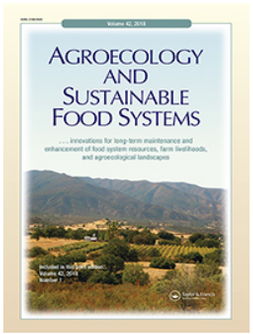

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Farmers' rights, local food systems, and sustainable household dietary diversification: A case of Uttarakhand Himalaya in north-western India

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ABSTRACT

The farmers and rural communities, world over, have contributed greatly in management of agrobiodiversity including plant genetic resources for food and agriculture (PGRFA). It is well accepted now that the efforts of farming communities in creation, conservation, exchange, and enhancement of PGR should be recognized and strengthened. Farmers' access and rights over seeds are considered an essential component of food sovereignty. In the present article, we discuss the aspects of farmers' rights, the community level seed systems, food sovereignty and the potential of farmer household production and dietary diversification in combating malnutrition and community health promotion with regard to farming communities of Uttarakhand hills in north-western India. Salient findings of two case studies, on farmers' varieties documentation and registration, and the potential of local food systems in addressing community health and nutrition were used to particularly showcase the nutritional contribution of native foods in the context of sustainable food-based approaches to community health and nutrition. Further, the need of a proactive alliance was suggested between local communities and their key allies collaboratively creating a research and advocacy agenda in support of agrobiodiversity and the revival of local food systems and landscapes within the broader framework of food sovereignty.

KEYWORDS

Farmers' rights; community seed systems; food sovereignty; household production and dietary diversity; nutritional security

Introduction

The transition from hunting–gathering to agriculture, the Neolithic revolution, started some 12,500 years ago with the domestication of a small number of wild plant species across various parts of the world, more particularly in the global south. The domestication of wild plant species led to the first agricultural revolution that provided us with a relatively secure source of food. The diversity we have today in these crops and domesticated animals is the result of the interaction between countless generations of farmers and the

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plants and animals they domesticated. It is a well-accepted fact that crop diversity and wild-harvested plants and animals have made and continue to make appreciable contributions to human diets (Heywood 2013). However, we have limited information on their importance in terms of energy intake, micronutrient intake and dietary diversification, and correlating agricultural biodiversity with human nutrition is generally difficult for a number of reasons including human diversity (DeClerck et al. 2011).

Further, the exploitation of agricultural biodiversity has provided enormous nutrition and health benefits but overexploitation of some resources and extensive habitat loss has negatively impacted the dietary diversity, nutrition, and health of some groups of society (Nakhauka 2009). We are now faced with attempting to assess these impacts, learn lessons, and seek a sustainable way forward (IAASTD 2009). New approaches have been explored which aim to integrate environmental and human health, focusing especially on the many interactions between agriculture, ecology, and human nutrition (Blasbalg, Wispelwey, and Deckelbaum 2011; Heywood 2013).

It is also a well-known fact that despite the success of the agricultural revolution in providing enough food to feed the world, today we are faced with issues of over- and undernutrition––both forms of malnutrition. More than a billion people today are underfed and suffering from acute malnutrition thus making them more disease-prone, while much of the developed world is at the same time facing a crisis of obesity caused by overnutrition. Overnutrition is increasingly aggravated by an unhealthy lifestyle, leading to diet-related diseases, such as cardiovascular disease, hypertension, cancer, diabetes, etc. This tendency is not confined to the developed world but is also spreading to countries undergoing rapid societal transition—so-called development-driven obesity (Heywood 2013). Worldwide 30% more people are now obese than those who are underfed. The causes of these nutritional challenges are many and complex as are possible solutions.

It has been argued that healthy human nutrition is best achieved by an approach to agriculture that is biodiverse, providing a varied and ecologically sustainable food supply. However, such an eco-nutrition model is sound in theory but very complex to achieve, as many variables are involved, in reality (Blasbalg, Wispelwey, and Deckelbaum 2011). Such a biodiverse food-based approach should be seen as an element in an overall strategy that also includes continuing improvement of agricultural production, breeding cultivars that are more resistant to disease and stress, nutritional enhancement of crops, industrial fortification, vitamin supplementation, and other nutrition–agriculture linkages (Chung et al. 2010).

There is therefore a necessity to broaden our approach even further and explore the linkages between agriculture, food production, nutrition, ethnobiology and ethnopharmacology, and the resource base of wild and agricultural biodiversity in the context of accelerating global change. At an institutional level,

both globally and nationally, these issues are often poorly coordinated (Heywood 2011).

It may also be emphasized that since the time of colonization, indigenous communities have witnessed a drastic decline in the health and integrity of indigenous cultures, ecosystems, social structures, and knowledge systems which are integral to our ability to respond to our own needs for adequate amounts of healthy indigenous foods. The changing food systems brought about by the forces of globalization have led to both challenges and opportunities. There is alarm that local culture and food traditions are disappearing, where multinational and transnational corporations are increasingly controlling national food in addition, for most countries, micronutrient deficiencies are of concern. It is, however, being argued the indigenous food sovereignty provides a restorative framework for health and community development and reconciling past social and environmental injustices in an approach that people of all cultures can relate to.

The globalization of the neoliberal model of agriculture has been countered by the formation of a transnational peasant and farm movement, the Via Campesina (Desmarais 2002, 2003). The Via Campesina emerged in 1993 as the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) was drawing to a close with the signing of, among 20 other agreements, the World Trade Organization's (WTO) Agreement on Agriculture and the Trade Related Intellectual Property Rights (TRIPS). According to the Via Campesina, food is a basic human right and "all peoples" and states must have the right to define their own agricultural and food policies" to ensure domestic food security and the well being of its farming population (Via Campesina 2000a, 2000b, 2007). Food sovereignty means ensuring that peasants, small farmers, and rural women have the right to all resources necessary for producing food; they must have greater access to and control over land, seeds, water, credit, and markets (Via Campesina 2000a).

Moreover, food sovereignty is only possible with the democratic control of the food system and recognition that "cultural heritage and genetic resources belong to all humanity" (Via Campesina 1996a). Food sovereignty goes beyond the common understanding of food security as guaranteeing that an adequate amount of food is produced and made accessible to everyone. Instead, food sovereignty deals with questions of what food is produced, where it is produced, how it is produced, and at what scale. The Via Campesina (1996b) argues that food security cannot be reached without food sovereignty.

There is, however, no uniform conceptualization of what food sovereignty constitutes. The definition has been expanding over time. It has moved from its initial focus on national self-sufficiency in food production ("the right of nations") to local self-sufficiency ("the rights of peoples"). There is also a growing emphasis on the rights of women and other disadvantaged groups, and on consensus building and democratic choice (Agarwal 2014).

In fact, food sovereignty is a radical alternative to the WTO's vision for agriculture. Whereas the WTO's guiding principles are the "right to export" at all costs and the "right to import" food as the best way to ensure food security, food sovereignty prioritizes local production for local consumption. It is not that the Via Campesina is opposed to agricultural trade, but stresses "food is first and foremost a source of nutrition and only secondarily an item of trade." Since food is a basic human- right "only the excess should be traded." In addition, this international trade "must serve the interests of society" rather than filling the bottomless pockets of transnational agribusiness corporations. Food sovereignty is simply not possible under WTO framework.

About 60–70% food in hilly areas of Uttarakhand state of India is still produced by small-scale farmers who use traditional farming methods and also sell their surplus produce locally. Small-scale ecological farming methods are considered the key to ensuring resilience to climate change. They are based on enhancing diversity––thereby increasing options to respond to climate instability. There is, therefore, a need to support these traditional systems in order to feed local communities and at the same time address the traditional food-based approach of community nutrition and health. Uttarakhand hills have a strong native food culture and traditions. A fair food system would be one where agricultural traditions are once again firmly rooted in their local landscapes. These traditions recognize that healthy food depends on healthy ecosystems, and this requires farmers to comply with the same laws of nature which give life.

Salient findings of the two model case studies, (i) farmers' varieties documentation and registration, and (ii) the potential of local food systems in addressing community health and nutrition, are being presented and discussed in the present article with regard to hilly areas of Uttarakhand state in north-western India where biodiverse traditional subsistence farming is predominantly practiced.

The case study on documentation and registration of farmers' varieties will facilitate addressing farmers' rights (FR). Two broad approaches to defining FR in India can be rightly considered: (1) FR as a form of IPR and (2) FR as a development right. The first approach poses FR parallel to Plant Breeders' Rights and argues that if commercial breeders can acquire intellectual property over their inventions, then farmers' innovations must also be recognized and rewarded. The second encompasses a range of concerns including food sovereignty, food security, livelihood rights, social justice, and access to resources. Beside adopting the first approach at large, India's policy also acknowledges the second view. Many stakeholders do feel that FR should move beyond ownership rights to incorporate development rights (Ramanna 2006). In a recent article, Peschard (2017) also elaborates in greater detail how FR in India are protected on paper under Protection of Plant Varieties & Farmers' Rights (PPV&FR) Act

2001, and has limited impact on the ground in addressing FR and preservation of agrobiodiversity.

The second case study on the potential of local food systems in addressing community health and nutrition will showcase how best the problem of malnutrition and food-related diseases can be addressed by reviving the native food culture and traditions. The need of a proactive alliance among diverse stakeholders collaboratively creating a research and advocacy agenda in support of agrobiodiversity and the revival of local food systems and landscapes within the broader framework of food sovereignty will be explored and advocated. Food sovereignty has yet not been formally adopted in the state policy of India in general and Uttarakhand hills in particular.

