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Green Growth and Agriculture in Himachal Pradesh

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Author Manish Anand, Fellow, TERI

Email: manand@teri.res.in

Reviewer Prakashkiran S Pawar, Fellow, TERI

Email: prakashkiran.pawar@teri.res.in

For more information

Project Monitoring Cell
T E R I
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003
India

Tel. 2468 2100 or 2468 2111
E-mail pmc@teri.res.in
Fax 2468 2144 or 2468 2145
Web www.teriin.org
India +91 • Delhi (0)11

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Green Growth and Agriculture in Himachal Pradesh

1. Introduction

Out of the total geographical area of 55.67 lakh hectares in Himachal Pradesh the gross cropped area is about 9.51 lakh hectares. With a net area sown of approximately 5.38 lakh hectares, the cropping intensity stands at 176.6%. About 81% of the total cultivated area in the state is rainfed with a gross irrigated area of 1.87 lakh hectare and net irrigated area of 1.06 lakh hectares. Consumption of fertilizers (nitrogen + phosphatic + potassic) per hectare of gross cropped area has increased from 35.9 kg/ha in 1997-98 to 50.2 kg/ha in 2012-13. Coverage of area under plant protection measures is likely to reach an all-time high of 5 lakh hectares in 2013-14 from 4.5 lakh hectares in 2006-07 with an increase in distribution of agrochemicals from 134 MT to 190 MT during the above periods (GoHP, 2014).

The share of agriculture including horticulture and animal husbandry in Gross State Domestic Product (GSDP) had declined from 26.5% in 1990-91 to 14.42% in 2012-13. In the 1990s, the sector showed an average annual growth rate of 5.7%, which is at par with national level. The economy of the state has shown a shift from agriculture sector to industries and services as the percentage contribution of agriculture and allied sectors in total State Domestic Product has declined from 58.56% in1970-71 to 37.82% in 1990-91and to 19.28% in 2013-14 (Figure 1). Agriculture is one of the major contributors to the total domestic product and has overall impact on other sectors via input linkages, employment and trade (Table 1).

The Agriculture and Allied Activities sector of the state's economy has recorded a growth rate of 4.2% during the Eleventh Five Year Plan and a growth rate of 4.5% in this sector has been envisaged during the Twelfth Five Year Plan (GoHP, 2012). Primary sector, which includes agriculture, forestry, fishing, mining and quarrying, during 2011-12, witnessed a negative growth rate of 5.2%. The agricultural production has increased from previous year but due to decrease in fruit production this sector registered a negative growth.

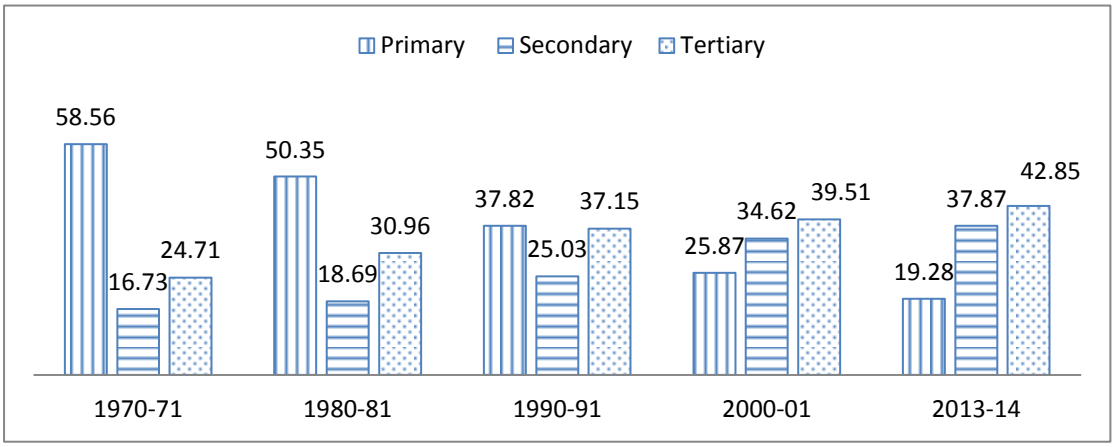

Figure 1 Sectoral contribution to gross state domestic product (%)

Source: Economic Survey of Himachal Pradesh, Economics & Statistics Department, Government of Himachal Pradesh (various years)

Table 1 Contribution of different sectors in the primary sector to the gross state domestic product

Primary sector	2012-13 (in INR billions)	Percentage increase/decrease over 2011-12
Agriculture and Animal Husbandry	56.02	10.6
Forestry and logging	21.15	6.6
Fishing	0.48	10.8
Mining and Quarrying	1.49	11.9
Total Primary	**79.14**	**9.5**

Source: GoHP, 2014

1.1 Employment and livelihoods

There has been a decline in the proportion of total workers engaged in agricultural pursuits from the year 1971 to 1991 indicating movement of workers from the agriculture sector to the secondary and tertiary sector (see, Table 2). However, thereafter in the decade of 2001, an increase in the proportion of agricultural workers and a slight decline in 2011 over 2001 has been observed. This may be probably due to the fact that higher economic returns from diversification towards high value cash crop might have motivated other farmers to engage in similar activities, and also to the fact that lack of technical skills in the work force might have posed challenge to the farmers to get gainful employment in the industry sector (GoHP, undated).

Furthermore, a shift in structure of economy from being an agrarian economy to a diversified economy has not resulted in a corresponding movement of agricultural workers to secondary and tertiary sectors indicating a fall in per worker productivity in the primary sector.

As per 2011 Census, 30.05% of the total population of Himachal Pradesh (68.65 lakh) is classified as main workers, 21.81% as marginal workers and the rest 48.15% as non-workers. Compared to the 2001 Census, there has been a decline in percentage of cultivators and increase in agricultural labourers in the 2011 Census. Of the total workers (main+marginal), 57.93% are cultivators and 4.92% agricultural labourers in 2011 as compared to 65.33% cultivators and 3.15% agricultural labourers in 2001.

Table 2 Changes in occupational structure as percentage of total population in Himachal Pradesh

Particulars	1971	1981	1991	2001	2011
A. Total workers	36.80	42.38	42.82	49.24	51.85
i) Cultivators and agricultural labour	75.82	57.46	53.48	68.65	62.85
ii) All other occupations	24.18	42.54	46.52	31.35	37.15
B. Non workers	63.20	57.62	57.18	50.76	48.15

Source: Census data (various years)

1.2 Landholdings

The average land holding size for Himachal Pradesh is 1.04 hectare (Table 3). Distribution of land holdings according to 2005-06 Agricultural Census shows that 87.03% of the total holdings are of small and marginal farmers. About 12.54% of holdings are owned by semi medium/medium farmers and only 0.43% by large farmers.

Table 3 Distribution of land holding - Himachal Pradesh

Size of holding (ha.)	Category (farmers)	No. of holdings (lakh)	Area (lakh ha.)	Av. size of holding (ha.)
Below 1.0	Marginal	6.36(68.17%)	2.58 (26.65%)	0.41
1.0-2.0	Small	1.76(18.86%)	2.45 (25.31%)	1.39
2.0-4.0	Semi-medium	0.88(9.43%)	2.40 (24.79%)	2.73
4.0-10.0	Medium	0.29(3.11%)	1.65 (17.05%)	5.69
More than 10.0	Large	0.04(0.43%)	0.60(6.20%)	15.00
	Total	**9.33**	**9.68**	**1.04**

Source: GoHP, 2014

1.3 Area, Production and Productivity

During the year 2012-13, the food grains production was achieved at a record level 15.68 lakh MT against 15.44 lakh MT during 2010-11. The production of Potato increased from 1.52 lakh MT in 2011-12 to 1.83 lakh MT in 2012-13. The production of vegetables witnessed a marginal increase from 13.8 lakh MT during the year 2012-13 as against 13.57 lakh MT in 2011-12. Due to an increasing shift towards commercial crops, the area under food grains is gradually declining from 853.88 thousand hectares in 1997-98 to 798.31 thousand hectares in 2012-13. There is an increase in productivity over the years as evident from the Table 4 below.

