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Sustainable Production Systems for Agriculture Development in Mountains of Himachal Pradesh, India

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Authors' contributions

This work was carried out in collaboration between all authors. Author AK designed the study, wrote the protocol and organized the review paper with the help of authors AD and JS. All authors read and approved the final manuscript.

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ABSTRACT

The paper examined the existing production systems in the mountains of Himachal Pradesh and suggested further improvement on the existing, which can help farmers to sustain. The study undertaken in low and mid hills of Himachal Pradesh is based on both primary and secondary data collected from 160 farmers (80 farmers from each zone). Under rainfed farming, maize-wheat was the main cropping system, but returns were better in maize-peas (Rs 71,239/ha). In irrigated areas, tomato-tomato-peas was the most profitable farming (Rs 5, 02,378/ha). Consumption of fat was the biggest gap in all categories of farmers.

Keywords: Production systems; average yield; gaps; mountains.

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1. INTRODUCTION

Himachal Pradesh (H.P) has emerged as leading state for development in the country and also leading ahead in hill agriculture and horticulture revolution. Economic growth in the state predominantly governed by agriculture and its allied activities; but showed not much fluctuation during nineties as the growth rate remains more or less stable. Agriculture is the main occupation in Himachal Pradesh and provides direct employment to 69 per cent of the total workers of the state, where around ninety-two per cent of the population of 6.1 million lives in 17000 rural villages [1]. The farming community of the state holds an area of 9.79 lakh hectares which is run by 8.63 lakh farmers out of the total geographical area of 55.673 lakh hectares, wherein, 87.03% of the total holdings are of small and marginal farmers. [2]. But the state harbours several 'niche' or specific situations/products, with potential comparative advantages over plains. This has led to transformation and diversification of agriculture in certain valleys and mountain areas of the state placed at the advantageous position in terms of producing certain commodities like temperate fruits and off-season vegetables. However, the process of diversification of agriculture has remained confined to a narrow production-base due to lack of necessary backward and forward linkages [3,4,5]. Majority cultivators are mainly growing food grains to meet subsistence needs. Moreover, the unplanned agricultural transformation in many areas of the state has also started facing second-generation problems threatening the overall sustainability of the system. Over the years, agricultural sector has adopted a diversification approach that demands for a focus on production of off-season vegetables that include potato, ginger, soybean, oilseeds, and pulses. At present, about 58,743 hectare constitutes production of 13.98 lakh tone in vegetables. The farmers focus more on growing cash crops for higher revenue earning as it suits the agro-climatic conditions in Himachal Pradesh [6].

But still there is need to develop location specific optimum farming systems which will be helpful to raise the standard of living of farm families by ensuring enough employment opportunities to them and to lead better quality life. The priority needs to be accorded to regional development by exploiting the agricultural potential of the region for which it has the comparative advantages. With this background, present study is an effort to study the economic viability of existing production system in targeted areas and to suggest viable modules of production systems suitable in a longer and sustainable manner.

1.1 Hypotheses to be Tested

To achieve the desired results the following hypotheses were formulated and tested through appropriate economic, mathematical and statistical tools.

a) The existing production systems are different than the optimum production system.
b) The existing level of income could be increased by following optimum production systems.
c) The optimum sustainable production systems will provide food, nutritional and livelihood security to the farmers of Himachal Pradesh.

2. MATERIALS AND METHODS

Himachal Pradesh has been divided into four agro-climatic zones, two zones, namely low hills sub-tropical (zone-I) and mid-hills sub-humid (zone-II) were purposively selected. Keeping in mind available resources and time three–stage stratified random sampling technique was employed to select the final sample on the basis of zones, districts and blocks in the state. Una and Mandi districts were selected, respectively in zone-I and zone-II. Una district has five developmental blocks, namely, Amb, Bangana, Gagret, Una and Haroli, Out of these five blocks, two blocks namely Bangana and Una were randomly selected. And Mandi district has ten developmental blocks, namely, Sadar, Balh, Sundernagar, Gohar, Seraj, Karsog, Gopalpur, Dharmpur, Chauntra and Drang. Out of these, two blocks, Sadar and Sundernager blocks were chosen. Further a sample of 40 farmers in each block (80 in each zone) was proportionally allocated, thus making a total of 160 final respondents. Farmers were further categorized into small, medium and large categories using cumulative cube root frequency method according to the size of their land holdings.