Representative farming situations in Uttarakhand Himalaya

Like most of India, agriculture is one of the significant sectors of the economy of Uttarakhand state. About 86% of the state consists of hills but most of the crop lands are in plains, the Terai and Bhabar region, where improved agriculture is practiced (Figure 1). On the other hand, the hilly areas of Uttarakhand state (parts of north-western Himalayas) traditionally grow diverse crops as polycultures. The crops include coarse cereals (minor millets-finger millet, barnyard

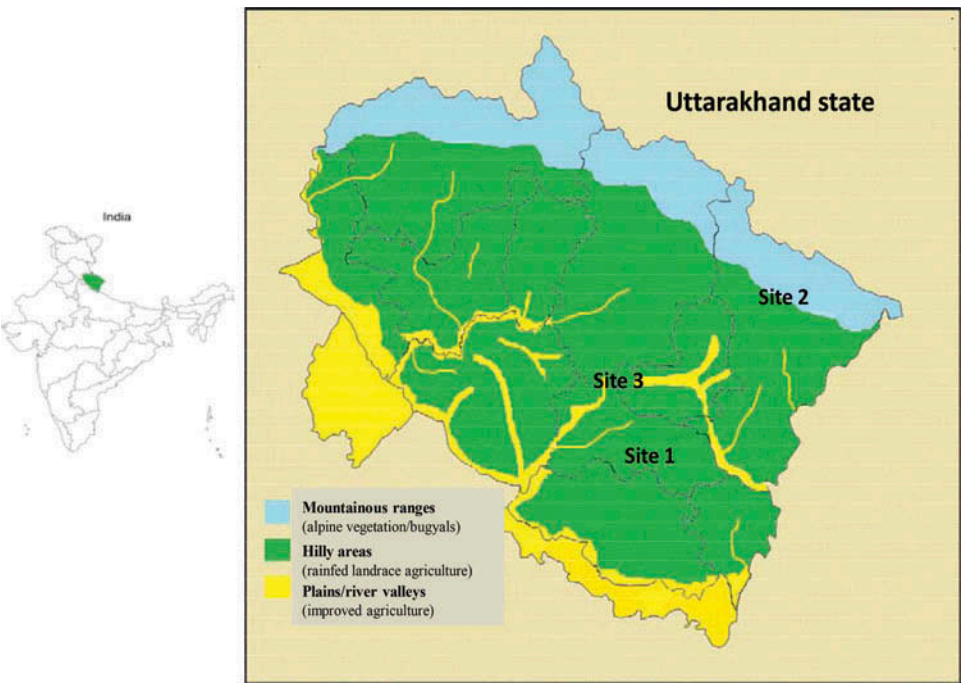

Figure 1. Representative farming situations in Uttarakhand state. (Site 1 was the main representative target site for both the model case studies; Sites 2 and 3 were additionally included for the case study related to comparison of farmer households' production and dietary diversity)

millet, foxtail millet, little millet, prosomillet), rice, wheat, barley, pulses (horsegram, black gram, black-seeded local soybean, lentil, cowpea, rice bean), oilseeds (mustard, sesame), several underutilized crops (amaranths, buckwheat, chenopods, tubers, yams, cucurbits, minor leafy vegetables, perilla, and others), numerous medicinal herbs, etc. Most of these native crops and their traditional landraces form the "functional foods" to hill farming communities with nutraceutical properties and high nutritional value. The subsistence harvests and uses of wild resources by native communities have been other important feature of traditional hill farming.

Fruits like apples, oranges, pears, peaches, plums, and citrus are also grown and important to the food-processing industry in certain areas. Livestock (buffalo, cattle, goats, sheep, and poultry) are integral to hill farming and contributes substantially to rural economy.

In Uttarakhand hills, there exists a self-contained food system, specific to different farming situations and communities which are deeply rooted in local traditions and culture. However, the forces of globalization and the vulnerabilities arising from poverty, discrimination, and marginalization in some sections of farmer households in the hill communities are increasingly affecting the native food culture. Limited access to diverse food resources is affecting the nutrition and health of native communities causing malnutrition among children and women.

The traditional hill agriculture is highly knowledge-based and farmer-led innovations are predominantly practiced. All farmer-led innovations are socioeconomic and are not of a technical nature. The driving forces for emergence of the farmer-led innovation paradigm are constraints to crop and livestock production.

Non-availability of quality seed of native crop varieties, lack of human resources (farm laborers), poor market infrastructure for native crops, high land fragmentation, and the changing climate, especially greater frequency and severity of droughts during the past two decades or so, have been the major constraints to traditional rainfed agriculture of Uttarakhand hills. Further, poor management of common property resources (CPRs) leads to declining fodder resources for livestock in crop–livestock small-scale mixed farming and declining sources of wild-harvested foods. The dynamic relationship among crops, livestock, and CPRs is increasingly breaking down now.

During the exploratory surveys in parts of Uttarakhand hills, we encountered the following three predominant representative farming situations (Figure 1; Photo Plates 1–3):

1. Small-scale crop–livestock mixed farming systems representing about 70% of cropped area under rainfed farming (Plate 1). The farming situations could be characterized by high household food production and dietary diversity. Only farmer-led traditional innovations were predominantly practiced. In the mixed crop–livestock farming system of the hills, there still exists a dynamic

Plate 1. Target Site 1––Agrobiodiversity-rich niche site(s) where traditional small-scale crop–livestock mixed-farming is practiced such as in Tarikhet block of Almora district and several other locations in Uttarakhand hills.

relationship among CPRs, native crops, and livestock. The livestock substantially contributes to household cash income, whereas the surplus crop produce, if any, is sold locally and contributes very little to the household cash income.

The important farmer-led innovations of the small-scale crop–livestock mixed farming systems are as follows:

- Landrace agriculture with almost 100% seed requirement met locally through ISS.
- The forest resources and crop residues augment the nutritive value of the fields both directly through its foliage (forest litter) and indirectly through the dung of the cattle fed with crop residues and with forest grass and foliage.
- Mixed cropping of legumes, for example, wheat intercropped with lentil during rabi (winter) season and ragi (finger millet) intercropped with native black-seeded soybean, horse gram, black gram, cowpea, etc., during kharif (rainy) season that form symbioses with nitrogen-fixing rhizobia bacteria.
- A more realistic and often overlooked practice––the unique system of crop rotation and keeping the farm land fallow in traditional rainfed hill farming. The farmer households in each village divide the farm area into two equal halves. In a 2-year cycle, one half portion of the farm area remains fallow alternatively during rabi (winter months) after the harvest of ragi, mix-cropped with several other crops, in the preceding kharif (rainy season). In the next cropping season (in March–April), rice, barnyard millet, potato, chili, etc., are planted in the farm area that remained fallow during the winter. In the other half portion of the farm area, wheat, intercropped with lentil and mustard, is planted in the rabi (winter) season after the harvest of rice, barnyard millet, potato, chili, etc., in the preceding kharif (rainy season). Farmers plant ragi, mixed-cropped with many other crops, in the following

kharif season after the harvest of wheat (May–June). After the harvest of ragi and other crops, this farm area remains fallow for the following rabi. The kharif season crops like rice, barnyard millet, chili, potato, etc., are grown in the fields which remained fallow in the preceding rabi season as they require more soil moisture and nutrition. On the other hand, mixed-farming of ragi and several other crops in the kharif season grown in the farm area where wheat crop had been grown during the preceding rabi season can tolerate nutrient and water stress when sown in already exhausted fields. The legume crops intercropped with ragi are capable of fixing atmospheric nitrogen into the soil, and can grow under low moisture. Keeping the land fallow, alternatively, in a 2-year cycle is a traditional crop rotation practice primarily aimed at fertility and soil-moisture management.

- In predominant small-holder crop–livestock mixed farming systems of Uttarakhand hills, the fallow fields during rabi season also serve as grazing ground for cattle and goats during winter months. The excreta of these animals dropped during grazing add organic matter to the soil. This organic matter increases soil fertility. Further, in the nomadic pastoralist systems of the higher Himalayan mountainous ranges, the shepherds with migratory flocks of sheep and goats were traditionally allowed to graze the fallow fields at lower elevations during winters. The shepherds lived in temporary shelters on the fallow farm fields with their flocks of sheep and goats. They kept shifting to other farms/fields after about one week or so. This method helped in adding more organic matter in form of animal wastes to farmlands of hill farming.
- Several crops used in traditional hill agriculture are multipurpose, most commonly for the requirements of grain for human consumption and straw as livestock feed. In fact, the traditional mixed farming system fulfills the nutritional requirement of humans, livestock, and the soil. The crops grown together are highly compatible with each other. Most of these crops can withstand droughts, floods, and pests, thus ensuring some output even at times of major stress or natural calamity.
- The traditional polycultures reduce disease or pest problems and consequently there is no pesticide use. Further, certain crops act as natural biofumigants, releasing pest suppressing compounds. Mustard, intercropped with wheat in hill farming, is best known for this effect. There exist varieties of mustard shown to be almost as effective as synthetic pesticides.
- In traditional hill farming, the essentials of on-farm evolution "that is, the generation of variation and its subsequent natural and farmer selection" are always possible. Further, there is increasing recognition that the diverse needs of resource-poor farmers cannot be addressed by planting a restricted range of high-yielding, high-input varieties. The farm households, therefore, require a range of varieties to fulfill specific socioeconomic as well as agroecological needs in the small farm system.