Table 4 Production and area under foodgrains and fruits in Himachal Pradesh

Year	Area		Production		Production per hectare
	Foodgrains (thousand ha.)	**Fruits (ha.)**	**Foodgrains (thousand MT)**	**Fruits (thousand MT)**	**Foodgrains (MT/ha.)**
1991-92	858	170768 (66767)	1340	342.3 (301.73)	1.56
1995-96	848.9	195684 (78292)	1363.3	311.81 (276.68)	1.61
2000-01	813.9	217226 (90347)	1112.1	428.03 (376.73)	1.37
2005-06	792.9	191668 (88560)	1068.69	695.52 (540.36)	1.6
2007-08	811.98	200502 (94726)	1440.66	712.84 (592.57)	1.77
2008-09	797.25	204629 (97438)	1226.79	628.07 (510.16)	1.53
2009-10	784.02	208154 (99564)	1111.16	382.24 (280.11)	1.41
2010-11	795.18	211295 (101485)	1493.87	1027.82 (892.11)	1.88
2011-12	790.70	214574 (103644)	1544.49	372.82 (275.04)	1.95
2012-13 (Tentative)	798.31	218303 (106440)	1567.72	555.70 (412.39)	1.96
2013-14 (Ant. Ach.)	794.47	-	1516.33	-	1.91
2014-15	795.50	-	1602.50	-	2.01

Year	Area		Production		Production per hectare
	Foodgrains (thousand ha.)	**Fruits (ha.)**	**Foodgrains (thousand MT)**	**Fruits (thousand MT)**	**Foodgrains (MT/ha.)**
(Target)					

Note Figures in parentheses indicate corresponding figures for apple

Source: Economic Survey of Himachal Pradesh, Economics & Statistics Department, Government of Himachal Pradesh (various years)

2. Resource use status, issues and challenges in agriculture in Himachal Pradesh

2.1 Land utilization

Agricultural systems are totally dependent on the availability of fertile land which is one of the main determinants of sustainable agriculture. Table 5 depicts land utilization pattern of the state of Himachal Pradesh.

The total geographical area in Himachal Pradesh increased by about 55.50 % from 2930.90 thousand ha in 1972-73 to 4559.01 thousand ha during 2009-10. The percentage net cultivated area to total geographical area decreased consistently over the years from 19.07 % in 1972-73 to 11.81 % in 2009-10. The proportion of current fallow, long term fallow and culturable waste land to total geographical area is 1.32, 0.48 and 2.81 % respectively which has been very low as compared to many other states. Over the years the forest and barren land showed an increase, whereas, reverse trend was observed in case of permanent pastures. The land put to non-agricultural uses sharply increased to 16.14 % in 2003-04 from 3.85 % in 1972 which may be due to diversion of common lands for non-agricultural purposes like, building construction, road network, industrial development etc. Thereafter, land put to non-agricultural uses as a percentage of total geographical area again witnessed a decline to 7.65 % in 2009-10.

Table 5 Land utilization pattern in Himachal Pradesh (Per cent)

Land category	1972-73	1981-82	1991-92	2003-04	2009-10
Forest	21.75	26.24	30.52	24.19	24.26
Barren	4.42	4.61	5.81	8.64	17.18
Non-agricultural uses	6.49	3.85	5.98	16.14	7.65
Culturable waste	4.33	7.80	3.42	2.83	2.81
Permanent pasture	40.64	35.78	33.94	33.34	32.99
Misc. tree crop	1.5	1.33	1.42	1.38	1.50
Current fallow	1.69	1.42	1.39	1.23	1.32
Other fallow	0.11	0.43	0.59	0.36	0.48
Net area sown	19.07	18.54	16.93	11.89	11.81
Total geographical area ('000' ha.)	**2930.9**	**3089.4**	**3390.5**	**4544.2**	**4559.0**

Source: Directorate of Land Records, Government of Himachal Pradesh (various years)

There has been a decrease in the net cultivated area over time. The irrigated area has almost remained constant over a period of time. Furthermore, erratic climatic conditions have posed challenges to the economic viability of farming in the state. Farmers have switched over from the agricultural profession leaving the land uncultivated. As a consequence, a significant portion of farm land gets abandoned. This has led to land degradation. In some of the niches of the state farmers have opted for cash crops like off-season vegetable crops and fruit cultivation and they are growing these crops over a period of time mainly because of its profitability. The monoculture of high value cash crops (cultivation of same crop over a period of time) along with extensive unbalanced fertilizer use and high doses of plant protection measures for a long time have seriously threatened the land quality and have led to decrease in per unit of land productivity. Overexploitation and degradation of land has become a major threat to sustainable agricultural development in general and production in particular. The other factors for land degradation might be fragmentation, migration, non-farm income, leased-out land etc. (Gupta, 2007)

To increase the crop production in the rain-fed areas, the land has been intensively utilized wherever possible. But there is a little scope for area extension which has created pressure on marginal lands and steeper slopes causing severe land degradation. It has been observed that due to migration from rural to urban areas the fallow land is increasing. This is likely to decrease the production and increase the land degradation.

Land degradation is a serious problem that threatens the sustainable development of the agriculture sector. Land degradation's impact on productivity may affect food security in some areas both through losses in aggregate production (and thus higher prices for all consumers) and through losses in income for those who derive their livelihood from agricultural land and agricultural labour (Wiebe, 2003)

The extent of desertification/land degardation in the state as per the remote sensing data of 2007 of Space Application Centre (SAC) is 2762.74 thousand ha which is 49.62% of the total geographical area of the state (See, Table 6). The major soil degradation problems as observed in the state are water erosion including topsoil loss and terrain deformation, flooding and acidity. Due to topographical factors the soil is subject to splash, sheet and Gully erosion resulting into degradation of the soil. Soil degradation has its impacts on the agricultural system of the state by way of decline in soil fertility, reduction in soil organic status, progressive diversion of agricultural land to non-agriculture uses, acceleration in soil erosion and sedimentation of water bodies.

Vegetal degradation observed mainly as deforestation/forest-blanks/shifting cultivation and degradation in grazing/grassland as well as in scrubland is the most significant process of land degradation in Himachal Pradesh (34.46%). This is followed by frost shattering observed due to the freeze and thaw action operating mainly in periglacial environment (13.32%) followed by water erosion (1.75%). Table 6 provides processwise distribution of the area under land degradation for Himachal Pradesh

Table 6 Processwise distribution of the area under land degradation for Himachal Pradesh

Desertification/ Land degradation Units	Area (ha)	Process wise Area (ha)
Forest-water erosion – low (Fw1)	52459	
Forest-water erosion – high (Fw2)	14347	
Land with scrub-water erosion – high (Sw2)	30426	97232
Forest- vegetal degradation-low (Fv1)	284465	
Forest vegetal degradation – high (Fv2)	65007	
Land with scrub-vegetal degradation – low (Sv1)	1248744	
Land with scrub-vegetal degradation – high (Sv2)	320413	1918629
Dune/ sandy area-wind erosion – low (Ee1)	259	259
Barren-mass movement – low (Bg1)	3434	
Barren-mass movement – high (Bg2)	1409	4843
Peril-glacial-forest shattering (in cold areas)- high (Lf2)	741783	741783
Water body/ drainage (W)	25937	
Settlement		
No Apparent Degradation (NAD)	2778617	
Total Area Under Desertification/ Land degradation		**2762746**
Total Geographical Area	**5567300**	

Source: SAC, 2007

2.2 Transitions in farm enterprises

There has been a change in the cropping pattern at the state level over the years brought about by diversification into production of cash crops like ginger, potato, off-season vegetables, kiwi, cherries, hops and into fields like apiculture and mushroom production. The process of crop diversification gained momentum in the nineties and has now encompassed many new areas in the low and mid hill districts. The area under foodgrain crops like rice, wheat, barley, other cereals and pulses has witnessed a decline while the area under fruits and vegetables has increased over the period (See, Table 7).

