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Organic Farming in Uttarakhand Himalaya, India

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ABSTRACT

This paper provides an overview of organic agriculture programmes that have been attempted in Uttarakhand state of India. Much of the rural land in India, especially in Himalaya is fragmented and the problems created by male outmigration coupled with market forces influence the viability of the future farming in the region. This paper identifies the key problems, their causes and the scope of solutions based on the perceptions of the farmers participating in the organic farming training and development. The present approach of providing subsidy as part of policy though encourages the farmers to take up the programmes, they need to build the capacity to continue the organic farming once the subsidy is withdrawn. The policy is currently looking at only to export the raw material from the region rather than value addition to increase the shelf life and export potential. Some potential actions for sustaining the organic farming in the state are suggested.

Key Words: Capacity Building; Locational Advantages; Policy Interventions; Indigenous Innovations; Himalaya; India

INTRODUCTION

The demand of organic food emerged during the 1970s when ill-effects of agrochemicals on environmental and human health were realized in the developed world. Therefore, organic farming drew attention for its potential to produce healthy food together with environmental conservation in the developed world (Mader et al. 2002, Halde et al. 2015) and as a new opportunity of income in food-surplus developing countries like India (Prasad 2005, Ramesh et al. 2005, Parvathi and Waibel 2016). With recognition of India as a megadiverse country and its Himalayan and Western Ghats regions as biodiversity hotspots in the 1990s (Myers 2000), in recent times organic farming is being viewed also as a means of conserving biodiversity and mitigating climate change (Anonymous 2004, Narayanan 2005). With the launch of the National Programme on Organic Products (NPOP), area of certified organic farm in the country registered a 100-fold increase during the 2000-2010 period (41,000 ha to 443,000 ha), with 1.33-fold increase in export in the last one year period (US $ 118 million in 2010 to $ 157 million in 2011) (www.apeda.gov.in). The scope and impacts of organic farming vary a lot within the country partly because of huge variations in agro-ecological conditions (Sehgal et al. 1990, Patil et al. 2014) and partly due to varied responses of provincial governments to the NPOP (Prasad 2005, Ramesh et al. 2005). This article provides an overview of strengths and weaknesses of organic farming in the hilly region of Uttarakhand (known as Uttaranchal until 2007) (Figure 1), the first and the only province in the country with elaborate organic farming policy framed in the year 2000.

Figure 1. The province of Uttarakhand, the first and the only province in India with an elaborate organic farming policy

PRE-EXISTING ADVANTAGES FOR ORGANIC FARMING

Agriculture is a minor land use in terms of spatial extent but is the backbone of local livelihoods in the Himalayan uplands. Despite population increase, the area under agricultural land use has not changed much over the past 30-40 years in Uttarakhand Himalaya as a result of socio-cultural restraints as well as legal ban on conversion of notified forests since 1890s, policies of supplying a quota of food grains at subsidised price, and promoting off-farm economy since 1970s. The hilly region had a comparative edge over many other areas in producing organic products for several reasons:

The Tradition of Organic Farming by Default

Majority of the traditional settled upland agriculture is organic by default because of problems of access to agrochemicals, poor crop response to chemical fertilizers in the widespread rainfed condition and fairly high crop yields as long as 20-30 Mg ha^{-1} $year^{-1}$ of traditional farm yard manure with a C/N ratio close to 25 was applied, weeds were recycled, terraces were maintained and traditional labor-intensive but environment-adaptive cropping systems were practised. Villages, with mean land holdings of 1.7 ha, livestock holdings of 5 adult units, > 4 ha of dense forest area available for producing traditional farmyard manure/sustaining livestock (forest leaf litter constituting bedding material in livestock sheds and litter-livestock excreta mixture used as manure) and traditional diversified food system, were food sufficient (Rao et al. 2003 and 2005, Semwal et al. 2004, Singh et al. 2008, Chandra et al. 2011, Bhadauria et al. 2012). Well managed traditional agroecosystems may have soil organic carbon levels of 13-18 g kg^{-1} much higher than the threshold of 7.5 g kg^{-1} for highly fertile soils in Indian agriculture (Prasad et al. 2003) and earthworm abundance (density:132-147 individuals m^{-2}; biomass:199-266 g m^{-2}) (Bhadauria et al. 2012) higher than the limits (80-120 individuals m^{-2}; 60-100 g m^{-2} biomass) set for 'good agricultural practice' in developed countries (Pfiffner and Luka 2007) and comparable to the scientifically designed modern organic systems (Whalen et al. 1998, Schmidt et al. 2003). Unlike some farmers in high hills in Himachal Pradesh who use night soil as manure (Oinam et al. 2008) which does not qualify for organic farming, farmers in Uttarakhand use

manure (leaf litter mixed with livestock excreta) acceptable worldwide. Croplands with low productivity and depleted soil organic carbon do exist, more so in the foothill region (Ramesh et al. 2010). In the high hills, low productivity and depleted agricultural soils are an outcome more of casual cultivation (due to labor shortage arising from outmigration and increasing tendency of viewing farming-based livelihoods as inferior to the secondary/ tertiary sector based ones) over the past few decades rather than any inherent biophysical stresses (Semwal et al. 2002, Bhaduaria et al. 2012) (Figure 2).

