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Present scenario of agriculture and its allied occupation in a typical hill village of central Himalaya, India

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ABSTRACT

In India, Uttarakhand is considered as agriculture state and development of the state primarily linked to the agriculture and its allied activities. In this study, a village Sariatal was selected in mid altitudinal hill range of central Himalaya with the objectives to assess the economy and energy efficiency of existing agroecosystem. Agriculture is the major source of revenue in this village. Overall energy input in agricultural activities of the village was 167 727.80 MJ/ha/y of which, agroforestry and home garden shared 89.41 and 10.59%, respectively. In terms of monetary benefit, per ha annual output was ₹ 59 249.38 (967.57 US$) for agroforestry system and ₹ 23 530 (385.86 US$) for home garden. The input output ratio in agroforestry systems and home garden was 1.34 and 1.23, respectively. The output/input ratio of the individual cereal crop indicated that wheat (23.28) contributed the highest among all followed by the paddy (17.97). The production of the green vegetables is also contributing in monitory budget with 19.58 output/input ratio. Farmers in the village also adopted allied occupation like apiculture, floriculture and mushroom production to generate the economy and self-employment.

Key words: Agroforestry, Energy budget, Hill agriculture, Home garden, Land use pattern

India is a land of agriculture, where agriculture contributes about 14.6% in gross domestic product (GDP) and supports over 58% of nation's population for livelihood (GOI 2010), Uttarakhand encompasses a geographical area of 53 483 km^2 which accounts for only 1.63% of country's area. The state contains about 4.53% forest area and about 3.1% agricultural area of the country (Uttarakhand at a Glance 2006-07). The people of hill areas generate the economy from its enrich wealth of nature and depended wholly or partially on it for their livelihood. In the same sequence agroforestry is a dynamic, ecologically managed natural resource system that through the integration of trees/woody perennials in farms and rangelands, diversifies and sustains production for increased social, economic and environmental benefits. This system is one of the best known traditional practices for livelihood, suitable land management and sustainable development (Kittur and Bargali 2013). The agroforestry systems not only support the livelihood but also mitigate the impact of climate change through carbon sequestration (Singh *et al.* 2008a, Bargali *et al.* 2009a, Arora *et al.* 2011).

The contribution of agriculture to the state's domestic product is about 22.4% (GOI 2007) and the population dependent on agriculture for their livelihood is about 75-85% (Malhotra 2005). Most of the area of state is under forests and wastelands thus leaving only a small amount of land (about 14%) for cultivation out of the total reported area of 56.72 lakh ha (GOU 2014). Agriculture in the Himalayan mountains is closely linked with animal husbandry and natural forests. Various studies conducted from the central Himalayan region (Rai 1993, Maikhuri *et al.* 1996, Semwal and Maikhuri 1996, Maikhuri *et al.* 2001, Pande *et al.* 2016) revealed that the agriculture practices require massive consumption of forest resources. In addition, agroforestry plays a major role in strengthening the system's ability to cope with adverse impact of changing climatic conditions (Mishra *et al.* 2010). In hill district of the state agriculture turn up as major source of the economy and revenue. Therefore, the study is an attempt to add some information about present agricultural scenario with the objectives to assess the cropping pattern and the energy budget of a typical hill village.

MATERIALS AND METHODS

The Kumaun Himalayan region spread over a geographical area of 51 125 km^2 (77^{0}34'to 81^{0}02' E longitude and 28^{0}43 to 31^{0}27' N latitude). In the present study, village Sariatal was selected from Bhimtal block in Nainital district of Uttarakhand state. It is situated in mid altitude (1 219 m) at 29^{0}23'N lat. and 79^{0}30'E long. It is well connected by motorable roads at a distance of 56

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km from Pant Nagar airport and 18 km from Kathgodam railway station on NH-87.

The climate of the studied site is characterized by long-cold winter and short summer. Mean minimum temperature ranged from 3ºC (January) to 15ºC (June) and mean maximum day temperature varied between 18ºC (January) and 32ºC (June). Most of the rainfall occurred in the months of July-September and average humidity fluctuates near the saturation point during the monsoon, lowest during the summer season. Soil of the study area is moderate fertile, predominantly sandy, slightly acidic in nature (Table 1).

Demographic features such as number of households (families), total population, litreacy rate, workers etc of the village are given in Table 2.

The village consisted 54 families having 300 human populations with 875 adult sex ratio, as compared to the national set up for rural areas (946/1 000) while in case of children, the sex ratio was good as compared to the national scenario (934/1 000; based on census 2011).

Total livestock population of the village was 162 which provide draught power, manure, milk, fuel and meat. Livestock were also considered as capital asset. The mixture of litter and cattle excreta is used as manure. Apiculture (bee keeping) and mushroom farming is well flourished and immerging activities to generate the economy.

The village is surrounded by the natural mixed forest dominated by *Bahunia variegata* and *Pinus roxburghii* while *Woodfordia fruticosa, Toona ciliata, Ficus rumphii* etc were the common associates.