Table 7 Area under principal crops in Himachal Pradesh (in thousand hectares)

Year	Cereals								Ginger	Chillies	Non-food crops	Fruits	Vegetables
	Wheat	Maize	Rice	Barley	Ragi	Common millets	Pulses	Total Food Grains			Oil Seeds		
1993-94	375.80	304.90	87.80	27.60	-	-	42.30	854.80	1.40	0.90	19.30	182.30	-
1994-95	374.90	308.50	82.80	26.30	-	-	39.60	847.80	1.30	1.10	18.50	189.69	-
1995-96	357.70	309.50	83.00	27.00	-	-	36.00	831.40	1.40	0.80	17.80	195.68	-
1996-97	373.00	307.30	81.70	24.60	-	-	36.40	840.20	1.40	1.20	20.80	196.21	45.80
1997-98	377.30	311.90	86.20	27.70	-	-	35.90	855.50	1.50	1.10	20.20	202.36	45.80
1999-00	370.60	299.90	80.20	25.90	3.90	15.20	32.60	828.30	2.00	1.00	14.60	212.95	
2000-01	362.70	298.10	81.50	25.60	41.10	10.80	31.10	814.70	2.30	0.90	-	217.23	44.80
2001-02	366.50	301.30	80.60	25.00	40.10	97.10	29.00	816.10	2.60	1.00	-	223.04	34.60
2002-03	359.50	299.80	80.60	23.60	32.20	99.90	29.70	806.40	2.50	0.80	15.70	176.21	44.30
2003-04	363.36	298.47	81.34	24.32	3.94	12.27	28.68	812.37	2.04	0.77	15.73	182.44	59.30
2004-05	369.77	298.61	79.52	23.43	3.47	8.90	29.34	813.04	2.04	0.74	11.19	186.90	46.21
2005-06	358.45	295.35	79.37	25.54	3.32	8.50	7.13	777.36	2.18	0.60	15.03	191.67	49.86
2006-07	362.25	299.04	69.21	24.10	2.95	7.48	22.90	787.91	2.27	0.62	14.90	197.45	52.05
2007-08	366.59	300.15	78.57	23.51	1.85	7.44	33.87	811.98	2.27	0.67	14.64	200.50	53.00
2008-09	360.07	298.81	76.72	22.63	1.29	8.58	31.16	799.45	2.17	0.64	15.44	204.63	58.74
2009-10	352.52	295.44	76.70	21.24	2.68	5.41	21.23	775.22	2.13	0.58	13.95	208.15	63.88
2010-11	357.24	296.37	77.06	22.34	2.32	5.72	33.70	794.76	2.08	0.73	14.28	211.30	65.08
2011-12	355.87	293.94	74.98	20.63	2.55	6.81	33.28	788.05	2.10	0.62	13.81	214.57	67.97

Source: www.indiaagristat.com

The process of diversification towards fruits and vegetable crops in the state started with the introduction of apple in the late fifties and sixties in district Shimla and Kullu. The process has now spread to different regions in many other districts, namely, Solan, Sirmaur and even to low and mid-hill districts and encompasses cultivation of high value crops like seasonal and off-seasonal vegetables. Over the years, the state has emerged as a leading producer of temperate fruits and off-season vegetables. Area under fruit crops increased from 1.70 lakh hectares in 1991-92 to 2.14 lakh hectares in 2011-12. Apple is the most important fruit crop accounting for more than two-fifths of the total area under fruit crops (48%) and around three-fourths of the total fruit production (76%).

The area under vegetable crops has also witnessed rapid increase in recent years. Area under vegetable crops increased from 69.84 thousand hectares in the 2007-08 to 79.81 thousand hectares in 2011-12.

Thus, the horticulture sector is emerging as a prime mover of the growth in agriculture in the last few years in the state. The process of crop diversification towards horticultural including vegetable crops is also manifested in rising share of horticulture in the gross value of output originating in agriculture which has gone up from 25.21%in 1999-2000 to 40.67% in 2006-07.

The drivers of agricultural diversification in the state largely pertains to adoption of a planning strategy that focused on overcoming constraints imposed by mountain specificities

viz., inaccessibility, marginality and fragility, creation of network of institutions like setting up of the Himachal Pradesh Horticultural Produce Marketing and Processing Corporation (HPMC), establishment of a number of R&D institutions by the centre and state government[1], introduction of support prices for different fruit crops, market consciousness among the farmers and availability of huge market in Delhi, emergence of relatively efficient marketing system, and emergence of self-help institutions like fruit growers' associations/cooperatives in some of the producing regions (Sharma, 2011).

2.3 Mechanization of the farm

Energy use in agriculture at the farm level can be categorized as either direct or indirect. Direct energy use in agriculture is in the form of diesel and electricity to operate mobile and stationary equipment to prepare fields, plant and harvest crops, and transport inputs and outputs to and from markets. Indirect energy is consumed off the farm for the manufacture of fertilizers and pesticides.

Due to recent trends in modernization of agriculture, there is an increase in energy input use in the form of tractor cultivation, use of threshers, tube well irrigation, diesel or electric engines, power sprayers etc. as depicted in Table 8.

Table 8 Number of farm power sources and implements in Himachal Pradesh

Particulars	1992	1997	2001
Ploughs	7,10349	4,62,439	6,31,470
Bullock carts	1,128	1,807	2,404
Cane crushers	1,878	1,213	1,135
Tractors	3,466	4,205	6,966
Oil engines	1,299	1,295	3,664
Electric pumps	1,222	2,530	7,325
Threshers	19,221	14,048	19,458

Source: GoHP, 2013a

Although the mechanization of the hill farms is on the rise, small land holding size and inadequate irrigation facilities is still limiting the usage of modern farm implements. Looking at the district-wise farm machinery use and gap in Himachal Pradesh provided in Table 9, the most noticeable change has been the use of threshers in the State varying from 46.1-52.0% in the high hill districts of Shimla, Sirmaur and Lahaul & Spiti to 92.0-96.0% in the low hill districts of Hamirpur and Bilaspur. The use of power tillers is quite low in all the districts and spray pumps is being used widely in the horticultural districts such as Kullu and Shimla. High usage of tractors is observed in the districts of Hamirpur, Bilaspur and Chamba. These districts having their livestock production system dominated by buffaloes has higher usage of chaff cutters.

[1] The research centres/ institutions included Agricultural University, a separate University of Horticulture and Forestry, Central Potato Research Institute at Shimla, National Institute of Mushroom Research at Solan, IARI Regional Research Station for Vegetable Research at Katrain (Kullu) and Institute of Himalayan Bio-resources Technology at Palampur.

