



## Resource integration for livelihood and nutritional security of farmers of Tehri Himalayas of India

POONAM KASHYAP<sup>1</sup>, M P SINGH<sup>2</sup>, V K SINGH<sup>3</sup>, A K PRUSTY<sup>4</sup>, R P MISHRA<sup>5</sup>, V P CHAUDHARY<sup>6</sup>  
and B GANGWAR<sup>7</sup>

ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut, Uttar Pradesh 250 110

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### ABSTRACT

Farming system approach is considered as most powerful tool for improving livelihood of small and marginal farmers. A study was undertaken during 2011-2015 to characterize the existing farming situation in New Tehri district of Uttarakhand with the objective of holistic improvement of livelihood, profit maximization and on-farm employment generation through integrated farming system (IFS) approach. Analysis of results revealed that crop + dairy was the predominant farming system (68%) followed by crop + dairy + horticulture + goatery. Introduction of improved cultivars of rice, maize, wheat and barley gave additional yield of 17 to 42 % over traditional cultivars. Similarly, introduction of improved cultivars and need based integrated pest management resulted in increased productivity of pre-dominant pulses like pigeonpea, blackgram, mungbean, kidneybean, horsegram, chickpea and lentil by 31% to 70%. Introduction of improved cultivars of soybean (Cv. PS 1092) and mustard (Cv. Pusa Bold) along with integrated plant nutrient management (IPNM) measures provided enhanced yield of 27% (soybean) and 46% (mustard) in Narendra Nagar, whereas yield enhancement of 15% (soybean) and 47% (mustard) was recorded in Thauldar Block. Interventions in horticulture component also resulted in yield improvement and enhanced productivity. The monthly vegetable availability increased from 110 to 154 kg house hold in the study area. The results of the study showed that annual requirement of proteins (110-125 kg) and carbohydrates (550 to 575 kg) for a five member can be easily met out through integrated farming system approach. This study envisaged that integrated farming system approach along with improved technological interventions may bring long-term farming system sustainability, improved livelihood and generate sufficient local employment which will restrict rural youth migration in hill areas of Uttarakhand.

**Key words:** Farming systems, Livelihood, Nutrition, System, Uttarakhand

Farming in Uttarakhand hills depends on mountain agriculture with fragmented holdings, limited irrigation facilities, soil and water erosion and several other eco-physical constraints. Farmers holdings are land locked with huge distance between market and desired resources. As a result, the majority of the rural population in the hills either survive on subsistence agriculture or migrate to other parts of country for employment. Therefore, government policies and development agencies face challenges in promoting livelihoods to retain rural youth through local employment and income generation and to enhance their

quality of life. On the other hand, most suited climate for high-value agriculture and off season field crops, vegetables and fruits opens new avenues for planners and developers in the coming decades (Singh *et al.* 2012).

In view of growing population pressure and gap between demand and supply, deterioration of natural resources in hilly eco-systems, agricultural enterprises diversification/intensification is the most suggestive means for rapid and year round income generation. Several earlier studies revealed that dairy, horticulture and other location specific enterprises may bring substantial increase in income, employment and nutritional security in the region (Gangwar *et al.* 2014). Such diversification is considered essential not only for liberation of rural masses from squalor of poverty but also for meeting the demands of milk, fruits, vegetables and other products of food basket (Behera *et al.* 2007) for narrowing the gap in achieving nutritional security.

The emergence of Integrated Farming Systems has enabled us to develop a framework for an alternative development model to improve the feasibility of small sized farming operations in relation to larger ones. Integrated approach of farming systems were found to outperform

<sup>1</sup>Scientist (Horticulture) (e mail: pakhihorti@gmail.com),  
<sup>2</sup>Principal Scientist (Agricultural Extension) (e mail: mpspdfsr@gmail.com), <sup>3</sup> Present address: Head (e mail: vkumarsingh01@yahoo.com), Department of Agronomy, ICAR-IARI, New Delhi, 110012, <sup>4</sup>Principal Scientist (Agronomy) (e mail: rp\_min@yahoo.co.in), <sup>5</sup>Scientist (Aquaculture) (e mail: aasiana143@gmail.com),  
<sup>6</sup>Senior Scientist, (Farm Machinery) (e mail: vp\_ch@yahoo.co.in),  
<sup>7</sup> Ex-Director (e mail: bgangwarpdfsr@gmail.com), ICAR-IIFSR, Modipuram, Meerut.

the normal farming systems in all four dimensions, viz. food security, environmental functions, economic functions and social functions. It takes holistic view involving interdisciplinary action in respect to available resources of the area for its maximum utilization. In changing socio-economic conditions of the farm families, farming system approach may assume most viable option to re-stabilize the farming community, improving their livelihood and restricting the migration towards urban areas. In this backdrop, a study was undertaken to characterize the existing farming situation in New Tehri district of Uttarakhand with the objectives to understand the prevailing cropping / farming system, their constraints and to delineate farming system strategies for livelihood improvement through appropriate component technology.