- In the traditional small-holder farming systems, there are no well-developed markets for traditional crops. The crop production and consumption decisions of farmer households are often linked. The consumption preferences continue to influence these decisions. The surplus crop produce is sold locally in the community, sometime through bartering. Profit maximization has never been the production objectives of the farmer households and market prices are a small fraction of the private incentive that farmer attach to maintaining crop diversity in small-holder hill farming. Cultural and consumption preferences, therefore, play a major role in decision making of farmer households. However, with enhanced awareness about the nutritional importance of local crops in the community, in well-functioning markets, the native crop landraces can be competitive and have enough potential to provide commercial opportunities fetching a premium price in local and distant markets. Maintaining crop landrace diversity in traditional farming landscapes also has public incentives to farmers and society. Genetic diversity in crop landrace populations has substantially contributed for adaptive response to changing climate and also has potential to generate novel variations needed to maintain the capacity of crops to adapt to change. The traditional farming systems thus provide an evolutionary service to the society.
- Livestock in traditional hill farming contribute substantially to rural livelihoods, employment, and poverty relief. They integrate with and complement crop production, embody savings, and provide a reserve against risks. The most common livestock species in mixed-crop farming are goats, cattle, buffaloes, and poultry. The raising of livestock is integrated with food crop production. While crops provide feed and fodder, livestock provide meat, milk, and milk products for subsistence and as a source of cash income. Livestock also supply draught power to till the land and provide power for other agricultural operations such as threshing and to a limited extent transport. In the mixed crop–livestock farming system, there exists a dynamic relationship between CPRs, crops, and livestock. Indeed, livestock are integral to the sustainability of the farming communities in Uttarakhand hills.

2. High-elevation mountainous areas adjoining Tibet have a mix of nomadic pastoralism, some arable land and wild harvesting including foraging and trading of medicinal herbs (Plate 2). Sheep and goats are the herded livestock. The level of household food production and dietary diversity is moderate to high. This system is representative of about 10% of the farming area in hills of Uttarakhand. Bhotia and Shoka tribes are the main inhabitants of the region. The agricultural economy of the valleys consists of subsistence and export (market) farming, as well as tending of livestock and harvesting of herbs for export (market) sale. In addition to cultivated herbs, many valley residents

Plate 2. Target Site 2––Niche site(s) at higher Himalayan ranges such as Johar valley in Pithoragarh district with nomadic pastoralists, and some arable land where native crops and medicinal herbs are grown and traded; the herded livestock include sheep and goats.

engage in medicinal herb foraging for income. Livestock grazing is practiced throughout the mountain valleys, although at rates significantly lower since the Indo–China conflict of 1962. Largely because the loss of trade with Tibet, demand for livestock and agriculture products as well as other professions linked to trade and agriculture including wool crafting and freight shepherding has dropped considerably.

- Important crops include naked (hull-less) barley, tatary buckwheat (*Fagopyrum tataricum*), potato, and many minor tubers, yams, leafy vegetables, and others. Consumption of meat (sheep and goat) is high in nomadic pastoralist societies. Cultivation and foraging of medicinal and other herbs, for export purposes in the past and now for local and distant national markets [viz. "Jambu" or "Feren" (*Allium stracheyi*); "Gandhrain" (*Angelica glauca*); "Kala jira" (*Carum carvi*); "Chuk", Sea-buck-thorn (*Hippophae rhamnoides* ssp. *salicifolia*), etc.], is common and is a major part of the economy for local communities.
- *Allium* spp., *Dendrobenthamia capitata, Elaegnus parvifolia, Epilobium royleanum, Fagopyrum dibotrys, Fragaria nubicola, Gautheria trichophylla, Holboellia latifolia, Lonicera angustifolia, Malus baccata* var. *himalaica, Oxyria digyna, Paeonia emodi, Podophyllum haxandrum, Prunus* spp., *Rheum* spp., *Ribes* spp., *Schisandra grandiflora, Sorbus aucuparia, Taraxacum officinale, Viburnum* spp., etc., are other wild plant food resources of nomadic pastoralists commonly occurring in alpine and mountainous meadows/bugyals.

3. A few interspersed river valleys where improved agriculture under assured irrigation is practiced and rice–wheat or rice–potato is the predominant cropping

Plate 3. Target Site 3––Niche site(s) where improved agriculture is practiced such as Someshwar valley in Almora and adjoining Garur valley in Bageshwar district; rice and wheat/potato crop rotation is the dominant cropping pattern.

pattern (Plate 3). Household food production and dietary diversity are very low. Livestock herding, particularly rearing of goats, is minimal with limited contribution of livestock to overall cash income of the households. The river valleys represent about 10% of the cropped area in the Uttarakhand hills. The famous Someshwar and Garur valleys, for example, consist of many villages with huge paddy fields as far as one can see; the valleys are well known for the ever-changing colors of the fields. Crossing through the valley gives an idea of how the daily life of a farmer is like in the hills; one finds more women working on the fields than men.

> A nutrition transition is clearly evident in farming situations in river valleys with the emergence of cash crop economies and impact of globalization in recent years. Enhanced use of improved crop varieties from FSS, synthetic fertilizers, and pesticides is commonly seen in these farming systems. About 70–80% of the cropped area is planted with a few improved cultivars of rice, wheat, and potato bred by public sector institutions. Some farmers, however, still cultivate native landraces, for example, the Thapachini landrace of rice, for their own household consumption. The production of improved cultivars is generally sold in markets for cash income. Relatively reduced access to indigenous food resources in farmer households has resulted in the replacement of diets of the hitherto diversified food resources by energy-dense and nutrient-poor foods. With the nutrition transition resulting from increasing socioeconomic change, the problems of being overweight and underweight frequently coexist. Socioeconomic disparities and increased access to energy-dense foods are creating an "obesogenic" environment in river valley areas.

In the past, there existed a dynamic relationship among CPRs, crops, and livestock of the mixed farming systems in the hills. These are under increasing pressure from different sources. The livestock production systems are becoming quite dynamic in certain areas and households with the recent accessibility to road networks and better connection to markets for milk. Farmers are being provided with a strong incentive to keep livestock, not only to fulfill the

traditional role of providing draught power, milk, meat, and manure for households, but also to generate cash income through the sale of milk and meat. In certain areas, there has been a shift in management practices, with linkages to CPRs beginning to break down.

The small-scale crop–livestock traditional farming practices of the Uttarakhand hills, therefore, hold a promise for food and nutritional security of farmer households. The general ignorance of the nature and use of nutrient-rich indigenous and traditional food resources over the years has resulted in these foods being left out of most nutritional strategies put in place to address food security and nutrition problems of the local population. Awareness about enhanced use of minor millets, native pulses/legumes, leafy and underutilized vegetables, native tubers and yams, minor fruits, wild-harvested foods, animal food products, etc., in daily diets, as "functional foods", can help address community health and nutrition in the region.

Material and methods

I) model case study on the documentation and registration of farmer varieties

The representative target site for the model case study on farmer varieties was an agrobiodiversity-rich niche village cluster (Table 1) in the Tarikhet block of the Almora district in Uttarakhand state (Figure 1, Site 1). The study site was comprised of 14 villages, about 1000 farmer households and 1000 ha of cropped area. The socioeconomic indicators of farmer households of the target region are presented in Table 2.

A participatory approach was adopted for documenting the landrace diversity. Interviews were followed by focus group discussions (FGD), through structured and semi-structured questionnaires, and informal discussions, and were done separately for men and women farmers of two age groups, 50–80 yrs and 30–50 yrs, respectively. The elderly farmers lacked formal education, but were considered experts in local indigenous agriculture. They are the ones who have preserved indigenous seeds and farming in the study area. The farmer households were surveyed in March 2016. Farmer fairs-cum-FGDs at the community level were also organized.

Between 15 and 20% of households per village were interviewed for landrace diversity in different crops. A total of 170 farmer households were surveyed. Both men and women farmers of each sampled household were interviewed. Once there was complete documentation of the landrace diversity, two biodiversity fairs-cum- FGDs were organized at the community level so that all villages could be duly represented. About 150 farmers participated in the biodiversity fairs and 25 representative farmers were shortlisted for the FGD. The fairs were organized on the 13th and 15th of March 2016 at the villages Suri

Table 1. Description of target villages, number of households, and average cropped area.