Locational Advantages-the Edge over Other Himalayan States

Unlike the neighboring Himalayan states of Himachal Pradesh and Jammu and Kashmir where agrochemical use became widespread following policies promoting them since 1970s, it was confined to only a few farmers in Uttarakhand hill region as policies did not encourage modern inputs. The north-eastern Himalaya, like Uttarakhand, had also escaped agrochemicals but shifting cultivation with 3-4 years fallow periods, predominant in that

Figure 2. Traditional agriculture has always been organic and built on environment-adaptive technologies. As forest leaf litter is used as bedding material in livestock sheds and courtyards and litter-livestock excreta mixture as farmyard manure, organic agriculture also fosters forest conservation. **a** (upper); cattle and forest leaf litter on the ground by the side of livestock shed, **b** (lower left): intensive organic agriculture in near-flat valley lands, **c** (lower right): in villages on slopes, forests are maintained on upper slopes and lower slopes are terraced for crop cultivation.

region, is neither an economically lucrative nor environmentally sound land use. Poor connectivity and infrastructure also put north-eastern India in a disadvantageous position compared to Uttarakhand (Ramesh et al. 2005 and 2010, Ramakrishnan et al. 2006). Uttarakhand is the native region of *Basmati* rice demanded for its unique fragrance of large size-non-sticky grains, in the developed countries for past several decades. As the desired qualities of the export variety were achieved under organic conditions, "organic labeling" was just a formal value addition.

Advantages of Growing Crops Demanded in Export Market

The crops demanded in the export market after 1990s were not the preferred local food (e.g., finger millet and amaranth) or were consumed in small amounts (e.g., turmeric, kidney bean, medicinal plants, tea) and expansion of these less labour-intensive crops provided opportunity of income from deployment of released labor in other economic activities (Gopichand et al. 2006, Singh et al. 2008). A crop like fingermillet gave higher yields when soil was enriched with organic manure than with chemical fertilizers (Singh 2005) and was also less-sensitive to climatic variability (Singh et al. 2008). Agroecological conditions and traditional crops/ cultivars at higher elevations are such that high yields are obtained even under rainfed conditions. The hill region of Uttarakhand is quite rich in wild edibles (e.g., *Morchella esculenta* and *Juglans regia*) and medicinal species (*Cordyceps sinensis*, *Aconitum* spp., *Picrorhiza kurrooa*) which qualified for organic market and thus complementing cultivated food crops (Maikhuri et al. 2000, Phondani et al. 2010).

Abundance of Organic Manure and Water

The hill region of Uttarakhand is rich in forest cover (64% of total area), the primary source of traditional farmyard manure (leaf litter and 50-70% of livestock feed available from forests) and water resources (upper catchment of the snow-fed Ganga and >1000 mm annual rainfall), the key inputs for sustaining organic farming. Since 1890s, local people have formal rights of utilizing non-timber forest products required for crop/animal husbandry free of any cost. Removal of leaf litter from forest floor in limited quantities and rotational grazing/ lopping sustains agricultural production on one hand and reduces threats to forest biodiversity (Mishra and Rawat 1998) and ecosystem functions (Semwal and Mehta 1996, Maren and Vetaas 2007, Nautiyal and Kachele 2007). However, land/livestock holdings are too small to make sale of organic crops a lucrative occupation as evident from outmigration and abandonment of agricultural land use which follows ecological degradation in terms of establishment of invasive species and decline in carbon stocks in farm land and increased threats to forest biodiversity and ecosystem functions from build-up of fuelload, release of dominants in the absence of small scale disturbacnces and illicit commercial exploitation of both timber and non-timber forest products (Sen et al. 1997, Singh et al. 2008, Mishra and Rawat 1998).

Immense Scope of Tourism

Several shrines (e.g., Badrinath, Kedarnath, Gangotri and Yamunotri, Hemkund Saheb), World Heritage Site Nanda Devi Biosphere Reserve, picturesque landscapes (e.g., Valley of Flowers), trek routes traversing through adventurous highly dissected terrains to glaciers (e.g., Pindar glacier), high elevation lakes (e.g., Hemkund, Nainital, Bhimtal, Sahastratal, Nachiketatal, Rupkund), white water rafting in Ganga and other rivers, and many rare species (e.g., tiger, snow leopard, musk deer) make Uttarakhand a preferred destination of all kinds of tourists – recreational, religious, adventurous and environment-loving ones. The tourists, apart from consuming the organic food themselves, would help in advertising the organic products of the region (Saxena et al. 2011). Farmers can substantially improve income by processing and trading organic food themselves which in turn is expected to discourage outmigration and ecological degradation arising from abandonment of agricultural land use (Semwal et al. 2002, Nautiyal and Kachele 2007).

