (kg)	275	3396	340	390	310	347	4285
Gross return (Tk.)	30250	373560	37400	42900	34100	38133	470943
Total cost (Tk.)	12100	149424	14960	17160	13640	15253	188375
Gross margin (Tk.)	18150	224136	22440	25740	20460	22880	282568

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.138 Utilization pattern of fishes before and after intervention at FSRD site, Kamalbazar, Sylhet during 2019 to 2022

Description	Before intervention (kg pond^{-1})	After intervention (kg pond^{-1})				
		Year I	Year II	Year III	Average	Average (%)
Consumption (kg)	110	130	120	170	140	40
Distribution (kg)	35	30	50	60	47	14
Selling (kg)	130	180	220	80	160	46
Total Production (kg)	275	340	390	310	347	100

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

11.4.2 Fish production through mixed culture in perennial pond at FSRD site Naikhongchari, Bandarban of BLRI component

Mixed fish culture (Tilapia with catla and rohu) was introduced at FSRD site Naikhongchari, Bandarban with four ponds. The average pond size was 28.75 dec. and depth was 1.5 m. Duration of the fish culture period was 6-8 months. The survival rate of the fingerlings was 75-82%. Feeds were supplied as per recommendation of BFRI. After intervention total production was calculated 1608 kg and 1657 kg pond^{-1} during Year-I & Year-II and Year- II and Year-III (Table 11.139). Before intervention production pond^{-1} was 1050 kg which reached 1633.5 kg after intervention (Table 11.140). Gross margin after intervention was estimated Tk. 131405 pond^{-1} which was Tk. 82500 before intervention.

Table 11.139 Performance of mixed fish culture at FSRD site Naikhongchari, Bandarban during 2020 to 2022 after six months culture

Year	Average area and depth of pond (dec. and m)	Name of species	Number of fingerlings released	Initial Size of fingerlings (inch)	Initial wt. of fingerlings (gm)	Average weight of fish at harvest period (g)	Recovery rate (%)	Total amount of fishes at harvest period (Kg)
Year- I & II	28.75 dec and 1.5	Monosex tilapia	7188	2.25	4.25	260	81	1514
		Catla	145	5.50	45.0	390	82	46
		Ruhu	145	5.25	42.0	420	79	48
Total (Year I & II)								1608
Year- II & III	28.75 dec and 1.5	Monosex tilapia	7188	2.30	4.5	275	79	1562
		Catla	145	5.60	45.5	410	80	48
		Ruhu	145	5.50	44.0	435	75	47
Total (Year II & III)								1657

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.140 Fish production and income before and after intervention at FSRD site Naikhongchari, Bandarban during 2020 to 2022

Description	Production before intervention (kg)		Production after intervention			Average production (kg ha^{-1})
			Production (kg pond^{-1})			
	pond^{-1}	ha^{-1}	Year I & II	Year II & III	Average	
Total production (kg)	1050	9021	1608	1657	1633.5	14025
Gross return (Tk.)	147000	1262922	241200	265120	253160	2174975
Total cost (Tk.)	64500	554139	114520	128990	121755	1046034
Gross margin (Tk.)	82500	708783	126680	136130	131405	1128941

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Picture 11.76 Mixed fish culture at FSRD Site, Naikhongchari, Bandarban

11.4.3 Monosex tilapia production at FSRD site Naikhongchari, Bandarban of BLRI component

Monosex tilapa culture was introduced at FSRD site Naikhongchari, Bandarban with one pond. The pond size was 8 dec. and depth was 1.2 m. Duration of the fish culture period was 6-7 months. The survival rate of the fingerlings was 71-76%. Feeds were supplied as per recommendation of BFRI. Total production after intervention was calculated 409 kg and 429 Kg pond^{-1} during Year-I and Year-II and Year-II and Year-III (Table 11.141). Before intervention production pond^{-1} was 325 kg which reached 419 kg after intervention (Table 11.141). Gross margin after intervention was estimated Tk. 16950 pond^{-1} which was Tk. 8000 before intervention.

Picture 11.77 Monosex tilapia culture at FSRD Site, Naikhongchari, Bandarban

Table 11.141 Performance of Monosex tilapia culture at FSRD site Naikhongchari, Bandarban during 2020 to 2022

Year	Average area and depth of pond (dec. and m)	Number of fingerlings released	Initial Size of fingerlings (inch)	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount of fishes at harvest period (kg)	Recovery rate (%)
Year- I & II	8 dec. and. 1.2 m	2400	2.25	4.25	240	409	71
Year- II & III	8 dec. and. 1.2 m	2400	2.0	4.00	235	429	76

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Table 11.142 Monosex tilapia production and income before and after intervention at FSRD site Naikhongchari, Bandarban during 2019 to 2022

Description	Production before intervention (kg)		Production after intervention			
			Production (kg pond^{-1})			Average production (kg ha^{-1})
	pond^{-1}	ha^{-1}	Year- I and Year-II	Year- II and Year- III	Average	
Total production (kg)	325	10034	409	429	419	12936
Gross return (Tk.)	32500	1003438	49080	51480	50280	1552395
Total cost (Tk.)	24500	756438	30585	34030	33330	1029064
Gross margin (Tk.)	8000	247000	18495	17450	16950	523331

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

Utilization pattern of fishes before and after Intervention at FSRD site Naikhongchari, Bandarban during 2019 to 2022 is presented in the Table 11.143. After intervention consumption and selling was increased, but distribution was unchanged. Consumption was increased from 45 kg to 63.5 kg, selling was increased from 258 kg to 333.5 kg.

Table.11.143 Utilization pattern of fishes before and after intervention at FSRD site Naikhongchari, Bandarban during 2019 to 2022

Description	Before Intervention	After Intervention (kg pond^{-1})		
		Year I & II	Year II & III	Average
Consumption (kg)	45	60	67	63.5
Distribution (kg)	22	27	17	22.0
Selling (kg)	258	322	345	333.5
Total production (kg)	325	409	429	419

* Year- I= Oct. 2019-Sep. 2020; Year- II= Oct. 2020-Sep. 2021; Year- III= Oct. 2021-May 2022

11.5 Off-Farm Activities

Participation of farm households in off-farm work has gained prominence in recent times as an income diversification strategy. Off-farm work enables farm households to stabilize household income and reduce vulnerability and uncertainties associated with agricultural production. Off-farm work is identified as a risk management tool that reduces income variability of farm households has been reported by some authors. Several studies allude to a positive effect of off-farm work on agricultural productivity, food security, and household income of farm households.

11.5.1 Off-farm activities at different FSRD sites of BARI component

Besides of agricultural production, some farm families' especially the women were engaged with weaving kantha, sewing cloths with machine, bee keeping and making different handicrafts with jute rope during their leisure periods. Some farmer had autoriksha, two-wheel tractor and rented them with custom hiring basis. Sometimes, one farmer also sale his labor as a cook.

FSRD site: Basantapur, Rajshahi

Off-farm activities, in addition to agricultural activities, are an effective way to boost farm total revenue. Initially, one family makes dresses on a custom-hire basis. Four households are initially hauling the manual van. Following the intervention, FSRD team motivated the recipients on the importance of converting the vans to be powered. The average gross margin increased by 82% after intervention, with an average gross margin of Tk. 34709 (Table 11.144). It would be beneficial to boost total farm revenue if all households could engage in certain off-farm activity.

Picture11.78 Off-Farm activities at FSRD site Basantapur, Rajshahi

Table 11.144 Average cost and return of off-farm activities at FSRD site Basantapur, Rajshahi during 2019 to 2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin increased (%)
	GR	TVC	GM	GR	TVC	GM	
Sewing cloth	7800	2120	5680	11893	3000	8893	57
Van pulling	38500	6000	32500	80400	19875	60525	86
Average	23150	4060	19090	46146	11438	34709	82

FSRD site: Amnura, Chapainawabganj

At the Amnura, Chapainawabganj site, almost every household engaged in off-farm enterprises such as 2-wheel tractor driving, mechanical katha sewing, grocery shop, livestock business, kumra bora, and so on. The average two income categories are included in this intervention. It was found that after intervention the avg. gross margin increased by 126% with, a gross margin of Tk. 28213 (Table 11.145).

Picture11.79 Off-Farm activities at FSRD site Amnura, Chapainawabganj

Table 11.145 Average eeconomics of off-farm activities at FSRD site Amnura, Chapainawabganj during 2019 to 2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin increased (%)
	GR	TVC	GM	GR	TVC	GM	
2WT operator	30000	15000	15000	55000	22500	32500	117
Sewing Katha mechanically	15000	5000	10000	32500	8575	23925	139
Average	22500	10000	12500	43750	15538	28213	126

FSRD site: Chanduria, Rajshahi

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Initially one household was started handicrafts making and finally most of the households were practiced handicrafts besides of other off-farm activities. It was found that after intervention the average gross margin increased by 95%, with the average gross margin of Tk. 5252 (Table 11.146). So, if all households could introduce some off-farm activities, it would be helpful to increase total farm income.

Picture11.80 Off-Farm activities at FSRD site Chanduria, Rajshahi

Table 11.146 Economics of off-farm activities at FSRD Site Chanduria, Rajshahi during 2019 to 2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin increased (%)
	GR	TVC	GM	GR	TVC	GM	
Sewing machine	3500	800	2700	6050	1650	4400	63
Handicrafts-Bag (Jute rope)	4600	1200	3400	9405	2310	7095	109
Handicrafts-Mat (Jute rope)	2500	500	2000	4950	990	3960	98
Average	3533	833	2700	6802	1650	5252	95

FSRD Site: Jiarokhi, Kushtia

Off-farm activities such as sewing clothing and kantha were practiced by three households. Off-farm activities were found to generate good cash revenue which helped resource-poor farmers make to earn extra income. It was found that after intervention the average gross margin increased by 400%, with the average gross margin of Tk. 15000 (Table 11.147). So, if all households could engage in some off-farm activities, it would be beneficial to raise their total farm revenue, which would help to improve the rural household's livelihood.

Picture11.81 Off-Farm activities at FSRD site Jiarokhi, Kushtia

Table 11.147 Economics of off-farm activities at FSRD Site Jiarokhi, Kushtia during 2019 to 2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin increased (%)
	GR	TVC	GM	GR	TVC	GM	
Khata making	12000	3000	9000	54000	18000	36000	300
Sewing	0	0	0	12000	3000	9000	-
Average	4000	1000	3000	22000	7000	15000	400

FSRD Site: Kamalbazar, Sylhet

Off-farm activities such as kantha sewing and honey production by bee keeping by honey box were done by four households. It was found that after intervention the average gross margin increased by 332%, with the average gross margin of Tk. 4750 (Table 11.148). Honey production had only recently begun following intervention, and farmers intended to profit in the future.

Picture11.82 Off-Farm activities at FSRD site Kamalbazar, Sylhet

Table 11.148 Economics of off-farm activities at FSRD site Kamalbazar, Sylhet, during 2019 to 2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin increased (%)
	GR	TVC	GM	GR	TVC	GM	
Kantha making	1500	400	1100	9000	3000	6000	445
Bee keeping	-	-	-	8000	4500	3500	-
Average	1500	400	1100	8500	3750	4750	332

11.5.2 Off-farm activities at FSRD site Naikhongchari, Bandarban of BLRI component

Comparative income from off farm activities before and after intervention is presented in the Table 11.149. After intervention gross margin from kantha sewing, bamboo basket making and plastic bag making increased 267, 144 and 210% with gross margin Tk. 5500, Tk. 20160 and Tk.18600, respectively at the FSRD site Naikhongchari, Bandarban.

Table 11.149 Economics of off-farm activities at FSRD Site Naikhongchari, Bandarban during 2019-2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin increased (%)
	GR	TVC	GM	GR	TVC	GM	
Kantha sewing	5100	3600	1500	14500	9000	5500	267
Bamboo basket making	11250	3000	8250	27300	7140	20160	144
Plastic bag	15000	9000	6000	37200	18600	18600	210

Picture 11.83 Off-farm activities at FSRD site Naikhongchari, Bandarban

11.6 Income enhancement through integrated farming

11.6.1 Income enhancement through integrated farming at different FSRD sites of BARI component

FSRD site: Basantapur, Rajshahi

Farmers' resources (land, labor, capital, etc.) have been used optimally by integrating year-round vegetables production, HYV seeds, improved cropping patterns, and production technologies, de-worming, vaccination program, and carp polyculture. As a result, farmer's income has increased, which may lead to improved livelihood. After intervention, the average per farm gross return and gross margin were Tk. 763525 and Tk. 443197, respectively, whereas before intervention, it was found Tk. 445450 and Tk. 263265 (Table 11.150).

Table 11.150 Technologies used and return from different component of farming systems at FSRD Site Basantapur, Rajshahi during 2019 to 2022

Name of component	Cost and return before intervention (Tk.)			Cost and return after intervention (Tk.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	4580	825	3855	25753	3472	22282	18427	378
Field crop	385540	162450	225090	562630	228175	334455	109365	49
Livestock	28820	15800	13020	113849	72200	41649	28629	219
Fisheries	3360	1150	2210	15147	5045	10102	7892	357
Off-farm	23150	4060	19090	46146	11438	34709	15619	81
Total	445450	184285	263265	763525	320330	443197	179932	68

FSRDsite: Amnura, Chapainawabganj

Farmers' resources (land, labor, capital, etc.) have been utilized efficiently to the integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technology, de-worming, vaccination program, and carp polyculture. The average per farm gross margin was Tk. 197925 prior to the intervention, but it increased to Tk. 373011 after the intervention of improved technologies (Table 11.151). In comparison to prior intervention, average gross margin increased Tk. 175086 which was 88% over before intervention.

Table 11.151 Technologies used and return from different component of farming systems at FSRD site Amnura, Chapainawabganj during 2019 to 2022

Name of component	Cost & return before intervention (Tk.)			Cost and return after intervention (Tk.) (avg.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	4280	875	3405	24141	3995	20145	16740	492
Field crop	283520	115250	168270	434035	177327	256708	88438	53
Livestock	27850	15500	12350	115333	55160	60173	47823	387
Fisheries	2400	1000	1400	12083	4312	7772	6372	455
Off-farm	22500	10000	12500	43750	15538	28213	15713	126
Total	340550	142625	197925	629342	256332	373011	175086	88

FSRD Site: Chanduria, Rajshahi

The results of integrated farming using a holistic approach showed a significant increase in total farm productivity and profitability. Farmers' income has been increased as a result of the enhanced technology

and resources available to them, which may lead to improved livelihood. During three consecutive years, the highest gross margin (Tk. 165229) was obtained from the field crop, followed by livestock (Tk. 26880), homestead (Tk. 17042) and fisheries (Tk. 9775). The lowest gross margin was obtained from off farm activities (Tk.5252). On the other hand, average gross margin increased (58%) over before intervention (Table 11.152).

Table 11.152 Technologies used and return from different component of farming systems at FSRD Site Chanduria, Rajshahi during 2019 to 2022

Name of component	Cost & return before intervention (Tk.)			Cost and return after intervention (Tk.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	8244	3978	4244	19367	2325.33	17042	12798	301
Field crop	164940	81508.8	120624	270075	104849	165229	44605	37
Livestock	55960	48100	7860	82087	55207	26880	19020	242
Fisheries	10500	4150	6350	17175	7400	9775	3425	54
Off-farm	3533	833	2700	6802	1650	5252	2552	95
Total	256006	126051	129955	406922	201859	205163	75208	58

FSRD Site: Jiarokhi, Kushtia

Farmers' resources (land, labor, and capital) have been used optimally by integrating year-round vegetables production, improved cropping patterns and production technologies, de-worming, vaccination program, and carp polyculture. As a result, farmer's income has increased, which may lead to improved livelihood. The highest gross margin (Tk. 309708) was found from field crops which was 24% higher than before intervention. After intervention, overall gross margin increased 52% through integration of different farm activities (Table 11.153).

Table 11.153 Technologies used and return from different component of farming systems at FSRD Site, Jiarokhi, Kushtia during 2019 to 2022

Name of component	Cost & return before intervention (Tk.)			Cost and return after intervention (Tk.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	2040	1000	1040	13440	8000	5440	4400	423
Nearby Homestead	0	0	0	3000	1000	2000	2000	100
Field crop	408300	158215	250085	471970	162262	309708	59623	24
Livestock	60000	47125	12875	82600	55000	27600	14725	114
Fisheries	2700	1000	1700	36000	7200	28800	27100	1594
Off-farm	12000	3000	9000	66000	21000	45000	36000	300
Total	485040	210340	274700	673010	254462	418548	143848	52

FSRD Site: Kamalbazar, Sylhet

By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labour, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased markedly. It was observed that maximum return recorded from the homestead area which was 2421%

increased after intervention of technologies. The second highest gross margin increased from off-farm activities that were 332% followed by livestock (50%). The average increment of gross margin after intervention was 26% compared to before intervention (Table 11.154).

Table 11.154 Technologies used and return from different component of farming system at FSRD site Kamalbazar, Sylhet, during 2019 to 2022

Name of component	Cost & return before intervention (Tk.)			Cost & return After intervention (Tk.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	420	150	270	10642	3833	6808	6538	2421
Nearby Homestead	6720	1500	5220	35493	9567	25927	20707	397
Field crop	762620	1487364	1920326	4135415	1754894	2380521	460195	24
Livestock	58400	35246	23498	88160	52896	35264	11766	50
Fisheries	30250	12100	18150	38133	15253	22880	4730	26
Off-farm	1500	400	1100	8500	3750	4750	3650	332
Total	859910	1536760	1968564	4316343	1840193	2476150	507586	26

11.6.2 Income enhancement through integrated farming at FSRD site Naikhongchari, Bandarban of BLRI component

By integration of year-round vegetables production, improved cropping patterns and production technologies, de-worming, vaccination program, mixed fish culture, the resources (land, labour, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. Before intervention, an average per farm gross margin was Tk. 92271 whereas it was Tk. 198674 after intervention through integration of different farm components (Table 11.155). The average increment of gross margin after intervention was 115% compared to before intervention.

Table 11.155 Technologies used and return from different component of farming systems at FSRD Site, Naikhongchari, Bandarban during 2019 to 2022

Name of component	Cost & return before intervention (Tk.)			Cost and return after intervention (Tk.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	7308	1900	5408	27681	5835	21846	16438	304
Field crop	71591	39833	31758	120333	55250	65083	33325	104
Livestock	30525	6253	24272	52320	9560	42760	18488	76
Fisheries	29916	14833	15083	50573	25848	24725	9642	64
Off-farm	31350	15600	15750	79000	34740	44260	28510	181
Total	170690	78419	92271	329907	131233	198674	106403	115

11.7 Feasibility study on integration among different household components at different FSRD sites during the years of 2019 to 2022

Integration is carried out to recycle resources as efficiently as possible (Fig 1). Livestock droppings and feed waste can be put directly into the pond to provide feed for fish and zooplankton, ensuring environmentally friendly integration. Livestock excrement can be used to nourish grass or other plant

growth, which can then be utilized as fish food. The fishponds can be utilized to irrigate vegetables, and the wastes and byproducts can be used to feed livestock. However, most manure lost upto half of its nitrogen content before it was converted to nitrate and used as fertilizer by plants. The quantity also became inadequate as the population increased so, chemical fertilizers and artificial feeds had to be purchased, eroding the small profits of the small farmers.

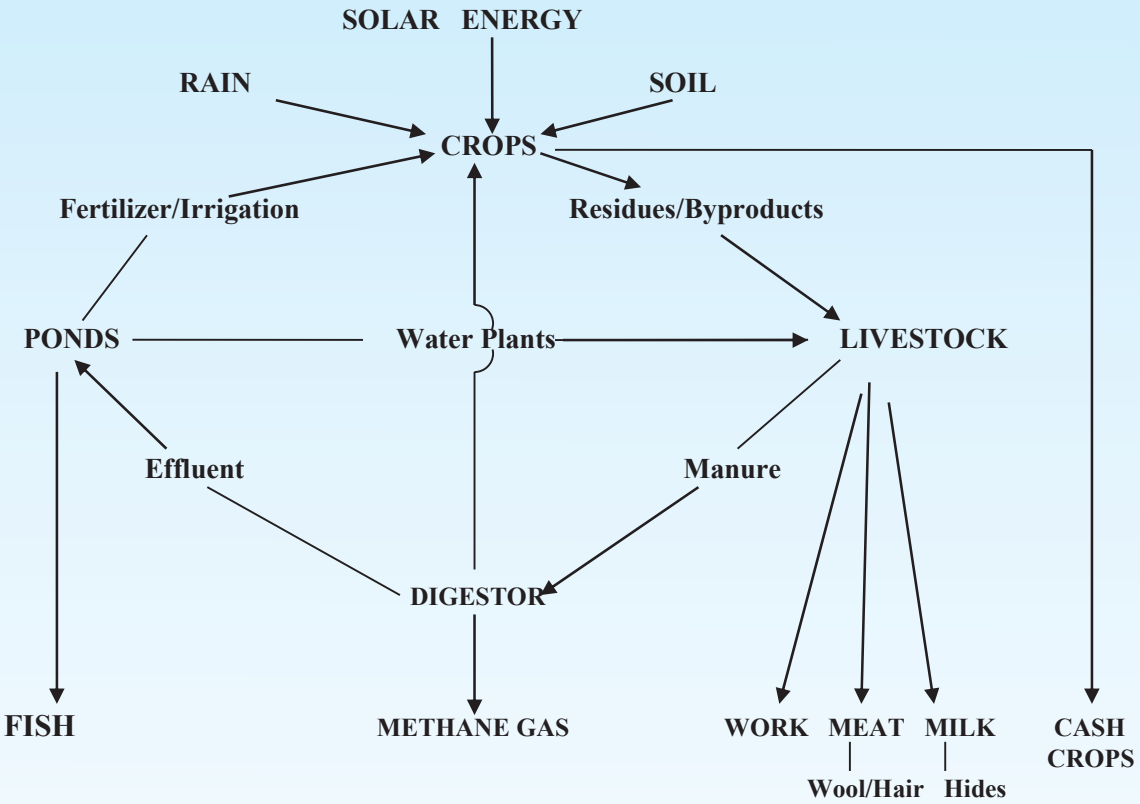

Fig 11.1 Flow diagram of Integrated farming

11.8 Livelihood Improvement (sustainability)

The term "means of securing the essentials of life (food, water, shelter, and clothes)" refers to a person's "means of securing the fundamental necessities of existence." A person's livelihood is described as a set of actions that are necessary for daily life and are carried out throughout one's life. Securing water, food, medication, shelter, and clothing are examples of such activities. A person's livelihood is determined by their ability to obtain the aforementioned necessities in order to meet their own and their family's basic needs. Improvement of livelihoods is a complicated system. Increasing the ability to earn enough money, the security of nutritious and secure food, medical treatment, education, assets, and an acceptable living leading to social standing may all contribute to improved livelihood (Table 11.156). However, the characteristics that were considered for the long-term viability of livelihood improvement at various FSRD sites are listed below.