S. no.	Village	Village panchayat	Geographic coordinates	Number of households (HH)	Average cropped area per HH (ha)*
1.	Inan	Inan	Alt: 1196 masl Lat: 29° 35′ 01.3″ N Long: 79° 30′ 16.7″ E	59	0.84
2.	Matila	Matila	Alt: 1529 masl Lat: 29 o 35′18.5″ N Long: 79 o 30′ 35.5″ E	100	0.70
3.	Suri/ Padyula	Suri	Alt: 1344 masl Lat: 29 o 34/22″ N Long: 79 o 30′ 50.5″ E	165	0.85
4.	Barsila/ Charsola	Garsyari	Alt: 1489 masl Lat: 29 o 34′16.3″ N Long: 79 o 31′18.2″ E	55	0.90
5.	Garsyari	Garsyari	Alt: 1337 masl Lat: 29 o 34′ 7.6″ N Long: 79 o 31′ 23.7″ E	85	0.94
6.	Dol	Suniakote	Alt: 1380 masl Lat: 29° 34′ 17.3″ N Long: 79 o 30′ 22.5″ E	30	0.86
7.	Suniakote	Suniakote	1102 masl; Lat: 29 o 33′30.4″ N Long: 79 o 31′ 32″ E	36	0.69
8.	Oliagaon/ Maharkhola	Harare	Alt: 1368 masl Lat: 29 o 33.6′ 6″ N Long: 79 o 32′ 11.9″ E	32	0.83
9.	Harare/ Sarka	Harare	Alt: 1437 masl Lat: 29 o 33′ 36″ N Long: 79 o 32′ 13.2″ E	135	0.80
10.	Bergaon/ Simora	Bergaon	Alt: 1407 masl; Lat: 29 o 33′ 35.7″ N Long: 79 o 32′ 13.2″ E	60	1.16
11.	Ookhina	Bergaon	Alt: 1133 masl Lat: 29 o 33′ 40″ N Long: 79 o 31′ 38.7″ E	36	1.38
12.	Siroli	Bergaon	Alt: 1104 masl Lat: 29 o 33′ 13.3″ N; Long: 79 o 31′ 43.8″ E	25	1.20

*Average holding/HH = 0.93 ha.

and Oliagaon, respectively. The participating farmer households were requested to identify, validate, and describe the landrace diversity they managed. A realistic assessment of unique landrace diversity was made and landraces for on-the-spot registration were tentatively short-listed. On-the-spot registration proposals were finalized for submission to the PPV&FR Authority to record the unique landrace diversity of the entire study site. The decision on uniqueness of diversity was finally taken in the final FGD, organized on the 17th of March at the ICAR-NBPGR Regional Station, Bhowali (Uttarakhand) involving diverse stakeholders: public sector research and extension agencies, other line departments, CSOs/NGOs, farmer representatives, etc.

Table 2. Socioeconomic indicators of farmer households (HH) of a representative target site in the Tarikhet block of Almora district in Uttarakhand state.

S. no.	Socioeconomic variables of farmer households	Target study site	Uttarakhand state
1.	Family size	7.42	5 (2008, India Development Indicators Revised, 2012)
2.	Female: Male (F:M) ratio	961	963 (2011 Census of India)
3.	Child sex ratio (<18 yrs of age, F:M)	896	890 (2011 Census of India)
4.	Literacy (%)	83.20	79.63 (2011 Census of India)
5.	Land holding per HH (ha)	0.93	0.68
6.	Livestock number per HH	8–11	6–10
7.	Average per capita cash income (INR) per HH*	33,259*	1,03,000 (Source: Directorate of Economics and Statistics, 2013–14)
8.	Contribution of crop produce to HH cash income (without taking home consumption into account)	6%	Not available
9.	Contribution of livestock to HH cash income (without taking home consumption products into account)	29%	20%
10.	Contribution of off-farm employment and service sector to HH cash income	65%	>50%

*Household per capita cash income excluding home consumption of local agricultural produce.

II) case study on farmer household production and dietary diversification

Representative farming situations in Uttarakhand hills are depicted in Figure 1. The representative target site (Figure 1, Site 1) for the model case study on farmer variety documentation and registration was also used to additionally document information on household production and dietary diversity. A participatory approach was adopted for documenting the information on crop diversity, livestock diversity, food production and consumption diversity, and associated indigenous knowledge (IK). Once there was complete documentation of the community seed and livestock breed management systems, household production and dietary diversity, and food and nutrition transition, the farmer households expressed their opinions in two FGDs on the following topics: the advantages/disadvantages of the existing farming systems; the pattern of change in production and dietary diversity over the years; the status of the existing IK in the community regarding biodiversity management; the role of native diversity, including wild-harvested foods in agricultural systems in food and nutritional security of farmer households; and the way forward showcasing the potential of local food in eradicating malnutrition and addressing the nutritional security of farmer households.

Further, a comparative study was performed with data on food production and dietary diversity from two other representative niche habitats: (i) high-elevation mountainous areas where long-haul pastoral/nomadic livestock herding is practiced together with crop husbandry and cultivation, foraging and trading of medicinal herbs (Figure 1, Site 2) and (ii) river valleys where improved agriculture and crop monoculture are practiced (Figure 1, Site 3). Information was

documented from about 100 households each in the two niche target sites representing a cluster of about 8–10 villages spread over a 50–60 km^2 area.

The household production and dietary diversity scores were measured as per FAO (2011) and Sibhatu, Krishna, and Qaim (2015) with minor modifications.

An exploratory study was conducted to relate the household production and dietary diversity with the nutrition and health of the three niche target sites on the following health indicators: (1) infant mortality rate, (2) maternal mortality rate, (3) level of malnutrition among children under 4 years, (4) malnutrition among women of reproductive age, (5) level of obesity among adults, (6) level of co-occurence of obesity in adults and malnutrition in children, (7) formal education about malnutrition among women, (8) incidence of communicable diseases (e.g., tuberculosis), and (9) incidence of food-related non-communicable diseases (e.g., hypertension and diabetes).

Results

Documentation and registration of farmer varieties (FV)

General description of farmer varieties/landraces in the study site

The landrace diversity of major staples and some important underutilized crops is presented in Table 3. The FV or landrace populations of all native/naturalized crops are often highly variable in appearance, but they are each identifiable and often have local names, particularly in rice, wheat and finger millet. Recognizing the names farmer give to varieties is important because the "farmer-named variety" is the unit that farmers manage and select over time. The name or description of an FV may be related to the original source of the material and the morphology of the plant (color, shape, height, growth habit, etc.). Both names and the traits that define these landraces also may be related to agronomic performance of the variety, such as flowering time, earliness and yield with or without inputs, or to the varieties' adaptation to particular environmental factors, such as to type of soil or resistance to certain diseases. Names and traits also may be related to the use of the product, such as rapid cooking time, taste, use for straw or other parts of the plant, or role in a religious ceremony or other rituals. Farmers perceive these factors at various stages in a plant's development, from seedlings to flowering to fruiting. Thus, the factors which farmers use to identify and shape FV are complex and interrelated, as sets of agro-morphological criteria combine to define a landrace. The number of landraces of different crops village-wise is presented in Table 3. The diversity status of major crops and the frequency of occurrence of unique landraces together with their distinctive features are presented in Table 4. On-the-spot registration proposals of 47 unique landraces in 20 crop species have been developed and will be submitted to the PPV&FR Authority for further follow-up.

Table 3. Number of crop landraces of major crops grown village-wise (total varieties/landraces recorded from the entire target site in parenthesis).

S. no.	Village	Wheat (4)	Barley (2)	Rice (11)	Finger Millet (7)	Barnyard millet(2)	Foxtail millet(1)	Lentil (2)	Soybean (local black, 2)	Horse gram (1)	Black gram(1)	Cowpea (4)	Perilla (1)	Mustard (1)	Others* (1 each)
1.	Inan	1	1	2	1	1	–	2	1	1	1	1	1	1	1
2.	Matila	1	1	1	1	1	–	2	1	1	1	1	1	1	1
3.	Suri/Padyula	2	2	5	4	2	1	2	2	1	1	1	1	1	1
4.	Dol	1	1	1	3	1	–	2	1	1	1	1	1	1	1
5.	Barsila/ Charsola	1	1	1	2	1	–	2	1	1	1	1	1	1	1
6.	Garsyari	2	1	4	4	2	–	2	1	1	1	1	1	1	1
7.	Suniakote	1	1	3	4	1	–	2	1	1	1	1	1	1	1
8.	Oliagaon/ Maharkhola	1	1	3	1	1	–	2	1	1	1	1	1	1	1
9.	Sarka/Harare	1	1	2	1	1	–	2	1	1	1	1	1	1	1
10.	Bergaon/ Simora	1	1	1	1	1	–	2	1	1	1	1	1	1	1
11.	Ookhina	1	1	2	1	1	–	2	1	1	1	1	1	1	1
12.	Siroli	1	1	1	3	1	–	2	1	1	1	1	1	1	1

*Maize, rajmash, fenugreek, field pea, sesame, Cleome viscosa, amaranths, miscellaneous cucurbitaceous, and other vegetables.

Table 4. Crop landraces and their unique characteristics.