Study is based on both primary as well as secondary data. The primary data were collected on well-designed pre-tested schedule by personal interview method, whereas, secondary data were collected from various offices and publications. The primary data were collected

from respondent farmers, progressive entrepreneurs, traders, scientists, veterinary officers, revenue officials, and other officials of Government of H.P. Simple statistical tools and Linear Programming Model was tried to fulfill the objectives of study.

3. RESULTS AND DISCUSSION

3.1 Section-I

3.1.1 Major crop area at farm level

The existing distribution of area under different crop groups was studied and it revealed that cereals dominated the cropping at farm level (Table 1). Rice, wheat, maize and barley was the main cereals, where wheat (27-34 per cent) followed by maize and rice was the main practice. Pulses were mostly grown on medium and large farms. The fodder crops like sorghum in *Kharif* and *Barseem* in winter were the important fodder crops. Over the years, vegetable production has become one of the leading practices, as promoted by research organization and also by state government, because of short duration and secured price in the market. Ladyfinger and tomato were the important vegetable crops grown in *kharif.* And peas, cauliflower, cabbage and potato were the main crops grown in *rabi* season. The area under vegetable crops ranged between 10-14 per cent on different categories of farms.

3.1.2 Average yields of crops of sampled farms

Average yield of different crops has been computed on different size of farms and presented in Table 2. The average yield showed a decline with the increase in the size of farm which could be attributed to the management problem. Average yield revealed that these were lower than the potential yields mentioned in the package and practices of CSK Himachal Pradesh Krishi Vishvaidyalaya, Palampur [7]. Hence, there existed ample scope for improvement with integrated package.

3.1.3 Existing production systems

In the study area, the size of holding of small, medium and large farms was worked out to be 0.25, 0.70 and 2.36 hectares respectively (Table 3). The major share of the area was allocated to foodgrains like wheat, maize and paddy. The total cropped area on small, medium and large farms was worked out to be 0.52, 1.39 and 4.46 hectares, respectively. The cropping intensity decreased with the increase in the size of farm and was worked out to be 206, 197 and 189 per cent on small, medium and large farms, respectively. This decrease in cropping intensity may be due to the reasons that big farmers are going for non-farm avenues. The important trees of farm forestry in the region were Khair *(Acacia Catechu),* Kikar *(Acacia arabica)*, bamboo (*Dendrocalamus strictus)*, biul (*Grewia optiva),* tuni *(Tuna ciliata)*, Shisham *(Delbargia sisoo)*, Khirak (*Celtis australis)* and Simble *(Bombax ceiba)*. Khair trees were mostly in pasture land and are sold for *Katha* processing.

The rainfed farming was most common accounting for about 80 per cent of the total operational holding. Fruits occupied only a small percentage of area. The field crops, mainly foodgrains, covered more than 50 per cent of the cultivated area. The commercial production of sub-tropical fruits like citrus, mango, guava, litchi and other sub-tropical fruits was almost negligible because of less favourable environment for these crops in selected villages. The female labour played the dominant role in farming particularly in case of small farmers and accounted for more than 60 per cent of the total labour engaged in farming. This might be due to the fact that male labour was mainly engaged in other off-farm avenues of employment and income generation due to small size of holding.

Table 1. Distribution of area under different crop groups (Percentage)

Sr. no	Particulars	Size of farmer		
		Small	Medium	Large
1.	Cereals	65.42	56.12	52.47
2.	Pulses	3.80	5.75	6.73
3.	Vegetables	11.54	14.39	10.31
4.	Oilseeds	7.7	8.63	17.71
5.	Miscellaneous crops	11.54	15.11	12.78
6.	Total cropped area over which percentages have been worked out (ha)	0.52 (100)	1.39 (100)	4.46 (100)

Source: Field Survey

The farmers of these zones generally used tractor hiring for first and second ploughing after harvesting the crop. However, sowing was mostly done with pair of bullocks.

