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Impact of Improved Agro-techniques on Sustainable Livelihood Empowerment: An Economic Study from West Bengal

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Abstract

The study has assessed the impact of viable technological interventions on food and livelihood security to the farmers of four selected disadvantaged districts, viz. Uttar Dinajpur, Dakshin Dinajpur, Malda and Murshidabad of West Bengal as a part of National Agricultural Innovation Project. The participatory and personal interview methods were followed to collect the information. The performance of the technological interventions was studied by following "Before-After" design. The cumulative effect of the technological packages like varietals replacement (VR), resource conservation technologies (RCTs), new crop sequencing (NCS), integrated farming system (IFS) increased the cropping intensity and augmented productivity for all major cereals (49.63%), oilseeds (43.02%), pulses (58.44%) and potato (23.85%), addressing the food insecurity issue of around 64.26 per cent farm families. The net effect resulted in higher return from the enterprises like crop, livestock, poultry, and aquaculture and value addition to the tune of 25.96 per cent, 86.04 per cent, 67.43 per cent, 45.59 per cent and 179.06 per cent, respectively and generating 27.19 per cent enhanced employment from different enterprises. Undoubtedly, the latest proven and economically viable technologies like RCT, VR, NCS, IFS and backyard poultry and goatery rearing have a good positive impact on food and nutritional security, leading to improvement of livelihood sustainability.

Key words: Cropping intensity, diversification, empowerment, food security, productivity, sustainability, livelihood, West Bengal

JEL Classification: O32, O33, Q16, Q18, R23

Introduction

In India, agriculture is facing challenges from unsustainable use of natural resources, deceleration in the growth of agriculture and also from threats as well as opportunities of opening of agricultural markets. There are wide gaps in yield potential and national average yields of most crop enterprises (Sulaiman, 2008). Relatively high degree of cropping diversification in this type of system is conducive to making efficient use of different types of nutrients available in the soil and to increasing bio-diversity (Dahal, 1996). The economic dimension of sustainability utilizes agro-ecosystem diversity to achieve minimum reliance on external inputs, and crop-livestock integration to offset the limits in economies of scale which result in increased productivity, food security, diet diversity, and income stability (Altieri, 1999), thereby serving livelihood and equity goals of resource-poor farmers.

A sustained economic growth, rising per capita income and growing urbanization are ostensibly causing a shift in the consumption patterns in favour of high-value food commodities like fruits, vegetables, dairy, poultry, meat and fish products from staple food such as rice, wheat and coarse cereals. The demand

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for and supply of these commodities have grown much faster than those of foodgrains (Kumar *et al.,* 2003; Joshi *et al.*, 2004). The share of these commodities in the total expenditure on food has increased from 34 per cent in 1983 to 44 per cent in 1999-2000 in the rural areas, and from 55 per cent to 63 per cent in the urban areas (Kumar and Mruthyunjaya, 2002). And, this change is not confined to the higher income group of the Indian society only but is visible in the lower income or 'below poverty line' segment also. Agricultural diversification is a core strategy of contemporary rural livelihood systems in developing countries (Ellis, 2000; Barrett *et al*., 2001; Niehof, 2004).

For attaining equitable targeted growth across a nation, there has to be appropriate technology intermediation in the weaker areas of livelihood practices— land-based, homestead-based as well as non-farm-based. It is more in the state of West Bengal where the status of material and human development has strong regional dimensions, more than other parts of the country. This necessitates identification of an effective mix of measures through dove–tailing livelihood parameters with appropriate research–led technology intervention. The main issues affecting livelihood situations in the disadvantaged areas are: (i) Enhanced deprivations and marginalization resulting out of ineffective land utilization, which again is caused due to imperfections in the soil as well as crop production environment, (ii) Limited capability of the marginal farmers and landless, including women to address the externalities and vulnerability, and (iii) Absence of institutional framework to utilize development gains. Also, under the limited scope of area expansion, the only option for increasing production is to enhance cropping intensity.

Under this background, the present study was conducted to find the impact of improved agricultural technological interventions on food and livelihood safety of the disadvantaged rural farming community in West Bengal.