#### MATERIALS AND METHODS

Study was undertaken in New Tehri district of Garhwal region of Uttarakhand, India during 2011 to 2015. A cluster of 10 villages in Narendra Nagar Agriculture Development Block (ADB) and Thouldar ADB were selected using stratified random sampling. The selected villages were located at a surrounding to Tehri reservoir at 642 to 1313 amsl. It is hilly district and most of its area is mountainous. Soils of the selected villages are red loamy soils. Climate of the region is mild hot in summers and serve cold winter. The average annual rainfall ranges between 1102-1894 mm, of which about 73.3% is received through south-west monsoon during July to September and remaining is received during winter months. The cropping system/farming systems are highly variable among these ADB and intensity varied in accordance with altitude, available resources and farmer's socio-economic condition. The selected locations are representative of hill areas of Uttarakhand state.

For benchmark survey, 10 villages located at different altitude of each ADB were selected. Stratified random sampling technique was used for selection of villages. In each village, ten farmers having different land holding size, socio-economic conditions and other available resources were selected. Therefore, hundred farmers in each cluster were selected and interviewed for the study during 2011. Since none of the farmers in selected villages were having >2 ha cultivated land therefore, our study was mainly focused on small (2-1 ha area) and marginal (<1 ha area) farmers. The information on prevailing cropping system/farming system, farm practices followed, irrigation water availability, farmers socio-economic condition and other available resources were collected with the help of pre-designed survey questionnaires. Farmer holding size group was characterized as large (>4 ha area), medium (2-4 ha area), small (1-2 ha area) and marginal (<1 ha area). The socio-personal characteristics of surveyed farmers was studied in terms of their age, education, occupation, household size, type of family, monthly income and participation in social activities. Based on information collected at onset of the study (2011), prevailing farming systems situation was characterized for various on-farm enterprises, the

major farm enterprises in the studied domain were crop, dairy, horticulture and goatery which vary with the farmers depending upon their resources. During the study major production constraints in existing farm enterprise were also identified through discussion with the farmers. Based on these constraint identified, critical input interventions were made for uplifting existing farming situation at 10 household in each village (Total 100 household in each ADB) during 2011-12 to 2013-14. In order to assess the impact of critical input intervention under different enterprise at house hold level and other related farming aspects, bench mark household were revisited during 2015 and information were recorded.

#### RESULTS AND DISCUSSION

In order to improve livelihood in hill region of Uttarakhand, critical constraints under different farm enterprises were identified and opportunities for its further upliftment were worked out. The major constraints identified in the area were scarcity of water, use of traditional cultivars of crop, fruit and vegetables, imbalance /inadequate nutrition, insect-pest and disease infestation, poor accessibility of market and lack of technical knowledge on improved package of practices.

##### *Farmers holding size*

Characterization of farm holding revealed that on an average, 71.2% farmers in Thouldar, ADB and 78.4% farmers in Narendra Nagar, ADB were under marginal farmer category. None of the farmers was belonging to medium and large farmers categorize in both the studied ADB.

##### *Socio-personal characteristics*

Results revealed that most of the farmers (55% to 67%) are in the middle age group (36 to 55 year age) followed by old (>55 years) and younger age group (<35 years). Small number of young farmer population may be ascribed as migration of youth towards urban areas in search of employment. The study area is characterized by difficult terrain, undulating topography, sparse population and agro-based economy. Agricultural hardship due to physical, geographical and environmental reasons compels its inhabitants to sustain on agriculture or migrate to the cities for employment. Lack of basic amenities in villages (Jayaraj 2013), the gradual disillusionment about agriculture by rural youth have triggered the migration of youth (Khanal and Watanabe 2006, Grau and Aide 2007). Majority of farmers were educated up to primary level or illiterate due to lack of proper educational infrastructure in terms of higher educational institution and farming was their main occupation. In general, household family member were more than 4 and their monthly income was <₹ 1000. The agricultural work force in this region faces many ordeals due to the adverse environmental and geographical configuration. Over all prevailing farming marked by problems of poor technology, lack of irrigation facilities, scattered landholdings, poor transport connectivity