Table 2 Average yield of major cops in sampled farms (q/ha)

Sr. No	Crops	Average yield		
A.	**Rainfed**	**Small**	**Medium**	**Large**
1.	Maize	40	39	36
2.	Sugarcane	300	263	260
3.	Jowar-bajra	297	286	268
4.	Wheat	30	28	27
5.	Barley	30	28	24
6.	Potato	150	146	-
B.	**Irrigated**			
1.	Paddy	45	41	39
2.	Maize	45	43	38
3.	Mash	11	10	9
4.	Ladyfinger	158	156	147
5.	Ginger	125	120	115
6.	Bajra-Jowar	380	372	358
7.	Tomato	375	297	288
8.	Pumpkin	-	-	294
9.	Cucumber	200	182	175
10.	Bottle gourd	-	250	243
11.	Bitter gourd	-	-	150
12.	Wheat	40	39	38
13.	Barley	39	38	36
14.	Potato	166	158	156
15.	Pea	195	190	183
16.	Cauliflower	300	290	278
17.	Cabbage	250	243	225
18.	Mustard	40	38	44
19.	Radish	-	150	133
20.	Lentil	-	14	12
21.	Barseem	391	382	350
22.	Potato	200	175	172

Source: Field Survey

Under rainfed farming, maize-wheat was the main cropping system. The other systems were maize and wheat grown mixed with pulses and oilseeds. Maize-*toria*-wheat cropping system was followed on approximately 5 per cent of area. Under irrigated conditions, paddy-wheat and *chari-berseem* were the two main cropping systems followed by the cauliflower-radish-potato cropping system. The other intensive vegetable cropping systems followed in these zones were, tomato-tomato-peas and tomato-bottle gourd-peas. The most intensive cropping system of four crops, namely potato-capsicum-spinach-cauliflower was also followed by the farmers owing tube-wells. Sugarcane-ratoon cropping system was followed on small proportion of irrigated area for home consumption purpose.

The buffalo and cows were major dairy animal accounting for about 90 per cent of the total dairy animals. Three sub-systems of animal rearing viz; stall feeding-cut and carry, complete grazing and partly by grazing and stall feeding were prevalent in the study area. The number of mules and ponies was negligible due to very less use of beasts of burden due to larger expansion of roads and availability of motor transportation in these zones.

The gross returns and net returns for different production systems at existing level have been depicted in Table 3. The most remunerative cropping system under rainfed condition was found to be maize + peas. Under rainfed conditions, second highest gross and net returns were in case of maize-toria-wheat cropping system which were Rs 14,186 and Rs. 12,593 and Rs. 11,811 per hectare on small, medium and large farms, respectively. Maize-wheat cropping system was the least efficient cropping system under dry farming conditions. Under irrigated production system, tomato-tomato-peas cropping system was most profitable yielding gross and net income of Rs. 6,22,863, Rs. 5,12,495 and Rs. 5,02,378 on small, medium and large farms respectively. The other remunerative cropping systems were tomato-cauliflower and tomato-radish-peas.

3.2 Section-II

3.2.1 Food and nutritional security

The National Policy on Agriculture seeks to actualize the vast untapped growth potential of Indian agriculture, strengthen rural infrastructure to support faster agricultural development, promote value addition, accelerate the growth of agro business, create employment in rural areas, secure a fair standard of living in terms of food, nutritional and livelihood security for the farmers and agricultural workers and their families. It also aims to attain growth that is sustainable technologically, environmentally and economically.

The farm families in mountains are facing not only the scarcity of food but also imbalance and malnutrition in their diet [8,9,10]. Therefore, the food security to rural poor means providing them adequate and quality food on sustainable basis. For achieving it, farm diversification and intensification can be regarded as the major objectives of the production systems approach which helps to improve their quality of life by providing them sufficient food and nutritional security.