The Study Area

The study was conducted in four disadvantaged districts, namely Uttar Dinajpur, Dakshin Dinajpur, Malda and Murshidabad of West Bengal which were brought under Sustainable Livelihood Empowerment sub-project of National Agricultural Innovation Project. The backwardness was characterized by low per-capita income, low yield per-acre of land, backwardness in industrialization, shortage of capital and entrepreneurship and the lack of infrastructure and large labour surplus. The West Bengal Human Development Report (2004) has clearly indicated of the prevalence of very poor health index, gender development index, and high degree of infant mortality rate (IMR) and consequently, low values of Human Development Index (HDI) across selected districts. A highly semi-humid atmosphere and medium rains characterize the climate of these districts. The economy of these backward areas depends mostly on the rudimentary agriculture and its allied activities. The total agricultural land of these four districts ranges from 76 per cent to 86 per cent. The districts have abundance of natural resources like bamboo, palms, creepers, fruit trees, etc; and agricultural produce like rice, jute, potato, wheat, maize and mustard. Therefore, by proper planning like introducing short gestation vegetables, improved varieties of field crops, utilizing homestead area and creation of small-scale village handicrafts through self-help groups (SHGs), there is a huge potential for the economic development of these districts of West Bengal.

Materials and Method

Data collection

The study is based on both secondary and primary data for the period from 2008 to March, 2012, collected through field programmes from 1314 respondents of NAIP–3 being operated since 2008. The sample units were scattered over ten villages of Itahar, Tapan, Manickchalk and Suti-I blocks of Uttar Dinajpur, Dakshin Dinajpur, Malda and Murshidabad districts respectively. Data were collected using a well-structured questionnaire and were triangulated by the PRA tools and interview results.

Analytical Tools

(a) Crop Diversification — To study the impact of crop diversification in the study area, following formula developed by Rasul and Thapa (2004) was used.

$$ICD = \frac{P_a + P_b + P_c + ...+ P_n}{N_C} \ (\%)$$

where, ICD is the index of crop diversification, Pa is the proportion of sown area (%) and subscripts a, b, c, ……., n denote different crops, and N_C is the number of crops.

Then analysis was carried out based on the following scoring system of sustainability:

Score index	ICD values (%)	Sustainable classifications
1	81-100	Very low sustainability
2	61-80	Low sustainability
3	41-60	Moderate sustainability
4	21-40	High sustainability
5	0-20	Very high sustainability

(b) Cropping Intensity — It was expressed using the following formula:

Cropping Intensity =
(Gross cropped area/Net sown area) × 100

(c) Index of Food Security — To obtain perception of households in terms of food security, they were asked (i) whether they always have enough and the desired type of food to eat, (ii) whether they have enough but not the desired food to eat, and (iii) whether they have either sometimes or always not enough to eat (Keenan *et al.,* 2001). To compare food adequacy precisely, an index of food security was constructed using following formula (Chen, 2000):

$$IFS = \frac{fd1* 1 + fd2* 2 + fd3 * 3 + f0 * 4 + fs*5}{N}$$

where

IFS = Index of food security,
fd = Frequency of responses indicating food insecurity (temporal + permanent),
fd2 = Frequency of responses indicating always not enough to eat,
fd3 = Frequency of responses indicating sometimes not enough to eat,
f0 = Frequency of responses indicating enough but not always the desired food,
fs = Frequency of responses enough of the desired food,
N = sample size, and
C = Coefficients of different adequate foodgrains, with figure 1 indicating food insecurity (temporal + permanent), 2 indicating always not enough to eat, 3 indicating sometimes not enough to eat, 4 indicating enough but not always the desired food and 5 indicating enough of the kinds of desired food.

Results and Discussion

Crop diversification is also related to minimization of risks in farming. It indicates the increasing number of crops or production enterprises per farm which helps insure the crops against various types of risk (Beets, 1990). The value of index starts from 100 (when only one crop is grown) and tends to become zero (when as many as 100 crops are grown). The lower is the index value, the higher will be crop diversification and thus, more sustainable will be the farming system as it is conducive to making efficient use of different types of nutrients available in soil and to increasing biodiversity (Dahal, 1996).

The study has revealed that the crop diversification index (ICD) was enhanced from 36.90 per cent to 18.73 per cent in cluster-I, from 40.03 per cent to 19.72 per cent in Cluster-II, from 34.04 per cent to 19.90 per cent in Cluster-III and from 43.71 per cent to 22.33 per cent in Cluster-IV (Table 1). Thus, as more area was brought under cultivation and high-yielding short-duration varieties were introduced, the growing of rice, jute and potato was replaced partly with other more profitable field crops like groundnut, maize, lentil, green gram and black gram. Therefore, the degree of sustainability was raised from high to very high in clusters I and III, moderate to high in cluster-IV and moderate to very high in cluster-II. Hossain and Kashem (1997) have also reported a higher chance of agricultural sustainability with increasing crop diversification, mixed cropping and use of organic fertilizers.