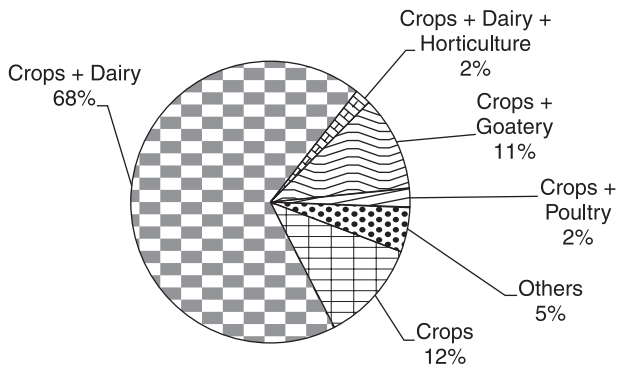


Fig 1 Prevailing farming systems in study clusters

and inaccessible markets etc. leading to a very poor and pathetic condition of the rural being in both the ADBs.

#### Pre-dominant cropping/farming system

Crop+dairy based farming system was predominant in both ADBs. Among the crops grown, rice, maize, barnyard millet, finger millet, wheat, rai, field pea and amaranths were pre-dominant crops, whereas potato and vegetables were grown in selected pockets where sufficient irrigation water was available. Buffalo and cow predominantly represent the dairy, whereas goatery and sheep rearing was mainly for meat and wool purpose. Most prevalent farming system under both the ADBs during onset of the study is given in Fig 1.

Survey revealed prevalence of diseases, viz. citrus canker, necrosis in aonla and malformation in mango among fruit crops while problems of damping off, *Fusarium* wilt and thrips and aphid attack were prevalent in vegetable crops in both the ADB. Traditionally people used to spray cow urine on to affected fruit and vegetable plants for control of insect pests. Therefore, integrated pest management practices needs major attention. Horticultural fruit plant like mango, citrus and guava and vegetables along with dairy farming may occupy the main component of farming system in both the ADBs. It was also observed that the adoption of improved cultivars in different crops was very low and farmers mostly relying on the traditional cultivars. Farmers used to depend on local varieties because of ease of reusing the same varieties for raising next crop due to non-availability of quality seeds in time in the region and lower affordability to purchase seeds of high yielding varieties. Mutual exchange of seeds and planting material is a common practice among villagers. The lower yield of traditional cultivars results in lower crop productivity in the region. Composting of cow dung was also not in practice. Farmer use un-decomposed FYM which become harbour for insect and pest and ultimately lower yield. Very few (<15 %) farmers were using inorganic fertilizer like urea as revealed from survey. Due to irregular availability of fodder for dairy, enterprise was also a neglected component of existing farming system as most families were in the process of downsizing the number of cattle. They are now keeping cows enough only for milk and ploughing the

field. The significant decline of cattle adversely impacts soil revitalization coming from manure.

#### Critical input intervention under different farm enterprise

**Cereals crops:** Different intervention made for cereal crops like rice, wheat, barley and maize has significant effect on productivity resulting in net gain in income. Combining effect of different input interventions, viz. use of high yielding varieties, nutrient management, insect pest and disease management through plant protection measures etc. in cereal crops resulted in 33%, 39%, 38% and 29% average yield enhancement in rice, wheat, barley and maize crop respectively at Narendra Nagar, ADB and 33%, 37%, 46% and 29% at Thouldar, ADB, respectively. With such intervention, net economic gain in rice, wheat, barley and maize crop was between ₹ 7860 to 8753/ha, ₹ 9692 to 9737/ha, ₹ 5402 to 7996/ha and ₹ 8012 to 16200/ha, respectively. Introduction of improved cultivars of rice (VL62, VL 154, PANT 11, Pant 12, VL 85, VL 209), maize (Mukta, Kanchan, Vivek M 31), wheat (VL 829, VL 802, VL 738, VL 907, VL 804) and barley (VL 56) gave additional yield of 17 to 42% over traditional cultivars in both the clusters. Similar yield gain with integrated nutrient weed and pest management was also obtained. Use of right age seeding (35-40 days old) for rice transplanting and line sowing of wheat could also brought an increased yield of 9-23% in rice and 24-41% in wheat crop along with up to 50% wheat seed saving over farmers practice of nursery raising, right aged rice seedling transplanting and broadcasting of wheat seed.