Table 9 District-wise farm machinery use and gap in Himachal Pradesh

Particulars	Parameter	Bilaspur	Chamba	Hamirpur	Kangra	kinnaur	Kullu	Lahaul & Spiti	Mandi	Shimla	Sirmaur	Solan	HP
Maize	% Use	14.53		65			6		39	2.6	17		
Sheller	Existing	1922		2634	2100		83		4048	388	1881		13056
	Requirement	2316		3136	3187		150		17958	10141	2600		39488
	Gap	394		502	1087		67		13910	9753	720		26433
Thresher	% Use	92.22	58	96			59	52	77	46.1	48		
	Existing	2448	69	2375	2891	7	383	0	6554	2722	2285	160	19894
	Requirement	2571	126	2566	3790	11	516	0	6869	5553	3700	205	25907
	Gap	123	57	191	899	4	133	0	315	2831	1415	45	6014
Iron	% Use	36.98	76	38			50	55	80	55.9	55		
Plough	Existing	14611	1215	14366	34019	4227	32156	139	131190	13582	37131	3449	286084
	Requirement	17533	1787	17365	47045	6105	49110	239	102395	72271	49921	5800	369571
	Gap	2922	572	2999	13026	1878	16954	100	28795	1311	12789	2351	83698
Spray	% Use	30.77	63	26			74	60	34	59.1	41		
pump	Existing	2964	519	1755	18349	6888	26216	2724	10822	69365	25426	38	165066
	Requirement	3705	787	50365	37889	9138	33491	618	15940	64740	52949	84	269706
	Gap	741	268	48610	13540	2250	7275	0	5118	4625	27523	46	109996
Chaff	% Use	43.92	65	67			1		17	2.81	17		
cutter	Existing	17977	808	5532	30195	789	244	1262	10439	17040	17675	2020	103981
	Requirement	22472	1349	52565	46347	2381	1486	1353	42440	40358	35381	3300	249432
	Gap	4495	541	47033	16152	1592	1242	231	32001	23318	17706	1280	145591
Power	% Use	0.12	1	0			0	2	3	0.5	1		
tiller	Existing	18	62	51	273	5	110	800	428	114	247		2108
	Requirement	77	86	525	2012	17	874		1713	2044	632		7980
	Gap	59	24	474	1739	12	764		1285	1938	385		6680
Tractor	% Use	56.37	46	66			10	27	24	5.6			
	Existing	442	39	1165	2342		644	183	2395	112			7322
	Requirement	465	104	1374	3719		890	245	2348	829			9974
	Gap	23	64	209	1377		246	62	47	717			2745

Source: GoHP (2013b)

2.4 Use of farm inputs

Use of fertilizers in agriculture started in the state in the late 1950s and early 1960s. Since then the level of fertilizer consumption in the state is continuously increasing. The level of fertilizer consumption has increased from around 30 kg/ha in1993-94 to around 51.3kg/ha in 2009-10 (Table 10).

Table 10 Fertilizer consumption per unit of gross cropped area in Himachal Pradesh

Year	Nitrogenous (N) (kg/ha)	Phosphatic (P) (kg/ha)	Potassic (K) (kg/ha)	Total (NPK) (kg/ha)
1993-94	25.79	2.55	1.74	30.08
1994-95	25.67	2.48	2.04	30.20
1995-96	26.17	2.70	2.37	31.25
1996-97	28.22	4.05	3.31	35.58
1997-98	27.38	4.44	3.52	35.34
1998-99	30.04	5.38	4.33	39.75
1999-00	28.84	6.02	4.17	39.03
2000-01	25.77	6.90	4.85	37.52
2001-02	28.78	7.37	5.87	42.02
2002-03	27.13	8.37	6.52	42.02
2003-04	32.35	9.11	7.53	48.98
2004-05	32.19	8.94	7.37	48.50
2005-06	32.17	10.31	8.33	50.81
2006-07	32.28	10.72	8.35	51.34
2007-08	36.04	9.93	9.70	55.67
2008-09	37.48	11.31	11.84	60.63
2009-10	33.30	11.59	11.71	56.60

Source: Fertiliser Statistics, The Fertiliser Association of India and Department of Economics & Statistics, Government of Himachal Pradesh

Although there has been a reduction in the area under plant protection measures as evident from Table 11. However, the use of pesticides has shown a sharp rise particularly in vegetable crops. There is also more use of herbicides or weedicides.

Table 11 Distribution of agrochemicals in Himachal Pradesh

Year	Coverage of area under plant protection measures (thousand hectares)	Distribution of agrochemicals (MT)
2007-08	440	135
2008-09	435	135
2009-10	442	169
2010-11	438	141
2011-12	315	120
2012-13	320	121
2013-14 (likely)	500	190
2014-15 (target)	350	135

Source: GoHP, 2014

Decrease in the number of farm animals per household which is also linked to the shortage of fodder is posing a challenge in the availability of Farm Yard Manures (FYM), particularly on vegetable and fruit-based systems. The fodder-scarcity was further aggravated with the decrease in number and area of grazing lands, infestation of pastures with obnoxious weeds and more thrust on vegetable cultivation. Low availability of farm based manures has led to increased dependence on inorganic fertilizers. Decrease in availability of FYM and increased use of chemical fertilizers has also led to increase in the ratio of the cost of fertilizers to FYM, particularly in mid-hills. Studies have established that overuse of agrochemicals and insecticides causes imbalance of soil available nutrients, loss of useful microbial flora and pose challenge in sustainably raising the crops in the long run.

2.5 Irrigation-water availability

Out of total net sown area of the state of 5.38 lakhs ha, only 1.06 lakhs ha is the net irrigated area. Of the total irrigated areas, 7.14% is irrigated by canals, 7.14% by wells & 85.71% by other sources of irrigation like kuhls, tube wells, shallow wells, lift irrigation, check dams, and storage tanks (Table 12).

Table 12 Net irrigated area in Himachal Pradesh through various sources (ha.)

Year	Canals	Tanks	Wells & Tube wells	Other Sources	Total
1997-98	3398	255	11820	87144	102617
1998-99	3178	258	11424	86655	101510
1999-2000	3337	270	13169	85131	101907
2000-01	3463	263	14172	105758	123656
2001-02	3666	257	12899	85284	102106
2002-03	3510	267	11764	108377	123918
2003-04	3520	3	13569	87989	105081
2004-05	3379	28	15512	85571	104490
2005-06 (P)	4010	654	16200	83163	104027
2006-07 (P)	4107	701	15744	86997	107549
2007-08 (P)	4390	236	15752	73172	93550
2008-09 (P)	4046	283	17432	86091	107852
2009-10 (P)	4104	149	19357	81966	105576

Source: Annual Season and Crop Reports, Directorate of Land Records, Government of Himachal Pradesh.

It is estimated that ultimate irrigation potential of the state is approximately 3.35 lakh hectares. Out of this, 0.50 lakh hectares can be brought under irrigation through major and medium irrigation projects and balance 2.85 lakh hectares of area can be provided irrigation through minor irrigation schemes by different agencies.

2.6 Measuring progress towards green agriculture

To address the environmental issues in the agriculture sector in Himachal Pradesh a wide range of initiatives have been undertaken by the government. Table 13 depicts the status of progress of some of these activities in Himachal Pradesh.

Table 13 Status of progress towards green agriculture in Himachal Pradesh

Action areas	Outcome indicators	2010/11	2011/12	2012/13	2013/14	2014/15
Treatment of area against erosion	Area treated under arable and non-arable land (Ha.)	829.5	500	550	0	-
Rain water harvesting	Construction of individual tanks (numbers)	1695	1145	1211	1215	1220
Efficient use of irrigation water	Installation of micro-irrigation system (Ha.)	3100	4252	2500	2800	3000
Soil health management	Health cards issued (numbers)	134607	124673	125000	125000	125000
Promotion of organic farming	Area under certified organic farms (Ha.)	894	1035	1000	1100	1200
	Area under conversion to organic farming (Ha.)	977	2060	2000	2000	2000
	Setting up of vermicompost units (numbers)	35659	38616	30000	30000	30000
Implementation of crop insurance	Formulation of contingent plan for Kharif	30/06/2010	30/06/2011	30/06/2012	30/06/2013	30/06/2014
	Formulation of contingent plan for Rabi	15/12/2010	15/12/2011	15/12/2012	15/12/2013	15/12/2014

Source: GoHP, 2013c

3. Institutional framework

A number of institutions have a bearing on the sector on issues pertaining to resource efficiency and green growth in agriculture in Himachal Pradesh. Figure 2 provides a snapshot of various institutions in the domain of policy & governance, research & extension, and marketing in the state. The Department of Agriculture is the nodal department for carrying out activities related to agriculture in the State. The Department of Agriculture concentrates on agriculture production and soil water conservation. Functions of the agricultural department include, imparting latest technology for increasing agricultural production, timely supply of agricultural inputs, spreading awareness among the farmers about various aspects of farming viz., soil and water conservation technologies, diversified farming, encouraging economic use of irrigation water, impart marketing facilities of agricultural produce, impart training on integrated pest management, encourage use of bio-fertilizers and, to create irrigation facilities to the farmers through minor/tank irrigation schemes so as to obtain maximum returns from their land.