POLICY INTERVENTIONS COMPLEMENTING THE PRE-EXISTING ADVANTAGES

Capitalizing over pre-existing advantages, the provincial government constituted Uttarakhand Organic Farming Council and Uttarakhand Organic Commodity Board as umbrella organizations during 2000-2003 followed by a number of specific programmes mobilizing organic farming and associated activities at all levels: individual farmers, farmer groups and non-governmental organizations:

Informing and Involving Farmers

The government established a network of enterprising local farmers and trained them in vermicomposting technology, use of biofiertilizers available in market, maintaining records required for organic certification and employed them as Master Trainers on a part-time basis for reaching out to the wider community. The government, by adopting an internal quality control system of certification (Master Trainers maintaining plot-wise input-output records, external officials monitoring the records and accredited agencies invited from time to time) and entrusting the tasks of certification and trade facilitation to its agencies, cushioned marginal upland farmers from risks, uncertainties and exploitation in the market.

Financial Support to Individuals and Village Groups

The government of Uttarakhand launched a number of programmes to promote organic farming (Tables 1 and 2). It recognized a village with all farmers agreeing to be organic as a 'biovillage' eligible for a grant of Rs five lakhs (Rupees 500,000) for developing community marketing facilities and Rs two lakhs (Rupees 200,000) for implementing a land use microplan approved by it.

Table 1. Farming activities/inputs supported by the government under different schemes in Uttarakhand (US $ 1 = Rs 52 in year 2012)

Activity	Financial support
Horticultural expansion: high density fruit trees (Normally on flat land where agriculture is practiced till the horticultural tree canopy hinders the light availability on the ground)	Rs 60000 ha^{-1} over 3 years up to 4 ha
Horticultural expansion: normal fruit tree density (Normally on terraced agricultural land where agriculture is practiced with interspersed horticultural trees)	Rs 30000 ha^{-1} over 3 years up to 4 ha
Vegetable cultivation (transplant species, e.g, tomato, cauliflower, cabbage)	Rs 33750 ha^{-1} up to 2 ha
Vegetables (seed species, e.g., spinach, cucurbits)	Rs 22500 ha^{-1} up to 2 ha
Floriculture-marigold	Rs 18000 ha^{-1}
Cultivation of spices	Rs 18750 up to 4 ha
Restoration of degraded horticultural systems	Rs 15000 ha^{-1} up to 2 ha
Water sources creation	Rs 100300
Protected agriculture	Rs 46800 $100m^{-2}$
Training	Rs 400-1000 day^{-1}
Vermicomposting (10 x 2.5 x1 m)	Rs 30000
One-time incentive for organic farming	Rs 10000 ha^{-1} up to 4 ha
Power operated agricultural machinery	Rs 17500 $unit^{-1}$
Power machine (20 hp)	Rs 150000
Improved honey bee hive	Rs 700
IPM and biopesticides	Rs 1000 ha^{-1} up to 4 ha
Potato cultivation Rs 20000 ha^{-1} up to 1 ha	
Construction of water harvesting tank	Rs 20000 ha^{-1}
Supply of certified seeds	paddy, wheat and barley @ Rs 2000 Mg^{-1} other crops @ Rs 4000 Mg^{-1}
Subsidy on micronutrients, biofertilizers, green manure crops, weedicides (butachlor, 2,4 D, isoproturon, sulfosuron, metribuzine and pentamthylens) and gypsum	25% of market price
Subsidy for various agricultural machinery (small machines to power tiller and tractor)	50% of price subject to a limit of Rs 2000-Rs 45000 depending on the item
Financial aid to bio-villages	Rs 500,000 for village common facility ; Rs 200,000 for microplan based development
Supply of chemical fertilizers at subsidized price	Urea @Rs 6 kg^{-1}, superphosphate, @Rs 19 kg^{-1}
Adoption of villages by Indian Farmers' Fertilizers Cooperative (IFFCO)	Some villages, a few farmers *

* IFFCO - a government of India setup adopts some villages, selects 4-5 farmers, provides them all inputs including agrochemicals, for five years

Table 2. Extent of certified organic farming and sale of organic commodities during the period 2007-11 (source: Uttarakhand Organic Farming Council; Uttarakhand Organic Commodity Board)

Year	Area (ha) of certified organic* farms	Value (Rs) of sale of organic commodities
2007-08	24,653	51,800,000
2008-09	27,651	65,800,000
2009-10	33,181	93,300,000
2010-11	105,466	Not available

*total net cultivated area 753,711 ha

Nevertheless, farmers were free to operate independently or in groups formed by them. Subsidy of Rs 30,000 was available to a family for adopting vermicomposting technology and Rs 10,000 for constructing small water harvesting structures to irrigate its own fields. Government agencies themselves maintained canal systems providing irrigation water free of cost to larger communities. Higher productivity of irrigated organic systems, more so the vermicompost-fed ones, compared to the traditional farmyard manure based rainfed systems would likely make organic farming an economic lucrative occupation (Chandra et al. 2011).

The government offers one-time financial support of Rs 10,000 per hectare (restricted to 4 ha per family) as one becomes eligible for organic label only after three years from the date of formal commitment for organic farming despite the fact that majority of hill farmers had never used agrochemicals previously (Figure 3).