Table 11.156 Livelihood improvement parameters (sustainability) have been made after intervention of the project activities at different FSRD sites during 2019 to 2022

Sl. No.	Area of consideration	Impact created	Indicator to assess the sustainability
1	Income enhancement	Gross margin increased by 68-88%	• Production of vegetables and fruits in homestead area was increased considering time and space properly • Production was done in integrated way (crop, livestock, fisheries, agroforestry) to minimize production cost and maximize yield • Used STB or FRG for balanced fertilization of crops (Cereals, Oilseeds, Vegetables etc.) • Used of modern varieties • Innovative technologies and mechanization • Used fallow land under cultivation • Increased farmers production skill due to training
2	Family nutrition	Improved satisfactorily	• Vegetables intake from homestead source increased 400-700% • Fruit intake from homestead source increased 100-200% • Fish and poultry meat and egg production and intake increased remarkably • Changed in consumption habit towards vegetables and fruit • Reduced no. of attack and frequency of diseases
3	Soil health	Maintenance/ Increased	• Used of organic matter (FYM) • Decreased the use of insecticides/chemicals due to use of organic matter and IPM technology
4	Resource use pattern	Increased	• Used homestead (100%) • Introduction of homestead vegetables production model for respective site using 8 to 10 production niches. • Every inch of land was used with time and space
5	Technical knowledge	Increased sharply	• Young girls and boys are engaged for implementation of new technologies • Training, field days, LSP activities, fortnightly meeting with field staffs and farming group and exchange of views with different type of peoples.
6	Adaptation innovation	Increase of 60-70%	• New crops, varieties are used and lentil var. BARI Masur-8 and mustard var. BARI Sarisha-17 dominated rapidly in the sub-project period. • Used of recommended fertilizers • Used of different preservation and curative measures of food and seeds • LSP activities
7	Employment	Increased	• Used of unutilized family labor • Women participation in Agricultural activities (Homestead vegetables, livestock, duck and poultry rearing, compost making) the new technology and created employment. • LSP development
8	Micro-environment	Improved	• Household wastes being used for composting and their used in crops • Used of IPM/bio-pesticides saved environment from pollution. • New plantation and increased vegetables contribute to favorable environment
9	Housing	Improved	• New house and repairing of house help in improve living
10	Social status	Improved	• Increased access of better living standard to people • Improved mental strength due to higher income, development of skill on technologies and public conduct.

Sl. No.	Area of consideration	Impact created	Indicator to assess the sustainability
11	Education	Improved	• Women empowerment especially increased income made them to educate their children for a better future.
12	Women participation	Increased	• Homestead vegetables cultivation • Tree plantation and nursing • Composting • Seed preservation • Homestead mini nursery • Cow, Poultry and Duck rearing • All these ensured women empowerment

12. Research Highlights

12.1 Homestead Component

12.1.1 Year-round vegetables and fruits production in homestead at five FSRD sites of BARI component

Title: Year-Round Vegetables and Fruits Production in Homestead

Background: In Bangladesh, vegetables and fruits constitute the primary dietary nutritious sources for the majority of the population. Bangladesh has an extremely low per capita consumption of veggies and fruits. Intensive vegetables and fruit cultivation could not only ensure nutritional security, but also create jobs, increase farm income, improve export possibilities, and reduce reliance on cereal consumption. Malnutrition is a severe problem among farmers in rural areas of Bangladesh, particularly among low-income populations. Malnutrition disorders such as iron deficiency, anemia, and exophthalmia are caused by lack of vegetables and fruits. Regular eating of green and yellow fresh leafy vegetables and fruits can help to reduce nutritional issues. It is a fantastic opportunity to involve female labor in domestic vegetables production because female laborers in Bangladesh are unwilling to work in the crop fields with men. With the rising incidence of hunger and a scarcity of land dedicated to vegetables production, the only viable choice, particularly for small-scale farmers, is to cultivate vegetables intensively in the homestead. Household wastes are an organic decomposed fertilizer that can be used to grow vegetables on homestead. With this goal in mind, homestead vegetables and fruit cultivation program was implemented at various Farming Systems Research and Development (FSRD) sites, following the site-specific homestead model.

Objectives

i) To utilize homestead resources in scientific way for producing fresh vegetables and fruits.

ii) To ensure vegetables and fruits round the year from homestead and improve family nutrition as well as income of the family.

iii) To utilize women labor in income generating activities.

Methodology: During the years 2019 to 2022, the vegetables cultivation program at homestead area was carried out at five Farming Systems Research and Development (FSRD) sites, namely Basantapur (Rajshahi), Amnura (Chapainawabganj), Chanduria (Rajshahi), Jiarokhi (Kushtia), and Kamalbazar (Sylhet), using the models shown in page 8-9. Before initiation of activities, an individual case study of each household was conducted to identify the resource base and potentials of different farm categories. Finally, twelve farmers from the marginal, small, and medium categories were selected for this program.

In the space, there were three to five beds. Each bed was 5 m x 1 m in size. For the vegetables production, recommended seed rate, spacing, and fertilizer doses were used for all the vegetables. When the vegetables were harvested the data were recorded. The product value was computed using each crop's local market price.

Besides homestead vegetables production, from 2019 to 2022, each farmer received saplings of fast-growing fruit trees (Papaya, Mango, Litchi, Guava, Coconut, Ber, Lime, Dragon fruit, Malta, etc). Fruit saplings were delivered and plantation was done in the homestead area and nearby homestead area according to farmers' preferences, agro-ecological suitability, and human nutrition requirements. A single Mango orchard and a mixed fruit garden containing Mango, Guava, and Litchi have been established in Rajshahi. At other locations, mixed fruit garden was also established. Irrigation, fertilizing, pest control, and other care of new and existing fruit trees were undertaken in this program.

Key findings

- Across the different FSRD sites, the highest average vegetables production (252 kg homestead^{-1}) was found in the Rabi season, followed by Kharif-1 season (206 kg homestead^{-1}) and Kharif-II (187 kg homestead^{-1}) seasons. However, round the year total vegetables produced maximum at Basantapur, Rajshahi (841 kg homestead^{-1}), followed by Jiarokhi, Kushtia (734 kg homestead^{-1}) and lowest in Kamalbazar, Sylhet (330 kg homestead^{-1}). After intervention of the improved technologies, vegetables production was increased significantly with a maximum at Kamalbazar, Sylhet (1470%) and a minimum at Chanduria, Rajshahi (504%) as compared before intervention.
- The average vegetables consumption per year per farm family was 380 kg after intervention and the increment was 458%, whereas consumption was only 68 kg per farm family per year before intervention. Vegetables consumption by a five-member farm family was on an average of 283, 241, 166, 287, and 67 g head^{-1} day^{-1} after program intervention at Basantapur, Amnura, Chanduria, Jiarokhi, and Kamalbazar, respectively, and the distribution of vegetables per year was recorded as 98, 67, 52, 83, and 35 kg, and the selling of vegetables per year was 218, 152, 161, 203, and 174 kg in Basantapur, Amnura, Chanduria, Jiarokhi, and Kamalbazar, respectively. The gross margin attained from the vegetables sector after program intervention was Tk. 14398, 11735, 9829, 10327, and 6808 at Basantapur, Amnura, Chanduri, Jiarokhi, and Kamalbazar, respectively, with the average gross margin of Tk. 10619 and an average increment of 838%.
- The management of existing fruit trees and the new plantation of quality saplings increased the availability of fruits round the year, which may partially fulfill the requirements of family nutrition of the farm Households. Higher quantity of average fruit production was found in Kharif-I (211 kg homestead^{-1}) followed by Kharif-II (117 kg homestead^{-1}) and Rabi (61 kg homestead^{-1}) season. However, round the year, total fruits are produced at Basantapur, Rajshahi (455 kg homestead^{-1}) and a minimum at Jiarokhi, Kushtia (192 kg homestead^{-1}). After implementation of the program, the fruit production was increased where maximum at Jiarokhi, Kushtia (1173%) and minimum at Chanduria, Rajshahi (140%) compared to before the intervention of the program.
- Participation of women in different farming and socio-economic activities ensured employment, changed their attitude towards the decision-making process in the family and had a positive effect on equity within the family.

Key words: Home garden, Safe vegetables, Fruits, Homestead model and Nutrition

12.1.2 Year-round vegetables and fruit production in the homestead at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Year round vegetables and fruit production in the homestead

Background: In the Naikhongchari, Bandarban there were found fallow and un-utilized land at homestead areas. Farmers have very few fruits trees and vegetables at their homestead. To bring this unused land in to exploited scientifically in considering time and space homestead vegetables and fruit production program was undertaken. Bangladesh Agricultural Research Institute (BARI) developed vegetables production model “Modified Khagrachari Model” was followed in vegetables production systems by 12 farmers with some modifications according the choice of the farmers and suitability of the hilly area.

Objectives

a) To ensure the vegetables and fruit availability round the year by efficient utilization of homestead
b) To increase vegetables and fruit consumption of family members.

Methodology

The open space of each vegetables garden was about 4 m x 3 m at homestead. For implementing "Modified Khagrachari Model, in sunny places, four beds were prepared by each farmer for cultivation of different short duration vegetables. The crops were selected for different production unit on the basis of the model with some modifications according the choice of the farmers and suitability of the hilly area (shown in page 9-10). Fertilizers N, P and K were applied in each crop at recommended rates. Irrigation was applied as and when necessary.

Key findings

The highest amount of vegetables produced from trellis (251 Kg) and lowest amount of vegetables was produced from backyard (23 kg). The vegetables production was maximum in Rabi season (148, 192 and 229 kg homestead^{-1} in 1st, 2nd and 3rd year, respectively) followed by Kharif-2 season. After intervention of the improved technologies, the average vegetables production was increased 84% compared to before intervention of the program. The average vegetables intake per year farm family was 320 kg after program intervention and the increment was 60%, whereas intake was only 200 kg per farm family per year before program intervention. After intervention, the average distribution of vegetables per year was recorded as 43 kg and average sell was 110 kg. Three years' average, fruits intake per year per farm family was 64 kg after program intervention, whereas it was only 50 kg before intervention and the increment was 28% mainly due to increment of total production and motivation. After intervention, the average distribution of fruits per year was recorded as 6.7 kg and sell of fruits per year was 19 kg. After intervention of homestead production system, the gross return from vegetables were Tk. 6465, 8613 and 4466 in 1st, 2nd and 3rd year, respectively. The average increment of income was 178% after intervention compared to before intervention. In case of fruits sector, after intervention, gross return per homestead was recorded as Tk. 1786, 2350 and 1554 in 1st, 2nd and 3rd year, respectively.

Key words: Homestead, Year Round, Modified Khagrachari Model, Vegetables and Fruits

12.2. Improvement of crops and cropping system

12.2.1 Improvement or development of alternate Cropping Pattern instead of existing Cropping Pattern at five FSRD sites of BARI component

Title: Improvement or development of alternate Cropping Pattern instead of existing Cropping Pattern

Background

The total cultivable land area is currently 7.95 million hectares (BBS, 2016), and decreasing at a rate of 0.44 percent per year. There is relatively little potential for growing cultivable land, but there is potential for raising cropping intensity from 194 percent to 400 percent by upgrading the current cropping pattern. Short-duration crops such as mustard, sesame, boro rice, mungbean, chickpea and aus rice could be incorporated into a rice-based cropping system. Sustainable crop production in Bangladesh is becoming increasingly essential in national issues such as food security, poverty reduction, and employment development. Several NARS institutes have created a number of high yielding and/or short duration crop varieties that can be used to increase cropping intensity and productivity. The study on cropping pattern development or improvement was undertaken to evaluate the feasibility of growing two to three crops in a year in a piece of land by incorporating new crops into the existing cropping pattern in order to produce more food within a limited area.

Objectives

i) To increase the cropping intensity producing two to three crops over the same piece of land in a year

ii) To increase the production efficiency of the individual crop by using improved varieties and optimum management practices

iii) To increase farmer's income and employment opportunity in agriculture.

Methodology: There were different types of cropping pattern exist in different locations. Among the existing cropping patterns, more prominent cropping patterns were considered for the improvement or replace by alternate profitable cropping pattern. To increase crop productivity, two cropping patterns were considered for development at each FSRD site under drought and rainfed eco-system. Mustard (var. BARI Sarisha-17)-Boro (var. BRRI dhan81)-T. Aman (var. BRRI dhan49) pattern against Boro (var. BRRI dhan28)-Fallow-T. Aman (var. Sharwna) and the Wheat (var. BARI Gom-30)-Sesame (var. BARI Til-4)-T. Aman (var. BRRI dhan51) pattern against Wheat (var. BARI Gom-28)-Fallow- T. Aman (var. Sharwna) were tested at FSRD site Basantapur, Rajshahi. In Amnura, Chapainawabganj low water requiring crops were chosen for this site due to extreme drought. Accordingly, Wheat (var. BARI Gom-30)-Mungbean (var. BARI Mung-6) - T. Aman (var. BRRI dhan51) against Wheat (var. BARI Gom-28)-Fallow-T. Aman (var. Sharwna) and the Lentil (var. BARI Masur-8)-Fallow-T. Aman (var. BRRI dhan51) against Fallow-Fallow-T. Aman rice (var. Sharwna) were tested. Lentil (var. BARI Masur-8)-Maize (var. Laltir339)-T. Aman (var. BRRI dhan87) against Fallow-Boro (var. BRRI dhan28)-T. Aman (var. Sharwna) and the Mustard (var. BARI Sarisha-18)-T. Aus (var. BRRI dhan82)-T. Aman (var. BRRI dhan87) against Fallow-Boro (var. BRRI dhan28)-T. Aman (var. Sharwna) were compared at Chanduria, Rajshahi. Lentil (var. BARI Masur-8)-Sesame (var. BARI Til-4)-T. Aman rice (var. BRRI dhan75) against Lentil (var. BARI Masur-6)-Sesame (var. Local)-T. Aman rice (var. BRRI dhan39) and Onion (var. BARI Piaj-4)-Sweet gourd (var. Local hybrid)-T. Aman rice (var. BRRI dhan75) against Onion (var. Local)-Sweet gourd (var. Local hybrid)-T. Aman rice (var. BRRI dhan39) was tested at Jiarokhi, Kushtia. Potato (var. BARI Alu-41)-T. Aus (var. BRRI dhan65)-T. Aman (var. BRRI dhan57) against Fallow-T. Aus (var. BR26)-T. Aman (var. BRRI dhan33) and the Mustard (var. BARI Sarisha-14)-T. Aus (var. BRRI dhan65)-T. Aman (var. BRRI dhan57) against Mustard (var. Tori-7)-T. Aus (var. BR26)-T. Aman (var. BRRI dhan33) were tested at Kamalbazar, Sylhet.

Key findings

Cropping Pattern-I

Improved Pattern (IP): Mustard (var. BARI Sarisha-17)-Boro (var. BRRI dhan81)-T. Aman (var. BRRI dhan49)

Existing Pattern (EP): Boro (var. BRRI dhan28)-Fallow-T. Aman (var. Sharwna)

Average rice equivalent yield (REY) of improved pattern was 14.48 t ha^{-1} against 9.65 t ha^{-1} in existing pattern. The increment of REY in IP was 50% over EP. The average gross margin of IP was Tk. 219210 ha^{-1} while it was Tk. 131690 ha^{-1} in EP. The MBCR of IP was 3.85 over EP.

Cropping Pattern-II

Improved Pattern (IP): Wheat (var. BARI Gom-30)-Sesame (var. BARI Til-4)-T. Aman (var. BRRI dhan51)

Existing Pattern (EP): Wheat (var. BARI Gom-28)-Fallow-T. Aman (var. Sharwna)

The whole pattern REY in IP was 12.87 t ha^{-1} while it was 8.87 t ha^{-1} in EP. The increment in productivity was 45%. The gross margin in IP was Tk. 153465 ha^{-1} and it was Tk. 111485 ha^{-1} in EP. The MBCR in IP was 1.97 over EP.

Cropping Pattern-III

Improved Pattern (IP): Wheat (var. BARI Gom-30)-Mungbean (var. BARI Mung-6)-T. Aman (var. BRRI dhan51)

Existing Pattern (EP): Wheat (var. BARI Gom-28)-Fallow-T. Aman rice (var. Sharwna)

Average REY in IP was 12.58 t ha^{-1} while it was found 8.58 t ha^{-1} in EP. The productivity increment was 47%. The gross margin in IP was Tk. 159107 ha^{-1} and it was Tk. 95810 ha^{-1} in EP. The MBCR in IP was 3.47 over EP.

Cropping Pattern-IV

Improved Pattern (IP): Lentil (var. BARI Masur-8)-Fallow-T. Aman (var. BRRI dhan51)

Existing Pattern (EP): Fallow-Fallow-T. Aman rice (var. Sharwna)

Average REY in IP was 11.85 t ha^{-1} while it was 4.89 t ha^{-1} in EP. The increment of productivity was 142%. The gross margin in IP was Tk. 163075 ha^{-1} and it was Tk. 67605 ha^{-1} in EP. The MBCR in IP was 3.80 over EP.

Cropping Pattern-V

Improved cropping pattern (IP): Lentil (var. BARI Masur-8)-Maize (var. Laltir339)-T. Aman (var. BRRI dhan87)

Existing cropping pattern (EP): Fallow- Boro (var. BRRI dhan28)-T. Aman (var. Sharwna)

Average REY in IP was 20.04 t ha^{-1} while it was 10.09 t ha^{-1} in EP. The productivity was 99% higher in IP than EP. An average, gross margin was Tk. 293048 ha^{-1} in IP against Tk. 103135 ha^{-1} in EP.The average MBCR was obtained 7.26.

Cropping Pattern-VI

Improved cropping pattern (IP): Mustard (var. BARI Sarisha-18)-T. Aus (var. BRRI dhan82)- T. Aman (var. BRRI dhan87)

Existing cropping pattern (EP): Fallow- Boro (var. BRRI dhan28)- T. Aman (var. Sharwna)

Average REY in IP was 15.98 t ha^{-1} while it was 10.36 t ha^{-1} in EP. The productivity was 54% higher in IP than EP. An average, gross margin was Tk. 207087 ha^{-1} in IP against Tk. 109180 ha^{-1} in EP.The average MBCR was obtained 3.91.

Cropping Pattern-VII

Improved cropping pattern (IP): Lentil (var. BARI Masur-8)-Sesame (var. BARI Til-4)-T. Aman rice (var. BRRI dhan75)

Existing cropping pattern (EP): Lentil (var. BARI Masur-6)-Sesame (var. Local)-T. Aman rice (var. BRRI dhan39)

Average REY was 15.42 t ha^{-1} in improved cropping pattern while it was 13.30 t ha^{-1} in existing pattern. The improved cropping pattern gave 15.94% higher REY than that of existing pattern. Whole pattern gross margin was Tk. 329890 ha^{-1} in improved cropping pattern which was Tk. 267796 ha^{-1} in existing pattern. The average MBCR was 12.66.

Cropping Pattern-VIII

Improved cropping pattern (IP): Onion (var. BARI Piaj-4)-Sweet gourd (var. Local hybrid)-T. Aman rice (var. BRRI dhan75)

Existing cropping pattern (EP): Onion (var. Local)-Sweet gourd (var. Local hybrid)-T. Aman rice (var. BRRI dhan39)

Average REY was 36.32 t ha^{-1} in improved cropping pattern while it was 30.63 t ha^{-1} in existing pattern. The improved cropping pattern gave 18.58% higher REY than existing cropping pattern. Whole pattern gross margin was Tk. 805015 ha^{-1} in improved cropping pattern which was Tk. 648348 ha^{-1} in existing cropping pattern. The average MBCR was 7.15.

Cropping Pattern-IX

Improved cropping pattern (IP): Potato (var. BARI Alu-41)-T. Aus (var. BRRI dhan65)-T. Aman (var. BRRI dhan57)

Existing cropping pattern (EP): Fallow-T. Aus (var. BR26)-T. Aman (var. BRRI dhan33)

The whole pattern REY was 28.48 t ha^{-1} in improved cropping pattern while it was 8.51 t ha^{-1} in existing pattern. The improved cropping pattern gave 234.67% higher REY than existing pattern. In improved cropping pattern whole pattern gross margin was Tk. 395590 ha^{-1} which was Tk. 90120 ha^{-1} in existing pattern. The average MBCR was 2.52.

Cropping Pattern-X

Improved cropping pattern (IP): Mustard (var. BARI Sarisha-14)-T. Aus (var. BRRI dhan65)-T. Aman (var. BRRI dhan57)

Existing cropping pattern (EP): Mustard (var. Tori-7)-T. Aus (var. BR26)-T. Aman (var. BRRI dhan33)

Average REY was 15.43 t ha^{-1} in improved cropping pattern while it was 12.64 t ha^{-1} in existing pattern. The improved cropping pattern gave 22.07% higher REY than existing pattern. Whole pattern gross margin was Tk. 179220 ha^{-1} in improved cropping pattern and Tk. 111950 ha^{-1} in existing pattern. The average MBCR was 5.53.

Key words: Cropping pattern, Crop productivity, Cropping intensity and Rice equivalent yield

12.2.2 Improvement of alternate Cropping Pattern instead of existing Cropping Pattern at FSRD site, Naikhongchari, Bandarban of BLRI component

Title: Development of the existing cropping Fallow-T. Aman (Local)-Fallow and Tobacco-Fallow-Fallow cropping pattern through inclusion of Cucumber, Brinjal and Fodder (BLRI HYV Napier)

Background: The crops and cropping system in drought and rainfed ecosystem were performed with a view to develop improved cropping pattern as well as to increase crop productivity by introducing new technology with variety. Poverty eradication, instant cash money, insufficient support for food crops production by the government, unstable market price for main crops etc. are root causes of getting encourage to tobacco cultivation for farmers. Animals as well as man, could not exist were if not plants, and among them are grasses, the most useful of all plants. Green fodders have cooling effect on the animal body, more palatable contain easily digestible nutrients, provide fresh effectively utilizable nutrients in natural form and slightly laxative. The use of concentrates no doubt will give the greatest animal production per unit feed intake, but this may not be economical in countries like Bangladesh where grains and concentrates are costly and/or in short supply.

Objectives

a) To validate different cropping patterns by introducing Cucumber, Brinjal and Fodder (BLRI HYV Napier).
b) To increase crop productivity by introducing new crops in the existing pattern.
c) To increase overall farm income.