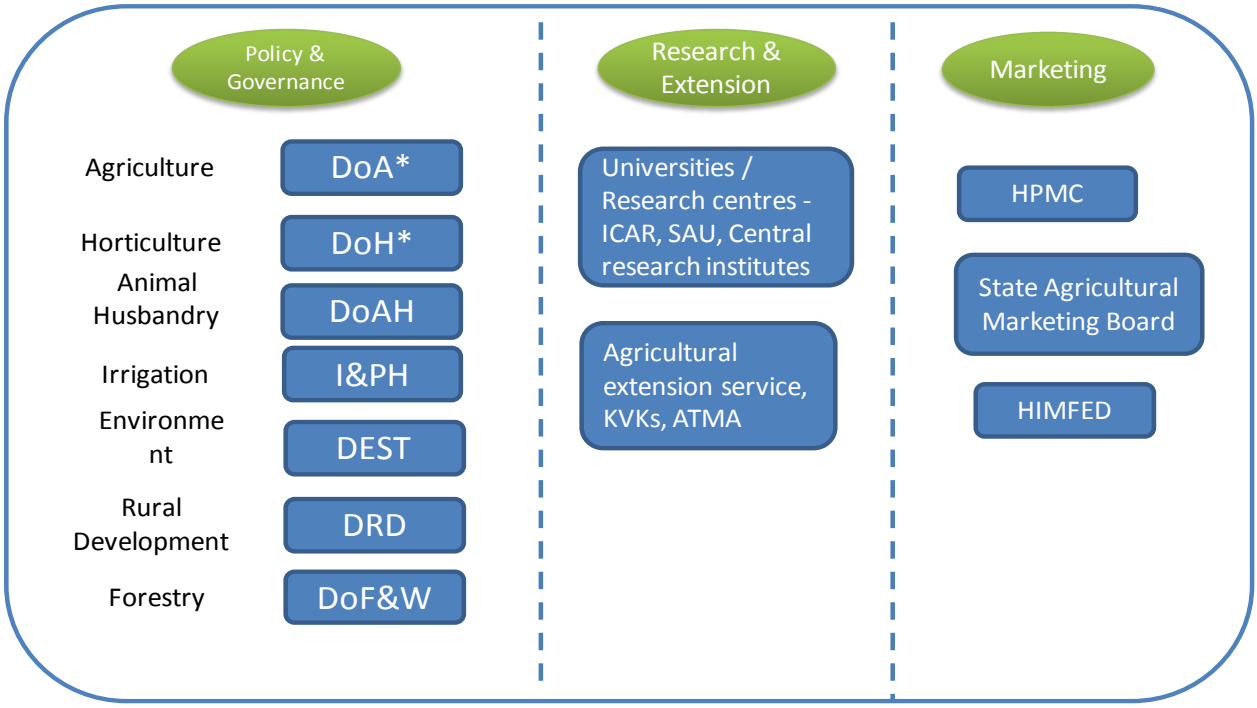

Figure 2 Snapshot of institutional framework in HP Agriculture Sector

Acronyms

*Nodal departments for agriculture and horticulture in the state

DoA	Department of Agriculture, HP
DoH	Department of Horticulture, HP
DoAH	Department of Animal Husbandry, HP
I&PH	Irrigation and Public Health Department, HP
DEST	Department of Environment, Science & Technology, HP
DRD	Department of Rural Development, HP
DoF&W	Department of Forest and Wildlife
ICAR	Indian Council of Agricultural Research
SAU	State Agricultural University
ATMA	Agricultural Technology Management Agency
HPMC	Himachal Pradesh Horticultural Produce Marketing and Processing Corporation
HIMFED	Himachal Pradesh State Cooperative Marketing and Consumer's Federation Ltd.

Department of Environment, Science & Technology (DEST) is a scientific department engaged in multifarious environmental activities including formulating, establishing and managing the State Government Policies on environmental issues. To ensure the sustainability of natural resources and to develop a long term perspective of achieving environmentally sustainable development, DEST, Government of Himachal Pradesh has undertaken the preparation of Environment Master Plan (EMP) for the State. Sectoral

approach to Environment Master Plan (EMP) has been adopted to mainstream environmental concerns. Agriculture included in the Natural Resources Management sector has been identified for EMP preparation. In the EMP for the agriculture sector, gaps have been identified within the existing institutional framework. Furthermore, institutional responsibilities to implement actions identified and approved by the nodal department and line departments have also been described. In order to address environmental issues identified in concerned sectoral guidelines, a number of interventions are required from the nodal department with identified line departments. Table 12 depicts the proposed actions, type of response and inter-sectoral responsibilities for the agriculture sector defined in the Environment Master Plan (EMP) for the State.

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Table 14 Proposed actions, type of response and inter-sectoral responsibilities for the agriculture sector in Himachal Pradesh

Issues	Causes	Impacts/Risks	Proposed Actions	Policy	Plan	Programme	Project	Coordination Agency	Collaboration Agency
• Predominant rainfed agriculture	• Irrigated area is 19 % only • Abnormal pattern of rainfall • Non-availability of water sources hilly terrain	• Frequent crop failures. • Vegetable low productivity.	• Introduction of water efficient micro-irrigation system. • Approach on a large scale rainwater harvesting • Increase use of mulch, organic manures, drought tolerant crops, etc. • Watershed development approach for rain fed agriculture			√	√	Agriculture	Horticulture, SAU's and R& D Institutes, NGO's, PRI's, IPH, Rural Development, I&PH
• Shift in cropping system by market driven forces	• Cereal-legume cropping system being shifted to vegetable crop due to increased income. • Increased availability of irrigation water. • Climate Change	• Soil health dwindling. • Reduction of area under Food Crops.	• Adherence to crops and cropping systems in line with soil fertility status indifferent agro climatic zones as per their suitability. • Need to identify crops which can adapt to climate change suitability. • Package of practices for the crops to be developed and practiced accordingly	√	√	√		Agriculture	SAU's & HPMB
• Inadequate soil and water conservation measures	• Soil and water erosion due to sloppy land, poor textured and less soil depth. • Lack of vegetation cover in catchment area. • Growing flood menace due to high intensity of rainfall.	• Sheet, rill and gully erosion. • Low productivity. • Washing away of cultivable area. • Cultivation of crops on high slope (> 30%)	• Promote soil conservation measures by people participation • Increase vegetation and vegetative conservation. • Emphasis on rainwater harvesting and conservation. • Promotion of contour terracing on sloppy fields. • Follow watershed development approach			√	√	Agriculture	Horticulture, Forest, IPH, Rural Development, SAU's, R&D Institute, I&PH
• Use of agrochemicals in agriculture	• Indiscriminate use of pesticides. • Inadequate awareness.	• Loss of useful microbial flora in soil. • Adverse impact on environment. • Ground water contamination and risk to human health due to residual effect.	• Promotion of biopesticides. • Promotion of organic farming. • Promotion of IPM technology. • Awareness campaigns to educate farmers.			√	√	Agriculture	Horticulture