Linking Organic Farming with Other Development Programmes

Production of organic products was linked with other economic development programmes. As National Rural Employment Guarantee Scheme provided wages to only one family member for 100 days in a year (Rs 12,000 per year) for carrying out village development works, organic farming and associated activities were expected to complement this programme.

The government assured supply of a quota of rice and wheat at highly subsidized price from its outlets [24 kg of rice and 11 kg of wheat @ Rs 3 kg^{-1} and Rs 2 kg^{-1}, respectively, families below poverty line and 10 kg each of wheat and rice @ Rs 6 kg^{-1} and Rs 4 kg^{-1}, respectively, to other families every month) as well as sugar and kerosene oil (0.6 kg of sugar per individual per month @ Rs 8.50 kg^{-1} and kerosene 5-7 L $family^{-1}$ $month^{-1}$ @ Rs 13.50 L^{-1} to both groups]. Secured supply of staple food was likely to increase farmers' attention to products demanded in the organic market.

Figure 3. Promotion of organic farming by one agency of the government (Agricultural Department) and chemical fertilizers by another one (Indian Farmers Fertilizers Cooperative Limited, IFFCO) creates confusion among farmers. a, selection of Tapovan for biovillage programme by the Agricultural Department which provides incentives for organic farming; b, selection of Mulaya village as an IFFCO adopted village where IFFCO supplies chemical fertilizers and other inputs free of cost to selected farmers.

The government developed snow-sports at Auli, opened core zone of the Nanda Devi Biosphere Reserve to tourists inaccessible to them since 1980s and provided financial support for operating homestays, restaurants and transport facilities. Many local crops, food dishes and their nutritive/medicinal values still 'lesser-known' to a wider community could induce a new class of tourists including participatory researchers, nature-lovers, enterprising farmers from outside the region and food technologists visiting the state in large numbers (Saxena et al. 2011). Increase in tourist inflow was expected to boost up organic products linked market economy.

NEGLECTED DIMENSIONS OF ORGANIC FARMING

Promoting Organic Agroforestry in Degraded Lands

Differing from the common scenario of agriculture causing deforestation and forest degradation in mountain areas in many developing countries (Saxena et al. 2007 and 2011), indigenous socio-cultural restraints on sale-purchase of farmland, hiring labour from outside the village for farming, profit motive in exchange of food grains/seeds within village, abandonment of agricultural land and forest conversion minimized agricultural land use expansion coupled with forest conservation. However, the changes in traditional value systems in recent years did result in ecological degradation (Nautiyal and Kachele 2007, Singh et al. 2008). At present, cultivable wastelands cover 391,650 ha and degraded forests 800,190 ha area compared to 491,349 ha of net sown area in Uttarakhand (Anonymous 2010). With food production being just on the margin of the local requirement in well managed organic villages on one hand and growing importance of Himalayan wild biodiversity and ecosystem services (Semwal et al. 2004, Singh et al. 2008), development of agroforestry could be a sustainable land rehabilitation strategy. Tree-crop mixed organic farming in abandoned agricultural land enabled carbon sequestration at a rate of 3,100 kg C ha^{-1} $year^{-1}$ (Semwal et al. 2002) compared to only 900 kg ha^{-1} $year^{-1}$ in pure crop systems receiving both inorganic and organic inputs (Kundu et al. 2007, Shreshtha et al. 2012) in sandy soils. Organic farming on $<2^0$ outward sloping terraces brings down soil erosion rates to 0.6 Mg ha^{-1} $year^{-1}$ compared to 4.3 – 36.9 Mg ha^{-1} $year^{-1}$ and 36.9 Mg ha^{-1} $year^{-1}$ on $5\text{-}10^0$ outward sloping terraces (Sen et al. 1997). Organic farming recuperates beneficial soil biota like earthworms (Bhadauria et al. 2012). Redeveloped organic agroecosystems could support higher agronomic yields at much lower environmental costs compared to the conventional systems (Das et al. 2010, Lee et al. 2010, Chandrasekhar et al. 2011). Carbon sequestration by developing tree-crop mixed organic farming in degraded lands in the developing countries qualifies for economic benefits provided in the United Nation's REDD+ programme but policies supporting long term research, awareness and capacity building programmes are needed (Liu et al. 2010, Ramesh et al. 2010, Crittenden et al. 2015, Prasad et al. 2016) to capitalize on this opportunity.

Conservation of Lesser-known Agrobiodiversity

Aspirations for higher income and increase in trade in the high hills following drastic improvement in accessibility after 1970 led to widespread abandonment of less profitable traditional crops (e.g., *Panicum miliaceum*, *Setaria italica*, *Fagopyrum tataricum*, *F. dibotrys*, *Hordeum himalayens* and *Pisum arvense*) and traditional management practices (e.g., growing *Perrilla frutescens* to dispel wildlife, mixing pulses with millets/rice and mustard with wheat to reduce insect pest/pathogen infestation and fallowing a field in winter season in alternate years), even though they were more resilient to environmental stresses and hence an asset in the face of global changes (Maikhuri et al. 2000, Rao et al. 2002, Singh et al. 2008). As hardly 5 out of around 40 crops grown in the region are demanded in the national or global market and present policies/programmes promote their export, there are serious risks of loss of biodiversity (Table 3). The aspirations for fast pace of economic development may pull farmers far away from their basic occupation of farming. For the past 4 years, one can observe the whole alpine village communities camping in alpine pastures collecting wild *Cordyceps sinensis* fetching a price of US $ 6000-6500 kg^{-1} with traders taking the product against cash payment in the village itself. Farmers do not know the use or factors determining abundance of this species. A drastic reduction in availability of the product after 2012 led them to realise over-extraction in the previous years. Nevertheless, the income from this wild species even now is 5-20 times higher than that from farming. Farmers are drawn more by the profits at present than by risks and uncertainties in future, e.g., poor demand in future following its domestication or its availability elsewhere too. Farmers need to be informed of the insurance and