Methodology: The experiment was conducted during 2020 to 2022 at the FSRD site Naikhongchari, Bandarban. Two alternate cropping patterns viz., CP-1: Cucumber-T. Aman-Brinjal, CP-2: Fodder (BLRI HYV Napier)-Fodder (BLRI HYV Napier)-Fodder (BLRI HYV Napier) were tested against existing CP-1: Fallow- T. Aman (Local)-Fallow and CP-2: Tobacco-Fallow-Fallow cropping pattern. Rice var. BRRI dhan49 in T. Aman season. Cucumber var. Green king (Lal Teer) and Fodder var. BLRI HYV Napier was used. The yield of each crop was converted to rice equivalent and tobacco equivalent yield for comparing the system productivity.

Key findings:

Cropping Pattern-I

Existing cropping pattern: Fallow-T. Aman (Local)-Fallow

Alternate cropping pattern: Cucumber-T. Aman-Brinjal

The average whole pattern rice equivalent yield (REY) was 78.19 and 5.67 t ha^{-1} in improved and existing cropping pattern, respectively. In improved cropping pattern gross margin was Tk. 1029750 which was Tk. 44400 ha^{-1} in existing cropping pattern. The average MBCR was found 2.2 over existing pattern.

Cropping Pattern-II

Existing cropping pattern: Tobacco-Fallow-Fallow

Alternate cropping pattern: Fodder (var. BLRI HYV Napier)-Fodder (var. BLRI HYV Napier)-Fodder (var. BLRI HYV Napier)

The average whole pattern tobacco equivalent yield (TEY) was 3.88 and 3.11 t ha^{-1} in improved and existing cropping pattern, respecitively. Average whole pattern gross margin in improved cropping pattern was Tk. 255390 ha^{-1} which was Tk. 193050 ha^{-1} in existing cropping pattern. The average MBCR was found 2.46 .

Key words: Gross margin, Rice equivalent yield, Tobacco equivalent yield, Alternate cropping pattern and MBCR.

12.3 On-Farm Verification/Production Program

12.3.1 On-Farm Verification/Production Program with improved varieties at farmers level of FSRD sites, BARI

Title: On-Farm Verification/Production Program with improved varieties at Farmers Field

Background: The Bangladesh Agricultural Research Institute and other NARS institutes have developed a huge number of contemporary crop varieties that are high yielding and have a short growing season. During 2019-22, on-farm verification studies was undertaken with several crops, including Mustard, Potato, Tomato, Lentil, Wheat, Bottlegourd, Sesame, Chickpea, Sunflower, Brinjal, Country bean etc., in order to find suitable crops nad varieties. During period 2019-2022, the identified suitable varieties were brought under production program at each location. The production program is the simplest and popular way of technology dissemination and farmers motivation.

Objectives

1. To create impact in the locality on high yielding crops and varieties.
2. To increase productivity and farmers income.

Methodology: FSRD locations included Basantapur (Rajshahi), Amnura Chapainawabganj), Chanduria (Rajshahi), Jiarokhi (Kushtia), and Kamalbazar, Sylhet, undertook production programs with Mustard, Potato, Tomato, Lentil, Wheat, Bottlegourd, Sesame, Chickpea, Sunflower, Brinjal, Country bean etc., from 2019 to 2022. Crop production was carried out using recommended crop management procedures with important variety.

Key findings: On-farm verification with high yielding crop varieties showed better performance in terms of earliness, higher yield and gross return. This program has created positive impact on total income enhancement. However, location-wise findings under production program are given below-

Location: FSRD Site: Basantapur, Rajshahi

Mustard: Among the short duration mustard variety var. BARI Sarisha-17 gave the highest seed yield (1.71 t ha^{-1}) and monetary benefit (Tk. 72250 ha^{-1}) followed by var. BARI Sarisha-14. The var. BARI Sarisha-18, yielded 1.80 t ha^{-1} with good quality oil.

Tomato: var. BARI Hybrid Tomato-11 (38.0 t ha^{-1}) showed better yield performance than var. BARI Hybrid Tomato-8 (18.50 t ha^{-1}).

Potato: The var. BARI Alu-7 gave the highest tuber yield (26.58 t ha^{-1}) followed by var. BARI Alu-41 (25.26 t ha^{-1}) and the lowest one in var. BARI Alu-25 (21.83 t ha^{-1}).

Lentil: var. BARI Masur-8 gave higher seed yield (1.78 t ha^{-1}) with a gross margin of Tk. 95417 ha^{-1}.

Chickpea: var. BARI Chola-5 is a popular variety in the Barind area. The seed yield of Chickpea was 1.51 t ha^{-1} with a gross margin of Tk. 71067 ha^{-1}

Location: FSRD site: Amnura, Chapainawabganj

Mustard: var. BARI Sarisha-14 (seed yield 1.57 t ha^{-1}) and BARI Sarisha-17 (seed yield 1.66 t ha^{-1}) performed better than local varieties.

Lentil: var. BARI Masur-8 gave a good seed yield (1.76 t ha^{-1}) with good market price.

Chickpea: var. BARI Chola-5 is now popular in the Barind area. The variety gave 1.58 t ha^{-1} seed yield with a good gross return (Tk. 78917 ha^{-1}).

FSRD site: Chanduria, Rajshahi

Lentil: var. BARI Masur-8 gave higher seed yield (1.82 t ha^{-1}) with a gross margin of Tk.101633 ha^{-1}.

Mustard: var. BARI Sarisha-17 gave higher seed yield (1.45 t ha^{-1}) and gross margin (Tk. 79085 ha^{-1}) followed by BARI Sarisha-14 between short duration variety. BARI Sarisha-18, a quality oil seed variety, yielded 1.93 t ha^{-1}. According to long duration variety, BARI Sarisha-16 gave higher seed yield (2.01 t ha^{-1}) followed by BARI Sarisha-11 (1.99 t h^{-1}) .

Wheat: Grain yield of var. BARI Gom-30 (4.15 t ha^{-1}) was slitly higher than that of BARI Gom-33 (4.01 t ha^{-1}).

Potato: var. BARI Alu-57 gave the highest tuber yield (35.30 t ha^{-1}) followed by BARI Alu-40 (34.77 t ha^{-1}) and the lowest one in var. BARI Alu-73 (22.50 t ha^{-1}). But gross margin was the maximum in var. BARI Alu-40 and it followed by var. BARI Alu-7.

Sesame: var. BARI Til-4 is a good variety which yielded 1.15 t ha^{-1} with a gross margin of Tk. 44000 ha^{-1}

Rice: var. BRRI dhan82 is a good variety which yielded 3.30 t ha^{-1} with a gross margin of Tk. 34500 ha^{-1}.

FSRD Site: Jiarokhi, Kushtia

Lentil: The seed yield of var. BARI Masur-8 was 2.12 t ha^{-1} and gross margin Tk. 126948 ha^{-1}.

Mustard: The seed yield of var. BARI Sarisha-18 was 1.72 t ha^{-1} and gross margin of Tk. 106125 ha^{-1}.

Potato: var. BARI Alu-53 gave the highest tuber yield (25.07 t ha^{-1}) and the lowest var. BARI Alu-7 (22.19 t ha^{-1}).

Sunflower: The seed yield of var. BARI Surjomukhi-3 was 3.20 t ha^{-1} and gross margin Tk. 162696 ha^{-1}.

FSRD Site: Kamalbazar, Sylhet

Potato: var. BARI Alu-46 gave the highest tuber yield (32.70 t ha^{-1}) followed by var. BARI Alu-41 (30.40 t ha^{-1}) and the lowest one from var. BARI Alu-53 (27.03 t ha^{-1}). All the potato varieties showed high gross margin and more than Tk. 200000 ha^{-1}.

Tomato: var. BARI Hybrid Tomato-5 contributed 52.80 t ha^{-1} with the gross margin Tk. 384567 ha^{-1}.

Mustard: var. BARI Sarisha-17 (1.62 t ha^{-1}) and var. BARI Sarisha-14 (1.45 t ha^{-1}) performed better than that of var. BARI Sarisha-18 (1.39 t ha^{-1}).

Sunflower: var. BARI Surjomukhi-3 performed better (2.12 t ha^{-1}) than BARI Surjomukhi-2 (1.90 t ha^{-1}). The var. BARI Surjomukhi-3 is a short height and less lodging habit.

Brinjal: var. BARI Begun-12, newly released variety gave the highest gross return (Tk. 1452000 ha^{-1}) and gross margin (Tk. 1255950 ha^{-1}).

Other vegetables: Bottle gourd var. BARI Lau-4 & Country bean var. BARI Sheem-6 yielded 66.05 and 17.50 t ha^{-1}, respectively.

Key words: Farm income, Gross margin, Production, Variety and Yield

Farmer's opinion: Farmers are interested in cultivating BARI Hybrid Tomato-11. BARI Masur-8 and BARI Surjomukhi-3 in the next year

12.3.2 Production Program at FSRD site Naikhongchari, Banarban of BLRI component

Title: Production program with improved varieties at Farmers Field

Background: The people of the Naikhoncgchari area normally used local varieties in crops production due to lack of eagerness about high yielding crops variety or lack of appropriate information. As a result, the farmers of that area deprived from higher crop production as well as higher income. So during 2020-22, some production program was undertaken Potato, Maize, Cowpea, Kidney bean, Cucumber, Brinjal, Sweet gourd in order to introduce new varieties of those crops among the farmers. Moreover, production program is the simplest and popular way of technology dissemination and farmers motivation.

Objectives

I. To increase production of different crops.

II. To increase income of the farm family.

Methodology

Production programs with Potato, Maize, Cowpea, Kidney bean, Cucumber, Brinjal, Sweet gourd from 2019 to 2022 were under taken. Recommended production procedure for each crop was carried out properly.

Key findings

Potato: The average tuber yield of potato (local) was 5.06 t ha^{-1}. The gross return, total variable cost and gross margin were calculated Tk. 151950, Tk. 65300 and Tk. 86650 ha^{-1}, respectively. The benefit cost ratio (BCR) was 2.33 which indicated that this technology is economically profitable.

Maize: The average yield of commercial hybrid variety maize (Hira-104) was 5.80 t ha^{-1}. The gross return, total variable cost and gross margin were calculated Tk. 145125, Tk. 60500 and Tk. 84625 ha^{-1}, respectively. The benefit cost ratio (BCR) was 2.40 which indicated that this technology is profitable.

Cowpea: The average yield of cowpea (local) was 1.48 t ha^{-1}. The gross return, total variable cost and gross margin were calculated 133650, 45300 and Tk. 88350 ha^{-1}, respectively. The benefit cost ratio (BCR) was 2.95 which indicated that this technology is profitable.

Kidney bean: The average yield of Kidney bean (local) was 2.22 t ha^{-1}. The gross return, total variable cost and gross margin were calculated Tk. 200250, Tk. 52300 and Tk. 147950 ha^{-1}, respectively. The benefit cost ratio (BCR) was 3.83 which indicated that this technology is profitable

Cucumber: The average yield of commercial Hybrid cucumber (Lal Teer) was 9.88 t ha^{-1}. The gross return, total variable cost and gross margin were calculated Tk. 247000, Tk. 135000 and Tk. 112000 ha^{-1}, respectively. The benefit cost ratio (BCR) was 1.83 which indicated that this technology is profitable.

Brinjal: The average yield of commercial Hybrid brinjal (Lal Teer) was 11.11 t ha^{-1}. The gross return, total variable cost and gross margin were calculated Tk. 333450, Tk. 175700 and Tk. 157750 ha^{-1}, respectively. The benefit cost ratio (BCR) was 1.90 which indicated that this technology is profitable.

Sweet gourd: The average yield of commercial Hybrid sweet gourd (Lal Teer) was 12.10 t ha^{-1}. The gross return, total variable cost and gross margin were calculated Tk. 266760, Tk. 125000 and Tk. 141760 ha^{-1}, respectively. The benefit cost ratio (BCR) was 2.13 which indicated that this technology is profitable.

Key words: Variety, Yield, Gross return, Gross margin, Benefit Cost Ratio and Profitable.

12.4 Livestock Production System

12.4.1 Livestock rearing and their management at homestead level at different FSRD sites of BARI component

Title: Livestock rearing and their management at homestead level

Background: Bangladesh agriculture's strongest sources of growth are livestock and poultry. Cattle and poultry are key sources of protein as well as a source of revenue for farmers on a family level. In Bangladesh, the majority of rural households have access to chicken, and some farmers raise local breeds with minimal supervision, particularly in the absence of vaccination. Chicken breed Sonali and duck breed Khaki Campbell showed potential to increase the supply of eggs and meat in rural areas. In Bangladesh, almost every rural household has the opportunity to raise chicken, ducks, pigeon and some farmers raise the native breed with little maintenance. Pigeon meat is highly soft and liked by all, making it a good source of protein and a quick source of revenue.

Vaccines are supposed to lower the severity of disease or restrict the frequency of disease in infected animals. Vaccines can protect cattle, goats, and chickens from a variety of diseases that result in decreased productivity, fertility, or death, as well as financial losses for farmers. Cow fattening and calf rearing are becoming increasingly common methods for increasing cattle growth. Dairy cattle bred at the farm level with improved management can produce more milk with better feed and management.

Objectives

- To improve farmers nutritional and socio-economic status.
- To popularize improved poultry, breed in the study area.
- to make easy availability of egg, milk and meat in rural area.

Methodology: Ten faeces samples of cattle were selected from different location by the symptomatic parasitic infection followed by investigated the parasites through faeces sample analysis for the confirmation. After confirmation of parasitic infestation, the tested animal was de-wormed with broad spectrum anthelmintics, such as Trilev-vet (Livamisole and Triclabendazole), for round worm and liver fluke, according to the body weight recommendations.

Vitamin A, D, and E-containing injections were also given to cattle after deworming. In the vaccinated group Anthrax vaccine, Foot and Mouth Disease (FMD) vaccine, Blood Quarter (BQ) vaccine, and Hemorrhagic Septicemia (HS) vaccine were injected as per recommended schedule. Cattle fattening program were also continued at some areas.

Farmers were encouraged to utilize cow dung to make farm yard manure (FYM) and vermicompost, as well as other domestic wastages, rather than utilize it as fuel. The green fodder Napier grass was found as a good and profitable crop to grow on the farmhouse and its adjacent areas, particularly on the pond bank. Farmers were urged to use FYM after each grass cut and farmers were encouraged to use green fodder as feed for their cattle. In addition to feeding their cattle, several farmers sold their produced (Napier grass) at the market.

Poultry disease is the most common problem but only effective immunization can reduce poultry mortality. During the sub-project speriod, a large number of poultry birds were vaccinated. BCRDV, RDV, Fowl pox, Fowl cholera, and Duck plague vaccines were given to the poultry birds according to the prescribed schedule. In some areas, chicken, pigeon, and duck rearing programs were also implemented.

Key findings

- Vaccination against major diseases, i.e., Anthrax, Foot and Mouth Disease and Black Quarter, reduced disease incidence of livestock below 5% at the FSRD sites, which contributed to higher production and economic return from cattle farming.
- Beef fattening of cattle by proper technology helps to gain body weight in animals and increases the farm income. The market value was estimated to have increased by 30-60%.

- Two farmers were rearing male goats at homestead level. The initial average body weight was 10 kg goat^{-1}, and after 10 months, the average body weight gained 14 kg goat^{-1}. The average gross margin was calculated at Tk. 6700 goat^{-1}.
- Vaccinating poultry on a regular schedule against ranikhet, fowl cholera, and fowl pox had a significant impact on lowering mortality rates (below 1%), higher production and higher economic return.
- Poultry rearing with sonali breed gain final body weight 1.38 kg from 0.35 kg. After nine months, the gross margin obtained per household was calculated as Tk. 7000–15000.
- In the case of duck rearing, the average body weight was obtained 2.15 kg. The monthly income obtained from eggs per household was calculated about Tk. 1900.
- In the case of pigeons, each farmer reared on an average of 10 pigeons. On an average of 15 pairs of squabs were born after six months and each farmer earned Tk. 2600 from pigeon rearing.
- Green fodder production with napier grass was started at farmers' land nearby homesteads and on the pond bank. It was found that an average of 74 t ha^{-1} of green fodder could be produced from a homestead or surrounding areas.
- After program intervention 1050 kg Farmyard manure (FYM) was produced with cowdung and household wastage per homestead, but it was only 320 kg before intervention. It may also help to keep the environment of the homestead area clean and to produce relatively safe vegetables.

Key words: Cattle fattening, Green fodder, Sonali chicken, Pigeon rearing, Anthrax, Foot and Mouth Disease, Black Quarter, BCRDV, RDV, Fowl pox, Fowl cholera, Duck plague and Vaccination.

12.4.2 Beef cattle fattening in the farmer's household at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Beef cattle fattening in the farmer's household

Background: Cattle fattening is an effective tool for poverty alleviation of the rural poor in Bangladesh. One of the advantages of the cattle fattening in the rural areas is that farmers use locally available cattle feed resources. Farmers of hilly area rear cattle but they do not follow scientific way. By rearing cattle as whole year they could not profit enough. Farmers were not aware about beef cattle fattening program. As such in the most economical way cattle fattening was conducted to gain maximum weight in shortest time period.

Objective

To increase cattle productivity and income of the farmers.

Methodology: Two round beef fattening activities were done where first round beef fattening just before 3 to 4 months of Eid-ul-Adha and second was done at the end of the year. Cattle fattening period was 3 to 6 months. The program was started at December 2021 and continued up to May 2022. The bulls of 24-30 months aged was selected for fattening program from each farmer. Under this program, bull was dewormed, vaccinated and supplied balance and improved feed. Body weight was recorded regularly.

Key findings: Initial body weight of the cattle was 155 kg. After 6 months of rearing body weight gained 210 kg due to deworming, vaccination and supplying of balance and improved feed. The net profit was Tk. 20000.

Key words: Beef, Fattening, Body weight, Income and Profit.

12.4.3 Goat rearing in the farmer's household to increase income of farmers at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Goat rearing in the farmer's household for increase income of farmers

Background: Goat rearing is an integral part of many farming systems in Bangladesh. Goat is famous for meat, milk and skin. Goat is one of the main sources of cash income for the farmers of Bangladesh. The programme was initiated at the FSRD site, Naikhongchari, Bandarban during October 2019-May 2022. Six

farmers were selected and each of them had given two Black Bengal doe collected from the local market.

Objectives

1. To increase income and productivity of goat at Drought and Rain fed land ecosystem.
2. To involve women participation in hilly area.

Methodology: Six farmers were selected and each of them had given 1-2 Black Bengal doe. 18-24 months aged goats were distributed among the six farmers during October 2019- September 2020. Average initial body weights of distributed goats were 10-12 kg. All goats were vaccinated against PPR disease. Extensive and semi-intensive system of goat rearing was followed. Technical support (feeding, vaccination etc.) were provided regularly. Data on body weight and kid production were also recorded regularly.

Key findings: Average initial body weights of distributed goats were 10-12 kg. From one household a total of 10 kids were borne during October 2019-May 2022. Average gross margin were found 6000, 23600 and Tk. 36000 in the 1st, 2nd and 3rd year respectively.

Key words: Black bengal goat, Doe and Household.

12.4.4 Sheep rearing in the farmer's household to increase income of farmers at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Sheep rearing in the farmer's household for increase income of farmers

Background: Sheep play role in the rural economy of Bangladesh by providing a source of employment, women empowerment and the tool for poverty alleviation. Among the small ruminants, native sheep are important source of meat production in Bangladesh.

Objectives

1. To increase productivity of sheep to meet up nutritional status and also increase income of hilly people.
2. To involve women participation in hilly area.

Methodology: The program was conducted at FSRD site, Naikhongchari, Bandarban during October 2019-May 2022. Six farmers, each was provided with three (2 F, 1 M) sheep for rearing. Sheep of aged 18 to 24 months were distributed among the 6 farmers. Average initial body weights of distributed sheep were 12-14 kg. The sheep were vaccinated and provided feed and treatment properly. The adult ewe gave birth new offspring after six months of rearing.

Key findings: Average initial body weight of distributed sheep were 12-14 kg. From one household a total of 13 lambs were borne during October 2019-May 2022. Average Gross margin 7000, 34600 and Tk. 47000 were found in the 1st, 2nd and 3rd year respectively from one farm household.

Key words: Sheep, Lamb, Gross margin and Body weight.

12.4.5 Hilly chicken rearing at farmer's household for meat purpose at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Hilly chicken rearing at farmer's household for meat purpose

Background: Hilly chicken farming is more profitable for its higher growth rate and market price. There is a high demand of hilly chicken's meat in the markets, especially in the restaurants of hilly areas. Marginal and small farmers of the FSRD site had few stocks of local chicken at their homestead but they do not have much knowledge on different aspects of poultry management. They were not well known about new breeds of poultry hilly chicken. As such hilly chicken were reared round the year to increase the income of the farmer.

Objectives

i) To improve existing poultry production system at Drought and Rain fed land ecosystem.
ii) To ensure the nutritional requirements of farm families.

iii) To make the female participants to engage in income generation

Methodology: Hilly chicken rearing was introduced among the cooperative farmers at the site during 2019-2022. During sub-project period, one hundred twenty (120) hilly day old chicks collected from hatcheries of BLRI were distributed among the 12 farmers (each farmer having 10) and their survival rate was almost 96.67%.

Key findings: Average initial weight during distribution was 45 g. The total variable cost for 1st, 2nd and 3rd year was 2700, 3000 and Tk. 3500, respectively with gross margin 350, 3950 and Tk. 4750, respectively. The increase of gross margin mainly due to genetically improved breed, adequate feed supplement and proper management.

Key words: Poultry, Hilly, Rearing and Chicken.

12.4.6 Duck rearing in the farmer's household at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Duck rearing at farmer household

Background: Farmers of the sub-project area reared duck in small scale. They were not aware about proper management of duck. Farmers were highly interested to include this new intervention in their existing farming system because duck rearing very easy and profitable. Farm family expressed their satisfaction on fulfillment the aesthetic need and as well as bear the expenditure of their child education.

Objectives

1. To increase farmers income.
2. To ensure the nutritional requirements of farm families.
3. To make the female participants to engage in income generation.

Methodology: Twenty five Khaki Campbell ducks were supplied among 5 farmers during October 2019-May 2022 and their survival rate was almost 100%. The routine works of vaccination was being followed regularly for Duck Plague beside natural feeds were given.

Key findings: Survivability rate of distributed duck among the farmers were found 100%. Initial body weight of duckling during distribution was 60 g. Average number egg production was 315 with gross margin were obtained 4200, 5800 and Tk. 6600 per family during 1st, 2nd and 3rd year, respectively.

Key words: Duck, Duckling, Rearing, Income, Poultry and Survivability.