#### Effect of technological interventions in pulses production

Pulses were mainly grown under rainfed condition in hill region. Non availability of quality seed was one of the major constraint resultantly leads lower productivity. Introduction of improved cultivars resulted in increase in yield (31 to 70 %) over local cultivars of pulses. Use of appropriate *Rhizobium* culture and need based integrated pest management, productivity of pre dominant pulses like pigeonpea (VLA1, ICPL-88039), blackgram (PU35), mungbean (SML-668), rajma (VL Rajma 125), horsegram (VLG 19), chickpea (Awarodhi) and lentil (VL 126) along with improved cultivars resulted in yield increase of pulses in the range of 31% to 70% in both the clusters.

#### Effect of technological interventions in oilseed production

Soybean and mustard is the prominent oilseed crop grown in the Uttarakhand hills. The average productivity of these crops with existing farmers practices was 1.8 t/ha for soybean and 0.64 t/ha for mustard crop. Introduction of improved cultivars of soybean (cv. PS 1092) and mustard (cv. Pusa Bold) and need based integrated pest management practices use of trap crops like marigold, use of yellow cards for aphids and thrips, application of neem oil, balanced nutrition etc. on average increased yield over existing farmers practice by 27% in soybean and 46% in mustard crop at Narendra Nagar and 15% in soybean and 47% in

Table 1 Effect of critical input intervention on yield of minor millets

Crops	Variety	% Yield increase over traditional cultivar	
		Narendra Nagar	Thouldar
Barnyard millet	Variety (PRJ 1, VL 207)	24-36	25-33
Finger millet	Variety (VL 149, PRM 3, PRM 1, VL 324)	22-28	21-26
Amaranthus	Variety (PRA 3)	24-33	23-31

Such yield gain in minor millets had added net return of ₹ 4624 to ₹ 4898/ha in barnyard millet (sale price of ₹ 15/kg), ₹ 4149 to ₹ 4670/ha in finger millet (sale price of ₹ 15/kg) and ₹ 8615 to ₹ 8966/ha, in amaranthus (sale price of ₹ 30 kg) crop at both the cluster.

mustard crop in Thouldar.

#### *Effect of technological interventions in minor millets production*

In rainfed situations, minor millets, viz. finger millet, barnyard millet and amaranthus were very common during monsoon season in hill region of Uttarakhand. With traditional/local cultivars of these millets, average productivity ranging between 0.9 to 1.31 t/ha. Introduction of improved cultivars like PRJ 1 and VL 207 of barnyard millet and VL 149, PRM 3, PRM 143 and VL 324 of finger millet and PRA 3 of amaranthus crop resulted in yield gain of 22 to 36% over existing crop management practice for millet in these locations (Table 1).

#### *Effect of technological interventions in fruit crops*

Farmers were provided improved varieties of fruit plants (mango- Amrapalli and Dasher, guava- L-49 and Allahbad Safeda, jackfruit- Singapore, lemon- Pant lemon-5, and bael- Narendra Bael-9) and trained for integrated disease-pest management and balanced nutrition. Estimation of fruit production after 05 years age was made in each ADB at the end of study. The overall estimated income through fruit plant at house hold level was ₹ 4340/annum at Narendra Nagar ADB and ₹ 3573/annum at Thouldar ADB at onset of the study. With improved fruit crop management practices, annual house hold income raised up to ₹ 13377 at Narendra Nagar and ₹ 16828/annum at Thouldar ADB.

Here it may be visualized that income may further be increase with the advancement of age and timely execution of crop management practices. Yadav *et al.* (2013) also found in his study that increase in fruit production could be attributed to improved vegetative growth, better availability of nutrients at vital growth period and greater synthesis of carbohydrates and their translocation to storage organs. Ghosh (2008) also recorded better performance of fruit crops with improved package of practices. These findings are also in line with the findings of Ershaad (2005).

#### *Kitchen gardening*

In both the clusters, farmers use to purchase vegetables from market for their own consumption and spend a sizeable income on it. To make them self-reliance, promotion of kitchen gardening on bare land nearby house/water sources etc. was done by providing mini kit of seasonal vegetables.