The village landscape could be divided into three land use types: (i) agri-silviculture system characterized by cultivation of agriculture crop such as wheat, paddy, peas etc with fuel or fodder tree such as *B. variegata, E. grandis* and *G. optiva* (ii) agri-horti-silviculture system, with many trees and crops mixed together resulting in high productivity of total aboveground biomass per hectare per year. In this system, in addition to the main crops, multipurpose trees (like *Grewia optiva*) were grown along with the fruit trees (like peach and pear). (iii) home garden system is a small piece of land involving deliberate management of multipurpose trees, shrubs and herbs in intimate association with annual and perennial agricultural crops to complete their daily requirements of food and fodder, within the compounds of individual houses and the whole entity being intensively managed by family labour.

Animal husbandry is one of the fundamental parts of hill agriculture. Farmers grow the crop not only for grain but also for by products (like straw) which serve as the feeding materials for their livestock. The use of genetically modified crops resulted in increased grain yields with fewer amounts of straw and posing the problem of fodder. This tendency of farmers is increasing pressure on nearby forests for fodder collection and is not a good sign to sustain the forest ecosystem.

Table 2 Physiographic and demographic description of studied village

Parameters	Particulars	Male (%)	Female (%)
Elevation			
Aspect	NE		
No. of households	54		
Pakka house (%)	20		
Semi pakka house (%)	54		
Kaccha house (%)	26		
Average family size	5.56		
Total human population	300	53.33	46.67
Sex ratio (adults)	875		
In the age group ≤6	31	48.39	51.61
Sex ratio (children)	1067		
Litreates	269	53.90	46.10
Illitreates	31	48.39	51.61
Total worker	120	68.33	31.67
Main worker	119	68.90	31.09
Main worker (cultivars)	67	59.70	40.30
Main worker (agricultural laborers) person/ family	3	2	1
Main worker (household industries) person/family	2	2	0
Livestock population	162		
Cow (%)	16		
Buffaloes (%)	10		
Bullocks (%)	04		
Goat (%)	25		
Hen (%)	45		

Table 1 Physico-chemical properties of the soil in different depth layer

Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	BD (g/cm3)	Moisture (%)	Porosity (%)	WHC (%)
0-15	53.00±0.35	34.38±0.30	12.32±0.40	1.51±0.01	5.56±0.12	42.81±0.62	35.57±0.24
15-30	54.30±0.37	34.73±0.23	10.94±0.09	1.44±0.00	5.37±0.08	45.44±0.02	30.66±0.63
	pH	C (%)	N (%)	P (kg/ha)	K (kg/ha)	C:N	SOM
0-15	6.7±0.00	0.69±0.003	0.22±0.006	15.06±6.117	184.41±29.43	3.10	1.18
15-30	6.6±0.01	0.52±0.008	0.18±0.004	11.23±3.243	162.66±19.28	2.88	0.89

BD= Bulk density, WHC= Water holding capacity, C=Carbon, N=Nitrogen, P=Phosphorus, K=Potassium, SOM=Soil organic matter.

Table 3 Energetic values of different inputs and outputs in the agroforestry systems

Category	Energy
Grains	16.2 MJ/kg
Pulses	17.0 MJ/kg
Oilseeds	23.07 MJ/kg
Potato	03.9 MJ/kg
Leafy vegetables	02.8 MJ/kg
Other vegetables	02.4 MJ/kg
Milk	04.2 MJ/kg
Green fodder	03.9 MJ/kg
Hay	14.5 MJ/kg
Straw	13.9 MJ/kg
Fuel wood	19.7 MJ/kg
Farmyard manure/compost	07.3 MJ/kg
Human labour	
Male sedentary work	00.418 MJ/h
Moderate work	00.488 MJ/h
Heavy work	00.679 MJ/h
Human labour	
Female sedentary work	00.331 MJ/h
Moderate work	00.383 MJ/h
Heavy work	00.523 MJ/h
One bullock-day	72.7 MJ/day

Source: Mitchell (1979).

Field survey was conducted in the village and information about live stock, agricultural land, seeds, fertilizer, manure, human-animal labour, fuel wood, fodder consumption and agricultural input/output of the household were collected through discussions with adult members/ head of the family using semi structured questionnaire (Bargali *et al.* 2007, 2009b, Pandey *et al.* 2011, Parihaar *et al.* 2014, Padalia *et al.* 2015). Twenty households were selected randomly for the estimation of inputs/outputs from agroforestry system as well as from home gardens. All agricultural and village data were converted to energy values using constants (Mitchell 1979). A standard energy value of various inputs and outputs is given in Table 3. Hours spent by males and females for sedentary, moderate and heavy works were multiplied by per hour energetic value of a given type of work and the products summed up to obtain total human labour input per day in a given land use system.

Similarly, duration of bullock power used was multiplied by energetic value of bullock power to compute total energy of this input. Energy inputs through seeds and manure and outputs through edible yields, fuel wood, fodder and by product were calculated by multiplying the amount of an input/output related to a given land use and its standard energetic value. Monetary values were calculated on the basis of buying and selling price in the nearby market.