S.no.	Crop	Landraces, frequency of occurrence, and unique characteristics
• Crops of rabi (winter) season*		
	Wheat	Four named landraces of wheat were documented of which Safed Mundiya (white earhead, unawned) and Jhunsia (awned) were common, and Lal Mundiya (red earhead, unawned) and Lamba Lal (long red earhead) are rare. The Jhunsia landrace is a recent introduction in the cropping system in view of its lower damage by wild boars and birds.
2.	Barley	Two barley types were recorded of which the four-rowed ones (in each spike, there are six rows of grain, with two pairs of rows overlapping) were common and typical six-rowed were rare in occurrence
3.	Lentil	Two types of lentil landraces were recorded. The black-seeded landrace was common in occurrence in view of its better cooking quality and taste. Lentil was generally mix-cropped with wheat in all villages and rarely grown as a sole crop.
4.	Mustard	Only one type of mustard, yellow-sarson, was grown across all target villages. It had high oil content and better oil quality. Mustard was usually mix-cropped with wheat except in a few villages where it was also grown as a sole crop. Area under mustard crop has consistently increased over the past two decades or so.
• Crops of kharif (rainy) season**		
5.	Rice	Of the 11 named varieties/landraces, three, Dudh/Dudhiya, Batesu and Bamkuwa, were common, and nine others, Nandhan, Laldhan/Ratua, Lamgudi, Kaothuni, Kaonovi, Juni, Gita and Jaulia were rare in occurrence. All these landraces were cultivated under rainfed conditions and were mostly tall types except Juni. The common types were invariably better yielder whereas the rare types were relatively poor yielder but better in cooking quality and taste.
6.	Ragi	Seven varieties/landraces were grown. Hara (stay green stem and earhead types), Kala (black-seed color) and Lal (red grain color), were all compact ear head types. The Chhitarua landrace with lax ear heads is late introduction in cropping system of the region, with early maturity and relatively high grain yield. Damage by wild animals is relatively low in this landrace. In Hara and Black types, both early and late varieties were recorded. The early types were relatively drought hardy and were common in frequency distribution. The Hara types were better for fodder quality of the straw. The Lal landrace is also early and drought tolerant.
7.	Barnyard millet	Two barnyard millet types were documented of which the landrace with red earhead color was common in occurrence than white earhead. It also had better straw quality.
8.	Foxtail millet	Foxtail millet is rarely cultivated. Only one landrace could be documented from only one household in Suri village. It is normally mix-cropped with barnyard millet.
9.	Soybean (the local black seeded)	Two types, small grained and bold grained, were recorded of which the small seed type was common. Small seed types were better in cooking quality and taste. Soybean is mainly mix-cropped with ragi.
10.	Horse gram	Only one type was recorded. It has grey seed-color and better cooking quality. It is usually mix-cropped with ragi.
11.	Black gram	Only one landrace was documented across all target villages with black-seed color. Black gram is normally mix-cropped with ragi.
12.	Cowpea	Four types, grey, white (early and late) and red seed types were grown and all were rare in occurrence. All were grain-types and grown mix-cropped with ragi.

(*Continued*)

Table 4. (Continued).

S.no.	Crop	Landraces, frequency of occurrence, and unique characteristics
13.	Sesame	Two types of sesame, black and brown seed types, were documented with brown type landrace commonly grown. Sesame is normally mix-cropped with ragi but also grown as a sole crop in some villages.
14.	Bhangira (*Perilla* sp.)	Only one landrace was commonly grown across all villages. It had better fragrance and high oil content. It is normally grown on field bunds but sometime grown as a sole crop in bigger plots.

*Fenugreek and spinach, as green vegetable, in kitchen gardens and field pea intercropped with wheat in some villages were also documented under rabi season crops.
**Other minor crops of kharif season were amaranths, intercropped with ragi; maize (yellow dent type); Cleome viscosa (spider flower, jakhia), as weed; rajmash, grown in backyard gardens mix-cropped with maize; several cucurbitaceous vegetables, yams, tubers, etc., in backyard gardens.

Status of loss of farmer varieties/landraces

Farmers recall growing a larger number of landraces, particularly rice and wheat, in the past. The loss of landrace diversity is mainly attributed to non-availability of seed of several of these locally rare landraces. Absence of off-farm job opportunities in the local community level has also contributed to neglect of traditional landrace agriculture, it being highly labor-intensive. Family labor has been the backbone of traditional agriculture in small-holder subsistence farming of the hills, and out-migration of family labor in search of off-farm jobs in urban areas is an important factor adversely affecting traditional agriculture and loss of landrace diversity. The loss of IK related to traditional farming is also contributing to loss of landrace diversity. The changing climate, especially greater frequency and severity of droughts during the past two decades or so, has also been equally detrimental to traditional rainfed agriculture. Increasing damage to crops by wild animals in recent years has also contributed to loss of native crop diversity. The enhanced deforestation in surrounding agroforestry/forestry areas leading to the loss of wild edible species has forced wild animals to enter into farmlands and damage crops. Farmers, therefore, are switching over to some new crops and crop landraces and improved varieties less damaged by wild animals.

State of community seed systems

Seeds of all above native crops/varieties have been selected and managed mainly by woman farmers. Much of this knowledge is gendered and passed down between generations from parents to their children. People embody their knowledge needed for each process, from sowing to harvest. Their knowledge and seed consistently have been localized along with their local climate, soil, and natural environment. It was shared among community members and passed on to next generations. Farmers shared good seeds and useful agriculture skills, which came from years of experience and contributions of the entire village community, so it had the character of public property. Indigenous villagers raised various crops calling for nutritional and cultural needs

These largely small-holder, subsistence-oriented farmer households do rely on informal seed systems (ISS) for all the native/naturalized crops. Farmers of these target villages have no access to formal institutions and the impact of formal crop improvement efforts in the target region leading to FSS has been negligible. Seeds used in ISS are produced, stored, and reused on-farms. Seed management, therefore, has a strong local decentralized character and is mostly done by women farmers.

The community level ISS in these target villages is also characterized by wide diversity at crop and also at variety levels for certain major staples, a relatively high number of landraces in rice, ragi, and wheat that are better adapted and more resilient, simple seed production techniques, poor storage facilities, and informal transfer of knowledge. There has been large-scale exchange and distribution of seeds at the community level. These small-holder farmers in such remote areas are, however, most vulnerable with regard to seed supply in the event of seed shortage due to economic, social, and natural calamities. Nevertheless, ISS for most of these farmers is a source of economic independence and resilience in the face of threats, with one of the most important being climate change. The ISS provides about 95–100% of the seed used in households of these target villages.

Farmer household production and dietary diversity

The production and dietary diversity of farmer households in the main target community (Site 1) is presented in Table 5. The production and consumption pattern of farmer households is presented in Table 6.

A relatively high household production and dietary diversity score for different food items and food groups produced and consumed were recorded in the community. A higher diversity score in the target region was also recorded for wild-harvested foods. Meat/fish/eggs, fruits, and pulses/legumes are the important food groups contributing to a higher dietary diversity score in the community.

Status of nutrition transition in the community

Contrary to some other regions of Uttarakhand State, the emergence of cash crop economies in the target site is minimal. Production and consumption diversity of native crops is relatively high compared to many other regions of the State. With the degradation of biodiversity in community CPRs and nearby forestry areas, there is, however, a decline in carrying capacity of wild indigenous food/fodder trees as well as some wild uncultivated food crops. This is negatively affecting availability of indigenous food resources and nutritional security of the local people. Increasing urbanization and large movements/migration of populations to urban centers, and reduced access to

Table 5. Status of production and dietary diversity of the agrobiodiversity-rich villages of niche target site.

Household characteristics	Pooled	Barsila/ Charsola	Bergaon/ Simora	Dol	Garsyari	Harare/ Sarka	Inan	Matila	Oliagaon/ Maharkhola	Ookhina	Siroli	Suniakote	Suri/ Padyula
• Number of households (HH)	68.16	55	60	30	85	135	59	100	32	36	25	36	165
• Average landholding /HH (ha)	0.92	0.9	1.16	0.86	0.94	0.80	0.84	0.70	0.83	1.38	1.12	0.69	0.85
• Production diversity (no. of crop/live-stock species produced)	32.06	31.6	32.4	32.7	33.6	35.23	26.79	34.85	32.56	31.78	31.32	29.57	32.34
• Food crop production diversity (no. of food crop species produced)	27.78	27.32	28.78	28.13	29.53	31.71	22.82	30.12	28.23	27.82	27.45	25.86	28.56
• Food variety score (no. of food items consumed)	22.13	20.23	22.15	23.72	25.83	26.73	18.70	19.62	22.26	21.82	22.23	19.72	22.53
• Food variety score only with respect to purchased foods (no. of food items consumed)	14.07	13.23	14.54	16.73	13.12	12.45	15.34	14.23	13.76	13.38	14.23	13.46	14.32
• Dietary diversity score (no. of food groups consumed)	6.43	6.16	6.22	6.32	7.15	6.96	6.97	6.12	6.23	5.92	5.72	6.23	7.21
• Dietary diversity score of healthy foods (no. of healthy food groups consumed)	5.49	5.32	5.42	5.67	5.89	5.98	5.32	5.45	5.34	5.44	5.23	5.12	5.66
• Dietary diversity score only with respect to purchased foods (no. of healthy food groups consumed)	3.24	2.64	3.45	3.65	3.67	3.54	3.78	3.72	3.83	3.67	3.63	3.42	3.53
• Food purchased from market, % of total food	29.37	32.43	32.57	31.18	20.72	28.45	19.52	32.6	34.23	33.52	32.76	33.56	20.85
• Dietary diversity of wild-harvested food	31.24	35.56	34.23	32.12	26.34	33.52	27.13	32.50	32.45	33.55	28.23	27.72	31.52

Table 6. Production and consumption pattern of major food groups in households of the niche target site (in percentage terms).

	Production pattern for consumption of food groups		Consumption pattern	
Food groups	Own produce	Purchased from market	Consumed daily	Consumed occasionally
1. Major cereals (wheat, rice, maize)	40	60	90	10
2. Minor millets (finger millet, barnyard millet, foxtail millet)	100	–	70	30
3. Vegetables	90	10	70	30
• Green leafy	50	50	80	20
• Others (root, tubers, cucurbits, etc.)				
4. Pulses/legumes	60	40	40	60
5. Oil/fats	30	70	100	–
6. Fruits	10	90	10	90
7. Milk and milk products	100	–	90	10
8. Meat/fish/egg	4	96	4	96
9. Sugar/other sweets	–	100	100	–
10. Spices and condiments	70	30	100	–
11. Wild-harvested foods	NA*	–	50	50

*Available locally in the community in surrounding agroforestry/forestry systems.

traditional indigenous food resources also exacerbates the nutrition transition phenomenon. Relatively reduced access to indigenous food resources in certain households has resulted in the replacement of diets of the hitherto diversified food resources by energy dense and nutrient-poor convenience foods. This shift cannot be considered a shift from traditional to modern energy-rich foods but a shift from a more diversified dietary pattern with some convenient improved food rich in energy but low in nutrition.