Table 3. Existing production systems at farm level

Farming system	Small		Medium		Large	
	Gross returns (Rs/ha)	Net returns (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Gross return (Rs/ha)	Net returns (Rs/ha)
A. Rain fed farming(Rs/ha)						
1. Maize – Wheat	1,08,550	10,066	1,02,750	8,653	95,250	7,691
2. Maize + Pulses – Wheat	1,33,860	13,816	1,26,238	11,865	1,17,766	10,819
3. Maize – Toria - Wheat	1,26,850	14,186	1,19,275	12,593	1,13,550	11,811
4. Jowar + Bajra – Barley	91,800	11,335	87,000	5,934	79,800	3,357
5. Maize – Peas	1,86,700	78,920	1,79,550	72,831	1,69,950	71,239
6. Sugarcane	-	-	-	-	-	-
B. Irrigated farming(Rs/ha)						
1. Maize –Wheat	1,32,600	28,635	1,27,900	27,122	1,19,750	19,633
2. Paddy – Wheat	1,35,150	25,114	1,27,900	21,542	1,23,300	18,463
3. Paddy – Barseem	1,14,300	21,593	1,07,800	15,270	1,00,500	13,919
4. Chari – Bajra – Barseem	1,11,150	18,857	1,08,600	14,969	1,01,700	14,519
5. Maize – Potato – Potato	2,88,700	68,211	2,57,550	38,631	-	-
6. Cauliflower – Radish – Potato	-	-	3,49,000	1,37,612	-	-
7. Cauliflower – Turnip – Wheat	3,25,000	1,30,974	3,07,400	1,30,708	3,02,600	1,25,071
8. Tomato – Radish – peas	6,04,000	4,05,017	5,32,100	3,49,996	5,15,000	3,41,870
9. Tomato – Wheat	3,75,000	2,40,346	3,10,500	1,87,080	3,01,200	1,82,408
10. Tomato – Tomato – Cauliflower	7,80,000	5,60,632	6,43,200	4,53,917	6,27,600	4,43,979
11. Tomato – Tomato – Peas	8,34,000	6,22,863	7,03,200	5,12,495	6,80,400	5,02,378
12. Tomato – Bottle gourd – Peas	-	-	6,15,600	4,29,452	5,95,800	4,18,720
C. Dairy Milch animals (Rs/animal)						
1. Cross-bred Cow	45,060	14,515	47,524	18,801	50,672	18,775
2. Buffalo	45,444	13,018	48,740	17,540	51,012	18,038
3. Local Cow	35,247	8,742	36,412	10,494	37,510	10,898
D. Fruits (Rs/ha)	86,652	51,271	84,017	50,398	81,617	49,824

Source: Field Survey

An attempt has been made to estimate per capita per day consumption on the different categories of farms and to find the extent of gap between the existing and recommended levels of nutrition intake (Table 4- Table 7).

3.3 Section-III

3.3.1 Employment generation for livelihood security

The different crop enterprises have a different potential of generating income and employment. Vegetable crops are labour intensive and provide gainful employment to marginal and small farmers along with other categories. In areas where irrigation facility is available the land could be intensively used, if vegetable crops are taken-up. In a short time they provide income, employment and nutrition to farmers. The employment generate by different crop enterprises has been presented in Table 8. All those enterprises which created more than 140 days/ha of employment were regarded as labour intensive crops with respect to more labour needed. The crops in this category were sugarcane, paddy, ladyfinger, ginger, tomato, wheat, peas, cauliflower, cabbage, potato and radish.

3.4 Section – IV

3.4.1 Optimum production systems

The optimized resource-use enhances the farm income by employing them gainfully. It also reduces the disguised unemployment on the farms. The commercial crops if properly grown can give five to ten times more returns than cereals. Farmers attain food, nutritional and livelihood security by diversifying their farm

business. The agricultural production being biological process is affected by physical, biological factors and uncertain market conditions. The physical factors include weather events, such as rainfall, temperature, humidity, evaporation, frost, hailstorms and strong winds. All theses factors are responsible for the biological hazards like the incidence of diseases, attack of insect-pests and consequently uncertain market situations. Therefore, farmers experience sharp fluctuations in their income from season to season and year to year. The lack of know-how about such changes and fluctuations has adverse effect on production and marketing. The decisions for making optimal use of all farm resources are difficult, unless correct predictions of yields, prices and resource availability are made. The diversification of the system not only enhances income but also reduce risk.