RESULTS AND DISCUSSION

Soil characteristics

Soil of the study area is moderate fertile. The correlation between physical and chemical properties of the soil is given in Table 4, which show highly significant relationship with each other. Bulk density showed the negative correlation with porosity while positively correlated with WHC, C, N, P and K ($P< 0.01$). Clay content of the soil was positively correlated with bulk density, WHC, C, N, P and K while negatively correlated with porosity.

Agricultural activities

The agriculture was the main activity of villagers,

Table 4 Correlation between physical and chemical properties of the soil

	Depth	Sand	Silt	Clay	bD	Mo	Po	WHC	pH	C	N	P	K
Depth	1												
Sand	.640	1											
Silt	-.110	.462	1										
Clay	-.251	-.313	-.216	1									
bD	-.497	-.353	-.172	.938**	1								
Mo	.129	.434	.109	.613	.635	1							
Po	.490	.502	.219	-.879*	-.931**	-.554	1						
WHC	-.527	-.278	-.218	.841*	.968**	.657	-.862*	1					
pH	-.378	-.761	-.738	.571	.616	.115	-.762	.595	1				
C	-.461	-.359	-.212	.956**	.995**	.608	-.907*	.956**	.609	1			
N	-.345	-.242	-.252	.952**	.977**	.684	-.861*	.956**	.569	.987**	1		
P	-.417	-.276	-.119	.965**	.987**	.656	-.885*	.938**	.522	.993**	.984**	1	
K	-.469	-.486	-.436	.898*	.959**	.525	-.920**	.948**	.788	.962**	.949**	.924**	1

bD= bulk density, Mo= moisture, Po= porosity, WHC= water holding capacity, C= carbon, N= nitrogen, P= phosphorus, K= potassium, **. Correlation is significant at the 0.01 level and * at the 0.05 level.

though most of the land is covered with forest leaving very little scope for diversification. Cropping pattern was mainly based on traditional agriculture. Wheat, rice, maize and finger millet were the main crops with the maximum area under cultivation. Cropping patterns were built around two discernible seasons locally referred to as *kharif* crop (rainy season crops) and *rabi* crop (winter season crops). Rice (*O. sativa)*, maize (*Z. mays*), finger millet (*E. coracana*) black soya (*G. soja*), ginger (*Z. officinale*) and turmeric (*C. longa*) were dominant rainy season crops, sown during June to August and harvested during October to December while wheat (*T. aestivum*), rape seed (*B. campestris*), gram (*C. arietinum*), pea (*P. sativum*) and potato (*S. tuberosum*) were dominant crops of winter season considered as rabi crops harvested during February to May. List of some most frequently used improved varieties of crops is given in Table 5.

Table 5 List of some commonly used improved crop varieties by the villagers

Crops	Varieties
Cereal crops	
Maize	Sweta, Kanchan
Rice	Pant Dhaan-10 (PD-10), PD-12, PD-18, Pusa Sugandh-5,
Wheat	UP-2572, UP-2565, UP-2526, UP-2684, PBW- 343, PBW-550, VL-2684
Raagi (Manduwa)	VL-Manduwa 149, VL-Manduwa 315, VL-Manduwa 324
Pulse crops	
Chickpea	PUSA-362, PG-186, PG-114, Suriya
Lentil (Mung)	PS-06, VL-507, Pant Mung-04, Pant Mung-05
Pea	VL-7, VL-10, Arkil, PS-1100, PSM-3
Soybean	PS-1347, PS-1225, PS-1092, PS-1241
Urad	PU-40, PU-31, PU-35
Vegetable crops	
Bottle gourd	Pant hybrid Lauki1,2 and 3
Broccolia	Ashwarya, Pusa Brockly KTS-1
Capsicum	California wonder, Tanvi, Indra
Coriander	Pant Haritima, Multicut
Egg plant	Pant Samrath, Pant Rituraj, Pant hybrid bengan 1,4
French beans	Pant Anupama, VL boni bean-01
Potato	Kufri Jyoti, Kufri Badshaah, Kufri Himalani
Tomato	Avinash, Manisha, Sahanshah, Badshah, Lyco
Oil yielding crops	
Mustard	Pant Pili Sarson-1, Uttara, PT-303
Fodder crops	
Barseem	Desi Miskavi
Maize	African tall, J-1006

Total four cereals and seven pulses were cultivated (Table 6). Farmers preferred the cereals over the pulses/oil yield crops due to high yield at low input cost. In cereals, wheat shared more than half (51%) while in the pulses, large proportion was contributed by pea (36%). The overall contribution of the different crops showed that cereals come forward as a main crop followed by vegetables, pulses and tubers.

The trend of fertilizer practice started after the green revolution and hills are also not untouched by this. Urea is being used in almost all crops (except in pulses) whereas, DAP was frequently used in home garden. According to 56% of the farmers, use of fertilizer is being increased during last 10 years, and this non-judicious manner of fertilizer application is resulting in increased input cost and adverse consequences on fertility and productivity of soil.