Issues	Causes	Impacts/Risks	Proposed Actions	Policy	Plan	Programme	Project	Coordination Agency	Collaboration Agency
• Threat from obnoxious weeds	• Outflow of weeds through rain, wind, irrigation water, cattle, birds, etc.	• Adversely affecting crop yields, pasturelands & soil fertility. • Damage in crop area. • Poisonous to human & animals. • Environmental degradation	• Identity and map areas infested with obnoxious weeds and prepare an action plan with suitable interventions depending on the species and extent of the areas infested, through community involvements. • Conduct techno – economic feasibility study and market based incentives for utilization of products derived from obnoxious weeds		√		√	Agriculture	Forest & Rural Development, SAU's & A.H.
• Low adoption of latest technology by the farmers	• Incompatibility of technology developed at research station vis-à-vis farmer's field. • Lack of awareness. • Poor financial conditions.	• Low crop productivity and farm income.	• Strengthening extension network. • Need to provide better extension and communication network • Need based and location specific R&D.			√	√	Agriculture	Horticulture, SAU's and R&D institute.
• Dwindling soil health	• Continuous cropping, high intensity. • Replenishment of nutrient is less. • Soil erosion. • Low use of organic matter.	• Poor soil health leading to low productivity. • Increase in cost of production.	• Integrated nutrient management. • Soil testing and judicious use of nutrients • Promotion of organic farming		√	√	√	Agriculture	Horticulture, SAU's and R&D institute.
• Suffering of farmers due to losses of crops on account of weather risk	• Frequent occurrence of natural calamities like drought, cloud bursts, heavy rains, hailstorms, temperature fluctuations, hailstorm, frost etc.	• Result in problems of soil and water erosion. • Productive soil is lost. • Loss to the crops and quality of produce is affected.	• Early warning of natural calamities of heavy rains, hailstorms, cloud burst and temperature to be given by IMD. • Crop insurance and contingency crop planning Integrated. • Natural Resource Management. • Develop and promote varieties tolerant to fluctuations of weather. • Strong support for protected cultivation. • GIS methods for detailed soil resource mapping and land use planning.			√	√	Agriculture	Horticulture, IMD, SAU's & R&D Institutes
• Inadequate	• Inadequate investment.	• Unremunerative	• Market led production System.			√	√	Agriculture	HPMC,

Issues	Causes	Impacts/Risks	Proposed Actions	Policy	Plan	Programme	Project	Coordination Agency	Collaboration Agency
marketing and postharvest infrastructure	• Inaccessibility of production area. • Difficult topography. • Lack of knowledge about modern system of marketing.	price to farmers. • Low returns due to inefficient marketing. • Loss in quality of produce. Damage/rottage.	• Sensitization of farming community regarding efficient marketing & post-harvest technology. • Creation of better marketing infrastructure facilities like marketing yard, transportation, collection, storage, grading and packing near the production area. • Need to develop and promote efficient post harvesting technologies. • Need to establish rural connectivity by constructing farm access roads. • Needs to develop sound market intelligence network. • Organize farmers into commodity groups & their capacity building. • Contract farming.						Horticulture HPMB, SAU's and R&D Institutes
• Increasingly small holdings may lead to non-cultivable land	• Average size of landholding is 1.1 ha and may further go down in view of fragmentation of holdings	• Subsistence farming results in unemployment. • Low crop yields. • Increase in current fallows.	• Promotion of precision farming. • Increasing cropping intensity. • Promotion of high value crops. • Bringing fallow land under cultivation. • Bringing more area under efficient irrigation through rain water harvesting. • Consolidation of holdings.	√	√	√	√	Agriculture	Horticulture, Revenue & I&PH
• Impact of climate change on agriculture	• Global Warming. • Aberration in weather • Industrialization	• Introduction/extension of new flora and fauna. • Change in crop/cropping seasons. • More biotic and abiotic stresses on crops.	• Need to strengthen R&D to develop varieties/techniques/technologies to mitigate the adverse impact of climate change. • Conservation of germplasm. • Strengthening of IMD to forewarning about weather up to micro level in hilly areas. • Creating awareness among farmers.	√	√			Agriculture	Horticulture, SAU's and R&D Institute

Source: GoHP, 2013b

4. Policy and regulatory interventions

Following policy interventions has been made by the state government and the central government towards the environmental sustainability of the agriculture sector and its future growth in Himachal Pradesh.

4.1 Schemes of the State Government

4.1.1 Promoting balanced use of fertilizers

With a view to provide fertilizers to the farmers at reasonable rates throughout the State, 100% subsidy on transportation of all kinds of fertilizers to retail sale points from Block Head Quarter HIMFED Godown is being given thereby bringing the uniform sale rates of fertilizer in the State. The State Govt. has also allowed subsidy on cost of Urea and Ammonium Sulphate @INR 200/- per MT, and on complex fertilizers NPK 12:32:16 and NPK 15:15:15 @INR 500/-per MT. These subsidies are provided under Plan and Non-Plan. Outlay proposed under this scheme is to meet expenditure of cost and transport on fertilizers besides staff cost. In order to ensure adequate supply of fertilizers, thegovernment has entrusted this responsibility to HIMFED/Cooperative Societies. The farmers are educated about balanced use of fertilizers as per soil testing nutrient basis. There is a budget provision ofINR 57.1 million for the year 2014-15.

4.2 Production of organic manures through vermiculture

From 2010-11 assistance ofINR 3750/- per farmer is being provided (50% assistance for construction of Vermi pit size of 10'x6'x1.5' includingINR 250/- for cost of 2 kg of Vermiculture and ISI marked HDPE vermin bed. 409114 such vermin composting units have already been set-up upto 2011-12. As per modified scheme, assistance ofINR 4000/- is being provided under RKVY to set up ISI marked HDPE portable vermi bed for production of vermicompost. About 26000 units will be setup during 2013-14. It is proposed to set up 28000 such units during 2014-15. In order to cover all the farming families, the scheme is required to be continued during 12th Five Year Plan (2012-2017).

4.3 Effective plant protection measures

About 650 MT of pesticides through 991 sale centers are supplied to the farmers. Besides this, Pesticide Testing Laboratory at Shimla has been set up with a capacity of 150 to 250 samples per year. One Bio Control Laboratory has been set up at Palampur and Mandi where conservation, pest situation augmentation, rearing and multiplication of bio-agents and training to extension staff and farmers are being done. This is a continued scheme and the provision is made for meeting the expenditure on cost subsidies of plant protection material. The plant protection material including equipments are supplied to the SCs/STs/IRDP families and farmers of the backward areas at 50% cost. The outlay proposed is to meet expenditure on subsidies and staff. There is a budget provision ofINR 229.8 million for the year, 2014-15.

4.4 Soil and water conservation

The Department of Agriculture, H.P. is executing two Soil and Water Conservation schemes under State Sector Scheme. The schemes are: (i) Soil Conservation Works. (ii) Water Conservation and Development. (iii) Integrated Watershed Management. (iv) Rural Infrastructure Development Fund, RIDF (Poly Houses and Micro Irrigation Projects). (v) Macro Management of Agriculture. For the execution of these programmes, an outlay ofINR 35294 million andINR 297 million including BASP has been proposed for the period of 12th Plan and Annual Plan 2014-15 respectively under Soil and Water Conservation Works/Schemes.

4.5 Diversification of Agriculture through Micro-Irrigation and other related Infrastructure

The project on Diversification of Agriculture through Micro-Irrigation and other related Infrastructure aims at increasing the area under efficient methods of irrigation viz., drip and sprinkler irrigation. The NABARD has sanctioned this project under RIDF-XIV amounting toINR 19.809 billion which shall be implemented in 4 years starting from 2008-09. In all, 17312 sprinkler/ drip irrigation systems shall be installed during the project period. Besides this, 16020 Nos. of water sources like tanks, shallow wells, shallow tube wells, deep tube wells, small and medium lifts and pumping sets shall also be constructed on the basis of actual need. For installation of Sprinkler and drip system farmer is being provided with 80% subsidy and for creation of water resources 50% subsidy.