Table 4. Per day Consumption of different commodities and their nutritive value on small farms

Product	Consumption (g/ml)	Energy (Kcal)	CHO (g)	Fat (g)	Protein (g)	Calcium (mg)	Iron (mg)
Maize	138	472	91	5	15	14	6
Paddy	169	583	132	0.85	11.5	17	1.2
Pulses	28	102	14	1.58	7.52	44.2	1.72
Wheat	150	521	108	2.26	17.8	61.9	8
Vegetables	220	123	24.12	0.50	7.43	140.7	6.33
Fruit	21	9.88	2.42	0.22	0.24	4.94	0.120
Sugar	44	175	44	0.00	0.044	5.28	0.068
Spices & Condiments	0.08	0.2	0.44	0.014	0.011	0.44	0.019
Dry Fruits	2	3.46	0.00	0.27	0.27	1.2	0.042
Egg	12.55	14.80	0.00	0.45	2.69	1.5	0.00
Meat	6.27	7.9	0.00	0.25	1.41	4.45	0.34
Fish	31.38	282	0.00	31.38	0.00	0.00	0.00
Oil & Fats	750	0.7	0.035	0.040	0.028	1.24	0.015
Milk	7.53	61	0.00	6.8	0.00	0.00	0.00
Ghee/Butter	3.45	12	0.22	0.87	0.83	27.25	0.072
Cheese	1583.26	2367.94	416	50.484	64.773	324.1	23.926
Total	169	583	132	0.85	11.5	17	1.2

Source: Field Survey

Table 5. Per day Consumption of different commodities and their nutritive value on medium farms

Product	Consumption (g/ml)	Energy (Kcal)	CHO (g)	Fat (g)	Protein (g)	Calcium (mg)	Iron (mg)
Maize	152	520	101	5.47	16.87	15.2	6.23
Paddy	163	565	127.46	0.81	11.08	16.3	1.14
Pulses	29	105	13.43	1.47	7.69	41.33	1.60
Wheat	146	505	104	2.19	17.22	59.86	7.73
Vegetables	243	143	28.08	0.58	8.66	163.8	7.37
Fruit	23.39	11	2.57	0.23	0.25	5.26	0.13
Sugar	41	163	41	0.00	0.041	4.92	0.064
Spices & Condiments	0.08	0.2	0.44	0.014	0.011	0.44	0.019
Dry Fruits	2.3	0.00	0.00	0.00	0.00	0.00	0.00
Egg	3	5.19	0.00	0.4	0.4	1.8	0.063
Meat	14.62	17.25	0.4	0.53	3.12	1.75	0.00
Fish	5.86	7.38	0.53	0.23	1.32	4.16	0.32
Oil & Fats	29.24	263	0.23	29.24	0.00	0.00	0.00
Milk	700	0. 64	29.24	0.04	0.026	1.15	0.0014
Ghee/Butter	6.43g	52.37	5.82	5.82	0.00	0.00	0.00
Cheese	4.1	14.26	1.03	1.03	0.99	32.39	0.09
Total		2372.29	455.23	48.054	67.678	348.36	24.7574

Source: Field Survey

Table 6. Per day Consumption of different commodities and their nutritive value on large farms

Product	Consumption (g/ml)	Energy (Kcal)	CHO (g)	Fat (g)	Protein (g)	Calcium (mg)	Iron (mg)
Maize	163	557	108	5.9	18	16.3	6.68
Paddy	181	624	142	6.5	20	18.1	7.42
Pulses	35	127	18	1.96	10.22	54.95	2.13
Wheat	163	564	116	2.44	19.23	66.83	8.63
Vegetables	257	157	30.84	0.64	9.50	179.9	8.09
Fruit	23.37	10.51	2.57	0.23	0.25	5.25	0.12
Sugar	40.85	163	40.60	0.00	0.041	4.9	0.06
Spices & Condiments	0.09	0.22	0.5	0.016	0.012	0.5	0.021
Dry Fruits	2.6	0.00	0.00	0.00	0.00	0.00	0.00
Egg	3	5.19	0.00	0.4	0.4	1.8	0.063
Meat	14.60	17.22	0.00	0.53	3.12	1.75	0.00
Fish	5.8	10.03	0.00	0.23	1.30	4.11	0.31
Oil & Fats	32	288	0.00	32	0.00	0.00	0.00
Milk	876	0.81	0.041	0.046	0.033	1.45	0.0018
Ghee/Butter	8.67	70.62	0.00	7.93	0.00	0.00	0.00
Cheese	4.67	16.25	0.29	1.172	1.125	36.89	0.098
Total		2610.85	458.841	59.994	83.231	392.73	33.6238