Table 6 Cereal and pulse crops produced by the local communities

Botanical name	English name	Local name	Family
Cereals crops			
Eleusine coracana (L.) Gaertn.	Finger millet	Manduwa	Poaceae
Oryza sativa L.	Rice	Dhan	Poaceae
Triticum aestivum L.	Wheat	Gehu	Poaceae
Zea mays L.	Maize	Makka	Poaceae
Pulses crops			
Cicer arietinum L.	Gram	Chana	Papilionaceae
Glycine max (L.) Merr.	Soya	Soyabean	Papilionaceae
Glycine soja Siebold & Zucc.	Soybean	Bhatt	Papilionaceae
Lens esculenta	Lentil	Masoor	Papilionaceae
Phaseolus lunatus L.	Lobia	Lobia	Papilionaceae
Phaseolus vulgaris L.	Kidney bean	Sem	Papilionaceae
Pisum sativum L.	Garden Pea	Mater	Papilionaceae

Medicinal plants

Thirty five plants with medicinal value were listed from both the agricultural cultivation and natural forest (Table 7).

In home garden agroforestry system, total 17 vegetable crops were commonly cultivated by the farmers (Table 8). The main vegetable crops of rainy season were cucurbits, *H. esculentus, S. melongena, C. esculenta* and *Z. officinale* while in winter season *L. esculentum, A. cepa*, *P. sativum, R. sativum, S. capcium* and green leafy vegetable while in summers, *S. tuberosum* and *A. sativum* were main vegetable crops.

Trees and shrubs used by the people

Total thirty five tree species were used by the local people for the fuel wood, fodder, fiber, fruits and timber etc. *B. variegata, B. rugulosa, D. butyracea, G. optiva* and *M. indica* were considered as the multipurpose trees.

Table 7 List of some medicinally important plants and their uses

Botanical name	Local name	Family	Part use	Uses
Trees				
Bauhinia variegata L.	Quweral	Caesalpiniaceae	R,B,F	Antidote to snake poison. The bark is astringent and useful in skin diseases.
Boehmeria rugulosa Wedd	Gethi	Urticaceae	L, B	Juice of the bark is applied to treat fresh cuts and blood coagulation.
Cinnamomum tamala (Buch.-Ham.) T. Nees & C.H. Eberm.	Tej Patta	Lauraceae	L, B	Useful in the treatment of ailments such as anorexia, bladder disorders, dryness of mouth and diarrhea.
Diploknema butyracea Roxb.	Chuyra	Sapotaceae	L, B, Fr	Used in the treatment of rheumatic pain, ulcers, itching, tonsils, leprosy and diabetes.
Ficus religiosa L.	Peepal	Moraceae	WP	Useful against diarrhoea, asthma, cough, earache, toothache. The bark is reported to possess antiulcer and wound healing activities.
Butea monosperma (Lam.) Taub.	Jangal ki aag	Fabaceae	R, F	Plant used as tonic, astringent, aphrodisiac.
Ficus rumphii Bl.	Gaujina	Moraceae	Fr, L	Used to treat foot and mouth disease of cattle.
Murraya koenigii (L.) Sprengel	Kadi patta	Rutaceae	L, R, Fr	Leaves applied externally in eruption and poisonous bite.
Woodfordia fruticosa (L.) Kurz	Dhaula	Lythraceae	R, L	Useful in leucorrhoea, toothache, hemorrhoids and considered a safe stimulant in pregnancy.
Zanthoxylum alatum Roxb.	Timoor	Rutaceae	Fr, Se	Extract of fruits is effective in expelling round worms.
Shrubs				
Berberis asiatica Roxb.	Kilmora	Berberidaceae	WP	Used in jaundice, dysentery, sugar, and gall stones.
Coriaria nepalensis Wall.	Makoi	Coriariaceae	L,S	Treatment of toothaches.
Debregeasia longifolia (Burm.f.) Wedd.	Tushari	Urticaceae	L, S	Leaves juice applied in the treatment of scabies.
Elaeagnus umbellate Thunb.	Gigroi	Elaeagnaceae	Fr, F, Se	The flowers and seeds are astringent and stimulant in nature, and used for the treatment of coughs.
Eupatorium adenophorum Sprengel	Ban-mara	Asteraceae	L,S	Leaves decoction applied on cut wounds and also used against infection of gum and tooth ache.
Lantana camara L.	Kuri	Verbenaceae	L, Fl, Fr	Useful in the treatment of diarrhea.
Myrsine africana L.	Rikhdalmi	Myrsinaceae	Fr	Roots powdered as decoctions to relieve body pain.
Rosa moschata Herrm.	Jangali gulab	Rosaceae	Fl, Oi	Astringent, tonic, antibacterial agent and in treatment of sore throat, tonsils and eye disease.
Rubus biflorus Buch.-Ham.	Van Hisalu	Rosaceae	R, L	Effective in the treatment of diarrhoea.
Rubus ellipticus Sm.	Hisalu	Rosaceae	R, B	The decoction of root recommended for curing fever.
Herbs				
Achyranthes aspera L.	Chirchita	Amaranthaceae	F, Se, L	Paste of fresh leaves is used for allaying pain from bite of wasps and also in skin diseases.
Ageratum conyzoides L.	Bukila	Asteraceae	F, L	It is also useful in the treatment of pneumonia by rubbing them on the chest of the patient.
Allium sativum L.	Lehsun	Liliaceae	WP	Treatment of cardiovascular and other metabolic diseases and diabetes.
Aloe barbadensis (L.) Burm.f.	Ghegwar	Liliaceae	WP	Anti-inflammatory effect, control blood-sugar and moisturizing agent to the skin.
Curcuma longa L.	Haldi	Zingiberaceae	Rh	Effective in skin allergy, hepatitis, and wounds.
Cynodon dactylon (L.) Pers	Doov	Poaceae	WP	Used in wounds and toothache.
Eleusine indica (L.) Gaertn.	Jharua	Poaceae	R, L	The cold decoction is drunk (250 ml), 3 times daily before eating is good for the treatment of lithiasis.
Mentha spicata L.	Pudina	Lamiaceae	WP	Effective in cough, fever and loss of appetite.