Table 3. Traditional crop diversity in Uttarakhand Himalaya, India

Crop species	Common name (local name)	Selected elements of traditional knowledge	Broad Elevation range, m
Allium cepa	Onion (Pyaz)	Requires irrigation and high manure input.	500-1200
Allium humile	Chives (Jimbu/ Faran)	Used as spice/condiment, cultivated on small-scale in agricultural fields and even on rooftops and village ruins and needs high manure input.	2300-3000
Amaranthus oleracea	Amaranth (Chaulai)	Cultivated on small scale for vegetable and also for grains often as rainfed mixed crop during Kharif (summer) season .	500-2500
Amaranthus frumentacea	Amaranth (Chuwa/ Ramdana)	A cash crop rich in protein, cultivated on large scale only at higher altitude areas as pure/ mixed rainfed crop during Kharif season and considered sacred food.	1500-3000
Brassica campestris	Mustard (sarson)	A Rabi (winter) season crop performs better in higher altitude areas; seeds yield cooking oil and tender leaves are widely used as green vegetable during winter season.	500-2200
Brassica spp	Mustard (Toria)	Source of cooking oil. Sometimes grounded seeds also mixed with cooked rice to prepare instant food.	500-2000
Cajanus cajan	Pigeon pea (Tor)	Grown in less fertile soil to improve soil fertility and one of the costliest legumes/pulses in the market.	500-1800
Carum carvi	Caraway (Kala Jeera)	Grown in selected high altitude villages, used as a condiment as well as a medicine and require high manure input.	2200-2900
Chenopodium album	Pig-weed (Bhetu)	In some areas used mostly as a vegetable	2000-2500
Cleome viscosa	Asian spiderflower (Jakhia)	Grows as a weed with Kharif season rainfed crops and used as a condiment having good market value	500-1500
Colocasia esculenta	Taro (Pindalu)	Needs irrigation and high manure input and grown as a cash crop in some areas	500-1500
Echinochloa frumentacea	Barnyard millet (Jhangora)	Does not need irrigation and possesses medicinal properties to cure jaundice and consumed widely as a substitute of rice. Crop by- product rated as the best quality fodder. Taste and food quality deteriorates after about one year of storage and therefore consumed soon after its production. Also used for making local alcoholic beverage.	500-1800
Eleusine coracana	Finger millet (Koda)	Does not need irrigation and used to be consumed in large quantities in traditional food. Taste and food deteriorates after prolonged storage and so consumed soon after its production. Also used for making local alcoholic beverage.	500-2200
Fagopyrum esculentum	Buckwheat (Oggal)	A rainfed crop consumed as food and also offered to gods and goddesses.	1900-2800
Fagopyrum tataricum	Buckwheat (Fafra)	A rainfed crop consumed as food, offered to gods and goddesses and also sold for income.	1900-2800
Glycine soja	Soybean	Does not need irrigation, introduced by government during 1970s-80s.	500-1700
Glycine sp.	Soybean (Kala Bhatt)	Does not need irrigation but many a times sown on the raised bunds of wet paddy fields. Traditionally consumed as a pulse soup and in a variety of snacks.	1000-2200
Glycine max	Soybean (Bhatt)	Does not need irrigation but mostly cultivated on the raised bunds of wet paddy fields. Traditionally consumed as a pulse soup and in a variety of snacks , specifically boiling the ripe pods to relish the cooked seeds during harvest season.	500-1400