Easy availability of wheat and rice through the Public Distribution System (PDS) in Uttarakhand hills, as well as enhanced purchasing power of certain households, is negatively impacting consumption of diversified nutrient-rich native foods. Now farmers work under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) and use the money to buy food (mainly wheat and rice) which is available at very low costs through PDS after the enforcement of the Food Security Act 2013. Certain households now also see traditional agriculture as an activity not worth the effort.

A comparative study on production and dietary diversity as well as certain health indicators (Tables 7 and Table 8) was performed between the main target community (Figure 1; Site1; Photo plate 1) and two other representative niche habitats/agroecologies: (i) high-altitude areas with nomadic pastoralism, limited arable land, and cultivation and foraging of medicinal herbs (e.g., Johar valley in Pithoragarh district; Figure 1, Site 2, Photo plate 2) and (ii) river valleys where crop monoculture is normally practiced (e.g., Someshwar valley in Almora district and adjoining Garur valley in Bageshwar district; Figure 1, Site 3, Photo plate 3). It is evident from Table 8 that farmer household

Table 7. Production and consumption pattern of major food groups in households of three different niche target sites of Uttarakhand State.

Household characteristics	Agrobiodiversity-rich niche site where traditional small-scale crop–livestock mixed-farming is practiced * (Niche site 1)	Niche site with nomadic pastoralism and some arable land** (Niche site 2)	Niche site where improved agriculture is practiced** * (Niche site 3)
• Average per capita cash income/annum (Rs.)/HH (excluding home consumption of local agricultural produce)	33,259	36,425	52,124
• Per cent contribution of livestock to HH cash income (without taking home consumption products into account)	29.60	34.60	5.50
• Production diversity (no. of crop/livestock species produced/reared)	32.06	28.70	14.20
• Food crop production diversity (no. of food crop species produced)	27.78	19.70	13.30
• Food variety score (no. of food items consumed)	22.13	18.50	9.30
• Food variety score only with respect to purchased foods (no. of food items consumed)	14.07	9.30	6.50
• Dietary diversity score (no. of food groups consumed)	6.43	5.60	4.30
• Dietary diversity score of healthy foods (no. of healthy food groups consumed)	5.49	4.50	3.40
• Dietary diversity score only with respect to purchased foods (no. of healthy food groups consumed)	2.24	1.80	2.20
• Food purchased from market, % of total food	29.37	21.32	18.30
• Dietary diversity of wild-harvested food	31.24	25.50	7.50

* The main target study site in Tarikhet block of Almora district.

** Higher Himalayan ranges (Johar valley in Pithoragarh district where nomadic pastoralism is practiced, the herded livestock includes sheep and goats).

*** Someshwar valley in Almora and adjoining Garur valley in Bageshwar district.

production and dietary diversity are more where the traditional small-scale crop–livestock production system is practiced followed by mountainous areas with a mix of nomadic pastoralism, crop husbandry, and wild harvesting and foraging of medicinal herbs, and river valleys where improved agriculture is practiced. With relatively greater per capita household income, the farmer households of river valleys have enhanced access to energy-dense foods low in nutrition leading to both malnutrition and obesity.

It is also evident from Table 8 that the problems of undernutrition and obesity coexist even in the Himalayan highlands. With the nutrition transition resulting from increasing socioeconomic change, the problems of being overweight and underweight frequently coexist even within the same village and even within the same household. Socioeconomic disparities and increased access to energy-

Table 8. Comparison of some health indicators of households of three different niche target sites of Uttarakhand state (last two decades).

Health indicator	Niche site 1	Niche site 2	Niche site 3	Uttarakhand state
1. Infant mortality rate	Nil	Nil	Nil	38 /1000 (SRS 2011), 32/1000 (SRS 2013) 43/1000 (AHS 2011)
2. Maternal mortality rate	Nil	Nil	Nil	292/100000 (SRS 2010–12) 188/100000 (AHS 2011)
3. Level of malnutrition among children under 5 years*	Low (2%)	Low (2%)	Moderate (10%)	High (~40–50%)
4. Malnutrition among women of reproductive age**	Low (3%)	Low (4%)	Moderate (12%)	High (~40–50%)
5. Level of obesity among adults	Low (3%)	Low (5%)	Moderate (14%)	Data not available
6. Level of coexistence of obesity in the adults and malnutrition in the children	Low (2%)	Low (4%)	Moderate (8%)	Data not available
7. Formal education about malnutrition among women	Low	Low	Low	Low
8. Incidence of communicable diseases (e.g., tuberculosis)	Nil	Nil	Nil	170/100000 (State level health reports)
9. Incidence of non-communicable diseases	Low(2%)	Low(2%)	Moderate (7%)	8% 5.7%
• Hypertension	Low (1%)	Low (2%)	Moderate	(MHFW-NPCDCS
• Diabetes			(5%)	Survey 2010)

Niche site 1: Agrobiodiversity-rich niche site where traditional small-scale crop–livestock mixed-farming is practiced.
Niche site 2: Mountainous regions with nomadic pastoralism, some arable land and medicinal herb foraging and trading.
Niche site 3: River valleys where improved agriculture is practiced.
*Based on three child malnutrition indicators, stunting, wasting and underweight.
**Based on the concept of nutritional anemia among women of reproductive age.

dense foods are creating an "obesogenic" environment particularly in river valleys as recorded in the present case study. In the present study, we noticed that malnutrition is not always the result of food scarcity; it can also be caused by foods that are poor in essential nutrients. Lack of access to nutrient-rich food has in turn led to nutritional deformities (like stunting), which increases the likelihood of obesity later in life.

State of food sovereignty movement in Uttarakhand

There is limited awareness about indigenous food sovereignty among farming communities of Uttarakhand hills. Indigenous food sovereignty is poorly understood conceptually by farmer households. The self-contained indigenous food systems that have sustained the indigenous peoples over the years are, however, largely dependent on landrace cultivation of native/naturalized

crops, rearing of native livestock breeds and harvesting wild foods for subsistence from nearby agroforestry/forestry areas. Ecological food provisions maximize the contribution of ecosystems and improve resilience and adaptation of production and harvesting systems, especially important in the face of climate change. The Uttarakhand hills thus provide a unique opportunity for food-sovereignty research and activism.

Discussion

Farmers' rights and the local seed systems

The majority of the genetic diversity maintained on-farm is managed by smallholder subsistence farmers of the representative target study site. Mainly the local community-level ISS dominates and the formal seed system (FSS) plays a negligible role. Farmers' seed systems depend on free exchange of seeds either through small gifts or barter exchange or to a limited extent trade. The system, therefore, needs protection from negative impacts of regulations designed to promote the FSS. Such negative impact may stem from IPR protection of FV, seed laws, biodiversity laws regulating access, etc. Implementing FR under the PPV&FR Act of India, therefore, remains a challenge. Further, the modern seed laws do not take into account important aspects of farmers' ISS. The FV in ISS are genetically heterogeneous as against the modern improved varieties under FSS that may be uniform and clearly distinct. It has been argued that the National Biodiversity Act, 2002; the Geographical Indications Act; the Patent Amendment Act; and the Seed Bill will all have implications for Farmers' Rights in India (Ramanna 2006). Further, it has been also argued that in view of conflicting politics of plant genetic resources and the lack of clear political will to implement FR, the realization of these rights in the coming years will continue to depend on the mobilization and vigilance of farmers' organizations and FR activists (Peschard 2017).

Addressing poorly developed seed systems for traditional food crops

Poorly developed seed systems have been a major constraint in deploying more diversity of several nutrient-rich traditional food crops in production systems. Improving farmers' capacities to select, produce, and manage quality seed of local food crop varieties will help strengthen the ISS of the community. The capacity building program should rely on farmers' IK and should involve the following:

- Farmer participatory seed selection for desired adaptive variations in native/naturalized crops.
- Quality seed production, maintenance, and storage of seeds of elite crop landraces.

- On-farm demonstrations on improved cultivation practices.
- Community-based in situ maintenance of local improved seed varieties.

There is a strong need to establish a traditional seed system network in which the farmers' knowledge of their traditional food system is acknowledged and reflected in the participatory nature of project activities. Also there is a strong need that the capacity strengthening activities are built on the existing IK of the participants.