The gain in productivity through replacement of varieties and adoption of improved agro-techniques has been depicted in Table 2. A perusal of Table 2 revealed that among the field crops, productivity gain was highest in black gram (87.5%), followed by maize (58.45%), green gram (56.25%) and rice (54.93%). It was due to the introduction of short-duration high-yielding varieties, namely 'Sarada' (WBU-108), 'Ganga-1', 'Sonali' and 'IET-4786', respectively and adoption of improved agro-techniques. Consequently,

Table 1. Pattern of crop diversification before and after NAIP intervention in West Bengal

Name of crop	Net sown area (ha)							
	Cluster-I		Cluster-II		Cluster-III		Cluster-IV	
	Before	After	Before	After	Before	After	Before	After
Rice	78.66	69.23	79.81	71.00	74.01	66.50	84.15	69.25
Jute	47.21	44.33	51.45	41.35	55.72	47.75	58.50	55.23
Potato	34.43	26.72	31.90	28.56	36.05	31.05	38.08	34.50
Wheat	21.28	28.25	23.75	31.50	19.00	23.74	14.79	21.81
Mustard	-	9.25	13.22	10.48	15.27	9.33	23.01	16.33
Lentil	-	7.27	-	7.98	-	6.58	-	9.78
Black gram	-	2.93	-	5.44	4.17	13.25	-	3.22
Groundnut	-	5.23	-	6.52	-	7.19	-	10.42
Green gram	-	3.12	-	4.05	-	4.95	-	13.11
Maize	2.94	7.25	-	8.26	-	2.75	-	6.37
Sesame	-	2.50	-	1.74	-	3.86	-	5.59
Total sown area (ha)	298	298	185	185	183	183	798	798
Index value of crop diversification	36.90	18.73	40.03	19.72	34.04	19.90	43.71	22.33
Type of sustainability	High	Very high	Moderate	Very high	High	Very high	Moderate	High

Table 2. Productivity gain through replacement of crop varieties and adoption of improved agro-techniques

Crop		Area covered (ha)	Number of households involved	Productivity (t/ha)*		Gain (%)
				Initial	Improved	
Cereals	Rice	105.56	748	1.42	2.20	54.93
	Wheat	115.96	603	2.14	2.90	35.51
	Maize	60.00	600	2.84	4.50	58.45
Pulses	Black gram	21.38	180	0.40	0.75	87.50
	Green gram	10.28	150	0.56	0.87	56.25
	Lentil	9.36	120	0.95	1.25	31.58
Oilseeds	Sesame	49.92	450	0.38	0.56	47.91
	Mustard	115.04	750	0.67	0.90	34.33
	Groundnut	10.16	175	1.26	1.85	46.83
Others	Potato	79.24	392	32.50	40.25	23.85
	Jute	271.36	930	1.75	2.20	25.71

Note: The productivity of crops represents the average yield of all the selected clusters

an impressive increase in productivity could be achieved for all major cereals (49.63%), oilseeds (43.02%), pulses (58.44%) and potato (23.85%).

The increase in income and employment generation through agricultural interventions with respect to the baseline information has been depicted sector–wise in Table 3. The increase in income was highest in the value addition (179.06%), followed by livestock (86.04%), poultry (67.43%), aquaculture (45.59%) and was lowest (25.96%) in crop cultivation[1]. The overall increase in income was 39.53 per cent vis-a-vis the baseline data. The employment generation was also highest in value-addition enterprise

[1] The value-addition intervention implied rice husking, composting, low cost protected horticulture and pit loom interventions.

Table 3. Impact of agro-techniques on income and employment generation sector-wise in West Bengal

Sector	Income (₹/household)		Employment (human-days/household)		Enhancement (%)	
	Baseline	Enhanced	Baseline	Enhanced	Income	Employment
Crop cultivation	18013	22690	43.5	49.8	25.96	14.37
Livestock	2251	4189	11.7	14.3	86.04	21.90
Poultry	1251	2094	10.5	12.5	67.43	19.05
Aquaculture	2877	4189	6.3	9.7	45.59	54.72
Value addition*	625	1745	2.4	8.3	179.06	252.97
Overall	25018	34908	74.3	94.5	39.53	27.19

*Rice husking, composting, low cost protective horticulture and pit loom intervention