Source: Field Survey

Table 7. Gap between recommended and existing level of nutrition-nutritional security gap on different categories of farms

Particular	Unit	Recommended	Existing level			Per cent Gap		
			Small	Medium	Large	Small	Medium	Large
Energy	Kcal	3362	2368	2372	2611	30	29	22
Protein	g	55	65	68	83	-18	-24	-51
Carbohydrates	g	450	416	455	459	8	-1	-2
Fat	g	20	50	48	60	-150	-140	-200
Iron	mg	29	24	25	33	17	14	-14
Calcium	mg	400	324	348	393	19	13	2

Source: Field Survey

Table 8. Labour employed for different crops (Per Hectare)

Sr. No	Crops	Man days
A.	**Rainfed**	
1.	Maize	138
2.	Sugarcane	168
3.	Jowar-bajra	115
4.	Wheat	132
5.	Barley	99
6.	Potato	136
B.	**Irrigated**	
1.	Paddy	164
2.	Maize	139
3.	Mash	115
4.	Ladyfinger	143
5.	Ginger	145
6.	Bajra-Jowar	140
7.	Tomato	173
8.	Pumpkin	108
9.	Cucumber	102
10.	Bottle gourd	113
11.	Bitter gourd	92

Sr. No	Crops	Man days
12.	Black gram	115
13.	Wheat	189
14.	Barley	113
15.	Potato	126
16.	Pea	140
17.	Cauliflower	144
18.	Cabbage	157
19.	Mustard	64
20.	Radish	147
21.	Lentil	98
22.	Barseem	108
23.	Potato	203

Source: Field Survey

Table 9. Suggested farming system for rainfed and irrigated production systems for small, medium and large farms in the study area

Farming system		Unit	Size of farm		
A. Rain fed farming(Rs/ha)			**Small**	**Medium**	**Large**
1.	**Rainfed**				
I.	Maize – Wheat	Percent	16.12	16.92	18.86
II.	Maize + Pulses – Wheat	Percent	3.10	3.78	4.16
III.	Maize – Toria - Wheat	Percent	12.71	13.40	14.19
IV	Maize – Peas	Percent	33.22	34.75	36.33
	Sub-Total	**Percent**	**65.15**	**68.85**	**73.54**
2.	**Irrigated**				
I.	Paddy – Wheat	Percent	10.09	6.90	4.12
II.	Chari – Barseem	Percent	1.03	1.32	1.90
III.	Paddy – Barseem	Percent	1.04	-	-
IV	Tomato – Tomato – Cauliflower	Percent	8.04	7.63	6.18
V.	Tomato – Tomato – Peas	Percent	11.10	10.40	8.68
	Sub-Total	**Percent**	**31.30**	**26.25**	**20.88**
3.	**Fruits**	**Percent**	**3.55**	**4.90**	**5.58**
4.	Operational holding	Hectare	0.253	0.707	2.360
	Cropping intensity**	Percent	210	215	219
5.	Dairy				
	Buffalo		-	1.00	2.00
	Cross – bred Cow		1	2.00	4.00

4. CONCLUSION

It reveals from the study that cereals dominated the cropping pattern among all categories of farmers. Average yield of majority crops was lower than potential yield, highlighting the need for strong extension services needed for bridging the gap at different levels. The rainfed farming accounts for majority (more than 80%) of operation holding, and maize-peas gave maximum return under all categories of farms. Suggested farming system under rainfed farming is maize-peas, followed by maize-wheat and tomato-peas, followed by paddy-wheat under irrigated conditions. The optimized resource-use will enhances the farm income by employing them gainfully. Commercial crops if grown properly can give five to ten times' higher return than cereals. Farmer also faces the problem of lack of awareness as major constraints for low yield of their crops.

COMPETING INTERESTS

Authors have declared that no competing interest exists.

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