4.6 Promotion of organic farming

The State Department of Agriculture intends to promote organic farming in terms of area expansion and increase in organic certification (2000 ha area approximately) in all districts. The promotion of organic farming i.e. area expansion and organic certification at farmer's field shall be done as per guidelines and terms and conditions for which services of service providers would be required. State Govt. has also approved the organic policy for the state so the major stress shall be laid on the promotion of Organic Farming during the 12th Plan period.

4.7 Precision farming and diversification of agriculture

The State Department of Agriculture has launched Pt. Deen Dayal Kisan Bagwan Samridhi Yojna with the assistance of NABARD under RIDF. The project, launched in 2009, is being implemented in all District of the State with an outlay of INR 3.53 billion. This project comprises of two parts – i) Production of cash crops through adoption of precision farming practices through polyhouse cultivation forINR1.54 billion, and ii) Project on Diversification of Agriculture through Micro-Irrigation and other related infrastructure for Rs.1.98 billion. For polyhouse and micro irrigation 80% subsidy is available, whereas, for creation of water source 50% subsidy is available.

4.8 Centrally sponsored schemes

4.8.1 Biogas Development Programmes

This is 100% centrally sponsored scheme on National Biogas and Manure Management Programme (NBMMP) under which subsidy of Rs.4000 per biogas plant of one cubic meter andINR 10,000/- per biogas plant of two & above cubic meter capacity is being provided. So far, installations of 44,403 biogas plants in the state up to 31st March 2014 have been anticipated. The targets for construction of Biogas plants of 1500 Nos. and 300 Nos. during the 12th Five Year Plan (2012-2017) and Annual Plan 2014-2015 have been fixed respectively.

4.8.2 Rashtriya Krishi Vikas Yojna (RKVY)

Under the RKVY scheme launched by the Government of India during the year 2007-08, the need felt projects for horticulture development based on the district plans are proposed for approval by the State level Sanctioning Committee (SLSC) of RKVY as State Horticulture Plan for inclusion into Rashtriya Krishi Vikas Yojna. The funds are received under two streams. Stream-I of the scheme envisages establishment & strengthening of mushroom units in private sector. Stream II components include area expansion under plantation, creation of water resources, on farm water management, protected cultivation, production of planting material, popularization of organic farming, promotion of integrated pest management, development of beekeeping, mechanization of horticulture, improvement of plant/soil health, transfer of technology, women empowerment and on farm handling of fruits. See, Table 15 for the pattern of assistance under stream II.

Table 15 Pattern of assistance under Stream II for components relevant to input and resource use efficiency in agriculture in Himachal Pradesh

Components	Projects	Amount
Creation of water Resources	i) Water harvesting from source to tank	Rs. 20,000/-per ha.
	ii) Creation of water storage tanks (300Cu.M.)	Rs.1,00,000/- per unit
	iii) Tubewell/borewell	Rs. 12500/- per unit
On farm water management	i) Drip irrigation	Rs.25000/- per ha.
	ii) Sprinkler irrigation	Rs.15000/- per ha.
Protected cultivation	i) Low cost greenhouse	Rs.125/- per sq.m.
	ii) Hi-tech greenhouse	Rs.325/- per sq.m.
	iii) Shade net	Rs.14/- per sq.m.
	iv) Anti hail net	Rs.500/- per tree
Popularization of organic farming	i) Vermicompost unit (30'x8'x2.5')	Rs.30,000/- per unit
Promotion of Integrated Pest Management	i) Insect traps, sticky bands, biopesticides etc.	Rs.1000/- per ha.
Mechanization of Horticulture	i) Manually operated equipments	Rs.1500/- per unit
	ii) Power operated equipments	Rs.5000/- per unit
	iii) Diesel engine	Rs.9000/- per unit
	iv) Power tiller	Rs.45000/- per unit
Improvement of Plant/Soil health	i) Use of micronutrients and biofertilizers	Rs. 1500/- per ha.

Source: www.rkvy.nic.in

4.8.3 Integrated Scheme of Oilseed, Pulses, Oil Palm and Maize (ISOPOM)

The Government of India launched this scheme during the year 2004-2005. In the new scheme all the ongoing schemes of OPP, NPDP and AMDP etc. have been merged. Only Maize crop has been kept for Himachal Pradesh. The main components of the scheme are distribution of weedicides, plant protection equipment, training camps for farmers, block demonstrations, IPM demonstrations, distribution of PVC, HDPE pipes for carrying water from the source to field and publicity regarding development of Maize. The scheme is being implemented on 75:25 basis.

4.8.4 National Project on Organic Farming

Under the scheme, 48 clusters consisting of 5800 farmers were registered. The Department of Agriculture provides assistance of Rs.1500 per farmer. This assistance would be provided in three years for documentation, data base management, training and capacity building, organic certification, linkage and value addition. Up to 2010-2011, 24,000 and 12,000 ha area is covered and assistance of INR 3750 per unit is being provided to the farmers to set up vermicomposting. 3,76,000 vermi complex unit have been setup in the State up to 2010-2011.

4.8.5 Sustainable Agriculture and Rural Transformation Holistic Initiative (SARTHI) Programme- Shivalik Range

In 12th Plan (2012-17), the Department of Science& Technology, Government of India is focusing on empowerment of the small and marginal farmers of Shivalik region including the states Punjab, Himachal Pradesh, Haryana, Uttarakhand and Jammu & Kashmir region.

The following technologies are identified for interventions in these areas:

- Invasive biomass control – management and utilization
- Enhanced livelihood options with primary and secondary value addition to forest/farm products with backward and forward linkages
- Cover management packages specific to the region linked to specially agricultural/horticultural practices
- Integrated cluster development package to include water management, aquaculture, small animal husbandry, fodder, vegetable seeds production, health & livelihood security and other focused activities.
- Any other technology for sustainable livelihood specific to the region

5. Barriers

An area-based integrated approach for agriculture in Himachal Pradesh with the fruit and vegetable production as a lead sector has enabled the state to be a major producer of fruits in India. Incorporation of regional specifics in the agricultural development strategy has helped the growth of the sector but at the same time the second order problems of sustainability associated with intensive agriculture practices and an increased emphasis on increasing production, has cropped up in the recent years which may pose challenge to the

sector and the livelihood of people dependent on it. Table 16 below enlists some of the barriers to green growth in Himachal Pradesh.

Table 16 Barriers to green growth in agriculture in H.P

Category	Barriers
Financial	• Lack of adequate financial support (subsidy/incentives) for setting up of biological input production units • High overhead costs of operations • Investment in infrastructure – locational implications of investment decisions such as building roads in poor soils doesn't benefit farmer much, and the investment implications of locational factors not adequately emphasized
Technological	• Mismatch between technology developed at research station and technology needed at farmer's field • Agricultural machinery utilization is very low • Late adoption of new farm technology (market uncertainty, fear of crop failure, threat to food security etc.) • Lack of new varieties • Increasing susceptibility to insects, pests and diseases • Falling yields • Erratic weather conditions • Harmful effects on soil • Mountain perspective and specifics not well integrated into R&D policies
Knowledge gaps	• Indigenous knowledge pertaining to managing scarce resources to improve soil fertility, soil moisture, irrigation, crop seeds, varieties and about mixed farming has not been incorporated in the mainstream agricultural system and practices • State of FYMs in different areas and promoting ways to improve it a better compost • Lack of knowledge about modern system of marketing • Need for development of nutrient management protocols with rotations, nutrient management strategies and on-farm input management with locally available resources • Understanding and incorporation of green growth as a policy and programme goal • Absence of systematic and quantified evidence of impacts of various policies and aspects on long term sustainability
Policy/regulatory measures	• Missing mountain perspective in macro-level policies; policy focus in mountainous areas on resource extraction, revenue maximization • Product pricing and compensation mechanism guided by conventional yardsticks rather than sustainability implication of pace and pattern of resource use • State schemes need to support the development of bio input enterprises and provisions need to be included in the support programmes • Inadequate marketing and post-harvest infrastructure • Rapid resource use intensification due to massive growth in demand

The issue of sustainability of the agriculture sector discussed above highlight the importance of sustainable land management and water management practices in agriculture, and livelihood improvement to ensure sustainability of the agricultural system. The following section proposes important strategies for the achievement of environmental sustainability in agriculture in Himachal Pradesh.