(*Continued*)

Table 7 (*Concluded*)

Botanical name	Local name	Family	Part use	Uses
Ocimum sanctum L.	Tulsi	Labiatae	WP	Aqueous decoction of leaves effective in gastric and hepatic disorder is a popular remedy for cold.
Oxalis corniculata L.	Katta-meetha	Geraniaceae	L,S	Appetizer, effective in skin diseases and fevers.
Parthenium sp L.	Gazar ghaas	Asteraceae	WP	Although contact with this plant causes dermatitis and respiratory malfunction in humans and animals, but it is used as remedy for eczema.
Rumex sp L.	Jangli palak	Polygonaceae	WP	Effective in constipation, headache and diabetes.
Trifolium repens L.	Satphal	Fabaceae	L, F	Useful for mentally retarded persons.
Trigonella foenumgraecum L.	Methi	Papilionaceae	L, S, Se	Appetizer, astringent and remove bad taste of mouth.
Zingiber officinale (Rosc.)	Adrak	Zingiberaceae	Rh	Useful in the treatment of various gastrointestinal disorders.

R = Root, F = Flower, S = Stem, Fr = Fruit, B = Bark, L = Leaves, WP = Whole Plant, Se = Seed, O = Oil

Table 8 List of vegetables cultivated in the study village

Botanical name	English name	Common name	Family
Allium cepa L.	Onion	Piyanz	Liliaceae
Amaranthus sp	Amaranth	Chaulai	Amaranthaceae
Brassica juncea	Rai	Rai	Brassicaceae
Brassica oleracea L.	Cauliflower	Gobhi	Brassicaceae
Chenopodium album L.	Pigweed	Bathuwa	Chenopodiaceae
Colocasia esculenta (L.) Schott	Arum	Arbi	Araceae
Cucumis sativus L.	Cucumber	Kheera	Cucurbitaceae
Cucurbita maxima Duch.	Pumpkin	Kaddu	Cucurbitaceae
Hibiscus esculentus L.	Lady's finger	Bhindi	Malvaceae
Lagenaria vulgaris Ser.	Bottle gourd	Lauki	Cucurbitaceae
Luffa cylindrical L.	Ghia torai	Torai	Cucurbitaceae
Lycopersicon esculentum L.	Tomato	Tamater	Solanaceae
Raphanus sativus L.	Radish	Muli	Brassicaceae
Solanum melongena L.	Egg plant	Bengen	Solanaceae
Solanum tuberosum L.	Potato	Aalu	Solanaceae
Spinacia oleracea L.	Spinach	Palak	Chenopodiaceae
Trigonella foenumgraecum L.	Methi	Methi	Papilionaceae

P. roxburghii, B. variegata and *M. indica* were considered as the best quality fuel wood, *G. optiva* and *F. roxburghii* as the best quality fodder, *Eucalyptus* sp. and D. strictus were the best quality plant for the commercial purpose (Table 9). Reduction of crop yields due to farm trees is reconciled with availability of fodder, fuel wood and other non-timber forest products near farm lands (Singh *et al.* 2008a & b, Bargali *et al.* 2004, Bargali *et al.* 2009a).

Horticulture

Sariatal village is bestowed with moderate agro climatic conditions and actively engaged in growing various horticultural crops, i.e. fruits. Total 13 fruit trees and one herb (Strawberry) was reported as horticulture crop (Table 10). There is lot of scope to generate the economy by the horticultural production. Among fruit crops, maximum area is occupied by citrus fruits, followed by peach and pear but in comparison to the national setup the overall productivity is low.

Apiculture

Owing to rich vegetation, bee keeping has been a conventional practice in the village. The production of the honey in the study year was about 23 500 Q with an average of 9.59 kg/box/year. Mainly two species of bee, i.e *Apis mellifera* (F.) and *Apis indica* (F.) commonly known as European and Indian bee, respectively, were common. The major feed plants were peach, mustard, forest tree vegetation and the seasonal flowers. To promote the apiculture, several facilities are being provided by the state government such as subsidy to purchase the bee colonies or supply the superior type of bee colonies and immigration facilities to the bee keepers. Apiculture serves double benefits by giving monitory to the landless or marginal farmers and on the other hand ensures the pollination.

Floriculture

Floriculture emerged as a commercial activity in the village. However, only a few farmers started it as an extra source of income. Open cultivation of cut flowers like marigold, rose, lilies, carnation, gerbera, chrysanthemum and other seasonal flowers have been taken up in the village.