Crop species	Common name (local name)	Selected elements of traditional knowledge	Broad Elevation range, m
Hibiscus subdariffa	Roselle (Sun)	Few plants are maintained in mixed crops during Kharif season. Used for fiber and also for its oily seeds.	500-1500
Hordeum himalayens	Naked barley (Wa-jau)	A staple rainfed food crop grown during Rabi in high altitude areas under rainfed condition .	1400-2800
Hordeum vulgare	Barley (Jau)	Rainfed crop grown on a small scale for making *sattu* (a traditional instant human food made by grinding roasted seeds) while raw grains are fed to livestock especially bullocks to perform arduous work like ploughing.	900-2200
Lens esculenta	Lentil (Masoor)	Rainfed Rabi (winter) season legume/ pulse.	500-1900
Macrotyloma uniflorum	Horsegram (Gahat)	Grown as a minor constituent of mixed crop in settled rainfed fields and as a pure crop in slash and burn agriculture (Katil) during Kharif season. An extremely useful staple and medicinal pulse to cure kidney stones. Boiling hot soup is poured over big boulders to break/crush them.	500-1800
Oryza sativa	Paddy (Satti)	Grown as mixed or pure crop in rainfed fields during Kharif season. It is one of the important staple food. This rice is considered to be less tasty and and also difficult to digest as compared to irrigated rice.	500-1800
Oryza sativa	Paddy (Dhan)	Needs intensive water and manure inputs and is the most important staple food crop of the region.	500-1000
Panicum miliaceum	Hog-millet (Cheena/ Bhangana)	An short duration (2.5-months) crop grown during transition period between Rabi and Kharif seasons used to be grown on a large scale in both rainfed (Cheena) and irrigated (Bhangana) conditions when public distribution system did not exist	500-1950
Perilla frutescens	Perilla (Bhangjeera)	Oil and medicinal crop grown in higher altitude rainfed fields. Takes around 10 months to ripen.	1200-2300
Phaseolus vulgaris	Kidney bean (Rajama)	An important cash crop of Kharif season cultivated as mixed or monocrop on a large scale in higher elevation villages.	1500-2500
Pisum sativum	Pea (Matar)	A cash crop cultivated in mono- as well as mixed-crop condition during Rabi season.	500-1500
Pisum spp	(Kong)	Traditional pulse of higher elevation.	2000-2500
Pleurospermum angelicoides	(Choru)	Used as a medicinal product/ condiment. Largely collected from wild but recently domesticated in a few high altitude villages.	2200-2900
Saussurea costus	(Kuth)	Used as a medicinal product/condiment. Largely collected from wild but recently domesticated in a few high altitude villages.	2200-2900
Sesamum indicum	Sesame (Til)	Rainfed oil crop of Kharif season which can grow in relatively infertile soils also.	1000-1600
Setaria italica	Foxtail millet (Kauni)	An early maturing Kharif season crop, ripens in about three months time and valued for food security by the small holders when public distribution system was not in place.	800-2000
Solanum tuberosum	Potato (Alu)	A cash crop grown on a large scale in higher altitude villages requiring 2-3 times more manure input as compared to traditional staple crops.	1000-2500
Sorghum vulgare	Pearl millet (Junyali)	Rainfed crop grown on a small scale in very few villages during Kharif season.	1200-2000
Triticum aestivum	Wheat (Gehun)	Staple crop grown both in irrigated and rainfed conditions during Rabi season and needs huge manure input.	500-2500
Vigna aconitifolia	Mat bean (Bhringa)	Traditional Kharif season pulse grown mixed with other crops on a small scale.	800-1600
Vigna angularis	Adjuki bean (Rains)	Traditional Kharif season pulse grown mixed with other crops on a small scale.	1200-1800

Crop species	Common name (local name)	Selected elements of traditional knowledge	Broad Elevation range, m
Vigna mungo	Black gram (Urad)	Traditional Kharif season pulse gown mixed with other crops on a small scale.	500-1600
Vigna radiata	Green gram (Mung)	Traditional Kharif season pulse grown mixed with other crops in smaller quantities	500-1000
Vigna unguiculata	Cow pea (Sonta)	Traditional Kharif season pulse grown mixed with other crops on a small scale.	500-1700
Vigna umbellata	Rice bean (Bhotiya)	Traditional Kharif season pulse grown mixed with other crops on a small scale.	1200-2200
Zea mays	Maize/Corn (Mungari)	Rainfed crop grown mixed with other crops in agricultural fields and as monocrop in kitchen gardens/ courtyards; consumed largely as a snack: mature cobs are roasted or boiled and the kernels/seeds are consumed.	500-1600
Zingiber officinale	Zinger (Adrak)	A traditional spice and medicinal plant cultivated on a large scale as a cash crop in some pockets.	500-1400

buffering agrobiodiversity would provide under fast changing and/or unpredictable global environmental changes (e.g., global warming and changes in precipitation), market trends (e.g., downfall in price and demand in market) and political/policy priorities (e.g., termination of policy of supplying food grains at subsidised price) before irrecoverable loss of agro-biodiversity.

Evaluating and Improving Indigenous Innovations

Having observed the ineffectiveness of biopesticide properties of lemon, guava and marigold promoted during training programmes organized by the government agencies, farmers came up with an effective formulation from *Urtica* sp., *Cannabis* sp. and *Melia* sp., growing naturally in the area. When the government agencies stopped distributing microbial consortia enabling accelerated composting, farmers identified cow urine as its replacement. Some farmers observed a drastic reduction in maturity period of local cultivar Palthi Urd (blackgram) following vermicompost application enabling increase in cropping intensity (Rawat 2009). These indigenous innovations need to be evaluated scientifically and further improved.