Cost of these mini kits were ₹ 20-25 each. With such intervention, monthly vegetable availability increased from 110 to 154 kg household in both the ADB. Initial bench mark survey made in the study revealed that farmers usually spend about ₹ 630 to ₹ 1010/month on vegetables, which could be easily saved with kitchen gardening of nutritious vegetables. Among the different season, maximum net saving through kitchen gardening was accrued during *rabi* (winter) season followed by *zaid* (summer) and least in *kharif* season. Over all annual net savings due to kitchen gardening per household was ₹ 12105 at Thouldar and ₹ 9617 at Narendra Nagar ADB.

It was observed that ladies put more attention on kitchen gardening as compared to gents and also had more benefits through nutritional kitchen gardening. Such interventions were eye opener to many progressive farmers of these ADBs and they started large scale cultivation of seasonal vegetables for enhanced income. The increase in yield of vegetables with improved practices could be attributed to the improved vegetative growth, better availability of nutrients at vital growth period and greater synthesis of carbohydrates and their translocation to the storage organs (Yadav *et al.* 2013). The observations of the present study are in line with the findings of Patel and Rajput (2003) and Kashyap *et al.* (2015).

#### *Dairy enterprise*

Among the dairy, rearing of cow and buffalo were very common in Garhwal region. Due to non-availability of quality fodder and poor feed management practices, malnutrition among the dairy was very common and, therefore, milk productivity was very low. In order to overcome such malnourishment among dairy, mineral mixture, with routine feed/fodder was given to milch animal. Also, green fodder availability throughout the year was ensured by growing berseem (cv. UPB 110) during winter and raising napiergrass on farm strip bunds/risers. Apart from these, insect pest and diseases infections were avoided /controlled through appropriate medicinal treatments.

Data obtained from different villages' indicates that improved dairy management practices has pronounced effect on milk yield with improved management practices on additional milk yield of 1487 to 1601 liter/lactation/ was obtained over existing dairy management practices. Economics computed for different improve dairy management practices indicated that improved dairy management practices had added income of ₹ 18926 in Thouldar ADB and ₹ 19108/lactation/household in Narendra Nagar ADB over existing management practices. The increased income was mainly attributed to increased dairy population, higher milk yield, reduced dry period, enhance

lactation periods and more farmyard manure production.

#### Effect on goatery enterprises

In rainfed condition goatery enterprise was the most common enterprises with marginal house hold (<1 ha area), which rear on wild grazing. Due to imbalanced nutrition and improper management practices, survival percentage of goats and their development was very poor. In order to improve health and enhance income through goatery enterprise, mineral mixture as a food supplement and medicines, viz. anti-mastitis, Anti-parasites and reproduction management were used. Such intervention not only improved the health of these goats but also their numbers were increased significantly/house hold and ultimately annual income from these enterprises was sizeably improved.

Assessing the change in income through goatery enterprise at house hold level, an estimated gain of ₹ 21440 to 33485/household/annum over the bench mark (2011) income (₹ 10185 to 22920/household/annum) from goatery enterprise was noticed.

#### Effect on overall household income, employment and nutritional security

At the end of the study house hold income through different enterprises was compared with initial bench mark year (2011). Results reveals that integration of different component enterprises (dairy, horticulture, goatery) along with crop has additive effect on total household income. Among the different components, maximum net economic gain was accrued through crops, followed by goatery, dairy and horticulture. Goat rearing at Narendra Nagar, ADB was more remunerative as compared to Thouldar, ADB. Use of bare land nearby the hand pump/water sources for kitchen gardening further added a sum of ₹ 9617 to 12105/household/annum to the net saving along with

quality vegetables as well as nutritional security (Table 2 and 3). Total house hold income was more at Narendra Nagar ADB as compare to Thouldar, ADB. Value addition of different households produce like barnyard millet and finger millet as 'packed atta', potato for chips making, milk as curd and ghee, fruit and vegetable as pickles, ketchup and 'murabba' also added extra net amount of ₹ 5478 to ₹ 19542/household in Thouldar, ADB (Table 2) and ₹ 7827 to ₹ 26434/household in Narendra Nagar, ADB (Table 3) compared with initial year (2011). The net annual income improvement through different component enterprises of integrated farming system approaches was to the tune of 81 to 158 % at Thouldar ADB (Table 2) and 67% to 134% in Narendra Nagar ADB (Table 3).