Table 4. Impact of adoption of agro-techniques on income, employment and migration village-wise across the selected districts in West Bengal

Name of village	Average annual income (₹/family)		Change (%)	Employment generation (humandays/family)		Change (%)	Migration		Change (%)
	Baseline value (March, 2008)	Afterwards (March, 2012)		*Baseline value (March, 2008)	Afterwards (March, 2012)		Baseline (March, 2008)	Afterwards (March, 2012)	
Cluster- I: Itahar block, Uttar Dinajpur District									
Bansthupi	32159	43350	34.80	79	120	51.90	45	36	- 20.00
Gotlu	21298	28159	32.21	66	99	50.00	67	50	-25.37
Sripur	20220	27549	36.24	85	117	37.65	42	32	-23.81
Cluster- II: Tapan block, Dakshin Dinajpur District									
Kashitara	36809.	48142	30.79	72	98	36.11	58	51	-12.07
Mahukuri	31200	42650	36.70	67	99	47.76	49	39	-20.41
Shibpur	28842	38924	34.96	78	110	41.03	45	37	-17.78
Cluster- III: Manikchak block, Malda district									
Pulintola	26292	32056	21.93	61	89	45.90	40	36	-10.00
Shankartola	25471	31298	22.88	76	112	47.37	48	35	-27.08
Cluster- IV: Suti – I block , Murshidabad district									
Dahina	48055	58654	22.06	84	114	35.71	42	37	-11.90
Gmabhira	31995	39753	24.25	75	94	25.33	48	41	-14.58

(252.97%), followed by aquaculture (54.72%), livestock (21.90%), poultry (19.05%) and crop cultivation (14.37%) with overall increase of 27.19 per cent across the study area.

The village-wise impact of adoption of agro-techniques on income enhancement, employment generation and migration curbing has been shown in Table 4. The rise in income per family was highest (36.7%) in the village Mahukuri under Tapan block of Dakshin Dinajpur, closely followed by Sripur village (36.24%) under Itahar block of Uttar Dinajpur district. The village Pulintola under Manikchak block of Malda district has shown the lowest change in annual income per family (21.93%). It was due to poor access to

resources and services in the area. The highest change in employment generation has been shown by the village Bansthupi (51.9%), followed by Gotlu village (50.0%), both under Itahar block of Uttar Dinajpur district. The village Gambhira under Suti-I block of Murshidabad district has shown the lowest change in employment generation (25.33%).

A clear impact was seen on rural migration. Overall, the migration was checked by 10 – 27 per cent from different villages. The highest reduction was seen in the village Sankartola (27.08%). The village Pulintola showed the lowest decrease in migration status per family (10.0%). It was seen that villages which could generate more employment had the maximum check on migration.

The impact of different technologies on income enhancement, employment generation and adoption percentage of the technology in the study area has been shown in Table 5. Across eight technologies offered, the adoption was highest of protective horticulture technology (87%), closely followed by improved crop husbandry (86%) and varietals replacement (81%). The lowest adoption was of bio-inputs production (8%) may be due to its complexity and marketing problem of the product. The employment generation was highest on adoption of backyard poultry and goatery technology, followed by varietals replacement and resource conservation technologies and was the lowest in contingent farming technology. The income enhancement was highest in adoption of resource conservation technologies, followed by varietals replacement and was lowest in the case of backyard poultry and goatery technology.

Under the limited scope for area expansion, the food production can be enhanced by raising cropping intensity. Higher cropping intensity means that a higher portion of net sown area is being cropped more than once during one agricultural year. The study has revealed that gross cropped area has enhanced by 42.2 per cent in cluster-I, 34.7 in cluster-III, 26.7 per cent in cluster-I and 14.3 per cent in cluster-IV after the introduction of technological interventions through (NAIP subprojects) in the study area (Figure 1). Although net sown area was found higher in cluster-IV and cluster-I than in rest of the clusters, but utilization of net sown area was less due to low adoption of introduced technologies and large landholding size.