12.4.7 Performance of turkey at farmer's level for egg and meat purpose at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Performance of Turkey at farmer's level for egg and meat purpose

Background: Turkey rearing has been introduced very recently in Bangladesh. Although mass people are still hesitating to accept it, it is rapidly gaining popularity among consumers. Turkey farming is more profitable than poultry farming as it takes less space, higher growth rate and higher market price of meat. Turkey birds mainly eat grasses and vegetables. As a result, farmers do not depend only on market's food. Besides, it can be kept in open areas, not like the poultry farm. There is a great demand of turkey meat in the markets, especially in the restaurants.

Objectives

1. To check the feasibility of turkey rearing under Drought and Rain fed land ecosystem.
2. To increase household income and improve the livelihood.
3. To increase the nutritional status of the hilly people.

Methodology: Thirty-six (36) Turkey chicks were distributed among the six farmers. The routine works of vaccination were followed regularly such as BCRDV, RDV and natural feeds (grass, and vegetables) were

provided as food. Some household gave commercial market food as supplemental feed. After 4-6 months', age female birds have been started laying eggs. Egg production and body weight gained was monitored regularly. At about 6-8 month's aged turkey birds gained commercial weight and ready to sale. Technical supports (feeding, vaccination, treatment etc.) were provided to the farmer as and when required.

Key findings: Initial body weight chick^{-1} of turkey during distribution was 56 g. Average numbers egg production was 310 with gross margin from turkey rearing were obtained Tk. 4200, 5000 and 5500 per family during 1st, 2nd and 3rd year, respectively. Farmers were highly interested in their existing farming system because turkey rearing under scavenging system was very easy and profitable.

Key words: Turkey, Gross margin, Body weight, Egg, Chick and Adult.

12.4.8 Rearing of pigeon at farmer household at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Rearing of pigeon at farmer household

Background: Farmers of the sub-project area reared pigeon in a very small scale. They were not aware about proper management of pigeon. Pigeon is a very good source of protein and also income generating.

Objectives

1. To increase farmers income.
2. To ensure the nutritional requirements of farm families.
3. To make the female participants to engage in income generation.

Methodology: Six selected farmers were given 12 pairs of pigeons for increasing income and nutrition of the farm family. Two pairs of pigeon were given to each farmer. The pigeon gave squab after two months of rearing. The routine works of vaccination were being followed regularly such as BCRDV, RDV and natural feeds being fed.

Key findings: Survivability rate of distributed pigeon among the farmers were found 100%. The number of pigeons was increased rapidly. After 6 month of rearing, average eight pair of squabs was found per family. Gross margin from pigeon were obtained Tk. 2500, 2900 and 6300 per family during 1st, 2nd and 3rd year, respectively.

Key words: Pigeon, Squab, Rearing, Income, Poultry and Survivability.

12.4.9 Improvement of cattle health through deworming and dewormed + vitamin ADE injection at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Improvement of cattle health through deworming and dewormed + vitamin ADE injection

Background: The profitability of livestock mostly depends on animal health. Farmers of hilly area rear cattle in less scientific manner and mortality higher. A wide range of diseases causes the reduction of production, fertility or death in cattle and economic losses to the farmers. Deworming practice is expected to reduce the severity of disease or limit the frequency of disease.

Objective: To increase animal productivity by improvement of cattle health.

Methodology: Vaccination program for cattle rearing was conducted with farmers lived around them. Two doses of deworming medicine were provided to the cattle at 35-40 days interval and one dose of vitamin ADE injection was given as per body weight of the cattle recommended by concerned personnel of Regional station, BLRI, Naikhongchari, Bandarban.

Key findings: It was found that, before deworming the frequency of disease incidence was higher whereas after dewormed the average body weight, disease incidence, lactation yield and the lactation period increased over the controlled cows. It was observed that body weight gained (130 and 135g), milk production (2.6 and 2.7 L/day) and lactation period (230 and 240 day) was increased by Dewormed+Vitamin ADE injection and only Dewormed cattle respectively, where as non-treated cattle showed lower performance.

Key words: Cattle, Vaccination and Deworming.

12.4.10 Vaccination on poultry at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Vaccination on poultry at FSRD Site

Background: The profitability of livestock mostly depends on animal health. Hilly farmers reared poultry birds but mortality rate higher. A wide range of diseases causes the reduction of production, fertility or death of poultry birds and economic losses to the farmers. Vaccines are expected to reduce the severity of disease or limit the frequency of disease.

Objective: To increase productivity of poultry birds by reducing mortality.

Methodology: Poultry vaccination program was conducted at the FSRD site, Naikhongchari. Cooperator farmers along with farmers lived around them were selected for vaccination program of their poultry birds. BCRDV, RDV and Duck plague were vaccinated on poultry birds. Routine vaccination on poultry birds were done as per recommended by concerned personnel of BLRI regional station, Naikhongchari, Bandarban.

Key findings: It was found that average mortality rate was 14% due to different diseases. After vaccination of birds all of the diseases reduced drastically and mortality rate was recorded 1-2%.

Key words: Poultry, Vaccination, BCRDV, RDV and Duck plague.

12.4.11 Vaccination on major livestock species to reduce mortality rate at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Vaccination on major livestock species to reduce mortality rate

Background: The profitability of livestock mostly depends on animal health. Farmers of hilly areas reared their livestock in less scientific way as a result mortality rate higher. A wide range of diseases causes the reduction of production, fertility or death in livestock and economic losses to the farmers. Vaccines are expected to reduce the severity of disease in infected animals or reduce the frequency of disease.

Objectives

(i) To improve health status and increase productivity by reduce mortality of livestock species.

(ii) Increase family income.

Methodology: Vaccination program was conducted at the FSRD site during October 2019 to may 2022. Cooperator farmers along with farmers lived around them were selected for the program of their major livestock species. Routine vaccination on major livestock species (Cattle, goat and Sheep) were vaccinated against major diseases such as PPR and FMD as recommended by concerned personnel of BLRI.

Key findings: It was found that before vaccination mortality of livestock species due to different diseases was 7.67%. After vaccination of major livestock species, all of the diseases reduced drastically and mortality rate was recorded 1.34% for major livestock species at FSRD site.

Key words: Livestock, Vaccination, PPR and FMD.

12.5 Fisheries Component

12.5.1 Performance of Carp Polyculture at seasonal pond at five FSRD sites of BARI component

Title: Performance of Carp Polyculture of fish at seasonal pond

Background: Polyculture refers to the technique of raising multiple fish species in the same pond. Compatible fish species with complementary feeding patterns are stocked in order to fill all of the biological niches in the pond environment. Different species of fishes are accumulated in the polyculture system depending on their compatibility and eating preferences. In the composite fish culture method, exotic kinds have been found and recommended for culture. Polyculture of three important Indian carp species, catla, rohu, and mrigal, as well as three Chinese carp species, silver carp, grass carp, and common carp, is the most successful pond fish culture system. Polyculture offers more opportunities to increase fish production per unit area than monoculture.

Objectives

i) To utilize unused or underutilized ponds by growing seasonal fish.

ii) To increase income of the farmers.

iii) To reduce malnutrition by eating fish from the mini ponds.

Methodology: The FSRD locations implemented a carp polyculture program in seasonal ponds to enhance farmers' income and alleviating rural people's protein shortage. Weeds and wild fish were removed from the pond for fish cultivation. One kg lime and 3 kg cowdung per decimal was applied in the pond before stocking fingerlings. Fingerling stocking density is mostly determined by the size, species, pond depth, and feed availability of the fingerlings. Silver carp, Catla, Rohu, Mrigal, Common, and Mirror carp fingerlings 20–30, 10–15, 15–20, 10–15 and 15–20 %, respectively was used in a polyculture system (while retaining 20–30 fingerlings decimal-1). Fish feed was supplied by co-operative farmers, while lime and fingerlings were by the project.

Key findings

In seasonal ponds, carp polyculture (Silver carp, Rajputhi, Rohu, Catla, and Mrigal) practices (5-21 decimal sized with 1.2 to 2 m depth) was used. Pond sizes in the High Barind area were typically small (5 to 7 decimal) and 20-21 decimal in Kushtia and Sylhet. The survival rate of fishes was observed range from 75-86%. In Basantapur, Amnura, Chanduria, Jiarokhi, and Kamalbazar, total fish production was found 119, 95, 100, 200, and 347 kg pond^{-1}, with gross margins of the 10102, 7772, 9775, 28800, and Tk. 22880 pond^{-1}, respectively. Farmers sold the majority of the fish (Avg. 88 kg pond^{-1}), consumed about 65 kg pond^{-1}, and distributed just 12 kg pond^{-1} to their neighbors, family, and well-wishers of the produced fish.

Key words: Carp polyculture, Fish, Gross margin and Seasonal pond.

12.5.2 Fish production through mixed culture in perennial pond at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Fish production through mixed culture in perennial pond

Background: Mixed culture is a fish culture technique in which more than one type of compatible fish is cultured simultaneously in a pond. This method enables maximum fish yield/production from a pond through utilization of available fish feed. Fisheries sector is a source of animal protein as well as play role to provide rural employment and poverty alleviation. Due to unavailability of water in pond round the year fish culture in pond was not observed at the FSRD site. Due to conflict with multiple uses of natural waters, ownership of land and risk of theft farmers were not interested to culture fish in the open water sources.

Objective: Fish production through utilization of available technologies to increase income and protein availability

Methodologies: Mixed fish culture (Tilapia with catla and rohu) was introduced at FSRD site in the four ponds. The average pond size was 28.75 dec. and depth was 1.5 m. Duration of the fish culture period was 6-8 months during 2019-2022.

Key findings: The survival rate of the fingerlings was 75-82%. Commercial feed was supplied as per recommended by the feed producer. After intervention, total production was calculated 1608 kg and 1657 kg pond^{-1} during Year-I-II and Year-II-III. Before intervention, production pond^{-1} was 1050 kg which increased 1633.5 kg after intervention. Gross margin after intervention was calculated Tk. 131405 pond^{-1} which was Tk. 82500 pond^{-1} before intervention as well as BCR was 1.95 which increased 3.5 after intervention. Among the total production farmers consumed, distributed to relatives and sold their fishes in the local market. It was observed that, farmers sold most of the portion (avg. 333.5 kg), consumed about (avg. 63.5 kg) and distributed (avg. 22 kg) to their neighbors, relatives and well-wishers of the produced fish. The farmers were benefitted by carp polyculture system and they showed further interest for farming of carp polyculture.

Key words: Fish, Fingerling, Mixed culture and Survivability rate.

12.5.3 Monosex tilapia production at FSRD site Naikhongchari, Bandarban of BLRI component

Title: Monosex tilapia culture in the seasonal pond of homestead

Background: Proper management is the key factor for getting profitability of fish culture in pond under homestead area. Before conducting the fish culture in pond, following activities were done chronologically i.e. pond selection, pond preparation, lime application, stocking density, fertilizer and manure management, supplementary food as per recommendation.

Objective: To improve the livelihood of farmers by increasing farm income through momosex tilapia production

Methodology: One seasonal pond was selected for fish culture with monosex tilapia at FSRD site Naikhongchari, Bandarban during 2020 to 2022. The pond size was 8 dec. and depth was 1.2 m. Duration of the fish culture period was 6-7 months.

Key findings: After imposing modern techniques in monosex tilapia culture, the production and income both were increased as well as survival rate of the fingerlings was 71-76%. Ready made feed was supplied as per recommended instruction by the feed producer. Total production after intervention was calculated 409 kg and 429 kg per pond during Yea-I and Year-II and Year-II and Year-III. Before intervention, production pond^{-1} was 325 kg which increased 419 kg after intervention. Gross margin after intervention was calculated Tk. 16950 pond^{-1} which was Tk. 8000 pond^{-1} before intervention.

Key words: Monosex tilapia and Seasonal pond.

12.6 Off-farm component

12.6.1 Additional income from Off-farm activities at different FSRD sites of BARI

Title: Additional income from Off-farm Activities

Background: Off-farm (non-farm) income refers to the portion of farm household income that comes from sources other than the farm, such as non-farm wages and salaries, pensions, and interest income. Since the last three decades or more, there has been evidence that small-holder farm households in developing nations does not rely solely on agriculture, but rather maintain a diverse income portfolio that includes off-farm activities.

Objectives

i) To utilize properly the unused labor of women and men for off farm activities.

ii) To increase income of the farmers.

iii) To create employment and women empowerment.

Methodology: The off-farm activity was conducted at different FSRD sites during 2019 to 2022. Some farm families' especially the women were engaged with off-farm activities such as weaving kantha and sewing cloth with machine, making handicrafts (Bag, Mat) with jute rope during their leisure periods and men were engaged with van pulling, 2WT operating as LSP and bee keeping.

Key findings: Off-farm activities have created positive impact among the farmers. It was found that after intervention the avg. gross return increased 156%, with the avg. gross return of Tk. 17585 per year. So, some off-farm activities would be helpful to increase total farm income.

Key words: Labor, Gross return, Off-farm activities and Women empowerment.

12.6.2 Additional income from Off-farm activities at FSRD site Naikhongchari, Bandarban of BLRI component

Background: Participation of farm households in off-farm work has gained importance in recent times as an income diversification. Off-farm work enables farm households to stabilize household income and reduce vulnerability and uncertainties associated with agricultural production. Off-farm work is identified as a risk management tool that reduces income variability of farm households. Several studies reported

positive effect of off-farm work on agricultural productivity, food security, and household income of farm households.

Objectives

i) Use of unused family labor.

ii) To add extra income and .

iii) Women empowerment.

Methodology: Some farm families' especially the women were engaged with off-farm activities such as weaving kantha, bamboo basket making and plastic bag making during their leisure periods. To implement the activities some inputs were provided to the beneficiaries. Program monitoring was done regularly.

Key findings: Off-farm activities created positive impact among the farm family where after intervention gross margin increased form kantha sewing (267%), bamboo basket making (144%) and plastic bag making (210%) compared to before intervention. Some off-farm activities would be helpful to increase total farm income of the farm families.

Key words: Gross margin, Gross return, Total variable cost, Off-farm activities

B. Implementation Status

1. Procurement:

Table B.1.1 Procurement of equipment and capital items of BARC component

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
Office equipment					
Furniture	2	30000	2	29000	
Computer and accessories	2	470000	2	469000	
Total	4	500000	4	498000	

Table B.1.2 Procurement of equipment and capital items of BLRI component

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
Equipments, Tools etc.					
i. Desktop	01	60000	01	59700	
ii. Laser Printer	01	20000	01	19850	
iii. Scanner	01	10000	01	9700	
iv. Camera	01	25000	01	24900	
Total		115000		114150	

2. Establishment/renovation facilities: BARC Component

Table B.2.1 Renovation facilities of BARC Component

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Room renovation			4 Room	4 Room	

3. Training/study tour/ seminar/workshop/conference organized

Table B.3.1 Information on training/workshop/meeting organized by BARC

Description	Number of participants			Duration	Remarks
	Male	Female	Total		
(a) Training on Farming System Research and Development	44	4	48	Three days long each batch	One batch for scientist and another batch for SAAO/ SSA/ SA.
(b) Workshop	194	19	213	Day long	Four workshops were held.
(c) Coordination meeting	38	0	38	Day long	Four coordination meetings were held.

Table B.3.2 Information on training/workshop/field days arranged by BARI

Description	Number of participants			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	100	60	160	1 Days	
(b) Meeting	636	424	1060	1 Days	

Table B.3.3 Information on training/workshop/field days arranged by BLRI

Description	Number of participants			Duration (Days)	Remarks
	Male	Female	Total		
Field day	5	7	12	Day long	FSRD site (03.06.22)

C. Financial and Physical Progress

C.1 Combined financial and physical progress of all component

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	11366667	10900647	10900647	0	100	
b. Field research/lab expenses and supplies	7411386	7042099	7042099	0	100	
c. Operating expenses	2715174	2431961	2431961	0	100	
d. Vehicle hire and fuel, oil & maintenance	1576200	1467388	1467388	0	100	
e. Training/workshop etc.	1819420	1716400	1716400	0	100	
f. Publications and printing	545750	545285	545285	0	100	
g. Miscellaneous	503253	528545	528545	0	100	
h. Capital expenses	612150	612150	612150	0	100	
Total	**26550000**	**25244475**	**25244475**	**0**	**100**	

Table C.2 Financial and physical progress of BARC Component

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	4107230	4104409	4104409	0	100	
b. Field research/lab expenses and supplies	300000	298432	298432	0	100	
c. Operating expenses	789207	618000	618000	0	100	
d. Vehicle hire and fuel, oil & maintenance	179500	144662	144662	0	100	
e. Training/workshop etc.	1261420	1241400	1241400	0	100	
f. Publications and printing	545750	545285	545285	0	100	
g. Miscellaneous	343893	343881	343881	0	100	
h. Capital expenses	498000	498000	498000	0	100	
Total	**8025000**	**7794069**	**7794069**	**0**	**100**	

Table C.3 Financial and physical progress of BARI Component

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	5658409	5645377	5645377	0	100%	
b. Field research/lab expenses and supplies	4764920	4724920	4724920	0	100%	
c. Operating expenses	1510424	1508061	1508061	0	100%	
d. Vehicle hire and fuel, oil and maintenance	1211459	1185989	1185989	0	100%	
e. Training/workshop/seminar etc.	558000	475000	475000	0	100%	
f. Publications and printing	0	0	0	0	100%	
g. Miscellaneous	96788	100183	100183	0	100%	
h. Capital expenses	0	0	0	0	100%	
Total	13800000	13639530	13639530	0	100%	

Table C.4 Financial and physical progress of BLRI Component

Fig in Tk

Items of expenditure/activities	**Total approved budget**	**Fund received**	**Actual expenditure**	**Balance/ unspent**	**Physical progress (%)**	**Reasons for deviation**
a. Contractual staff salary	1601028	1150861	1150861	0	100	
b. Field research/lab expenses and supplies	2346466	2018747	2018747	0	100	
c. Operating expenses	415543	305900	305900	0	100	
d. Vehicle hire and fuel, oil & maintenance	185241	136737	136737	0	100	
e. Training/workshop etc.	0	0	0	0	100	
f. Publications and printing	0	0	0	0	100	
g. Miscellaneous	62527	84481	84481	0	100	
h. Capital expenses	115000	114150	114150	0	100	
Total	**4725000**	**3810876**	**3810876**	**0**	100	

D. Achievement of Sub-project by Objectives (Tangible form): Technology generated/developed

Table D.1. Technology generated/developed by BARI Component

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e., product obtained, visible, measurable)	Outcome (short term effect of the research)
a) General objective: Maximizing Farm Productivity through dissemination of Farming Systems Research Technologies and efficient use of Farm Resource	Modified vegetable production model development. 1. Modified Barind Model for FSRD Site: Basantapur, Rajshahi and Amnura, ChapaiNawabgonj	Vegetables production increased by 600-700% after intervention compared to before intervention	Maximum utilization of homestead area for safe and nutritious vegetables production.
b) Specific objective: i) To develop integrated farming technologies to maximize farm productivity with efficient use of farm resources.	Cropping patterns development using farm resources judiciously (10) CP1: Mustard-Boro-T. Aman CP2: Wheat-Sesame-T. Aman CP3: Wheat-Mung-T. Aman CP4: Lentil-Fallow-T. Aman CP5: Lentil-Maize-T. Aman CP6: Mustard- T. Aus-T. Aman CP7: Lentil-Sesame -T. Aman CP8: Onion- Sweet gourd-T. Aman CP9: Mustard-T. Aus-T.Aman CP10: Potato-T. Aus-T. Aman	Rice equivalent yield increased in developed cropping pattern compared to existing pattern as follows- CP1:50% CP2: 45% CP3: 47% CP4:142% CP5: 99% CP6: 54% CP7: 16% CP8: 19% CP9: 235% CP10: 22%	Cropping intensity and productivity increased to a satisfactory level.
c) 1. To maximize the farm productivity and efficient utilization of drought & rainfed ecosystem.	Twelve varieties of seven different crops bring under the production programs.	The Tomato var. BARI Hybrid Tomato-11, Potato var. BARI Alu-46, Mustard var. BARI Sarisha-14, 17and 18, Sunflower var. BARI Surjomukhi-3 and Brinjal BARI Begun-12 were grown with higher productivity and successfully accepted by the farmers.	Increasing crop productivity in all the regions.
d) To integrate component technologies (crops, livestock, fisheries, agro-forestry and year round vegetables and fruit production at homestead, etc.) for improving farm productivity and establish linkage with different stakeholders.	Improved technologies for crop, livestock, fisheries, year round vegetables and fruit production at homestead, fruit orchard was used and byproduct of one component was used as main product to another component.	Productivity increased in all components. Crop sector- 45-50%, livestock-200%, fisheries-300-400%	Productivity increased in all components.

Table D.2. Technology generated/developed by BLRI Component

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
1. To maximize the farm productivity with efficient use of farm resource in the Drought and Rain-fed eco-system.	Sheep rearing in the farmers' household for increase income of farmers	Increased number of lamb with gross margin Tk. 47000 family^{-1} at final year.	Production and income of farm family could be increased as well as involvement of women participation could be increased.
	Goat rearing in the farmers' household for increase income of farmer's	Increased number of kid with gross margin Tk. 36000 family^{-1} at final year.	Production and income of farm family could be increased as well as involvement of women participation could be increased.
	Duck and poultery rearing in the farmer's household for increase income of farmer's	Increased number of egg production (88 farm family^{-1}) and egg consumption (277%) compared to before intervention. The average income from egg was found Tk. 5036 farm family^{-1} month^{-1}.	Egg production, income and daily consumption by farmer could be raised as well as involvement of women participation could be increased.
	Hilly chicken rearing in farmer's house hold for meat purpose	Increased number of egg and meat production and farm family^{-1} was earned gross margin Tk. 4750 year^{-1}.	Meat production, daily consumption and income by farmer could be raised. Involvement of women participation could be increased.
	Beef fattening programme as a source of income generation at the FSRD site: Nakhongchari, Bandarban.	Initial body weight of the cattle was 155 kg. After 6 months of rearing body weight gained 210 kg due to deworming, vaccination and supplying of balance and improved feed. Farms earned net profit was Tk. 20000 from cattle fattening.	Income of farmer will be increased as well as involvement of women participation could be increased.