Mushroom production

Mushroom production is gaining popularity in the

Table 9 Tree and shrubs species and their uses

Species	Local name	Family	Habitat	Uses
Agathis robusta (C.Moore ex F.Muell.) Bailey	Kauri	Araucariaceae	T/C	Ti, Fu
Berberis sp. L.	Kilmora	Berberidaceae	S/F	Med, Fu
Bauhinia variegate L.	Quweral	Caesalpiniaceae	T/ F	Med, Fu, Fo
Boehmeria rugulosa Wedd.	Gethi	Urticaceae	T/F	Fo, Fi, Fu
Bombax ceiba L.	Semal	Malvaceae	T/F	Com, Fi, Fo, Fu
Butea monosperma (Lam.) Taub.	Jangal ki aag	Fabaceae	T/F	Com, Fu
Cinamomum tamala (Buch.-Ham.) T. Nees & C.H. Eberm.	Tej Patta	Lauraceae	T/C	Med, Fu,
Coriaria nepalensis Wall.	Makol	Coriariaceae	S/F	Med, Bev, Fod
Debregeasia longifolia (Burm.f.) Wedd.	Tushari	Urticaceae	S/F	Fi, Fo, Pul
Dendrocalamus strictus Nees.	Lathi baans	Poaceae	G/F	Com, Ti, Fo
Diploknema butyracea Roxb.	Chuyra	Sapotaceae	T/F	Fu, Fo,Ti
Elaeagnus umbellate Thunb.	Gigroi	Elaeagnaceae	S/C	Ed, Fu, Fod
Eucalyptus grandis W.Hill ex Maiden	Eucalyptus	Myrtaceae	T/C	Ti, Pul
Ficus cunia	Khayunia	Moraceae	T/F	Fo, Fu
Ficus religiosa L.	Peepal	Moraceae	T/F	Med, Fu
Ficus roxburghii Wall.	Timila	Moraceae	T/F	Fo, Fu, Ti
Ficus rumphii Bl.	Gaujina	Moraceae	T/F	Ed, Med, Ti
Grevillea robusta A.Cunn. ex R.Br.	Silver Oak	Proteaceae	T/C	Ti, Fod
Grewia optiva L.	Bheemal	Malvaceae	T/F	Fu, Fod, Ti
Hovenia dulcis Thunb.	Aunga	Rhamnaceae	T/C	Ed, Ti, Fu
Lantana camara L.	Kuri	Verbenaceae	S/F	Fu, Com
Myrsine Africana L.	Rikhdalmi	Myrsinaceae	S/C	Ed, Med, Fod
Olea ferruginea Royle.	Jetoon	Oleaceae	T/C	Ed, Ti, Fu, Fod
Olea glandulifera Desf.	Garur	Oleaceae	T/F	Ti, Fu
Pinus roxburghii Sarg.	Cheer	Pinaceae	T/F	Ti, Fu, Com
Pyrus pashia Linn.	Mehal	Rosaceae	T/F	Ed, Ti, Fod
Ricinus communis L.	Castor	Euphorbiaceae	S/F	Med
Toona ciliate M. Roem.	Tun	Meliaceae	T/C	Fod, Fu
Woodfordia fruticosa (L.) Kurz	Dhaula	Lythraceae	T/F	Med, Fu, Fod
Zanthoxylum alatum Roxb.	Timoor	Rutaceae	T/C	Fu, Fod, Med

T=Tree, S=Shrub, G=Gress, C=Cultivated, F=Forest, Ti=Timber, Fu=Fuel, Med=Medicinal, Fo=Fodder, Fi=Fiber, Com=Commercial, Bev= Beverage, Pul=Pulp industry.

village. It gives the good monitory budget and serves as the cash crop. The common cultivated mushroom species in the village were button mushroom (*Agaricus bisporus)*, ghucchi (*Morchella*) and puff ball (*Lycoperdon perlatum*). The farmers sold the mushroom in the open market at the rate of about ₹. 200 /kg therefore, provide wealth and employment to the local villagers.

Energy and monetary budget of the village

Overall energy input in agriculture (agroforestry system + home garden) in the village was 167 727.80 MJ/ha/y. In agroforestry systems, total energy input was 149 954.16 MJ/ha while in home garden it was about 17 773.54 MJ/ha/y which was eight times less in comparison to the agroforestry system. Approximately, 98% of the total energy input added in agroforestry system as well as in home garden was by the manure and remaining percentage was shared by the seeds, human and drought power. In agroforestry systems the manure input was eight times more in comparison to the home gardens while the human power input was three times more (Table 11).

Total per ha annual energy output from agroforestry was 202 128.69 MJ/ha/y which was nine times more in comparison to home garden (21 881.51 MJ/ha/y). Fuel (42%) added the highest energy output followed by fodder (32%).