Suggested guidelines for finalizing registration proposals of FV

Facilitating documentation and on-the-spot registration of FV, the suggested guidelines based on important lessons learnt from the case study are as follows:

(1) Identify agrobiodiversity-rich niche habitats, as operational units, in the State or a given target region and systematically document FV of all operational units. In Uttarakhand hills, we suggest documenting FV of the entire patti as one unit, a patti being a revenue circle consisting of a group of villages (average 40–50 villages).
(2) Often farmers are inconsistent in naming a variety/landrace; hence, the documentation on varieties/landraces needs to be done in respective cropping seasons for on-site verification/validation involving farmer households.
(3) Much of the agricultural knowledge is gendered and seeds of native crops are selected and managed mainly by women farmers. Uniqueness of FV or landraces, therefore, needs to be ascertained in FGDs at the community level, particularly involving elderly women farmers.
(4) Matrix rankings of farmer selection criteria need to be done for all landraces of a particular crop following appropriate methodology and the distinct and unique characteristics recorded. Let the farmers rank all of the FV or landraces for different traits.
(5) Information on loss of native landrace diversity needs to be documented. The information will be used for conducting meta-population studies on FV or landraces going extinct locally but found again as a colony from one of the other member populations in the network.
(6) Information on informal seed exchange and introduction of new diversity in production landscapes at periodic intervals in the village/region also needs to be documented. For landraces with the same names covering a wide geographic area in the region/state/country, a conscious decision needs to be taken as how many populations from a region/state/country are to be notified for registration. Original site of occurrence of a named landrace and its subsequent spread to other areas needs precise documentation. Introduction of new landrace diversity in a community/region and

longevity of its continued cultivation will decide whether it merits to be registered on behalf of that particular farming community. We can always expect certain adaptive variations being developed, based on farmer selection criteria, if any given landrace is under continuous cultivation in that community/region for more than two decades or so. Such elite landraces with widespread distribution can be registered on behalf of that community, in similar fashion as Essentially Derived Varieties (EDV) in formal breeding programs. An access and benefit sharing (ABS) mechanism also needs to be worked out under such situations for an FV or landrace.

(7) Seed samples of each landrace from farmer households in a village need to be collected randomly and, after due authentication, bulked as one population for the entire village. It is always better to procure seed samples from the seed lot stored for next generation planting by farmer households.

(8) Since much of the agricultural knowledge and seed management of FV or landraces have a character of public property, the unique diversity for on-the-spot registration with the PPV&FR Authority needs to be finalized for the entire operational unit, e.g., a patti in Uttarakhand State and duplication across villages in a patti avoided.

Native food culture, reversing the nutrition transition trend and food sovereignty

There has been a resurgence of interest in agricultural biodiversity within traditional food systems and the possible role these resources could play in ongoing efforts to steer populations away from carbohydrate and energy-rich foods that are typical of simplified diets to more diversified diets that engender household food and nutrition security. In spite of nutrition transition trends in many other parts of Uttarakhand, it is widely acknowledged that in the representative target region rich in crop and livestock diversity and use of wild-harvested foods, the food traditions are still prevailing in the life of rural households to a greater extent. This is indeed heartening that the traditional food habits are still playing a great role in contemporary food habits of the target communities; therefore, the possibility of reversing the trends in favor of dietary diversification from dietary simplification looks promising. It was found that the root cause of both malnutrition and overnutrition/obesity is inadequate or improper nutrients. Consumption of an appropriate portion of food rich in essential nutrients can eliminate both pandemics.

The exploratory study of the household production and dietary diversity of different representative farming situations in Uttarakhand State clearly indicated that high production and dietary diversity are linked with better community health and nutrition. Growing a range of local crops supplemented by wild-

harvested foods helps provide much diversity in the diet in traditional farming areas. It may also be emphasized that better and balanced nutrition in the human diet depends not only on growing a diversity of crops but also on the diversity within the crops (Mouille, Charrondiere, and Burlingame 2010). The micronutrient superiority of landrace cultivars complemented with wild-harvested food resources in traditional hill farming has been revealed by the present research findings. Past research has shown substantial inter-varietal differences, for example, for beta-carotene in sweet-potato cultivars and the pro-vitamin A carotenoid of banana cultivars (Burlingame, Charrondiere, and Mouille 2009; Lutaladio, Burlingame, and Crews 2010). The protein content of rice cultivars has also been reported to range from 5 to 13% (Kennedy and Burlingame 2003). Intake of one variety rather than another can be the difference between micronutrient deficiency and micronutrient adequacy in traditional farming. Unfortunately, we lack detailed information about such diversity within most crops at the cultivar level and the role it plays in nutrition because of the general neglect by researchers/professionals (Burlingame, Charrondiere, and Mouille 2009) and much of the evidence is anecdotal.

Coates et al. (2007) suggest that dietary diversity, typically measured in the form of a count of food groups or food group frequency, can be used as a proxy indicator for nutrient adequacy. Adequate human nutrition thus involves regular intake of a wide range of nutrients, some of which must be consumed on a frequent basis, even if in small quantities. Balanced nutrition in the human diet depends not only on growing a diversity of crops but also on the diversity within the crops (Mouille, Charrondiere, and Burlingame 2010). The micronutrient superiority of some lesser-known cultivars and wild varieties over others has been confirmed by certain recent research (Heywood 2013).

We believe that the trend in nutrition transition can be slowed down and certain approaches are needed to move the nutrition transition in a more positive direction. Among the suggested public health promotion strategies, policies and intervention approaches (Smith 2013) are as follows:

- Holistic integrated food and nutrition interventions.
- Addressing under- and overnutrition simultaneously.
- Involving communities in planning interventions using a bottom–up rather than top–down approach.
- Focusing on diversification of diets rather than a reliance on fortified foods and supplementation where possible.

Since the time of colonization, indigenous communities have witnessed a drastic decline in the health and integrity of indigenous cultures, ecosystems, social structures, and knowledge systems which are integral to their ability to respond to their own needs for adequate amounts of healthy indigenous foods. Within the larger society in which they live, despite the wealth of

knowledge rural indigenous people have of their local environment and food system, they often face vulnerabilities derived from extreme poverty, discrimination, and marginalization. It has been rightly argued that the emerging concept of food sovereignty emphasizes farmers' access to land, seeds, and water while focusing on local autonomy, local markets, local production–consumption cycles, energy and technological sovereignty, and community-level farmer-to-farmer networks (Altieri 2009).

The case study on household production and dietary diversity will set the stage for the future research to demonstrate how these local foods contribute to food security, nutrition, and health. Our long-term objectives will be to address scientific issues, public health, and policy, with the goal of influencing local, national, and international policies for environmental protection of indigenous peoples' land and food resources. In this way, communities can be encouraged to strengthen their use of local food and sustain knowledge of their local food systems for essential contributions to cultural protection, well being, and health. Local biodiversity should be recognized as a significant contribution to a sustainable agriculture–food–nutrition strategy alongside improvements in agricultural productivity and agronomic practice, nutritional enhancement of crops, industrial fortification, vitamin supplementation, and other nutrition–agriculture interventions (Heywood 2013).

Uttarakhand hills are primarily an agriculture-based society with a rich native food culture and traditions. Kuhnlein et al. (2009) rightly stated that

The dimensions of nature and culture that define a food system of an indigenous culture contribute to the whole health picture of the individual and the community-not only physical health but also the emotional, mental and spiritual aspects of health, healing and protection from disease.

Kuhnlein et al. (2009) further assert that indigenous people never separated food from medicine, depending upon which part of the plant is used, the season of the year and physiological condition of the person using the crop, the same plant can be consumed as food or medicine. Further sustainability of the environment happened to be one of the critical issues in the food acquisition and consumption of indigenous communities world over (Demi 2016). Industrial agriculture on the other hand is premised on a business model through neoliberal policies. The current WTO policy has worsened the plight of small-holder farmers, creating backlogs of unemployment in the Global South and widening the poverty gap between the rich and the poor in most countries.

One of the commonest criticisms of advocating a greater use of local agricultural biodiversity in the form of traditional crops, underutilized species, and wild-harvested species to address under- or malnutrition is precisely that it is local and it is assumed therefore that it will have little impact on the global picture. Yet, at least 20% of the world food supply comes from traditional multiple cropping systems, most of them small farm units often of 2 ha or less (Altieri 2009). There is ample evidence on the ground that local biodiversity and

ecosystem services play an essential role in the lives of communities throughout the developing world, by providing a social safety net for food, medicine, fiber, fuel wood, etc., that can act as a route out of poverty and a source of income generation, and can prevent people from falling further into poverty or in extreme cases as an emergency lifeline through the provision of "famine food" (Roe, Walpole, and Elliot 2010). It can also play a major part in addressing issues of malnutrition (Heywood 2013).

The expected outcome of the study, in line with that outlined in Policy Brief of Prague Global Policy Institute––Glopolis (glopolis.org/en/articles/food-sovereignty-way-achieve-food-security), is, therefore, as follows:

(i) Local knowledge and skills that conserve, develop, and manage localizing food systems in Himalayan agroecologies is supported and technologies that undermine local food systems are discouraged. Ecological food provisions maximize the contribution of ecosystems and improve resilience and adaptation of production and harvesting systems, especially important in the face of climate change.
(ii) Showcasing production and dietary diversity of local food help eradicate malnutrition particularly among women and children.
(iii) Showcasing "food sovereignty" as a way to achieve "food security" in small-holder indigenous farming communities of Indian Himalayas. Food is a basic human right and cannot be seen just as a commodity for local/national/regional/international agri-business.
(iv) The indigenous food providers of the Indian Himalayas are supported and valued. Policies that undermine and threaten their livelihoods are discouraged.
(v) Using traditional knowledge of indigenous food systems as an effective way to promote healthy market food choices to prevent the adverse effects of acculturation.

With rich native food culture and more than 80% area under traditional farming, except a few river valleys, Uttarakhand hills offer hospitable conditions for an indigenous food-sovereignty movement. Unlike food security, food sovereignty has to be a process coming from the bottom up—from the peasants and from the communities (Schiavoni 2015, 2017).

It has been rightly argued by those concerned with the global food-sovereignty movement that it is the small-scale farmers that actually have control of the food system, of information, and of food culture as against the social perception in the Northern hemisphere that the large food chains feed society (Patel 2009). Facing this, in the entire world, and especially in the Northern hemisphere of USA, Canada, Europe, impressive associations of critical consumers, and producers are being developed. In France, for example, there are 3000 producer–consumer associations. In Canada and the USA, where there is a common problem of

reduced numbers of farmers, there is an enormous demand from citizens to have control over what they eat, how it is produced, and who produces it. They are demanding a new type, a new model of farmer, one that isn't trained in a productivist model (Patel 2009).