E: Information/Knowledge generated/Policy generated

Table E.1 Information/knowledge generated/policy generated by BARI Component

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
i) To maximize the farm productivity and efficient utilization of drought and rainfed ecosystem	Year-round vegetables and fruits production in homestead area	Vegetables and fruit: Consumption, Distribution and selling of vegetables and gross margin were increased about 378% and 492% at Basantapur and Amnura, respectively.	Income and family nutrition of farmers could be raised
	Production program with different varieties of Mustard, Potato, Tomato, Lentil, and chickpea	The following crop varieties were identified as suitable for the tested location- Mustard var. BARI Sarisha-14, 17 &18, Lentil var. BARI Masur-8, Chickpea var. BARI Chola-5, Potato var. BARI Alu-25 & 41, Tomato var. BARI Hybrid Tomato-11.	Productivity of different crops will be increased. Modern and high yielding crops varieties have been disseminated.
	Improvement of the cropping pattern Fallow – T, Aus- T. Aman with inclusion of potato var. BARI Alu -410.	Improved patterns were tested and 234% higher REY was obtained compared to existing cropping pattern.	Income and productivity could be raised
	Spraying of Mango and other fruit trees.	About 1186 numbers of fruit trees were sprayed.	Income and fruits production could be raised
	Establishment of homestead and nearby homestead fruit garden.	About 2328 numbers of different fruit saplings were supplied.	Income and family nutrition of farmers could be raised
	Vaccination program of cattle, goat, sheep, chicken, duck and pigeon.	Significantly reduced disease incidence and mortality rate.	Survival rate and production of cattle, goat, chicken, duck and pigeon have been increased
	Cattle fattening program at farmers' level.	Cattle body weight and market value (28-65%) was increased.	Cattle health and production have been improved
	Goat rearing at farmer's house hold.	The average gross margin was obtained Tk. 2033 goat^{-1}.	Goat rearing system has been practiced.
	Rearing of Sonali chicken at farmers' household .	Range of average gross margin was 4151to Tk.10349 household $^{-1}$.	Income and family nutrition of farmers could be raised
	Duck rearing at farmer's household .	Monthly income ranges from Tk. 1100 to 2400 household $^{-1}$	Income and family nutrition of farmers could be raised
	Pigeon rearing at farmer's household .	Income ranges from Tk. 1250-5300 household $^{-1}$.	Income and family nutrition of farmers could be raised.
	Farm Yard Manure (FYM) production at farmer's house	About 1050 kg FYM produced per household	Soil health and crop productivity could be

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
	Green fodder production at farmer's household .	About 74 t ha^{-1} Napier grass produced per house hold per year.	Green fodder for cattle could be available.
	Maximization of farmer's income through carp poly culture technique at low-cost management in seasonal pond.	Range of gross margin was 8000 to Tk.17133 $pond^{-1}$.	Income and family nutrition of farmers could be raised.
	Income enhancement through off-farm activities.	The average gross margin was increased 96%.	Income of farmer especially women farmer could be raised.
ii) To integrate component technologies (crops, livestock, fisheries, agro-forestry and homestead gardening, etc.) for improving farm productivity.	Direct and indirect Integration among different farm components.	1. Crop-livestock integration 2. Crop- livestock Fisheries- fisheries-Agroforestry integration.	Sustainable farming system could be established.
iii) To establish linkage with different stakeholders.	Local Service Provider (LSP), Field Day, and media program	Two LSP have developed (one male + one female). Field day and media helped to disseminate year round vegetables and fruit production at homestead and field crops technologies.	Linkage improved among the Researcher-Extension personnel-Farmers-Media.
iv) To create awareness about modern agricultural technologies among the participating farmers	Modern technologies on crop, livestock and fisheries	Production program, training and field day were done on modern technologies.	Farmer's knowledge could be improved.
v) To improve family income and livelihood through empowering woman in farm activities	Judicial use of all farm resources for improving family income.	Improvement of livelihood and women involved in homestead gardening program.	Social status of woman farmers could be improved.

Table E.2 Information/knowledge generated/policy generated by BLRI Component

General objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
1. To maximize the farm productivity with efficient use of farm resources 2. To Improve family income	Goat rearing in the farmer's household for increase income of farmers.	Increased number of kid with gross margin Tk. 36000 per family at final year.	Production and income of farm family could be increased as well as involvement of women participation could be increased.
	Sheep rearing in the farmers' household for increase income of farmers.	Increased number of lamb with gross margin Tk. 47000 per family at final year.	Production and income of farm family could be increased as well as involvement of women participation will be increased.
	Duck rearing in the farmer's household for increase income of farmer.	Increased number of egg production (88 farm family^{-1}) and egg consumption (277%) compared to before intervention. The average income from egg was found Tk. 5036 farm family^{-1}month^{-1}.	Egg production, income and daily consumption by farmer could be raised as well as involvement of women participation will be increased.
	Hilly chicken rearing in farmers house hold for meat purpose.	Increased number of egg production (360 farm family^{-1}) and each farm family was earned gross margin Tk. 4750 year^{-1}.	Meat production, daily consumption and income by farmer could be raised. Involvement of women participation will be increased
	Beef fattening programme as a source of income generation.	Initial body weight of the cattle was 155 kg. After 6 months of rearing body weight gained 210 kg due to deworming, vaccination and supplying of balance and improved feed. The net profit was found Tk. 20000 cattle^{-1} from fattening program.	Income of farmer could be increased as well as involvement of women participation will be increased
	Vaccination programme on livestock and poultry.	The major livestock (Cattle, goat and Sheep) and poultry birds (Chicken and duck) were vaccinated during the project period. After vaccination of livestock and poultry birds, all of the diseases reduced drastically and mortality rate was recorded 1.34% and 1.2% for livestock and poultry birds, respectively.	Mortality rate of livestock and poultry birds could be reduced which lead to higher family income.

General objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
	Small scale pigeon rearing in farmer's household .	Gross margin from pigeon rearing were obtained Tk. 2500, Tk. 2900 and Tk. 6300 per family during 1st, 2nd and 3rd year, respectively.	Involvement of women participation. Meat production and daily consumption by poor farmer could be raised and also income and family nutrition of farmers could be increased.
	Turkey rearing in the Farmer's house hold.	Average number of egg production was 310. Gross margin from turkey rearing were obtained Tk. 4200, Tk. 5000 and Tk. 5500 farm family^{-1} during 1st, 2nd and 3rd year, respectively.	Income and family nutrition of farmers could be increased as well as involvement of women participation would be increased.
	Cultivation of Napier grass in homestead.	Total production of green fodder was found 65.70, 75.5, 82.15 t ha^{-1}, respectively with gross margin 19710, 22365 and Tk. 24650 were recorded during 1st, 2nd and 3rd year, respectively.	Farmer family income would be increased as well as scarcity of cattle would be reduced.
	Year-round vegetables and fruit production at homestead.	The income from vegetables was Tk. 6465, 8613 and 4466 in 1st, 2nd and 3rd year, respectively. The average increment of income was 178%. Income from fruits production homestead-1 were recorded as 1786, 2350 and Tk.1554 in 1st, 2nd and 3rd year, respectively.	Safe and fresh vegetables and fruits intake were increased. Enhance total farm productivity and income.
	Cropping pattern practiced by the cooperative farmers Cucumber - T. Aman - Brinjal	The gross margin was Tk. 36938 ha^{-1} with MBCR 2.20.	Crop production as well as income of the farmer could be raised through improved cropping pattern
	Maximization of farmers' income through carp polyculture technique at low cost management	Total fish production was calculated 1608 kg and 1657 kg pond^{-1} during Year-I & Year-II and Year-II & III. Gross margin after intervention was estimated Tk. 131405 pond^{-1} with BCR (3.5) after intervention.	Enhanced total farm productivity and income. Increase intake of nutrition in each farm family.
	Empowerment of rural woman through off-farm activities.	Average gross margin was recorded Tk. 12625 homestead^{-1}	Income and involvement of women participation could be increased.
3. Creating awareness on system based agricultural technologies among the participating farmers	Farmer's field day	In field day, 12 farmers were participated.	Create awareness among the farmers on new technologies.

F. Materials Development/Publication made under the Sub-project

Table F.1 Materials Development/Publication made under the Sub-project by BARC Component

Publication	Number of publications		Remarks
	Under preparation	Completed and published	
Booklet	-	2	• Potato-T. Aus-T. Aman Cropping Pattern: A Modern and Improved Technology for Using Fallow Land of Sylhet Region. • Modern Technology of Hilly Chicken Rearing under Rural Condition in the Hilly Area.
Video documentary	-	1	Video documentary on farming system research

Table F.2 Materials Development/Publication made under the Sub-project by BARI Component

Publication	Number of publications		Remarks (e.g., paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
FSRD Site: Basantapur Rajshahi			
Booklet	01		
TV program		02	1. Title: উঁচু বরেন্দ্র এলাকা অসময়ে টমেটো চাষ Telecasted in BTV on 07 September 2020. 2. Title: সমন্বিত খামার ব্যবস্থাপনার মাধ্যমে কৃষকের জীবনমান উন্নয়ন Telecasted in BTV on 12 September 2020.
FSRD Site, Chanduria Rajshahi			
TV program		1	BTV, Mati O Manus program
FSRD Site: Jiarokhi Kushtia			
TV program	-	03	1. Maasranga Television telecasted Production Program of mustard var. BARI Sarisha-18. 2. Bangla Television telecasted chicken distribution. 3. Bangla Television telecasted vegetable seed distribution.
FSRD Site: Kamalbazar Sylhet			
Booklet		01	Potato-T. Aus-T. Aman Cropping Pattern: A Modern and Improved Technology for Using Fallow Land of Sylhet Region.
TV program	-	01	GTV
News Paper/Popular Article	-	03	1. Prothom Alo 27 February 2019. 2. Financial E xpress 18 March 2019. 3. The Daily Sylheter Dak 08 February 2022.

Table F.3 Materials Development/Publication made under the Sub-project by BLRI Component

Publication	Number of publications		Remarks (e.g., paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Booklet	01		পাহাড়ি এলাকায় আধুনিক পদ্ধতিতে গ্রামীণ পরিবেশে হিলি মুরগি পালন প্রযুক্তি

G. Description of generated Technology/Knowledge/Policy

i. Technology Fact Sheet

BARI Component

Fact Sheet-1

Title of the Technology: Mustard-Boro-T. Aman rice: A profitable cropping pattern in irrigated High Barind Tract

Introduction: The undulated land topography, low soil fertility, soil acidity, high temperature, and low and erratic rainfall distinguish High Barind Tract (HBT) from other parts of Bangladesh. It is recognized as the most drought-prone area in Bangladesh. Expansion of irrigation facilities by BMDA, farmers are cultivating Boro rice in some areas of HBT and Fallow-Boro-T. Aman rice is a popular cropping pattern in this area. There is a scope to include another short-duration crop between the fallow periods of T. Aman and Boro rice. For increasing productivity, an alternate cropping pattern (Mustard -Boro-T. Aman rice) has been developed.

Description: One upland crop (Mustard) and two wetland crops (Boro and T. Aman rice) are included in this cropping pattern. In the event of an upland crop, dry land preparation is required, which entails breaking soil clods and leveling the field. Seeds are broadcasted at the soil in field capacity condition. Wet land preparation is essential for Boro and T. Aman rice. Stagnant water is collected either from rainfall or irrigation, and the land is puddled before rice seedlings are transplanted. In this cropping pattern, mustard is seeded first in the Rabi season followed by Boro and T. Aman rice. Mustard, Boro, and T. Aman rice have field durations of 90-92 days, 90-93 days, and 108-111 days, respectively. Turnaround time of the pattern is 75-77 days. The fertilizer dose is calculated based on the whole cropping pattern rather than the single crop following Handbook on Fertilizer Recommendation-2018, BARC. Micronutrient fertilizers are applied once in a year. The rice crop residue is kept at a height of 20 cm for incorporation a significant amount of nutrients into the soil. During fertilizer dose determination, residual effects of P, K, and micronutrients should be taken into consideration for succeeding crops. If the lands are dry before land preparation, more irrigation may be needed to bring the soil up to field capacity condition. Intercultural activities are carried out to ensure normal growth of component crops.

Cultivation procedure of Mustard: Land is prepared by power tiller for Mustard cultivation. If the soil is very dry then light irrigation can be applied prior to land preparation. After well preparation of land, the seeds of mustard are sown on 2nd week of November. Basal fertilizers are applied @ 90-27-32-15-1-1 kg ha^{-1} N-P-K-S-Zn-B. All the fertilizers are applied as basal except half of the urea. Half of the urea is top dressed at 25 days after sowing. Top dress is followed by thinning and weeding. The Mustard var. BARI Sarisha-14 and BARI Sarisha-17 is used in this cropping pattern. Mustard is usually sown in broadcast @ 7.5 kg ha^{-1}. Thin out seedlings are used as green vegetables. One or two irrigations are applied as and when necessary. Plant protection measures are taken if mustard is infested by pest and diseases. When 80% of the pods turn straw-colored, the crop is ready to harvest. Mustard is harvested within first week of February.

Cultivation procedure of Boro rice: After harvest of mustard, land is irrigated and puddled by power tiller for Boro transplanting. Fertilizers are applied @ 217-150-80-56-10-0 kg ha^{-1} of N-P-K-S-Zn-B, respectively. All fertilizers are applied during final land preparation except urea. Urea was top dressed

equally at 20 and 50 DAT followed by weeding. Thirty five to forty day old seedlings of BRRI dhan81 are transplanted in 1st week of February at a spacing of 20 cm x 15 cm apart with 2-3 number per hill. Irrigation is applied at 15-20 times after transplanting and continued up to 15 days before harvest. Plant protection measures are taken if Boro rice is infested by pest and diseases. Carbofuran @15 kg ha^{-1} should be applied for controlling stem borer. Boro rice is harvested at 2nd week of May.

Cultivation procedure of T. Aman rice: After harvesting of Boro rice, the land is irrigated and puddled by power tiller for transplanting of Aman rice. Twenty three to twenty five day old seedlings of BRRI dhan49 are transplanted at a spacing of 20 cm x 15 cm with 2-3 numbers per hill at 2nd week of July. Fertilizers are applied @ 100-12-30-10-1.5 kg ha^{-1} of N-P-K-S-Zn. All fertilizers are applied during final land preparation except urea. Urea is applied in 3 equal splits, the 1st one is 8-10 days after transplanting of seedlings, the 2nd one at early tillering stage and 3rd one at 5-7 days before panicle initiation stage. Irrigation is applied as and when necessary. Two times hand weeding is done following the urea top dressing. Crop protection measures are taken if it is infested by pest and diseases. T. Aman rice is harvested in the second week of November.

Suitable location/ecosystem: The technology is suitable for medium highland to highland of AEZ-26 with irrigation facilities. The technology can also be followed in the other medium high lands to highlands if irrigation facilities exist.

Benefits: Rice equivalent yield of the improved cropping pattern is 14.48 t ha^{-1} which is 50% higher than existing cropping pattern. The gross margin in improved cropping pattern is Tk. 219210 ha^{-1} which is 66% higher than the existing cropping pattern. The marginal benefit cost ratio of the improved cropping pattern is 3.85.

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Fact Sheet-2

Title of the technology: An improved cropping pattern Wheat-Sesame-T. Aman rice for partial irrigated area in High Barind Tract

Introduction: High Barind Tract (HBT) is recognized as the most drought prone area in Bangladesh. Now BMDA is working more for harvesting of rainwater through preparing and excavating pond and canal. So, famers have a scope in some area to provide partial irrigation. Wheat-Fallow-T. Aman rice is a predominant cropping pattern in HBT. But, still there is a scope to include a short duration crop between fallow period of Wheat and T Aman. For increasing productivity, development of alternate cropping pattern is needed. In this context, new cropping pattern (Wheat-Sesame-T. Aman rice) is developed with diverse crop combination where two cereals and one oil-seed crop are included.

Description: Two cereal crops namely, wheat and T. Aman rice; and one oil seed crop i.e., sesame are included in the cropping pattern. For sowing of upland crop, lands are prepared at the joe condition of the soil by breaking soil clods and leveling of field. Seeds are sown in line with the help of strip tillage machine or broadcasting at field capacity condition of soil. For land preparation of T. Aman rice, stagnant water is accumulated either from rainfall or irrigation sources and soil is puddled and rice seedlings are transplanted. In this cropping pattern, first crop starting from Rabi season with Wheat followed by Sesame and T. Aman rice. The field duration of the Wheat, Sesame and T. Aman rice are about 120-124 days, 85-90 days, and 123-125 days, respectively. Total turnaround time in the pattern is 35-37 days. So, farmers can easily follow the improved cropping pattern. The fertilizers are applied according to Handbook on Fertilizer Recommendation-2018, BARC, on whole pattern basis rather than the single crop. Micronutrient fertilizers

are applied once in a year. The rice crop residue remains 20 cm height and incorporates into the soil, which add a considerable amount of different nutrients. Residual effect of P, K and micronutrients become available for succeeding crops. If the lands remain dry before land preparation additional irrigation may be applied to prepare land at field capacity. Intercultural operations were done to support normal growth of the component crops.

Cultivation procedure of Wheat: After harvesting of T. Aman rice land is prepared by power tiller for wheat cultivation. At joe condition, the land preparation and seed sowing are done in the last week of November. The seed rate of wheat is 120 kg ha^{-1}. The Wheat variety is BARI Gom-30. Fertilizers are applied @ 103-25-41-27-2-1.5 kg ha^{-1} of N-P-K-S-Zn-B, respectively. All the fertilizers are applied as basal except half of the urea. The remaining half of the urea is applied as top dress after first irrigation at crown root initiation stage after 17-21 days sowing of seeds. Another two light irrigations are applied before booting (50-55 days) and flowering stages (70-75 days). Crop protection measures are taken if wheat is infested by pest and diseases. The crop becomes matured when 80% panicle turn into yellow in colour. Wheat is harvested in last week of March.

Cultivation procedure of Sesame: The land is prepared by power tiller for sesame. The land is prepared well and the seeds of sesame are broadcasted at field capacity condition of soil moisture at the last week of March. The sesame variety is BARI Til-4. Seed rate of sesame is 7.5 Kg ha^{-1}. Fertilizer dose are applied @ 60-15-37-12 kg ha^{-1} of N-P-K-S. Half of N and all nutrients should be applied as basal during final land preparation. Remaining half of N should be applied as top dress at 25-30 DAS. If the soil moisture is too low irrigation is necessary at 25-30 DAS and 55-60 DAS. Plant protection measures are taken against pest and diseases. Sesame is harvested in the mid-June.

Cultivation procedure of T. Aman rice: At early July, land is irrigated and puddled by power tiller for T. Aman transplanting at 2nd week of July. Twenty to twenty five days old seedlings of BRRI dhan51 are transplanted at spacing 20 cm x 15 cm with 2-3 numbers per hill. Fertilizers are applied @ 86-13-15-10 kg ha^{-1} of N-P-K-S. All P, K, and S fertilizers are applied as basal. Urea is applied in 3 equal splits, the 1st one as immediately after seedling establishment, the 2nd one at early tillering stage and 3rd one at 5-7 days before panicle initiation stage. Irrigation is applied as and when necessary. Top dress is followed by weeding. Crop protection measures are taken if it is infested by pest and diseases. T. Aman rice is harvested in the 2nd week of November.

Suitable location/ecosystem: The technology is suitable for medium highland to highland of AEZ-26 with partial irrigation facilities. The technology can also be followed in the other medium high lands to highlands if irrigation facilities exist.

Benefits: Rice equivalent yield of the improved cropping pattern is 12.87 t ha^{-1}. The gross margin in improved cropping pattern is Tk.153465 ha^{-1} which is 38% higher than the existing Wheat-Fallow-T. Aman cropping pattern. The marginal benefit cost ratio of the improved cropping pattern is 1.97.

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Fact Sheet-3

Title of the technology: An improved cropping pattern Wheat-Mungbean-T. Aman rice for partial irrigated area in High Barind Tract

Introduction: Prolonged drought, high temperatures, uneven distribution of rainfall due to climate change, soil acidity and low soil fertility are major stresses affecting agricultural production in High Barind Tract

(HBT). With the availability of irrigation, farmers are cultivating Boro rice in some area of HBT. But still there is some area having partial irrigation facilities (mainly from pond, canal and so on). In this area, Wheat-Fallow- T. Aman rice is a predominant cropping pattern. After harvest of wheat the land remain fallow for 90 days. Mungbean is an important legume which matured in 60-80 days. So, mungbean can easily be grown as short duration summer pulse crops between the fallow period of wheat and T. Aman rice. The inclusion of grain legumes in the Wheat-Fallow-T. Aman rice cropping pattern would supply substantial amount of biomass and N to soil. Moreover, the farmers will get some quantity of pods which will provide vegetable protein to the family and improve farmers' economic condition. In this situation, brown manure can be an alternative source of organic manure which can also improve the soil health. For increasing productivity, new cropping pattern, Wheat-Mungbean-T. Aman rice is developed for partial irrigated area against Wheat-Fallow-T. Aman rice cropping pattern.

Description: In this cropping pattern, two cereal crops (wheat and T. Aman rice) and one pulse crop (mungbean) are included. Dry land preparation is required for upland crop, where lands are prepared at the joe condition of the soil by breaking soil clods and leveling field. Seeds are sown in broadcasting or in line with machine at field capacity of soil. For land preparation of T. Aman rice, stagnant water is accumulated either from rainfall or irrigation sources and soil is puddled then rice seedlings are transplanted. In this cropping pattern, three crops are cultivated in sequence starting from Rabi season with Wheat followed by Mungbean and T. Aman rice. The main field duration of the wheat, mungbean and T. Aman rice are about 120-124 days, 75-80 days, and 120-125 days, respectively. Total turnaround time in the pattern is 45-50 days. So, farmers can easily practice the improve pattern. The cropping pattern-based fertilizer dose is considered rather individual crop. Micronutrient fertilizers are applied once in a year. The rice crop residue remains 20 cm height and incorporates into the soil, which can add a considerable amount of different nutrients. Residual effect of P, K and micronutrients are considered in fertilizer dose determination for succeeding crops. If the lands remain dry before land preparation additional irrigation may be applied to prepare land at field capacity. Intercultural operations were done to support normal growth of the component crops.

Cultivation procedure of Wheat: After harvesting of T. Aman rice land is prepared by power tiller for wheat cultivation. At joe condition, the land preparation and seed sowing are done in the last week of November. The seed rate of wheat is 120 kg ha^{-1}. The Wheat variety is BARI Gom-30. Fertilizers are applied @ 103-25-41-27-2-1.5 kg ha^{-1} of N-P-K-S-Zn-B, respectively. All the fertilizers are applied as basal except half of the urea. The remaining half of the urea is applied as top dress after first irrigation at crown root initiation stage after 20-22 days sowing of seeds. Another two light irrigations are applied before booting (50-55 days) and flowering stages (70-75 days). Crop protection measures are taken if wheat is infested by pest and diseases. The crop becomes matured when 80% panicle turn into yellow in colour. Wheat is harvested in last week of March.