Building Local Capacity in Marketing and Production of Value-added Products

Small farms and settlements, remoteness and poor understanding of national/global markets delimit margin of profits to hill farmers tuned to subsistence economy since generations. As a recent example, farmers around the Nanda Devi Biosphere Reserve, succeeded in domesticating costly medicinal species such as *Allium humile*, *A. stracheyi*, *Carum carvi*, *Pleurospermum angelicoides*, *Dactylorhiza hatagirea* and *Megacarpea polyandra* during 1980s (Maikhuri et al. 2000) but this innovation could not scale up because farmers were unable to market the product. Policy support is needed to build local capacity of escaping exploitation in a competitive market rather than making farmers dependent on government regulated marketing systems. The present system of Government agencies mediating the trade has deficiencies: (a) it does not improve farmers' marketing skills and entrepreneurship, (ii) vested interests of individuals among government officials and power-wielding individuals of the community, at times, reduce the margin of profits to traders or farmers or both, and (c) the very existence of government agencies is endangered by revenue constraints and changing political priorities (Farooquee and Saxena 1996). Services of many Master Trainers, the cushions between government officials and traders and farmers, appointed in the year 2002 were terminated in 2007 and many of the continuing ones work half-heartedly as they foresee similar action any time in future. All this results in a huge margin of profit to the middlemen in the marketing channel (Table 4).

Government agencies and policy mechanisms should help farmers directly by providing subsidy or indirectly by bringing traders at the farm gate but with an ultimate goal of building local capacity and a clear plan of withdrawal. Initially, government could operate such that its operational costs were recovered and at the same time farmers were ensured of profits. The operational costs

Table 4. Selling price (Rs kg^{-1}) of selected crops grown organically in traditional agriculture in the village and retail outlets at the district headquarters (in March 2012)

Crop	Village	Retail outlet
Rajma (Chakrata) (*Phaseolus vulgaris)*	65-80	140
Soybean (*Glycine soja)*	14-20	40
Soybean (Bhatt/Kale) (*Glycine* spp)	40-45	80
Rains (Naurangi) (*Vigna angularis)*	30-35	60
Urd (*Vigna mungo)*	40-50	72
Gahat (*Macrotyloma uniflorum)*	45-50	80
Tor (*Cajanus cajan)*	50-60	112
Jhangora (*Echinochloa frumentacea)*	10-20	35
Manduwa (*Eleusine coracana)*	10-12	20
Buckwheat (*Fagopyrum esculentum* and *F. tataricum)*	25-40	70
Amaranth (*Amaranthus frumentaceus)*	15-20	60

could be reduced by making use of the existing institutions, e.g., the Village Council (Gram Sabha), Forest Council (Van Panchayat), Youth Forum (Yuvak Mangal Dal), Women Forum (Mahila Mangal Dal) and Eco-development Committee at village level rather than creating the new ones.

Farmers may be informed of the success of cooperative elsewhere: the sustainability of The Lahaul Potato Society established in the 1960s with negligible support from the government (Baumann and Singh 2000), the self-reliance among Manangees in Nepal who achieved prosperity without accepting any national or external aid (Aase 2011) and advancement of organic farming in some parts of Thailand without any subsidy from the government (Thapa and Rattanasuteerakul 2011).

The present policies focus on export of raw products. Marketing of value added products would improve local human and social capital apart from enhancing local incomes without agricultural expansion. Focus on export ignoring the potential of local market for organic food and traditional crops are other drawbacks. Under the influence of wheat-rice eating mainstream society, the hill people started viewing the millets, pseudo-cereals and many local pulses as 'coarse food' or 'poor-man's food' which, though may taste different, are nutritionally better than wheat-rice (Maikhuri et al. 2000). Government of Uttarakhand serves meals to school level students but rarely serves the traditional crops. Organic traditional food seldom finds a place in food served in government funded events. A big market of traditional crops and organic food can be created by promotion of consumption of traditional crops and organic food within the State by the

Figure 4. Agriculture over a large area has been abandoned as a result of outmigration. There is also an emerging trend of a few rich farmers purchasing the land of the poor farmers who, mostly, are organic. Policies promoting rejuvenation of traditional organic farming in abandoned agricultural land by the resident farmers and discouraging purchase of land of poor farmers for non-agricultural/non-forest use would promote sustainable land management as well as enhancement of economic well being of poor farmers. **a** (left), construction on highly productive agricultural land, and **b** (right) abandonment of agricultural land leading to invasion by pine with comparatively poor ecosystem services.

Figure 5. There is a trend of rich families renting out their lands to Nepalese farmers who use huge quantities of agrochemicals for maximizing profits. Local farmers are not able to visualize the long term environmental and social costs of renting out land and over use of chemicals.

government. The retail centers of both raw and processed products should be spread out all across the State unlike the present state where the products are displayed only on some specific occasions/events. The Royal Project of Thailand is an example where the project provides all inputs to farmers, procures the produce and markets it in all the three forms: the raw food, preserved food and cooked food.

The present policies neither favour contract farming nor do they encourage cooperative farming (Figures 4 and 5). Because of small holdings at present and further reduction in size in future (because of increase in population and Forest Conservation Act ruling out any agricultural expansion in forest land), farmers would be more secured and will also develop competitive skills with contract farming with bigger private firms, government firms and public-private partners.