It is believed that one of the effects of producer–consumer associations is to support the new farmers, who are increasingly coming from urban areas. In Europe, for example, many farming men and women now make a living based on local markets. They have a much better chance of survival than those farmers who depend on the transnationals for their inputs and sales. This is a very clear reality. To overcome this, urban social movements must come together with peasant movements to develop a new type of agriculture and training that dignifies the profession, in order to excite young people (Patel 2009).

Food sovereignty advocates rightly argue that the anti-poverty approach runs the risk of reducing the issue of hunger and malnutrition to a humanitarian problem for rich countries to solve, a position which is highly contested by countries and societies which have long depended on agriculture for the livelihood (Mazhar et al. 2007). Wittman, Desmarais, and Wiebe (2010) defined food sovereignty as the right of nations and people to have control over their own food systems, including their own markets, production modes, food cultures, and environments. Food sovereignty works with the concept of self-sufficiency in food production, democracy, and diversity. Lack of appreciation of these complex issues explains in part the rising cases of chronic diseases such as obesity and hypertension associated with overeating in the midst of food insecurity (Martin 2012). The rising cases of chronic illness such as cardiovascular diseases, diabetes, and certain cancers among native communities across the globe have been attributed to moving away from traditional foods rich in fiber, fruits, vegetables, and leafy greens to foods high in fat, sugars, and salt (Bjerregaard 2010; Delormier et al. 2009). Nestle (2007) asserted that different cultures understand their relation to food differently. Whereas the goal of food and eating within many indigenous communities is a means of expressing culture, upholding traditions, and strengthening cultural knowledge about the world (Willow 2005), the goal of conventional nutritional science research reduces foods to its biochemical properties and categorizes it according to chemical compounds (Lupton 1996; Scrinis 2002; Warde 1997).

The native food culture of Uttarakhand hills can be discussed here in greater detail based on local IK in the context of food, viz. spirituality, food security, harvesting regulations/restrictions, and reliance on locally available material as outlined by Demi (2016).

The predominantly crop–livestock small-scale mixed farming systems of Uttarakhand hills encourages farmer households to consume more traditional crops instead of animal flesh, except for the nomadic pastoralists of high mountainous regions who depend relatively more on animal products. In

indigenous animal husbandry of Uttarakhand hills, the livestock are mainly fed with crop by-products while substantive food is mainly reserved for human consumption. Such systems save humans from competing with livestock for food and ensuring food sufficiency. In contrast, industrial agriculture contributes to creating food insecurity through the use of whole grains and cereals as key components of animal feed (Demi 2016). The transformation of US diets from high-calorie crop products to low-calorie meat, for example, has greater environmental consequences (Albritton 2012), with meat production contributing disproportionately to greenhouse gas emissions (Carlsson-Kanyama and Gonalez 2009; UNEP 2012). Further, feeding farm animals on crop by-products and forage ensures production of lean meat that helps reduce fat-related complications and diseases (Bernard et al. 2006, 2009; Demi 2016).

Dependence of local communities of Uttarakhand hills on diverse plant resources including wild-harvested foods ensures that the plant species are protected, and in this way an effective mechanism of sustainability that indigenous communities can employ to maintain a cosmic balance with the ecosystem could be duly showcased by the present case study research.

The important tradition of harvesting regulations/restrictions commonly practiced in local farming communities/food cultures of Uttarakhand hills also ensures sustainability and helps control human desires which is considered an important learning in environmental education (Orr 2004).

Use of local readily available materials, for example, use of forest litter, animal waste, farm-yard manure, etc., and avoidance of synthetic fertilizers, except in river valleys where modern agricultural practices are followed, ensure that safe organic foods are produced for human consumption. These practices intend to help improve human health and preserve the environment for future generations.

Indigenous diets worldwide are varied, suited to local environments, and can counter malnutrition and disease. For many indigenous communities, their food systems are complex, self-sufficient and deliver a very broad-based, nutritionally diverse diet. But the disruption of traditional lifestyles due to environmental degradation, and the introduction of processed foods, refined fats and oils, and simple carbohydrates, contributes to worsening health in indigenous populations and a decline in the production of nutrient-rich foodstuffs that could benefit all communities. Kuhnlein et al. (2009) argued that "Indigenous peoples' food systems contain treasures of knowledge from long-evolved cultures and patterns of living in local ecosystems". Therefore, traditional food systems need to be documented so that policymakers know what is at stake by ruining an ecosystem, not only for the indigenous peoples living there, but also for everyone.

Not only does food diversity have relevance in a public health and food policy sense, but also in individual counseling in clinical practice. Assessment of a patient's food variety can be rapid and semi-quantitative, encouraging

small and consequential changes in diet. When ethnicity is taken into account, in the clinical setting, this process can be even more rewarding for the practitioner and patient (Wahlqvist 2005).

The present case study clearly indicates that malnutrition is not the result of food scarcity but foods poor in essential nutrients. Although the problem of diminished food sovereignty and food insecurity is one that affects all people, not just indigenous communities, indigenous peoples are uniquely situated to offer solutions. Armed with ancient traditional knowledge and a deep connection to their lands, indigenous communities, and particularly indigenous women are developing projects and building networks to revitalize local food capacity and strengthen food sovereignty.

The present case study, therefore, shows that with a strong native food culture and traditional agriculture, Uttarakhand hills provide us with a great opportunity for food-sovereignty research and activism. A recent article by Henderson (2017) argues that the articulation between the state and peasant organizations' internal structures––the class characteristics of their mass bases, their leaderships, and the modes of interaction between the two––is critical for determining the nature of contemporary struggles guided by the discourse of food sovereignty. Schiavoni (2017) emphasizes a historical, relational, and interactive (HRI) framework, in the context of Venezuela, that can help us to understand the crisis facing food system, and implications for food-sovereignty research and activism.

Conclusion

To facilitate implementation of FR, both in form of IPR or development rights, systematic documentation of FV is a prerequisite. India has been a member of the WTO, a contracting party to the IT-PGRFA and also has a sui generis system in place for protection of plant varieties and FR in form of PPV&FR Act 2001. Before formulating policies, the Government of India should, therefore, assess both the FSS and community-level ISS of small-holder subsistence farming in remote and marginalized areas in order to be objective and addressing the needs of the local farmers. An integrated seed system needs to be developed to address the issue of quality seed production and trading of FV. It has been observed that lack of quality seed of several elite FV in the target region has been the major factor responsible for their loss from traditional production landscapes. Farmers' access to and rights over seeds of native landraces are the very pillars of traditional agriculture, and thus represent an essential component of food sovereignty. The national policies should, therefore, consider formulating policies based on local needs along sound scientific lines. Beside IPR protection of FV, the developmental rights through enhanced exchange and use of native diversity aimed at livelihood and nutritional security of farming communities will help address the FR in true spirit. Most of the native crops and their elite landraces have proven potential to fetch premium prices in national/

international markets. Community Seed banking linked with on-farm conservation of native crop diversity, exploring various "value-added" interventions as benefit enhancing options of native crop diversity to farmer households and aspects of food sovereignty can help realize FR in the true sense. Major changes in policies, institutions, as well as research and development approaches that support agroecological innovations in Himalayan highlands are considered essential for food sovereignty, and food and nutritional security of the farming communities. The need for introduction, adaptation, and implementation of good farming practices with associated enabling environments and to address environmental and health issues linked to agriculture will be required to maintain local food security and sustainable livelihoods.

Intensification of crop and livestock production, in smallholder crop–livestock systems of hilly areas is essential for mitigating human suffering and providing time for needed social and economic changes. Harnessing the potential of well-integrated crop and livestock systems at various levels of scale (on-farm and area wide), and that often have agroforestry and forestry inputs, is one of the powerful entry points to address such needs, issues, and opportunities. The integration of crop and livestock production systems increases the diversity, along with environmental sustainability, of both sectors. At the same time, it provides opportunities for increasing overall production and economics of farming. This would reduce the preference for specialized livestock production systems, in view of their problems with environmental and economic sustainability. A shift toward organic production systems is also expected to have enduring impacts in farming communities in Himalayan highlands.

Further, the small-scale ecological farming methods are the key to ensuring resilience to climate change in Himalayan agroecologies. They are based on enhancing diversity––thereby increasing options to respond to climate instability. There is a need to support these traditional systems in order to feed local communities and at the same time address the traditional food-based approach of community nutrition and health. A fair food system would be one where agricultural traditions are once again firmly rooted in their local landscapes. These traditions recognize that healthy food depends on healthy ecosystems, and this requires farmers to comply with the same laws of nature which give life. A proactive alliance between indigenous peoples, local communities, and their key allies is needed to collaboratively create a research and advocacy agenda in support of agrobiodiversity and the revival of diverse local food systems and landscapes within the broader framework of food sovereignty.

Traditional food resources need to be made frontline strategies for nutrition interventions. Revitalization of traditional food systems can be an imperative starting point. There is a need to re-assess existing food and nutrition-related health and agriculture policy, and develop cross-sectoral implementation strategies on food security, nutrition, and health. Further, there is need of

continuous policy advocacy activities to educate functionaries across different sectors. Developing food composition databases is vital for effective advocacy tools and critical for cross-sectoral policy and program development.

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