Net return of energy through the agroforestry system was 52 174.53 MJ/ha/y while in home garden it was 4 107.97 MJ/ha/y. The input output ratio in agroforestry systems and home garden was 1.34 and 1.23, respectively. These values were within the range 0.26 to 3.99 reported by Singh *et al.* (1997) for Himalaya. Upadhyay *et al*. (2012) reported input output ratio between 0.11-2.57 for the eastern part

Table 10 Common fruit plants of the village

Species	English name	Local name	Family
Citrus sinensis (L.) Osbeck	Orange	Santara	Rutaceae
Citrus limetta Risso	Sweet lemon	Malta	Rutaceae
Citrus limon (L.) Burm.f.	Lemon	Nimbu	Rutaceae
Citrus pseudolimon Tan.	Hill lemon	Galgal	Rutaceae
Citrus reticulata	mandarin orange	Keenu	Rutaceae
Diospyros kaki Thunb.	Persimmon	Kaku	Ebenaceae
Fragaria ananassa Duchesne	Strawberry	Straw-berry	Rosaceae
Litchi chinensis Sonn.	Leechi	Leechi	Sapindaceae
Mangifera indica L.	Mango	Aam	Anacardiaceae
Musa paradisiaca L.	Banana	Kela	Musaceae
Prunus persica (L.) Stokes	Peach	Aru	Rosaceae
Psidium guajava L.	Guava	Amrood	Myrtaceae
Punica granatum L.	Pomegran-ate	Anar	Lythraceae
Pyrus communis L.	Pear	Nashpati	Rosaceae

of India while Nautiyal *et al*. (1998) reported low (0.63) ratio for simultaneous agroforestry system of Garhwal Himalaya. Another study carried out by Parihaar *et al.* (2015) reported 9.08 output/input ratio for agroforestry system and 1.23 for home garden in Kumaun Himalaya. The agroecosystem studies in central Himalaya indicated that agricultural in the area can be sustainable if pressure on forestland can be reduced. This could be achieved by reviving the support system and each hectare of agriculture land should be supported by 10-15 ha of forests (Singh *et al*. 1984, Ralhan *et al.*1991). Highest per ha monetary output was ₹ 59 249.38 (967.57 US$) for agroforestry and ₹ 23 530 (385.86 US$) for home garden.

Table 11 Details of energy budget, expenditure and returns by agroforestry and home garden in the study village

Input/Output*	Agroforestry	Home garden
Input		
Human power**	130.52	57.60
Drought power	581.60	69.72
Seeds	2655.69	192.41
Manure	146586.35	17453.81
Total input	149954.16	17773.54
Output		
Food grains	44845.66	3928.47
Vegetables		7953.60
By products	5641.44	627.20
Fuel wood	85910.59	1096.19
Fodder	65731.00	8276.05
Total output	202128.69	21881.51
Net return	52174.53	4107.97
Out/input ratio	1.34	1.23

*Energy in (MJ/ha/y), **Energy in (MJ/ha/day).

The output/input ratio of the individual cereal indicated that wheat (23.28) contributed the highest among all followed by the paddy (17.97). The production of the green vegetables also giving the good monitory budget with 19.58 ratio. However, the study conduct by Upadhyay *et al*. (2012) in Odisha concluded that paddy, corn, tubers and fresh vegetables contributed 7.78, 24.19, 5 and 20.68, respectively. The average seed input, crop output and crop output: crop input for different agricultural and home garden crops is given in the Table 12.

Table 12 Details of seed input, output of different crops in the agriculture and home garden at the studied village

Particulars	Seed input (kg/h)	Out put (kg/h)	Input/output ratio
Cereals and pulses crops			
Maize	35.10	261.04	7.43
Mandua	3.61	28.51	7.89
Paddy	25.70	461.84	17.97
Pea	4.25	39.35	9.25
Wheat	58.63	1365.46	23.28
Others	15.06	84.93	5.63
Average of cereal and pulses crops	23.72 ± (8.58)	373.52 ± (209.63)	11.90
Vegetables crops			
Tubers	29.26	116.17	3.97
Fresh vegetables	13.68	267.87	19.58
Average of vegetables	21.47 ± (7.79)	192.02 ± (75.85)	11.77

Constraints in agricultural practices

The low agricultural yield reflects the small fragmented and scattered land holdings, unfavorable climatic conditions for some crops, inadequate availability of improved inputs and technology and lack of credit and marketing facilities (Dewan and Bahadur 2005) makes agriculture as a difficult task in hill regions. The status of operational land holdings in Uttarakhand highlights the status of land holdings in the state (Table 13). As per the agricultural census 2001, average land holding in Uttarakhand are similar to the national average. But the overall land holding is lower than the national average because almost 70% of the land holdings in Uttarakhand are marginal and 18% are small.

Water conservation is another constraint in the village as majority of agriculture is rainfed. Soil erosion, poor transportation facilities, scarcity and expensive chemical fertilizers, poor education and less awareness are also listed as major problem of the hill agriculture. Other than this the

Table 13 Operational holdings, 2001

Operational holdings	No. of operational holdings (in '000 ha)		Area operated (in '000 ha)		Average size of holdings (ha)	
	UK*	India	UK	India	UK	India
Marginal (< 1 ha)	628	76122	243	30088	0.39	0.40
Small (1-2 ha)	158	22814	221	32260	1.40	1.41
Semi-medium (2-4 ha)	78	14087	212	38305	2.72	2.72
Medium (4-10 ha)	24	6568	132	38125	5.50	5.80
Large (> 10 ha)	1	1230	36	21124	36.00	17.17
All holdings	889	120822	844	159903	0.95	1.32

* Uttarakhand (*Source:* Agricultural Statistics at a Glance 2007.)

role of mediator and unavailability of a proper surplus market cause loss in income, as a result most of the able-bodied men have migrated to other places in search of employment. Only women are left behind in the hills and they have to look after the farms and house responsibilities both.