Conflicting Policies

Policies promoting organic farming operate parallel with those which discourage it (Table 1). Indeed, complete abandonment of agrochemicals may not be a judicious choice in view of evidence showing higher productivity of agrochemical-based agricultural systems and production of unhealthy food in some organic systems (Mader et al. 2002, Prasad 2005, Patil et al. 2014). There is a need of developing an objective decision making tool: where and how long to practice organic farming and conventional agrochemical based farming. In the absence of such tools, farmers will operate in a state of confusion. The survey of farmers' perceptions about key problems, their causes and the scope of their solutions showed that organic farming was not a priority concern of the majority (Table 5).

CONCLUSIONS

Upland people have started looking at farming as a dull and unattractive occupation because of their inability to satisfy their needs such as quality education, health and comforts from it alone, lack of effective innovations enabling reduction in labor and time inputs in farming and their limitations in realizing the potential benefits from traditional farming. Increasing the area under organic farming alone is not likely to satisfy farmers' needs and aspirations. Policies need to consider the scope of enhancing farmers' capacity along multiple directions – raising productivity, improving food quality, enhancing local capacity for storage, value addition and marketing. Policies are bound to change with changing national and international political and economic scenarios. Farmers would benefit in long term if they

Table 5. Key problems, their causes and scope of solution based on farmers' perceptions in hilly region of Uttarakhand

Key problems	Causes	Scope of solution
Inability of farming to satisfy the needs such as quality education, health and comforts	Small and fragmented land holdings	Consolidation of land holdings is constrained by huge biophysical heterogeneity and enlargement of holdings by environmental conservation laws and policies. Operational holdings can be enlarged by encouraging cultivation of lands of migrants by the resident farmers, individually or in groups and/or through public-private partnerships.
	Low crop yields due to water and nutrient stresses	Yields can be improved by establishing small irrigation systems designed for life saving irrigation on slopes and flood-irrigation only in flat valley lands together with improvement in quality of traditional farmyard manure (Rao et al. 2003) or by using vermicompost (Bhadauria et al. unpublished)
	Lack of policies protecting farmers from exploitation and uncertainty in monetary market	Policy incentives for cooperative farming, storage, value addition and marketing, contract farming and public-private partnership enterprises
	Lack of policies promoting local crop storage, value-addition and marketing capacity	
	Lack of quality social infrastructure (health, education and comforts) around rural areas	Special subsidy on quality education and health facilities to farmers practicing sustainable agriculture in remote areas Promotion of quality education and health facilities in remote areas
Lack of effective innovations enabling reduction in labor and time inputs in farming	Limited local innovation capacity	Initiation of participatory farming systems research and development programmes and promotion of farmer-to-farmer exchange of knowledge and experiences
	Priorities to agricultural development in the alluvial plains in national/provincial policies	
	Neglect of hill specificities in conventional agricultural research and development programmes, e.g., financial support to heavy machinery difficult to transport on steep slopes and operate on narrow terraces	
Inability to realize the potential benefits from traditional farming	Weakening of traditional institutions which used to discourage abandonment of agricultural land, protect crops and livestock from wildlife and encourage efficient use of water for irrigation and forest resources for fodder and manure	Recognition and appreciation of the strengths of traditional institutions in conventional/formal development programmes
	Restricted access to areas rich in high quality leaf litter (a constituent of manure) and fodder, the key inputs in traditional organic farming	Improvement in traditional livestock husbandry and farmyard manure production and application practices
	Supply of food grains at subsidized price and secured income from employment in government schemes	Consideration of sustainability of farming practices while determining the entitlement of benefits from government welfare/development programmes

	Lack of any reward for practicing sustainable organic farming or penalties for under-utilization (e.g., abandonment of agricultural land use by absentee farmers) and degradation of agricultural lands (e.g., over-use of agrochemicals by Nepalese tenant farmers)	
	Creation of multiple institutions, with poor inter-institutional coordination and often conflicting interests and objectives, e.g., government agencies promoting organic farming coexisting with those agrochemicals (e.g., Indian Farmers' Fertilizers Cooperative (IFFCO) providing modern inputs free of cost to selected farmers, subsidy on agrochemicals available from government agriculture/horti-culture/ rural development agencies and soft loan for modernizing traditional agriculture; Village Council (Gram Sabha), Forest Council (Van Panchayat), Joint Forest Management, Youth Welfare Forum (Yuvak Mangal Dal), Women Welfare Forum (Mahila Mangal Dal) within a village	Review of the outcome of existing institutions, reorganization of institutions, reconciliation of conflicts and rejuvenation of traditional decision making in general assembly of the whole village community (rather than by the handful elected or selected individuals), with leaders and elders facilitating the decision making process

make use of the opportunities provided in the present policies to build their capacity so that they are not adversely affected when policy support is withdrawn. One would expect that farmers come forward for (i) development of participatory guarantee systems freeing the government with the burden of certification, (ii) direct links with consumers by operating 'organic restaurant' close to farms and letting the consumers themselves observe farm operations, offering the supply of products to consumers at their residences and also on farm and by producing packed value added/processed food and thus enlarging the range of choices to consumers, (iii) public pressure for mandatory consumption of organic food in the events fully funded by the government and (iv) establishment of participatory research stations for further improvement in the existing organic farming system.

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