The cropping intensity was highest at cluster-II (217%), followed by cluster-I (191%), cluster-III (178%) and cluster-IV (158) and was higher than their respective baseline values. Therefore, it may be concluded that interventions of new crop sequencing,

Table 5. Impact of different agro-techniques on income enhancement, employment generation and adoption level

(Type of extension method = Verification trial)

Technology	Farmers who adopted technology (No.)	Area in ha or Unit in No.*	Adoption level (%)	Employment generation (humandays)	Income enhancement (₹/ha or ₹/unit)
1. Improved crop husbandry	1048	234	86	9.2	6733
2. Introduction of new crops	832	105	68	7.5	6124
3. Varietals replacement	989	848	81	11.0	7749
4. Resource conservation technologies	149	50	12	10.6	8241
5. Improvement in homestead based production system through multi-tier and pond dyke based horticulture	1065	14	87	7.4	5760
6. Backyard goatery, poultry and apiary	350	1300	29	26.7	181
7. Bio-inputs production	95	190	8	6.5	2293
8. Contingent farming with short-gestation crops	386	26	32	4.0	4124

*Unit in number indicates the number of livestock (goat/ poultry birds) or number of boxes for apiary or number of bio-input pits distributed per family. Here, One unit of Goatery = Two goats, One unit of poultry = Two female birds (hen) with one male bird (cock), One unit of apiary = One apiary box and one unit of bio-input production = One bio-input pit.

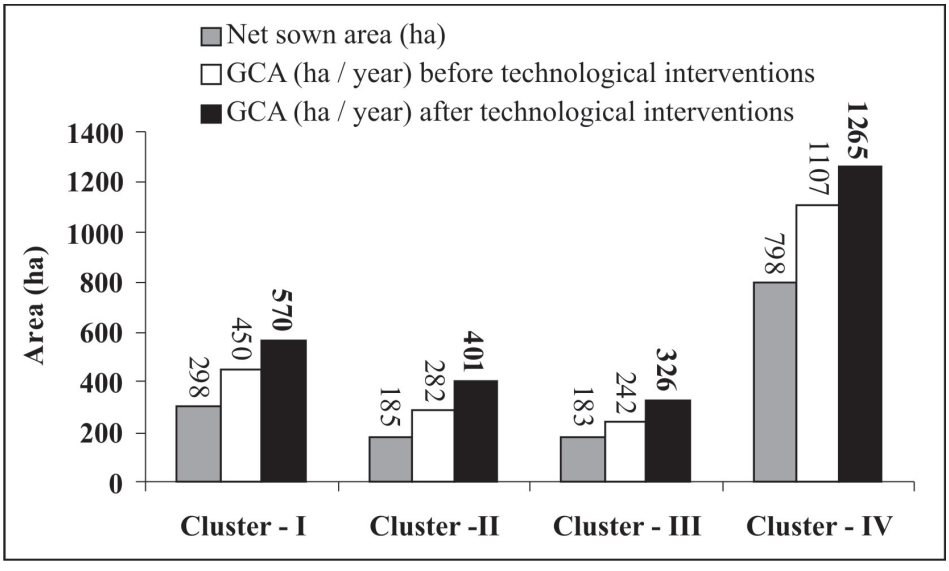

Figure 1. Impact on gross cropped area (GCA) for the technological interventions

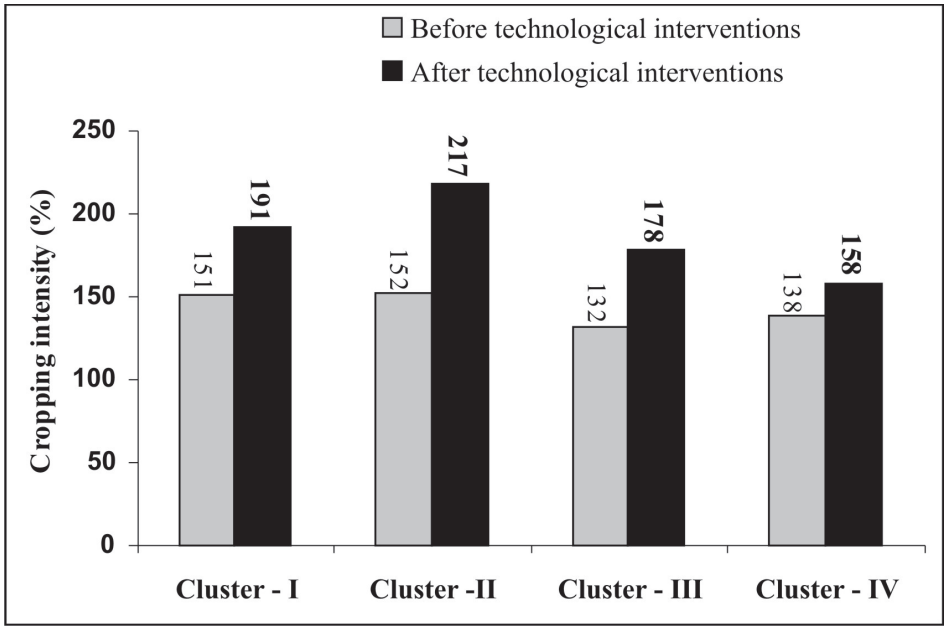

Figure 2. Cropping intensity before and after technological interventions

resource conserving technologies and varietals replacement increase the cropping intensity which will help in enhancement of livelihood status and food security of the people.