Cultivation procedure of Mungbean: The land is prepared well and the seeds of mungbean are broadcasted at field capacity of soil moisture at the last week of March. The mungbean variety is BARI Mung-6. Seed rate of mungbean is 30 kg ha^{-1}. Fertilizers are applied @ 20-20-20 kg ha^{-1} of N-P-K-S, respectively. All the fertilizersare applied as basal during final land preparation. Irrigation is necessary if the soil moisture is too low. Curative measures are taken against pest and diseases. Mungbean is harvested in the mid-June.

Cultivation procedure of T. Aman rice: At early July, land is irrigated and puddled by power tiller for T. Aman transplanting at 2nd week of July. Twenty to twenty five days old seedlings of BRRI dhan51 are transplanted at spacing 20 cm x 15 cm with 2-3 numbers per hill. Fertilizers are applied @ 86-13-15-10 kg ha^{-1} of N-P-K-S. All P, K, and S fertilizers are applied as basal. N is applied in 3 equal splits, the 1^{st} one as immediately after seedling establishment, the 2^{nd} one at early tillering stage and 3^{rd} one at 5-7 days before panicle initiation. Irrigation is applied as and when necessary. Top dressing of urea is followed by weeding. Crop protection measures are taken if it is infested by pest and diseases. T. Aman rice is harvested in the 2nd week of November.

Suitable location/ecosystem: The technology is suitable for medium highland to highland of AEZ-26 with partial irrigation facilities. The technology can also be followed in the other medium high lands to highlands if irrigation facilities exist.

Benefits: Rice equivalent yield of the improved cropping pattern is 12.58 t ha^{-1}. The gross margin of improved pattern is Tk.159107 ha^{-1} which is 66% higher than the existing Wheat-Fallow-T. Aman cropping pattern. The marginal benefit cost ratio of the improved cropping pattern is 3.47.

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Fact Sheet-4

Title of the Technology: An improved cropping pattern Lentil-Fallow-T. Aman rice for highland in rainfed High Barind Tract

Introduction: Farmers are cultivating boro rice in some areas of HBT. However, there are still some entirely rainfed areas in HBT where only T. Aman rice is grown. Normally, farmers cultivate long duration T. Aman rice variety (Sharwna). They dry the collected biomass on the crop field after rice harvest. As a result, the residual soil moisture loss, and the Rabi crop is unable to germinate due to a lack of soil moisture. Pulse (lentil) is a deep-rooted and low water requiring crops. It is a good source of plant protein for humans, as well as beneficial to soil health. After harvesting T. Aman rice, lentil may be cultivated in extreme drought area by using residual soil moisture. Lentil-Fallow-T. Aman rice, a new cropping pattern has been developed for rainfed areas against existing Fallow-Fallow-T. Aman rice cropping pattern for increasing total productivity.

Description: One upland crop lentil and one wet land crop T. Aman rice are grown in this cropping pattern. After preparation of land, lentil seeds are directly sown in the soil under field capacity condition. T. Aman required wet land preparation. Stagnant water from rainfall sources is used followed by soil puddled, and rice seedlings are transplanted. In this cropping pattern, seeds of lentil are sown in the Rabi season followed by T. Aman in the kharif-2. Lentil and T. Aman have almost similar field durations of 110-112 days and 115-118 days, respectively. Rainfall can often cause crop establishment to be delayed, especially in upland areas. Fertilizer doses are used based on the cropping pattern rather than individual crop. Micronutrient fertilizers are applied once in a year. Pulses crop residue adds a significant amount of nitrogen to the next crop and increases the availability of other nutrients. After application of recommended dose of fertilizer, residual effects of P, K, and micronutrients become available for succeeding crops.

Cultivation procedure of Lentil: After the harvest of T. Aman rice the land is prepared by power tiller. The seeds of lentil are broadcasted at joe condition of the soil in the third week of November. The Lentil var. BARI Masur-8 with seed rate @ 60 kg ha^{-1} is used. Fertilizers are applied @ of 20-20-20--0-0-1 kg ha^{-1} of N-P-K-S-Zn-B. All fertilizers should be applied as basal during final land preparation. Weeding is done at 25 days after sowing. Usually, one light irrigation is required at sowing for ensuring germination. Necessary prevention measure is taken for controlling foot and root rot and stemphylium blight diseases. Lentil is harvested in the second week of March.

Cultivation procedure of T. Aman rice: After rainfall in July, the land is puddled by power tiller and seedlings of T. Aman are transplanted in 2nd week of July. Twenty three to twenty five days old seedlings of BRRI dhan51 are transplanted at a spacing of 20 cm x 15 cm with a 2-3 number per hill. Fertilizers are applied @ 86-15-35-8-1-0 kg ha^{-1} of N-P-K-S-Zn. All P, K, S, and Zn fertilizers except urea are applied as

basal. Urea is applied in 3 equal splits, the 1st one is 8-10 days after transplanting, the 2nd one at early tillering stage and 3rd one at 5-7 days before panicle initiation stage. Irrigation is applied as and when necessary. Two times hand weeding is done following the urea top dressing. Crop protection measures are taken if it is infested by pest and diseases. T. Aman rice is harvested in the second week of November.

Suitable location/ecosystem: The technology is suitable in the medium highland to highland of High Barind Tract (AEZ # 26) in extreme drought area where soil pH is about to neutral. The cropping pattern can be practiced in clay loam to silty clay soil.

Benefits: The REY of the improved cropping pattern was 11.85 t ha^{-1}, which was 142% higher than existing cropping pattern. The gross margin in improved cropping pattern is 141% higher than the existing cropping pattern. The improved cropping pattern has a marginal benefit cost ratio of 3.80.

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Fact Sheet-5

Title of the Technology: Development of alternate cropping pattern Lentil-Maize-T. Aman rice against Fallow-Boro-T. Aman ricein Level Barind Tract of Rajshahi

Introduction: The Level Barind Tract covers a portion of the Rajshahi district (Tanore) (LBT). The soil is silty loam in texture, and irrigation facilities are superior to HBT's. Fallow-Boro-T. Aman rice is commonly used by farmers. Boro rice required huge amount of irrigation water, which is harmful to the environment. Boro farming is completely reliant on groundwater. As a result of uplifting ground water, the cost of production rises, reducing profit. Further more, the level of ground water is decreasing day by day. A new cropping pattern, Lentil-Maize-T. Aman rice, can be used as an alternative to Fallow-Boro-T. Aman rice for enhancing productivity and conserving natural resources. Lentil and maize can help to compensate for a lack of pulse and foodgrain, respectively. Lentil and maize are a deep-rooted crop with a low water need compared to Boro rice. Lentil is a good source of vegetable protein for humans, animals as well as beneficial to soil health. After harvesting T. Aman rice, it may be produced in LBT areas using residual soil moisture. After lentil, summer maize can be produced in same land.

Description: Two upland crops lentil and maize as well as one wetland crop, T. Aman rice are grown in this cropping pattern. Dry land preparation for upland crops is required, which is done through breaking soil clods and leveling the field in the joe condition. Lentil and maize seeds are directly sown at the soil's field capacity condition. Wet land preparation is required for T. Aman cultivation. Stagnant water from rainfall sources is pooled here, the soil is puddled, and rice seedlings are transplanted. In this cropping pattern, three crops are grown sequentially; start with lentil in Rabi season, then maize and finally T. Aman rice. The lentil, maize and T. Aman have field durations of 116-118 days, 101-103 days and 97-99 days, respectively. Crops were harvested at physiological maturity rather than harvesting maturity to reduce turnaround time. Fertilizer doses were determined on the basis of cropping pattern rather than individual crop following Handbook on Fertilizer Recommendation-2018, BARC. Once in a year, micronutrient fertilizers are applied. Pulses crop residue adds a significant amount of nitrogen to the next crop and increases the availability of other nutrients. Residual effects of P, K, and micronutrients are considered during fertilizer dose determination for succeeding crops. Weeding may be required to keep the crop field clear.

Cultivation procedure of Lentil: After harvesting of T. Aman rice, land is prepared for Lentil with a harrow and power tiller, and seeds are sown @ 35 kg ha^{-1} at field capacity condition using residual soil moisture in mid to late November. The variety of lentil is BARI Masur-8. Once in a year, micronutrient fertilizers are applied. N-P-K-S-Zn-B is applied at the rate of 18-30-25-18-1-1 kg ha^{-1}. All fertilizers are

applied as a basal. Foot and root rot and stemphylium blight diseases are controlled by proper treatment. Lentil is harvested in mid March.

Cultivation procedure of Maize: After land preparation maize seeds are sown in the 1st week of April with commercial hybrid (Lalteer 339). Fertilizers are applied at the rate of 152-52-74-26-2.5-1.2 kg ha^{-1} of N-P-K-S-Zn-B. One third of the urea and all other fertilizers should be applied as basal during final land preparation. The remaining two third of urea should be applied into two equal splits, as top dressing after sowing of 30-35 and 60-65 days, respectively. For cultivation of maize irrigation is required at 20-25, 40-45 and 65-70 DAS. Pest and disease are control as and when necessary. Maize is harvested in first week of July.

Cultivation procedure of T. Aman rice: After rainfall or irrigation in late July, the field is puddled by a power tiller for T. Aman transplantation. Twenty to twenty five days old seedlings of BRRI dhan87 are transplanted at 20 cm x 15 cm spacing with 2-3 number per hill. Fertilizers are applied at the rate of 90-10-25-12-1 kg ha^{-1} of N-P-K-S-Zn-B, respectively. All of the P, K, S, Zn and B fertilizers are used as basal. N is applied in three equal splits: the first after seedling establishment, the second during early tillering, and the third 5-7 days before panicle initiation stage. Pest and disease are controlled as and when necessary. T. Aman is harvested in last week of October.

Suitable location/ecosystem: The technology is suitable in the Level Barind Tract of drought area. The cropping pattern can be practiced in clay loam to silty clay soil.

Benefits: The REY of improved cropping pattern is 20.04 t ha^{-1} where as it was 10.09 t ha^{-1} in existing cropping pattern. REY in improved cropping pattern is 99% higher than the existing pattern. The gross margin of improved cropping pattern (Tk. 293048 ha^{-1}) is 184 percent higher than that of existing cropping pattern (Tk.103135 ha^{-1}). MBCR was estimated 7.26.

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Fact Sheet-6

Title of the Technology: Development of alternate cropping pattern Mustard-T. Aus-T. Aman in Level Barind Tract of Rajshahi against Fallow-Boro-T. Aman rice

Introduction: The Level Barind Tract covers a portion of the Rajshahi district (Tanore) (LBT). The soil is silty loam in texture, and irrigation facilities are far superior to HBT's. Fallow-Boro-T. Aman rice is commonly used by farmers. Boro rice required huge amount of irrigation water, which depleted water table as a result affect the environment. As a result of the uplift of ground water, the cost of production rises, reducing profit. Furthermore, the level of ground water is decreasing day by day. A new cropping pattern, Mustard-T. Aus-T. Aman rice, can be used as an alternative to Fallow-Boro-T. Aman rice for enhancing productivity and conserving natural resources. Mustard can help to compensate for a lack of edible oil.

Description: Three crops (Mustard, T. Aus and T. Aman) are included in this cropping pattern of which one is upland crop (Mustard) and two is wetland crops (T. Aus and T. Aman rice). In case of upland crop, dry land preparation is required through breaking soil clods and leveling the field for suitable joe condition. Seeds of mustard are sown following broadcasting in soil under field capacity condition. Wet land preparation is essential for T. Aus and T. Aman rice. Stagnant water is collected either from rainfall or irrigation, and the land is puddled before rice seedlings are transplanted. In this cropping pattern, Mustard, T. Aus, and T. Aman are planted in the Rabi season, Kharif-I season and Kharif-II season, respectively. The field duration of Mustard, T. Aus and T. Aman rice are 85-90 days, 95-100 days, and 102-105 days, respectively. The turnaround time of whole pattern is 65-68 days. The fertilizer dose is applied according to

Handbook on Fertilizer Recommendation-2018, BARC, on whole pattern basis rather than the single crop. Micronutrient fertilizers are applied once a year. Due to application of recommended dose of fertilizer, residual effects of P, K, and micronutrients become available for succeeding crops. For sequential cropping, the irrigation and water management schedule is the same as for individual crops. Intercultural activities are carried out to ensure that the component crops grew normally.

Cultivation procedure of Mustard: The land is prepared by power tiller for Mustard cultivation. Prior to land preparation if the soil is very dry then light irrigation can be applied. After well preparation of land, the seeds of Mustard are sown in broadcast @ 7.5 kg seed ha^{-1} at field capacity of soil moisture on 2nd week of November. The Mustard variety BARI Sarisha-18 is used in the cropping pattern. Fertilizers are applied @ 126-35-46-29-2.5-2 kg ha^{-1} of N-P-K-S-Zn-B. All the fertilizers are applied as basal except half of the urea. Remaining half of the urea is top dressed at 20-25 days after sowing. Top dress is followed by thinning and weeding. One or two irrigations are applied as and when necessary. Plant protection measures are taken if mustard is infested by pest and diseases. When 80% of the pods turn straw color, the crop is ready to harvest. Mustard is harvested within first week of March.

Cultivation procedure of T. Aus rice: About one month after of harvesting the mustard, land is irrigated and prepared by puddling with power tiller for T. Aus transplanting. Fertilizers are applied @ 76-11-38-6.4-0-0 kg ha^{-1} of N-P-K-S-Zn, respectively. At final land preparation, one third of urea and other fertilizers are applied as basal dose. Rest of the two third urea is applied as top dress two times at about15 and 30 days after transplanting. Twenty to twenty five days old seedlings of BRRI dhan82 are transplanted at 20 cm × 15 cm spacing with 2-3 numbers per hill in the middle of May. If necessary, irrigation is applied in the first month of transplanting. When rainy season starts the crop is usually grown as rainfed. Two times hand weeding is done following the urea as top dressing. Usually, irrigation is not necessary for T. Aus cultivation. However, if needed a light irrigation may be applied as and when necessary. Crop protection measures are taken if Aus is infested by pest and diseases. Special care may be needed to protect Aus rice crop during maturity stage from bird. T. Aus rice is harvested during 1st week of August.

Cultivation procedure of T. Aman rice: After harvesting the T. Aus rice, the land is irrigated and puddled by power tiller for transplanting of T. Aman at second week of August. Twenty three to twenty five days old seedlings of BRRI dhan75 are transplanted at 20 cm x 15 cm spacing with 2-3 number per hill. Fertilizers are applied @ 115-27-44-13-1-0 kg ha^{-1} of N-P-K-S-Zn. All P-K-S-Zn are used during land preparation. Urea is applied in 3 equal splits, the 1st one as immediately after seedling establishment, the 2nd one at early tillering stage and 3rd one at 5-7 days before panicle initiation stage. Irrigation is applied as and when necessary. Two times hand weeding is done following the urea top dressing. Crop protection measures are taken if it is infested by pest and diseases. In the mid- November, T. Aman is harvested.

Suitable location/ecosystem: The technology is suitable for medium highland to highland of AEZ-25 with irrigation facilities. The technology can also be followed in the other medium high lands to highlands if irrigation facilities exist.

Benefits: The Rice equivalent yield of the improved cropping pattern is 15.98 t ha^{-1}. The gross margin (Tk. 207087 ha^{-1}) which is 89.67% higher than the existing Fallow-Boro-T. Aman cropping pattern. The marginal benefit cost ratio is 3.91 of the improved cropping pattern.

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Fact Sheet-7

Title of the Technology: Improvement of existing cropping pattern Lentil-Sesame-T. Aman rice through inclusion of suitable high yielding varieties in High Ganges River Floodplain (AEZ-11)

Introduction: Sustainable crop production is becoming a growing challenge for Bangladesh's congested population's food and nutrition security. The total cultivable land area is currently 8.59 million hectares, and decreasing at a rate of 0.73% each year. There are some opportunities to increase cropping intensity (192%) by enhancing the improved cropping pattern with short-duration crops variety. It is possible to increase cropping intensity by employing optimum management strategies to produce more food within a given area. Lentil-Sesame-T. Aman is one of the most important existing cropping patterns in Kushtia. Due to cultivation of low yielding crop varieties, yield in existing pattern is reducing. NARS institutes have recently developed short-duration high-yielding Lentil, Sesame, and T. Aman rice varieties, which have created opportunity for upgrading existing Lentil-Sesame -T. Aman cropping pattern and increasing total productivity and farmer's income.

Description: Land preparation is separately required for Lentil-Sesame-T. Aman cropping pattern.Two upland crops (Lentil and Sesame) and one wetland crop (T. Aman) are cultivated in this cropping system. Dry land preparation is required for upland crops, breaking of soil clods and leveling the field to the optimal condition. Lentil and sesame seeds are sown directly in the field at soil's field capacity condition. For transplantation of T. Aman rice, land required to puddle with stagnant water accumulated from rainfall or irrigation sources. Then rice seedlings are transplanted in the land. In this cropping pattern, three crops are grown with lentil in the Rabi season followed by sesame in kharif-I season and finally T. Aman rice in kharif-II season. The field duration of three crops is about 310-315 days. Crops are harvested at physiological maturity stage to reduce turnaround time. The fertilizer doses are calculated on the basis of the cropping pattern rather than the single crop following Handbook on Fertilizer Recommendation-2018, BARC. For sequential cropping, the irrigation and water management schedule is the same as for individual crops. If the fields are dry before land preparation, more irrigation may be required to prepare the land to field capacity. Rainfall cause crop establishment might be delayed. Weeding may be required to keep the crop field clear.

Cultivation procedure of Lentil: After harvest of T. Aman rice, the land is prepared by power tiller for lentil cultivation. The seeds of Lentil are broadcasted at joe condition of the soil in the third week of November. The Lentil variety is BARI Masur-8 with seed rate @ 60 kg ha^{-1}. Fertilizers are applied @ of 21-17-18-10-0-1 Kg ha^{-1} of N-P-K-S-Zn-B. All fertilizers should be applied as basal during final land preparation. Weeding is done at 25 days after sowing. Usually, one light irrigation is required at sowing period for ensuring germination. Necessary prevention measure is taken for controlling foot and root rot and stemphylium blight diseases. Lentil is harvested in the second week of March.

Cultivation procedure of Sesame: The land is prepared by power tiller for Sesame cultivation. The land is prepared well and the seeds of Sesame are broadcasted at field capacity of soil moisture at the last week of March. The Sesame variety BARI Til-4 with seed rate 7-7.5 kg ha^{-1} is used. Fertilizers are applied @ 55-28-22.5-19-1.8-1.7 kg ha^{-1} of N-P-K-S-Zn-|B. Half of N and all other fertilizers should be applied as basal during final land preparation. Remaining half of N should be applied as top dress at 25-30 days after sowing. Top dress is followed by thinning and weeding. One or two irrigations may be applied if the soil moisture too low. Curative measures are taken against pest and diseases. Sesame is harvested in the third week of June.

Cultivation procedure of T. Aman rice: After harvest of sesame, the land is irrigated and puddled by power tiller for T. Aman. Twenty-three to twenty-five days old seedlings of BRRI dhan75 are transplanted at 1st week of August at 20 cm × 15 cm spacing with 2-3 number per hill. Fertilizers are applied @ 115-27-44-13-1-0 kg ha^{-1} of N-P-K-S-Zn. All P, K, S, and Zn fertilizers except urea are applied as basal. N is applied in 3 equal splits, the 1st one as immediately after seedling establishment, the 2nd one at early tillering stage and 3rd one at 5-7 days before panicle initiation. Irrigation is applied as and when necessary. Two times hand weeding is done following the urea top dressing. Crop protection measures are taken if it is infested by pest and diseases. In the mid November T. Aman is harvested.

Suitable location/ecosystem: The technology is suitable for the medium highlands of the High Ganges River Floodplain (AEZ-11). The improved cropping pattern can be practice in clay loam to sandy loam soil. The technology can be used in other medium high lands with similar soil and climatic conditions.

Benefits: The REY of improved cropping pattern is 15.42 t ha^{-1} whereas the existing pattern REY is 13.30 t ha^{-1}. The gross margin of improved cropping pattern is 23% higher than the existing cropping pattern. MBCR of improved pattren is 12.66.

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Fact Sheet-8

Title of the Technology: Improvement of existing cropping pattern Onion-Sweet gourd-T. Aman rice through inclusion of suitable high yielding varieties in High Ganges River Floodplain (AEZ-11)

Introduction: Sustainable crop production is becoming a growing challenge for Bangladesh's congested population's food and nutrition security. The total cultivable land area is currently 8.59 million hectares, and decreasing at a rate of 0.73% each year. There are some opportunities to increase cropping intensity (192%) by enhancing the improved cropping pattern with short-duration crops and variety. It is possible to increase cropping intensity by employing optimum management strategies to produce more food within a given area. Onion-Sweet gourd-T.Aman is one of the most important existing cropping pattern in Kushtia. The cultivation of low yielding Onion, Sweet gourd and rice varieties in existing pattern reduces the crop production. NARS institutes have recently developed short-duration high-yielding Onion, Sweet gourd and T. Aman rice varieties, which have created opportunity for upgrading existing Onion-Sweet gourd-T. Aman cropping pattern and increasing total productivity and farmer's income.

Description: Two upland crops (Onion and Sweet gourd), and one wetland crop (T. Aman) are included in this cropping pattern. Dry land preparation is required for upland crops, breaking of soil clods and leveling the field to the optimal condition. Forty five to fifty days old onion seedling were transplanted maintaining 15 cm x 10 cm spacing and sweet gourd are sown directly in pith with a spacing of 300 cm x 300 cm. For transplanting of T. Aman rice, land required to puddle with stagnant water accumulated from rainfall or irrigation sources. Then rice seedlings are transplanted in the land. In this cropping pattern, three crops are grown with onion in the Rabi season followed by sweet gourd in kharif-I and finally T. Aman rice in kharif-II. The field duration of three crops is about 315 days. Crops are harvested at physiological maturity stage to reduce turnaround time. The fertilizer doses are calculated on the basis of the cropping pattern rather than the single crop following Handbook on Fertilizer Recommendation-2018, BARC. For sequential cropping, the irrigation management schedule is the same as the individual crops. If the fields are dry before land preparation, more irrigation may be required to prepare the land to field capacity. Rainfall cause crop establishment might be delayed. Weeding may be required to keep the crop field free from weeds.