5.1 Sustainable land management

The net cultivated area is decreasing and the area is being shifted to non-agricultural uses. This might cause a serious threat to sustainable agricultural development, food security and livelihood. Given the importance of land in agriculture, its conservation becomes very crucial for long-run agricultural production. In this regard development and implementation of land use policies and its integration to the policies on forest and water so as to provide coherence in management of these resources needs to be undertaken. Further there should be laws related to land use so that the incidence of degradation of agricultural land and the shifting of agricultural land to non-agricultural uses could be checked. The barren, uncultivable waste land etc. may be allotted for non-agricultural purposes like buildings, roads etc.

Fragmentation of land has resulted in productivity losses and impoverishment in the region. Land husbandry initiatives such as the Mid-Himalayan Watershed Development Project, which includes the Himachal Pradesh Reforestation Project (HPRP), the world's largest clean development mechanism (CDM) undertaking, have improved agricultural yields and productivity, and raised rural household incomes. The ongoing Project has converted about 9,000 ha of rainfed area into irrigated land through watershed management techniques[2].

5.2 Research and technological interventions for agricultural production

To make agricultural sector more remunerative so that the migration to urban areas is checked, there is need to develop technology for rainfed agriculture. Efforts should be made to increase the yield and profitability of rainfed crops. Switch over to varieties with low input requirements, leveling of fields and control of weeds in fallow land, use of FYM, mulching etc. were some of the measures adopted by the farmers to control the land degradation.

The yield gap in the experimental and farmer's field is wide as depicted in Table 17 signifying a greater need for agricultural research attuned to the needs of the farming community. The research thrust has been mostly on the major crops while research on millet such as *Eleusine coracana* (Ragi), *Setaria italica* (Koni), *Panicum miliaceum* (cheena), *Paspalum scrobiculatum* (Kodo) and pseudocereals like green chenopod, grain amaranth, buckwheat which are adapted to poor fertile soils and tolerant to moisture stress has largely been neglected. As the state has large area under rainfed agriculture (about 81%) there is a need

[2] http:/ / www.worldbank.org/ en/ news/ press-release/ 2012/ 09/ 27/ 37-million-additional-financing-himachal-pradesh-mid-himalayan-watershed-development-project-india-18000-farmer-households-benefit.

for adequate research focus on the development of crop varieties suited for cultivation in these areas.

Table 17 Yield gaps in agricultural crops in Himachal Pradesh

Crop	Yield (In quintals)		
	Research Plots	Farmer's Plots	State Average
Maize	53.6	35.3	20.5
Wheat	35.9	33.0	14.7
Paddy	56.2	51.0	12.5
Blackgram	10.5	7.8	3.7
Sesame	7.5	6.4	1.2
Rapeseed & Mustard	13.0	9.3	2.7
Linseed	11.0	9.5	3.2

Source: GoHP, 2005

Technology is an important factor determining the future of agriculture and food security. Under the condition of diminishing per capita availability of arable land and irrigation water resources, the role of technology as a driver of change in farm operations and output is critical. In this context, increase in foodgrain production in the region was largely possible because of technological innovations in the form of high yielding varieties of crops. However, there has been a slowing down of productivity gains because of pressure on the natural resource base due to intensive agricultural practices including over-use of fertilizers. The impacts associated with the above have been in the form of declining soil fertility, soil erosion, depleting levels of water available for agricultural purposes, salinity, water logging, etc. Therefore care must be taken so that technological innovations do not degrade the environment in the long term.

Technology can also be used to address the problems of over-exploitation of resources in the region. Frontier technologies like biotechnology, information and communication technology, renewable energy technology can provide ample opportunities to overcome the prevailing technology fatigue.

In order to minimise the harmful effects of intensive use of chemical fertilizers and pesticides, a holistic view of soil fertility based on retaining its natural nutrients is required. For this, a crop management system that promotes the use of organic manures, biofertilizers and biopesticides and the judicious use of agrochemicals should be adopted. In areas that have witnessed deterioration in the natural health of soil due to pesticide contamination, bioremediation techniques such as usage of pesticide degrading bacteria (bioaugmentation) can be undertaken.

Further, dissemination of knowledge through Agricultural Information Centres (AICs) about falling quality of soil; water etc. so that land use management practices for sustainable development can be adopted by the farmers.

5.3 Indigenous knowledge and traditional agriculture

Agriculture probably comprises the largest collection of indigenous practices worldwide. Traditional knowledge can improve availability, accessibility and utilization of food grains through increased, stable and sustainable production, better storage facilities, lower food grain losses and improved soil quality (World Bank 2004). Indigenous knowledge in Himachal Pradesh has a wide gamut that includes use of organic manures, green manuring, composting, multi-cropping. However, the uses of these practices have almost faded into insignificance with the adoption of modern agricultural methods. A manifestation of this is, for example, the disappearance of traditional crop varieties.

There have however been efforts of late to revive indigenous knowledge and traditional practices in agriculture. In general, traditional knowledge should be incorporated into new technologies, with NGOs and multilateral agencies working in close association with locals to encourage further innovations. As a basic starting point, the body of indigenous knowledge should be researched extensively, formally recorded, and made freely available.

6. Ways forward

6.1 Short-term

- Practicing and maintaining traditional mixed cropping and mixed farming
- Adequate and timely supply of agricultural inputs like improved seeds, fertilisers, plant protection materials and improved agricultural implements
- Regulatory mechanism to ensure quality of inputs
- Improving the infrastructural facilities for transportation and marketing
- Improving the productivity levels especially in horticultural produce like apples where over-aged plantation needs to be replaced by new dwarf, spur bearing and high yielding plantations
- Ascertaining soil health through soil health cards in order to address emerging deficiencies of secondary and micronutrients, decline of water table and its quality of water, decreasing organic carbon content, and overall deterioration in soil health
- Demonstration and effective dissemination of improved farm technology that maintain a balanced use and conservation of mountain resources such as micro propagation, drip irrigation, greenhouse cultivation, plastic mulching, fertigation, use of biofertilizer and biocontrol agents, vermiculture, and organic farming

6.2 Medium-term

- Restoration of soil fertility
- Soil and water conservation measures for improving the productivity of soils by checking inundation of forest areas and ensuring adequate vegetation cover in catchment areas
- Increasing area under irrigation and wider adoption of approach of watershed development. The poor growth in surface irrigation has obliged farmers to depend heavily on ground water exploitation thereby depleting ground water resources

- Researching on farmers' technological innovation and the way know-how of the farming community could be harnessed to develop appropriate technologies for mountain agriculture.
- Greater focus on upland-lowland linkages

6.3 Long-term

- Preservation and protection of mountain biodiversity as a repository for prospective technological options for green agriculture
- Adopting an integrated approach to technology development sensitive to specifics of mountainous agriculture encompassing different land-based activities ranging from crop production to forestry
- Greater emphasis on skill improvement keeping in mind the gender perspective in mountain agriculture development to increase off-farm employment and check the growth of pressure on land.

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