The salient features of food security are '*food availability'* and '*accessibility'*. Food availability refers to the supply of food, whereas accessibility refers to the ability to obtain food either through own production or purchase from the market (Bahiigwa, 2002). The assessment of variables such as equity and food security is highly relevant for agricultural sustainability and livelihood security in the rural areas (Pretty, 1995; Rasul and Thapa, 2003). In this investigation, farmers were asked whether or not their food supply was enough all the year round. It was observed that with the introduction of improved agro-techniques and intensification of crop diversification, the overall food deficiency was mitigated by 8.75 per cent for the

Table 6. Food security analysis before and after technological interventions

Items	Wi	Number of responded									
		Cluster-I		Cluster-II		Cluster-III		Cluster-IV		Overall	
		Before	After	Before	After	Before	After	Before	After	Before	After
Food insecure (temporal+ permanent)	1	38	3	27	1	39	4	19	0	123 (9.36)	8 (0.61)
Always not enough to eat	2	73	4	73	10	92	6	44	4	282 (21.46)	24 (1.83)
Sometimes not enough to eat	3	142	33	90	40	142	62	118	33	492 (37.44)	168 (12.79)
Enough but not always the kind of food desired	4	130	317	101	203	119	296	59	184	409 (31.13)	1000 (76.10)
Enough of the kind of food desired	5	3	29	2	39	1	25	2	21	8 (0.61)	114 (8.68)
Total sample size	-	386	386	293	293	393	393	242	242	1314	1314
Index of food security	-	2.97	3.95	2.92	3.92	2.88	3.84	2.92	3.92	2.92	3.9
Type of sustainability		Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate	High

Wi = Weightage of Score

households who had temporal and permanent food insecurity, by 19.63 per cent for households who always had not enough food to eat and by 24.65 per cent for the households who sometimes did not have enough food to eat (Table 6). Also, the overall food sufficiency enhanced from 31.13 to 76.10 per cent for those households who had enough food but not always the kind of food they desired and from 0.61 to 8.68 per cent for households who had enough of the kinds of food they desired (Table 6).

It was observed from the study that there were intra-regional differences in attaining food sufficiency. According to sustainability classification, food security which was moderate augmented to the level of high standards in all clusters in the study area. The report of Altieri (1987) and World Commission on Environment and Development (1987) have also highlighted that inequitable or inefficient food distribution mechanisms are widely responsible for the persistence of hunger in the world today.

Conclusions

The present study has envisaged the farmers' prerogative in income enhancement and employment generation to get a tangible outcome in the study area in terms of offered agricultural technologies. The efficacy of the offered technologies has been studied in terms of productivity, crop diversification, cropping intensity, employment generation, profit margin, adoption percentage and migration reduction which will ultimately reduce vulnerability of the disadvantaged rural areas.

The protective horticultural technology has depicted immense potential of adoption by the farmers of the study area as it is not only a low cost simple technology in which local available resources can be used but it also leads to increase in annual income of the poor farm families. Among the introduced improved agro-techniques, resource conserving technologies particularly zero tillage wheat cultivation; varietals replacement and new crop sequencing have shown high acceptability and adaptability. The profit margin has been enhanced due to adoption of crop diversification and increase in cropping intensity which have promoted food and nutritional security of the farm households.

The management of backyard poultry and goatery has been observed to be another choice of the farmers from the basket of livelihood opportunities to generate more employment and get higher income. In a nutshell, all the introduced technologies have shown satisfactory and positive performance in terms of the income enhancement, employment generation, migration mitigation, livelihood sustainability attainment and standard of living improvement in the study area. It

can be concluded from the study that that the basket of technological packages comprising resource conservation technologies, new crop sequencing (NCS), integrated farming system (IFS), crop diversification and scientific management of livestock can definitely boost up production, productivity, and employment generation even in the disadvantaged areas and can uplift the socio-economic status of the rural poor and sustain food and nutritional security.

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