#### Farming system enterprise diversification

At onset of study, crop component enterprises of farming system was the most prevalent and occupied about 57-58% of the total household income followed by dairy (11-20%) and goatery enterprise (16-27%). With different critical input interventions and improved farming awareness programme household enterprise diversification also took place. After 03 years of study, the contribution of dairy, horticulture and goatery enterprise total household income was not only improved, the other ancillary/complimentary enterprises like, kitchen garden and value addition were also having sizable contribution to household income. Such diversification not only led to total higher house hold income, but also reduced the dependency on single enterprises of crops.

Similar performance of integrated farming systems (IFS) have been reported by Frei and Becker (2005) where synergism between farm enterprises increased productivity was Most studies have focussed on the sustainability of IFS in terms of productivity and economic viability.

Table 2 Changes in overall household income (all values in ₹) under different farming systems scenarios in Thouldar ADB

Farming system scenarios	Crop		Dairy		Horticulture		Goatery		Kitchen gardening		Value addition		Total house hold income		
	2011	2015	2011	2015	2011	2015	2011	2015	2011	2015	2011	2015	2011	2015	% increase over 2011
Crop	33368	42671								12105		5478	33368	60254	81%
Crop+ dairy	35702	46408	12118	31044						12105		12538	47820	102095	113%
Crop + horticulture	33368	42671			3573	16828				12105		10741	36941	82345	123%
Crop + dairy +horticulture	35702	46408	12118	31044	3780	18405				12105		10796	51600	118758	130%
Crop + goatery	33368	42671					10185	31625		12105		11232	43553	97633	124%
Crop + dairy + goatery	35702	46408	12118	31044			10185	31625		12105		15754	58005	136936	136%
Crop + dairy + horticulture + goatery	35702	46408	12118	31044	3780	18405	10185	31625		12105		19542	61785	159129	158%

Table 3 Changes in overall household income (all values in ₹) under different farming systems scenarios in Narendra Nagar ADB

Farming system scenarios	Crop		Dairy		Horticulture		Goatery		Kitchen gardening		Value addition		Total house hold income		
	2011	2015	2011	2015	2011	2015	2011	2015	2011	2015	2011	2015	2011	2015	% increase
Crop	47381	61542								9617		7827	47381	78986	67%
Crop+ dairy	49085	65480	9796	28904						9617		13520	58881	117521	100%
Crop + horticulture	47381	61452			4340	13377				9617		12667	51721	97113	88%
Crop + dairy +horticulture	49085	65480	9796	28904	4650	15820				9617		13180	63531	133001	109%
Crop + goatery	47381	61452					22920	56405		9617		17846	70301	145320	107%
Crop + dairy + goatery	49085	65480	9796	28904			22920	56405		9617		24061	81801	184467	126%
Crop + dairy + horticulture + goatery	49085	65480	9796	28904	4650	15820	22920	56405		9617		26434	86451	202660	134%

#### Employment generation through integrated farming system approach

With technological intervention, significant employment generation was also noticed over the year in both the ADBs (Table 4). Integration of different variable enterprises had added employment and the maximum man days/annum was noticed under crop + dairy + horticulture+goatery enterprises followed by crop+dairy+goatery and crop+dairy+horticulture. As compared to cropping system alone, crop+dairy+horticulture+goatery farming system had 582 to 588 additional man days//household/annum. Here it may be ascribed that adoption of integrated farming system in hill region of Uttarakhand ecosystem will not only improve the socio-economic condition of the rural population but also will be reduced the unemployed youth migration towards urban areas.

#### Nutrition security under farming system approach

Our result clearly demonstrated that integration

Table 4 Employment (mandays/ha) generation through different farming systems approaches

Farm enterprise	Thouldar		Narendra Nagar	
	2011	2015*	2011	2015*
Crop	196	290	184	283
Crop + dairy	420	454	409	537
Crop + horticulture	300	418	312	450
Crop + horticulture + dairy	524	678	547	724
Crop + goatery	386	514	372	500
Crop + goatery + dairy	610	770	603	759
Crop + goatery + dairy + horticulture	741	878	729	865

\*Includes 52 man days for kitchen gardening and 24 man days for value addition.

crop+dairy+horticulture+goatery+kitchen gardening had substantial improvement on total protein and carbohydrate production at house hold level. As per Indian Council of Medical Research recommendation annual requirement of protein and carbohydrate for a >5 member family ranges between 110-125 kg protein and 550 to 575 kg carbohydrate which can be easily be met out through integrated farming system approach.

This study envisaged that integrated farming system approach along with improved technological interventions may bring long-term farming system sustainability, improved livelihood and generate sufficient local employment which will restrict rural youth migration in hill areas of Uttarakhand.

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