Cultivation procedure of Onion: After harvest of T. Aman rice, the land is prepared by power tiller and breaking of soil clods and leveling the field to the optimal condition. Forty-five to fifty days old onion seedling were transplanted maintaining 15 cm x 10 cm spacing at joe condition of the soil in the second week of December. The Onion variety BARI Piaj-4 with seed rate @ 7.5 kg ha^{-1} is used in this cropping pattern. Fertilizers are applied @ of 240-260-150-50-1-0.5 Kg ha^{-1} of N-P-K-S-Zn-B, respectively. Half of N and all fertilizers should be applied as basal during final land preparation. Remaining half of N was applied in two equal splits at 20 DAT and 40 DAT under moist soil condition and mixed thoroughly with the soil. Weeding and mulching was done thrice at 12-15, 25-30 and 45-50 DAT. The cropland was

irrigated three times at pre planting, 22-25 and 40-45 DAT. Four times fungicides (Rovral at 10-15, 40-45 DAT, Amister top at 20 DAT, Nativo at 54-64 DAT) and insecticide (Imitaf at 20- 22, 40-45, 54-64 DAT and Amanection benzoet at 62-72 DAT) were applied. The crop was harvested in the second week of March.

Cultivation procedure of Sweet gourd: In mid February seeds of sweet gourd are sown directly with a spacing of 300 cm x 300 cm in onion field. The variety of Sweet gourd is commercial hybrid. Fertilizers are applied @ 50-25-20-15-0-0-0 kg ha^{-1} of N-P-K-S-Zn-B respectively, after harvest of onion. One or two irrigations may be applied after harvesting the onion if the soil moisture too much low. Necessary prevention measure is taken for controlling pest and diseases. Sweet gourd is harvested in the last week of June.

Cultivation procedure of T. Aman rice: After harvest of sweet gourd, the land is irrigated and puddle by power tiller for T. Aman rice. Twenty three to twenty five days old seedlings of BRRI dhan75 are transplanted at 20 cm × 15 cm spacing with 2-3 number per hill in the 1st week of August. Fertilizers are applied @ 115-27-44-13-1-0 kg ha^{-1} of N-P-K-S-Zn, respectively. N is applied in 3 equal splits, the 1^{st} one as immediately after seedling establishment, the 2^{nd} one at early tillering stage and 3^{rd} one at 5-7 days before panicle initiation. Irrigation is applied as and when necessary. Two times hand weeding is done following the urea top dressing. Crop protection measures are taken if it is infested by pest and diseases. In the mid-November T. Aman is harvested.

Suitable location/ecosystem: The technology is suitable for the medium highlands of the High Ganges River Floodplain (AEZ-11). The improved cropping pattern can be practice in clay loam to sandy loam soil. The technology can be used in other medium high lands with similar soil and climatic conditions.

Benefits: The REY of improved cropping pattern is 36.32 t ha^{-1} where as it is 30.63 t ha^{-1} in existing pattern The improved cropping pattern's gross margin is 24% higher than the existing cropping pattern. The MBCR of improved croping pattern is 7.15.

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Fact Sheet-9

Title of the Technology: Development of cropping pattern Potato-T. Aus-T. Aman at Surma Kushiyara Flood plain

Introduction: Surma Kushiyara Flood plain of AEZ 20 covers the majority of Sylhet's territory. Fallow-T. Aus-T. Aman is the dominant cropping pattern in this area. There is the possibility of including a crop prior to the T. Aus season. Potato crops are an excellent choice for this purpose. Incorporating potato into existing cropping pattern, total productivity and cropping intensity can be increased. So, improved cropping pattern Potato-T. Aus-T. Aman is a profitable production method in this area.

Description: Three crops are produced in this cropping pattern: potato, T Aus, and T. Aman and individual crops required land preparation. The land is prepared for potato production by bringing the soil in joe condition (field capacity). After leveling the field, potato tubers are planted in furrows. For T. Aus and T. Aman crops, wet land preparation is necessary. So, stagnant water from rainfall or irrigation sources is required. The soil is puddled, followed by rice seedlings are transplanted. Three crops are cultivated in this cropping pattern, commencing with potato in the Rabi season followed by T. Aus in kharif-1 and finally T. Aman in kharif-2. The total field duration of three crops is around 281 days. Crops are harvested when they reached physiological maturity. Fields are released seven days before to the start of the preceding crop. Rainfall can sometimes cause delay the next crop's establishment. In such condition, irrigation may be required to keep soil moisture at field capacity during the planting of various crops.

Cultivation procedure of Potato: Land is prepared with power tiller for potato cultivation. If the soil is dry, irrigation is applied prior to final land preparation. Potato tubers are sown in furrows at 25 cm spacing in the last week of November. Fertilizers are applied at the rate of 150-40-175-22-4-2 kg ha^{-1} of N-P-K-S-Zn-B, respectively. Half of the urea and all other fertilizers are applied as a basal dose.The other half of urea to be applied as a top dressing at 30-35 DAS i.e. before earthing up. Potato var. BARI Alu-41 is used. Potato tubers are planted in rows 60 cm × 25 cm with seed rate 1.5-2.0 t ha^{-1}. Carbofuran at the rate of 15 kg ha^{-1} should be used to control soil insects. If the potato is affected with pests or diseases, appropriate protection measures to be taken. Potatoes are harvested last week of February.

Cultivation procedure of T. Aus rice: Land is irrigated and puddled by power tiller for T. Aus transplantation i.e., one month after potato harvest. Fertilizers are applied at the rate of 134-53-83-60-0-0 kg ha^{-1} of N-P-K-S-Zn-B. Except urea, all fertilizers are applied during final land preparation. Urea is applied in two equal splits as top dressed at 20 and 45 DAT. Twenty five day old seedlings of BRRI dhan65 are transplanted at 20 cm × 15 cm apart with 2-3 number per hill in the last week of May. During the growing stage, irrigation is to be given if necessary. Plant protection measures are taken if rice is infested by pest and diseases. T. Aus is harvested at last week of July.

Cultivation procedure of T. Aman rice: After harvest of T. Aus, the land is irrigated and puddled by power tiller for Aman transplantation. Fertilizers are applied at the rate of 150-53-83-60-0-0 kg ha^{-1} of N-P-K-S-Zn-B, respectively. Except urea, all fertilizers are applied during final land preparation. Urea is applied in two equal splits as top dressed at 20 and 45 DAT. Twenty five to thirty days old seedlings of BRRI dhan57 are transplanted at 20 cm × 15 cm spacing with 2-3 number per hill in the first week of August. Irrigation is to be applied as and when necessary. For stem borer control, carbofuran @15 kg ha^{-1} should be used. Plant protective measures are taken if Aman rice is infested by pests and diseases. T. Aman is harvested in the 1st week of November.

Suitable location/ecosystem: The technology is suitable in the medium highland of greater Sylhet region where irrigation facilities prevail. The cropping pattern can be practiced in the highland and medium highland of other areas of the country where irrigation facilities are available.

Benefits: Rice equivalent yield of the alternate cropping pattern is 28.48 t ha^{-1}. The gross margin is 339% higher than the existing Fallow-T. Aus-T. Aman cropping pattern. The marginal benefit cost ratio of the improved cropping pattern is 2.52.

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Fact Sheet-10

Title of the Technology: Mustard-T. Aus-T. Aman rice, a profitable cropping pattern for AEZ-20 under Surma Kushiyara Flood plain soil in Sylhet region

Introduction: In Sylhet, land remains fallow (about 31.25%) shortly after harvest of T. Aman rice under Fallow-T. Aus-T. Aman rice cropping pattern, which covers the majority areas of Sylhet region. There is an ample scope to introduce a short duration winter crop in between T. Aman and T. Aus rice. Short duration mustards are outstanding option for introduced in the existing cropping pattern. Inserting mustard into fallow period of existing cropping pattern, the total productivity and cropping intensity will be increased.

Description: Three crops are cultivated in this cropping pattern viz. mustard, T. Aus, and T. Aman rice. Land preparation is required separately for each crop. The land is prepared for mustard production by bringing the soil in joe condition (field capacity). After leveling the field, mustard seeds are sown in

broadcast method. For T. Aus and T. Aman crops, wet land preparation is necessary so, stagnant water from rainfall or irrigation sources is required. The soil is puddled, then by rice seedling are transplanted. Three crops are cultivated in this cropping pattern, commencing with mustard in the Rabi season followed by T. Aus in kharif- I season and finally T. Aman in kharif-II season. The total field duration of three crops is around 285 days. Crops are harvested when they reached at physiological maturity. Fields are released seven days before to the start of the preceding crop. Rainfall can sometimes hamper the next crop's establishment. In such condition, irrigation may be required to keep soil moisture at field capacity during the planting of various crops.

Cultivation procedure of Mustard: Land is prepared with power tiller for mustard cultivation. If the soil is dry, irrigation is applied prior to final land preparation. Mustard seeds are sown in broadcast method in the third week of November and land is leveled after sowing seeds. Mustard var. BARI Sarisha-14 is used at the rate of 7.5-8.0 kg ha^{-1}. Fertilizers are applied at the rate of 115-27-35-1.5-1 kg ha^{-1} of N-P-K-S-Zn-B, respectively. Half of the urea and all other fertilizers are applied as a basal application, while the other half of urea to be applied as a top dressing at 25-30 DAS i.e. before flowering. If the mustard is affected with pests or diseases, appropriate protection measures to be taken. Foliar spray with mancozeb (0.2%) at 40-45 DAS followed by hexaconazole (0.05%) at 55 DAS is used for effective controlling Alternaria leaf spot of mustard. Mustard is harvested in the 2nd week of February.

Cultivation procedure of T. Aus rice: Land is irrigated and puddled by power tiller for T. Aus transplantation after one month harvest of mustard. Fertilizers are applied at the rate of 134-53-83-60-0-0 kg ha^{-1} of N-P-K-S-Zn-B. Except urea, all fertilizers are applied during final land preparation. Urea is applied in two equal splits as top dressed at 20 and 45 DAT. Twenty five day old seedling of BRRI dhan65 are transplanted at 20 cm × 15 cm apart with 2-3 number per hill in the last week of May. During the growing stage, irrigation is to be given if necessary. Plant protection measures are taken if rice is infested by pest and diseases. T. Aus is harvested at last week of July.

Cultivation procedure of T. Aman rice: After harvest of T. Aus, the land is irrigated and puddled by power tiller for aman rice transplantation. Fertilizers are applied at the rate of 150-53-83-60-0-0 kg ha^{-1} of N-P-K-S-Zn-B, respectively. Except urea, all fertilizers are applied during final land preparation. Urea is applied in two equal splits as top dressed at 20 and 45 DAT. Twenty five to thirty days old seedlings of BRRI dhan57 are transplanted at 20 cm × 15 cm spacing with 2-3 number per hill in the first week of August. Irrigation is to be applied as and when necessary. For stem borer control, carbofuran @15 kg ha^{-1} should be used. Plant protective measures are taken if Aman rice is infested by pests and diseases. T. Aman is harvested in the 1st week of November.

Suitable location/ecosystem: The technology is suitable in the medium highland of greater Sylhet region where irrigation facilities prevail. The cropping pattern can be practiced in the highland and medium highland of other areas of the country where irrigation facilities are available.

Benefits: Rice equivalent yield of the alternate cropping pattern is 15.43 t ha^{-1}. The gross margin is 60% higher than the existing Fallow-T. Aus-T. Aman cropping pattern. The marginal benefit cost ratio of the improved cropping pattern is 5.53.

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BLRI Component

Fact Sheet-1

Title: Sheep rearing in the farmers' household for increasing income and improvement of livelihood at hilly area

Introduction: Livestock is an integral component of Bangladesh agriculture which plays an important role in the national economy. Sheep is very important and promising animal genetic resources in the developing countries like Bangladesh. The contribution of sheep in Bangladesh can be summarized as a source of meat, skin and wool. Native sheep are extremely resistant to various infectious diseases including PPR. They can be reared in harsh management condition and relatively poor quality feed. No extra labour is required for sheep rearing. Most of the sheep of Bangladesh are indigenous in nature with few crossbreds (Bhuiyan, 2006).Though the sheep was localized in particular areas of the country, they are now found all over the country but very fewer in hilly area. Hilly areas have lot of natural pasture for ruminant feeding. So, sheep rearing program in tribal area will be supportive for conservation of native sheep, increase the production of sheep as well as increasing animal protein source and improvement of livelihood of hilly people.

Description: Eighteen to twenty four month old sheep were distributed among 6 farmers of, Khamar Chakpara and Chakdhala villages of Naikhongchari, Bandarban in the year 2019. Three sheep (2 Ewe and 1 Ram) was distributed in each farmer. The average initial body weight of the sheep during distribution period was 12-14 kg. Food, vaccinations and treatment support were provided to the farmers under this project for sheep rearing. Project personnel organized training and yard meetings on various topics with the aim of creating awareness among the farmers about modern methods of sheep rearing. Hands-on training was provided to the farmers in various sheep management services such as feeds, feed processing (silage, hay, UMS etc.), sharing, deworming, dipping and other treatment. BLRI developed improved variety Napier-4 grass cuttings were distributed to the farmers without any charge from the germplasm bank of Naikhongchari Regional station, BLRI. Thirteen kids were born per household during October 2019 to May 2022 period.

Suitable location/ecosystem: The technology is suitable in the hilly area of Naikhongchari, Bandarban. The technology may be used in other parts of the country.

Benefits: Average gross margin per household was found 7000, 34600 and Tk. 47000 in the 1st, 2nd and 3rd year respectively.

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ii. Effectiveness in Policy Support

BARI component

- Better utilization of fallow land under drought and rainfed ecosystem toward increasing cropping intensity and productivity through cultivation of drought tolerant crops, which would help to achieve the SDG goal-2 target.
- Integrated farming systems approach helps to increase the cropping intensity and crop diversity as well as livestock and fishery production.
- Technology generation and dissemination should be proceeded linearly for success of Farming system Research and Development activities.
- Low water requiring short duration HYV crops (pulses. oilseeds and minor cereal) could be introduced in the existing cropping system to increase productivity. Cultivation of Boro rice shall be discouraged for sustaining natural resources.
- Reducing malnutrition through increase production of vegetables, fruits, eggs, meat and fish.
- Livelihood improvement of the farm household.
- Women empowerment will be ensured somehow through creating employment and income enhancement of women.

BLRI component

- Increase production and farmers' income at hilly area.
- Organic agriculture produces environmentally sustainable farming at hilly area.
- Integrated cultivation ensures better management of resources.
- Better resources utilization.
- House hold farming pattern diversification at hilly area.

H. Technology/Knowledge generation/Policy Support

i. Immediate impact on generated technology (commodity & non-commodity)

BARI component

- Increases vegetables, fruits and other crops production as well as farmers' income.
- Creates employment opportunities for women and day labors.
- Clean the homestead environment through compost preparation with the wastage as well as green crop production.
- Higher yield and cropping intensity by improved management practices and proper utilization of resources.
- Average fish production increased through carp polycultuer then before intervention.
- Reduce mortality rate of livestock & poultry and increase income from livestock and poultry.
- Increase farmers's income through beef fattening, goat, chicken, duck and pigeon rearing.
- Higher production leads to higher consumption rates added to nutritional support for drought and rainfed areas of resource poor farmers.
- As a whole integrated farming system approach increased livelihood of resource poor farmers.

BLRI component

- Increased cropping intensity and productivity at Drought and Rainfed ecosystem.
- Increases total farm productivity and farmers' income.
- Cultivation of newly BLRI developed fodder variety increased fodder production as well as income.
- Increase farmers' income from goat, sheep, turkey, hilly chicken and pigeon rearing.
- Creates employment opportunities for daily labors at Drought and Rainfed ecosystem.

- Increase production and farmer's income as well as nutritional status of hilly people.
- Increase women participation in homestead production system including livestock production.
- Farming system approach accelerates agricultural growth and thereby it will improve livelihood through income enhancement, labour utilization, employment generation, family nutrition and improvement of soil health and resource pattern.

ii. Generation of new knowledge that help in developing more technology in future (combined)

- Modification of homestead vegetables and fruits production models based on location for greater suitability and acceptance that can supply safe and fresh vegetables and fruits which can meet up farm family demand of food and nutrition and also can contribute to achieve SDG#2.
- Short duration high yielding Mustard variety will be accommodating to increase cropping intensity in Boro-T. Aman-Fallow cropping pattern.
- Cultivation of high value and high yielding Tomato varieties will be helpful to increase total productivity.
- Chewing type sugarcane cultivation and seedling production at homestead level.
- Cultivation of high yielding and late blight resistant potato varieties.
- Proper management of fruit trees will help to increases production and income.
- Cultivation of newly BRRI released rice varieties in the existing cropping pattern.
- Regular vaccination of cattle and poultry birds.
- Chicken, duck and pigeon rearing under semi-scavenging system.
- LSP (local service provider) could help for expansion of new technology at community level.
- Cultivation of newly BLRI released fodder variety.
- Beef fattening, sheep and goat rearing through improved feed and health management.
- Hilly chicken and Duck rearing in Drought and Rainfed ecosystem.
- Total productivity increase through Cucumber - T. Aman - Brinjal cropping pattern.

iii. Technology transferred that help increased agricultural productivity and farmers' income (combined)

- Year-round vegetables production in the homestead area using the "Modified Barind Model" for the High Barind region, the "Goyeshpur Model" for the Kushtia region, and the "Golapgonj Model" for the Sylhet region.
- Mustard-Boro-T. Aman rice cropping pattern for high to medium high land with irrigation facilities.
- Carp polyculture in a seasonal pond.
- Fodder production in homestead or nearby homestead
- Beef fattening
- Sonali chicken rearing in farmers' household.
- Year-round vegetables production in homestead following modified Khagrachari model at Naikhongchari, Bandarban.
- Duck and hilly chicken rearing at Naikhongchari, Bandarban.
- Production system of vegetables and fruits, spice, culture of high value fish and rearing of Turkey, hilly chicken, duck, Black Bengal goat and sheep rearing and beef cattle fattening at Naikhongchari, Bandarban

iv. Policy Support

From the research achievements, some policy recommendation can be stated which are as follows:

1. Over the tested locations, it was found that the average vegetables production per homestead per year was 645 kg. On the contrary, there are about 14870576 farm households in the rural areas of Bangladesh. If at least 50% of households can be brought under intensive vegetables cultivation

following a respective area-wise production model, it will help to produce a huge number of safe vegetables, which in turn will help to save the mainland for vegetables production. The saved land from vegetables production can be used to produce deficit crops like pulses, oilseeds, etc., which will help to bring food security somehow in the country. From the above views, it is anticipated that full support may be given to produce safe and nutritious vegetables in homestead areas all over the country. For this regard, Local Service Provider (LSP) system may be developed for maintaining the input supply chain especially seed.

2. Appropriate pre-disaster and pos-disaster measures should be properly implemented by government. Drought and rainfed area can be properly utilized by supplementary irrigation, water harvest technology, short duration low water requiring crop like pulses, oilseeds and minor cereal should be provided to the affected farmers. For that measures should be taken through government.
3. The traditional systems have been replaced by the establishment of commercial cash and staple crop production systems that have been promoted by governments.
4. As integrated farming is economically and environmentally sound, the motivation for integration would appear to be national policy.

I. Information regarding Desk and Field Monitoring

i. Desk Monitoring

BARI Component: Not Applicable

BLRI Component

BARC have regularly arranged monitoring workshops to identify the different problems in each FSRD sites and to provide suggestions accordingly to the specific problems. Consultants and scientists of FSRD have regularly shared their experiences to help us understand more about the FSRD approach

ii. Field Monitoring

BARI Component

Table I.2.1 Field Monitoring information of FSRD site Basantapur, Rajshahi of BARI component

Sl. No.	Date	No. of visit	Name and addresses of team visit	Output
01	05 December 2019	01	Coordination Unit Team BARC, Dhaka	Visited to Basantapur, Godagari and Amnura, Chapainawabganj activities and provided necessary suggestion.
02	06 February 2020	01	PIU-BARC, NATP-2 (Director, PIU)	Visited to Basantapur, Godagari, Rajshahi activities and experssed satisfaction
03	11 February 2020	01	World Bank/IFAD technical mission team D	Visited integrated farming (IF) activities of Basantapur, Godagari, Rajshahi and experssed satisfaction
04	11 June 2020	01	BARI Team (DG & Director Research) BARI, Gazipur	Visited to Basantapur, Godagari, Rajshahi and experssed satisfaction
05	11 July 2020	01	Ministry of Agriculture (Ad. Secretary)	Visited IF activities at Basantapur site and expressed satisfaction
06	07 November 2020	01	BARC Team (Executive Chairman) BARC, Dhaka	Visited IF activities of Basantapur, Godagari, Rajshahi and experssed satisfaction
07	07 November 2020	01	PIU-BARC, NATP-2 (Director, PIU)	Visited to Basantapur, Godagari, Rajshahi and experssed satisfaction
08	27 December 2021	01	PMU Team (Sector Coordinator Extension and others), Dhaka	Visited IF activities of Basantapur, Godagari, Rajshahi and experssed satisfaction
09	16 January 2022	01	PIU-BARC, NATP-2 Team	Visited different activities of IF at Basantapur, Godagari, Rajshahi and experssed satisfaction

Table I.2.2 Field Monitoring information of FSRD site Amnura, Chapainawabganj of BARI component

Sl. No.	Date	No. of visit	Name and addresses of team visit	Output
01	05 December 2019	01	Coordination Unit Team BARC, Dhaka	Visited to Amnura, Chapainawabganj activities and provided necessary suggestions.
02	06 February 2020	01	PIU-BARC, NATP-2 Team (Director, PIU)	Visited to Basantapur, Godagari, Rajshahi and experssed satisfaction
03	11 July 2020	01	Ministry of Agriculture (Ad. Secretary)	Releasing fingerling to Amnura site and expressed satisfaction
04	16 January 2022	01	PIU-BARC, NATP-2 Team, Dhaka	Visited to Amnura activities and experssed satisfaction

Table I.2.3 Field Monitoring information of FSRD site Chanduria, Rajshahi of BARI component

Sl. No.	Date	No. of visit	Name and address of team visit	Output
01	06/12/2019	01	Coordination Unit Team BARC, Dhaka	Visited farming system project activities Chanduria, Tannore, Rajshahi and expressed satisfaction
02	28/03/2021	01	PIU-BARC, NATP-2 Team (Director)	Visited farming system project activities Chanduria, Tannore, Rajshahi and took good impression of the people.
03	11/06/2020	01	BARI Team (DG & Director Research), BARI, Gazipur	Visited farming system project activities Chanduria, Tannore, Rajshahi and gave advice to the people through field day.
04	24/10/2021	01	Dr. Rina Rani Saha, Dir (ORC), BARI	Visited farming system project activities Chanduria, Tannore, Rajshahi and gave advice to the people about oilseed crops
05	15/02/2022	01	PIU-BARC, NATP-2 Team, Dhaka	Visited farming system project activities Chanduria, Tannore, Rajshahi and expressed satisfaction as well as gave advice to the people regarding nutrition.