In the present study, simultaneous agroforestry was the traditional land-use system and a high level of plant diversity maintained by the farmers through the crop rotation and coexistence of mono- and mixed cropping practices.

Average per ha annual energy inputs in agroforestry system was approximately eight times more than home gardens while per ha energy outputs obtained from agroforestry system was nine times more. Use of chemical fertilizers and pesticides increased the inputs manifolds.

Farmers adapted the allied occupation of agriculture like apiculture, floriculture and mushroom production to generate the economy and self-employment.

Most of the farmers have abandoned their traditional practices, discarded the traditional/local verities of seeds and depend on the government and private sector to provide necessary inputs. Animal husbandry, once an integral and valued part of agriculture, is relegating to secondary importance.

Agriculture is heavily dependent on energy flows from uncultivated lands such as forests and grasslands recycled into manure through livestock. This clearly shows that this system is closed, self-contained and self-reliant.

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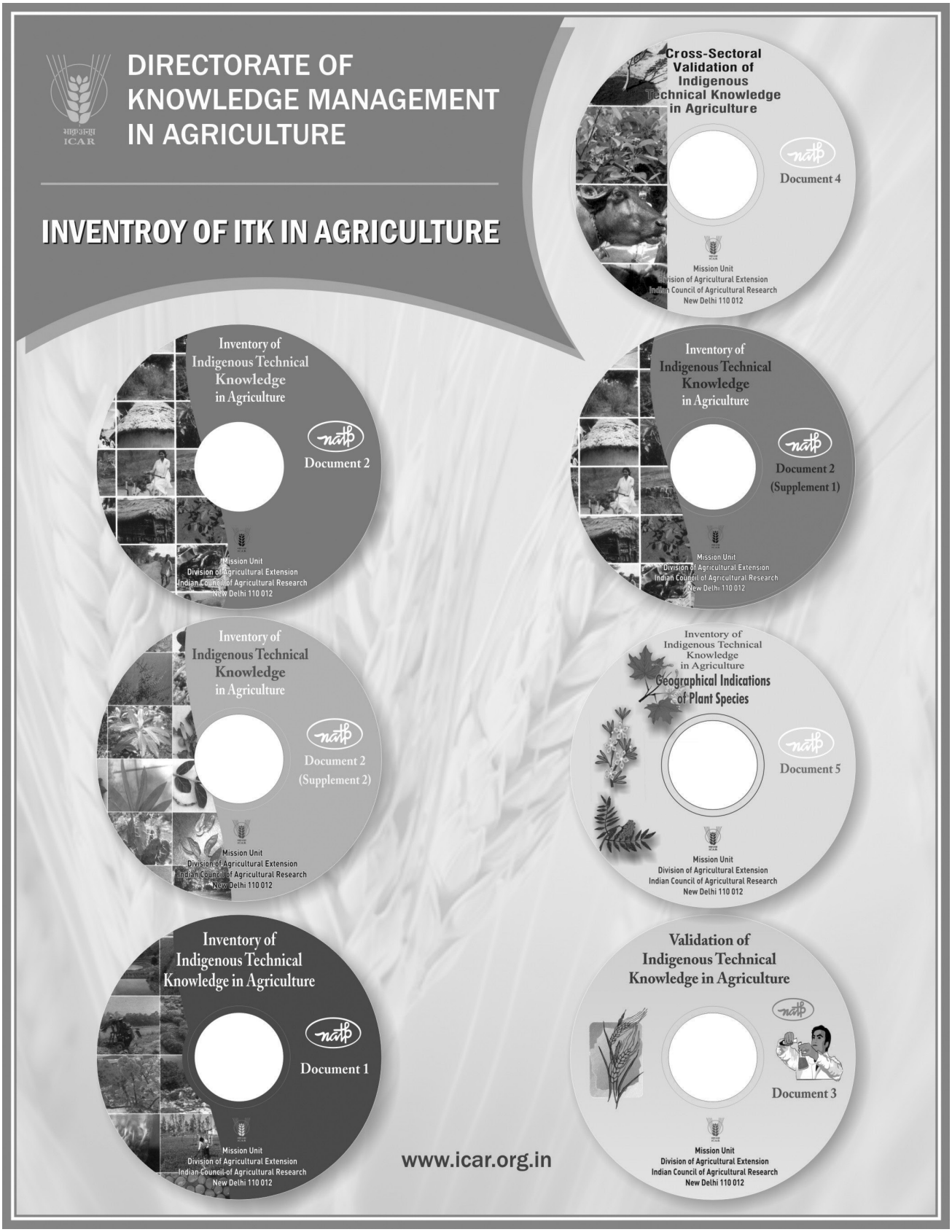
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