Table I.2.4 Field Monitoring information of FSRD site Jiarokhi, Kushtia of BARI component

Sl. No.	Date	No. of visit	Name and addresses of tea visit	Output
01	23-03-2020	01	BARI Team, BARI, Gazipur	Visited homestead, Field crop, Livestock, Fisheries and Off-farm activities. The team sharing opinion with farmers and BARI FSRD team and provided valuable suggestions regarding nutrition aspects of different pulse crops and pest management for integrated farming. Farmers gathered knowledge about integrated farming activities for better maintenance of their life
02	22-03-2022	02	PIU-BARC, NATP-2 Team, Dhaka	Visited homestead, Field crop, Livestock, Fisheries and Off-farm activities. The team sharing opinion with farmers. Farmers gathered knowledge about integrated farming activities for better maintenance of their life

Table I.2.5 Field Monitoring information of FSRD site Kamalbazar, Sylhet of BARI component

Sl. No.	Date	No. of visit	Name and addresses of team visit	Output
01	19 Aug 2021	01	Director, PIU-BARC, NATP-2	Farmers gathered knowledge about integrated farming activities for betterment of their life.
02	05 Feb. 2022	01	Coordination Unit Team (EC, BARC), Dhaka and BARI Team (DG), BARI, Gazipur	Farmers gathered knowledge about integrated farming activities for better production of field crops.

Table I.2.6 Field Monitoring information of FSRD site Naikhongchari, Bandarban of BLRI component

Sl. No.	Date	No. of visit	Name and addresses of team visit	Output
01	04.06.2021	01	Coordination Unit Team (EC & MD) BARC, Dhaka	Visited FSRD work and advised to the farmers for better management. Identify the field problem and provide suggestion to solve respective problems.
02	27.08.2021	01	BLRI Team (DG)	Inauguration of vaccination program. Visit FSRD work and advised to the farmers for better management.
03	24.4.2022	01	PIU-BARC, NATP-2 Team, Dhaka	Making video documentary.
04	13.5.2022	01	BLRI Team (DG)	Increase awareness among the farmers.
05	-	32	Internal Monitoring	Update all information and Visit FSRD work and advised to the farmers for better management.

iii. Weather data, flood/salinity/drought level (if applicable) and natural calamities

BARI Component

FSRD Site: Basantapur, Rajshahi

I.3.1 Weather data of FSRD Site Basantapur, Rajshahi during the years of 2019- 2022

Month	Temperature (°C)						Total rainfall (mm)		
	Avr. Max			Avr. Min					
	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22
October	31.40	33.63	32.99	23.01	25.01	24.50	173.8	98.3	115.2
November	29.99	30.23	29.42	18.30	17.39	17.36	3.4	0.2	0
December	23.67	25.17	26.37	11.70	13.09	14.23	0.2	0	0.7
January	23.33	23.75	23.41	11.45	11.44	12.22	16.2	0	3.1
February	26.72	29.09	25.96	12.56	12.85	12.64	0.6	0	39.1
March	31.61	34.57	34.85	18.05	19.27	19.86	3.5	0	0
April	34.44	37.52	36.77	21.69	22.85	25.69	32.7	15.3	19.6
May	33.80	34.63	44.92	24.18	24.40	24.30	187.3	196.6	178.1
June	35.81	34.22		26.35	25.99		121.8	265.1	
July	34.50	34.22		26.48	26.60		261.5	329.5	
August	34.59	44.35		27.18	26.55		143.7	528.3	
September	34.09	34.15		26.83	26.24		214.8	148.8	

FSRD site: Amnura, Chapainawabganj

I.3.2 Weather data of FSRD Site Amnura, Chapainawabganj during the years of 2019- 2022

Month	Temperature (°C)						Total rainfall (mm)		
	Avr. Max			Avr. Min					
	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22
October	31.40	33.63	32.99	23.01	25.01	24.50	173.8	98.3	115.2
November	29.99	30.23	29.42	18.30	17.39	17.36	3.4	0.2	0
December	23.67	25.17	26.37	11.70	13.09	14.23	0.2	0	0.7
January	23.33	23.75	23.41	11.45	11.44	12.22	16.2	0	3.1
February	26.72	29.09	25.96	12.56	12.85	12.64	0.6	0	39.1
March	31.61	34.57	34.85	18.05	19.27	19.86	3.5	0	0
April	34.44	37.52	36.77	21.69	22.85	25.69	32.7	15.3	19.6
May	33.80	34.63	44.92	24.18	24.40	24.30	187.3	196.6	178.1
June	35.81	34.22		26.35	25.99		121.8	265.1	
July	34.50	34.22		26.48	26.60		261.5	329.5	
August	34.59	44.35		27.18	26.55		143.7	528.3	
September	34.09	34.15		26.83	26.24		214.8	148.8	

FSRD Site: Chanduria, Rajshahi

I.3.3 Weather data of FSRD Site Chanduria, Rajshahi during the years of 2019- 2022

Month	Temperature (°C)						Total rainfall (mm)		
	Avg. Max			Avg. Min					
	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22
October	31.40	33.63	32.99	23.01	25.01	24.50	173.8	98.3	115.2
November	29.99	30.23	29.42	18.30	17.39	17.36	3.4	0.2	0
December	23.67	25.17	26.37	11.70	13.09	14.23	0.2	0	0.7
January	23.33	23.75	23.41	11.45	11.44	12.22	16.2	0	3.1
February	26.72	29.09	25.96	12.56	12.85	12.64	0.6	0	39.1
March	31.61	34.57	34.85	18.05	19.27	19.86	3.5	0	0
April	34.44	37.52	36.77	21.69	22.85	25.69	32.7	15.3	19.6
May	33.80	34.63	44.92	24.18	24.40	24.30	187.3	196.6	178.1
June	35.81	34.22		26.35	25.99		121.8	265.1	
July	34.50	34.22		26.48	26.60		261.5	329.5	
August	34.59	44.35		27.18	26.55		143.7	528.3	
September	34.09	34.15		26.83	26.24		214.8	148.8	

FSRD Site: Jiarokhi, Kushtia

I.3.4 Weather data of FSRD Site Jiarokhi, Kushtia during the years of 2019- 2022

Month	Temperature (°C)						Avr. RH (%)			Total rainfall (mm)		
	Avr. Max			Avr. Min								
	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22
October	38°C	38°C	38°C	28°C	28°C	28°C	89	87	88	700	750	800
November	32°C	32°C	32°C	26°C	26°C	26°C	80	81	82	100	100	100
December	22°C	22°C	22°C	12°C	12°C	12°C	60	62	58	10	5	10
January	21°C	21°C	21°C	11°C	11°C	11°C	58	60	60	10	5	5
February	25°C	25°C	25°C	15°C	15°C	15°C	64	63	62	10	10	5
March	30°C	30°C	30°C	24°C	24°C	24°C	79	80	78	20	15	10
April	34°C	34°C	34°C	27°C	27°C	27°C	88	85	87	30	20	25
May	39°C	39°C	39°C	32°C	32°C	32°C	89	88	90	50	20	50
June	38°C	38°C	38°C	31°C	31°C	31°C	88	87	89	200	250	250
July	38°C	38°C	38°C	30°C	30°C	30°C	89	88	87	300	350	320
August	37°C	37°C	37°C	28°C	28°C	28°C	86	87	85	500	550	500
September	38°C	38°C	38°C	24°C	24°C	24°C	89	88	89	600	620	575

FSRD Site: Kamalbazar, Sylhet

I.3.5 Weather data of FSRD Site Kamalbazar, Sylhet during the years of 2019- 2022

Month	Temperature (°C)						Avg. RH (%)			Total rainfall (mm)		
	Avg. Max			Avg. Min								
	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22
October	31.60	35.83	33.50	23.40	19.40	24.60	76	79	70	342.00	561.50	239.90
November	30.10	33.67	30.40	19.80	15.83	18.50	71	65	65	9.60	151.20	0.00
December	26.20	30.47	27.20	14.90	13.47	15.90	66	68	63	0.40	126.70	14.60
January	29.20	26.60	25.90	9.53	14.20	14.50	69	68	73	10.90	Trace	16.10
February	32.47	29.60	26.70	13.53	15.20	14.00	54	60	60	203.10	0.00	24.60
March	33.90	33.30	33.50	16.80	20.50	20.20	49	57	59	712.30	127.30	86.70
April	35.00	33.80	31.90	18.33	22.20	22.20	57	75	65	2212.00	142.30	281.40
May	35.83	33.00	31.10	19.57	23.80	23.30	75	73	78	1802.80	364.80	839.00
June	36.43	32.20	29.70	22.57	25.30	24.60	83	76	77	2465.10	670.40	1456.20
July	36.87	32.90	34.00	23.93	25.90	25.90	85	81	79	2071.90	647.90	782.90
August	36.90	31.80		23.67	25.40		80	75		1163.30	913.80	
September	36.10	34.60		22.97	26.00		83	73		1433.60	198.20	

BLRI Component

Table I.3.6 Average temperature, rainfall, humidity, rainy days and average sun hours in Bandarban

	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Avg. Temperature °C (°F)	19.5 °C (67.1) °F	22.7 °C (72.8) °F	26.2 °C (79.1) °F	28 °C (82.5) °F	27.9 °C (82.2) °F	26.8 °C (80.2) °F	26.2 °C (79.1) °F	26.3 °C (79.3) °F	26.3 °C (79.3) °F	25.8 °C (78.4) °F	23.4 °C (74.1) °F	20.5 °C (68.8) °F
Min. Temperature °C (°F)	13.9 °C (57) °F	16.6 °C (61.8) °F	20.3 °C (68.5) °F	23.5 °C (74.2) °F	24.6 °C (76.3) °F	24.7 °C (76.5) °F	24.4 °C (75.9) °F	24.4 °C (75.9) °F	24.1 °C (75.3) °F	22.9 °C (73.1) °F	19.1 °C (66.4) °F	15.5 °C (60) °F
Max. Temperature °C (°F)	26 °C (78.8) °F	29.7 °C (85.4) °F	33 °C (91.3) °F	33.8 °C (92.9) °F	32.5 °C (90.5) °F	30.2 °C (86.3) °F	29.2 °C (84.5) °F	29.6 °C (85.3) °F	29.9 °C (85.8) °F	29.8 °C (85.6) °F	28.4 °C (83.1) °F	26.2 °C (79.2) °F
Precipitation / Rainfall mm (in)	5 (0.2)	13 (0.5)	46 (1.8)	65 (2.6)	232 (9.1)	416 (16.4)	435 (17.1)	334 (13.1)	292 (11.5)	186 (7.3)	45 (1.8)	16 (0.6)
Humidity(%)	67%	57%	57%	70%	79%	87%	90%	89%	89%	88%	79%	74%
Rainy days (d)	1	1	3	7	14	20	22	21	20	14	4	1
avg. Sun hours (hours)	9.2	9.9	10.0	9.6	8.6	7.1	6.8	7.3	7.7	7.8	8.3	8.3

Bandarban's climate is classified as tropical. The month with the highest relative humidity is July (89.83 %). The month with the lowest relative humidity is February (57.34 %). On an average temperature of 28.0 °C in April is the hottest month of the year. On an average, January is the coldest (19.5 °C) month of the year. The highest number of rainy days is July (28.70 days) and lowest in January (0.77 days). The most daily hours of sunshine is March with an average of 10.03 hours with total 310.83 hours of sunshine throughout March. January is the fewest daily hours month with an average of 6.77 hours of sunshine a day. Around 3055.12 hours of sunshine are counted throughout the year. On an average there are 100.57 hours of sunshine per month.

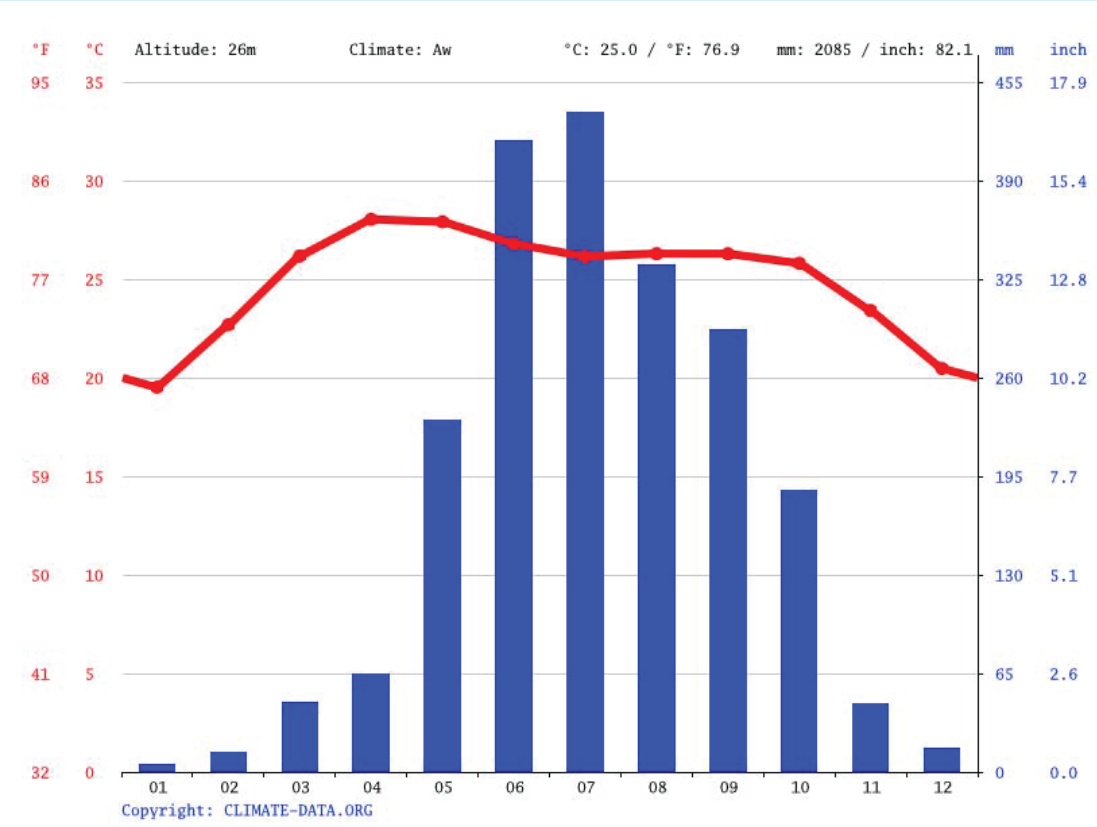

Figure I-3 Climate graph of Bandarban district by Month

Environmental matrix, self-scoring environmental and social safeguard check list

Table I.3.7 Environmental Screening Matrix

Sl. No.	Environmental issue	Component	Improvement/Deterioration*				Remarks
			Small	Moderate	Large	None	
1	***Biodiversity***	Flora			+		
		Fauna		+			
		Genetic diversity	+				
		Exotic varieties				√	
		Local varieties/ cultivars	+				
		Hybrids	+				
2	***Soil quality***	Organic matter	+				
		Chemical fertilizer use		+			
		Soil salinity				√	
		Fertility status		+			
		Microbial activity		+			
		Heavy metal contamination				√	
		Water quality				√	

Sl. No.	Environmental issue	Component	Improvement/Deterioration*				Remarks
			Small	Moderate	Large	None	
3	***Agro-Chemicals***	Pesticide use		+			
		POPs				√	
		IPM		+			
		Pest infestation	+				
		Bio-pesticides	+				
		Health hazard				√	
4	***Pollution***	Soil				√	
		Water				√	
		Air				√	

Note:- Assessment is for the proposed project only and its cycle.

- Only the major environmental issues are considered. Depending on the objective and nature of the proposal, assessment would include only those specific issues which are relevant.
- Health, Safety and Environment (HSE) are the primary concerns and thus all to be centered around HSE

- Genetic Diversity: To cover Crop/Livestock/Fisheries/Forestry as applicable.
- Chemical Fertilizer: Single, imbalanced, use of contaminated one.
- Heavy Metal Contamination: From project activities by Arsenic, Lead, Cadmium or any other.
- Health Hazards: To be considered in respect of residual effect of pesticide, use of chemicals in preservation, processing and artificial ripening besides non-compliance to safety measures like, use of masks, gloves etc.
- Pollution: Quality aspects as influenced by the project activities.
- Small(less than 20%), Moderate (Between 20-50%) and Large (Over 50%)
- If 'improvement put +sign, and if 'deterioration' put -sign in front of the box chosen.

J. Sub-project Auditing

Table J.1 Sub-project auditing information of BARC component

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Foreign Aided Project Audit DirectorateAudit Complex (6th Floor), Segunbagicha, Dhaka	No objection raised	7,73,416	Satisfactory	
Foreign Aided Project Audit Directorate Audit Complex (6th & 11th Floor) Segunbagicha, Dhaka.	No objection raised	17,58,312	Satisfactory	
Foreign Aided Project Audit Directorate Audit Complex (6th & 11th Floor) Segunbagicha, Dhaka.	No objection raised	30,52,314	Satisfactory	
Total		55,84,042		

Table J.2 Sub-project auditing information of BARI component

Types of audits	Major observation/ issues/objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Foreign Aided Projects Audit Directorate (FAPAD)	No objection raised	1,26,85,168	Satisfactory	Three audit has beencompleted by this time

Table J.3 Sub-project auditing information of BLRI component

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
GoB	No objection raised	823346	19.11.2020	Satisfactory
	No objection raised	1624840	11.10.2021	
	No objection raised	1280685	16.10.2022	
Total		3728871		

K. Lessons Learned

BARI Component

- An integrated farming is an eco-friendly approach in which waste of one enterprise becomes the input of another thus making efficient use of resources. In addition, every inch of land can be used by this system according to honorable Prime Minister direction.
- Integrated farming is a promising technology for livelihood improvements of farmers but it needs multidisciplinary well experienced strong scientific team for more successful integration of technologies.
- Inclusion of suitable variety, quality seed and improved crop management can enhance cropping intensity and productivity compare to existing cropping pattern.
- Soil health need to be improved by inclusion of pulses crop in the existing cropping pattern.
- Incase of pigeon rearing, supplementary feed should be provided regularly.
- Regular vaccination is needed to livestock and poultry birds for more success and lower mortality.
- There is a wide scope to utilized the homestead pond to increase family income as well as meet up family nutrition.
- Farmers training as well as result demonstration activities have positive impact on technology dissemination.
- Farming system is a science of survival and prosperity.
- If female farmers involved in the farming activities, higher profit margin could be possible.

BLRI Component

- Vegetable's production in the homestead following modified Khagrachari Model to increase production, consumption as well as income of farmer family.
- Rearing of hilly chicken for meat and egg purpose along with Turkey rearing for meat purpose, sheep and goat rearing for boost up income and thus improves nutrition consumption and livelihood.
- Cattle fattening is also boost up farmer income and thus also improves nutrition consumption and livelihood.

L. Challenges

BARI component

- Rainfall that is uneven; heavy rain/ flood.
- Short-term and irregular funding hamper the smoothness of the program.
- Homestead activities may be hampered sometimes due to laborious work.
- Many of the farmers have not well acquainted to all component especially, pond and livestock.
- Lack of irrigation water in dry season (Kharif-1) in Barind area.
- Cowdung is used for cooking fuel in greater Rajshashi.
- Lack of strong multidisciplinary scientific team like fisheries and livestock to implement the program.
- Lack of proper agricultural knowledge of farmers.
- Lack of proper machinery and spare parts for mechanization.
- Lack of climate change resilient technology.
- Lack of seed production and storage facilities for a huge number of vegetables.
- Seasonal ponds hamper the fish production.
- Unstable market prices of the inputs and outputs.

BLRI component

- Lack of proper knowledge about new crop varieties, livestock breeds, high value fish species and their modern methods of cultivation, among the stackholders.
- Lack of mechanization and irrigation facility as well as knowledge on post management of resources of poor farmers.
- Lack of quality seeds/fingerlings/livestock breed of different high value of crops, livestock and fish.
- High price and less quality of inputs.
- Farmers are not acquainted with high yielding crops, varieties and technologies adopted for the concerned hilly area.
- Lack of proper storage and processing facilities at the local level due to farmers are bound to sell their products during harvesting periods at lower price.
- Lack of proper marketing facilities and low price of agricultural products at farm level.
- COVID-19 pandemic affected the key sub-projects activities and field visit activities.
- Sub-project period was short and it needs minimum 5 years for technology development.

M. Suggestions for Future Planning

BARI component

- Local Service Provider (LSP) needs to establish at each location for sustainable mechanization, seed/seedling exchange system.
- Multidisciplinary team including crop, livestock , fisheries scientist and economist should be involved at each research site for more effective research and development.
- Marketing channel needs to develop for ensuring maximum price of farmers product.
- Soil health needs to address in case of intensive cropping system.
- Farmers capacity on agricultural technologies needs to develop through hands on training.
- Women employment has been created in their homestead activities like vegetables. production, management of fruit trees, poultry rearing, cattle rearing and composting. The activities include them gender mainstreaming.

- Intensive and diversified cropping is possible so activities regarding cropping system intensification can be taken to increase production.
- Irrigation facility development is also a prime need for the intensification of cropping in the drought and rainfed area.
- Fallow land should be utilized with appropriate technology.
- Success stories of FSRD sites may be disseminated through mass media, conferences, seminars and training etc.
- Farming system research and development (FSRD) activities may be strengthened through the country.
- Several training on different components required to facilitate the improvement of the skill of the farmers.
- Strong linkage should be developed among the NARS, DAE, DLS and DOF for dissemination of technology.
- A permanent FSRD team comprise of crops, livestock and fisheries scientists should be placed permanently with supporting field staff.
- Integrated farming approach should be given priority for the development of livelihood of farmers.
- Farming system research project should be continued for at least five years to get better finding.

BLRI component

- Farmers of hilly areas are always struggling of natural calamities. There is more need to conduct research on the production of horticulture and fields crops, livestock and fish adopting with the natural calamities.
- Long term planning needs for implementing the FSRD activities for developed suitable technology for farming system research and development.
- Adequate number of scientific personnel especially for crop, fisheries and livestock component should be needed to recruit at each FSRD site.
- Strong linkage should be developed among the NARS, DAE, DLS and DOF for proper dissemination of FSRD technologies.
- Monitoring/field visit/exchange visit should be more to evaluate the sub-project's activities.
- Multidisciplinary expert's team with strong scientific knowledge needed for successful integration of technologies.
- Hands on training needs to develop agricultural knowledge of farmers on different agricultural technologies to increase their production as well as income.
- Marketing system and storage facility should be developed to ensure proper price of vegetables, fruits, livestock and fisheries products.
- To remove all forms of hunger and malnutrition, farming system research should be emphasized on supporting small scale farmer for supplying sufficient and nutritious food all the year round.
- Farming system research unit with proper manpower should be developed at institute level after complete of the sub-project.

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