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Future Food Sustainability Can Be Traced Back into Local People's Socio-Cultural Roots in Uttarakhand Himalaya, India

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Abstract: Sustainable food system ensures adequate and safe food supply in an eco-friendly manner. We assessed food sustainability perception and practices of local community through structured interviews in sub-alpine settlements of Uttarakhand Himalaya. Major perceived challenges towards food sustainability were identified using Rank-Based Quotient analysis. Association with various socio-demographic factors (e.g., age, gender, education, socio-economy, and socio-culture) was tested. An overall neutral perception (mean score 2.9) and moderately sustainable practices (mean score 3.1) were observed. Respondents with higher socio-cultural score showed more sustainable food sourcing practices and more positive social and economic sustainability perception, as well as higher participatory willingness. Female respondents were more dependent on sustainable food sources than the males. Education level influenced food quality choice. People identified higher food production cost as major economic constraint; while small landholdings and labor migration were main social challenges. Land and water management issues and climate uncertainty were the major environmental constraints. Socio-cultural exposure played significant role in ranking these sustainability constraints. We encourage direct involvement of socio-culturally active people and conducting extensive outreach programs for future sustainable local food system in vulnerable Himalayan valleys.

Keywords: sustainable food system; public perception; socio-demographic factors; socio-culture; food sustainability constraints



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1. Introduction

Our modern food system is under constant scrutiny of 'sustainability' criteria with increasing complexities in our lifestyle and socio-economic standards. A sustainable food system (SFS) delivers food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security for future generations are not compromised [1]. Food security truly exist only when all people at all times have physical, social, and economic access to food of sufficient quantity and quality to meet their dietary needs for an active and healthy life coupled with a sanitary environment [2]. Several ecological, environmental and climate change-related crises (e.g., population growth, resource scarcity, biodiversity loss, pollution, greenhouse gas emissions, etc.) threaten global food security and sustainability [3–7]. The situation has been aggravated in the recent COVID-hit world [8,9]. Increasing production efficiency, restraining consumption demand, and improving governance are some of the major strategies for creating food sustainability [7].

A typical food system involves various stages, like production, post-production, supply chain, consumer's food sourcing, choice of quality, consumption pattern, management of food waste, governance, and policy decisions. Addressing environmental, economic,

and social dimensions of food sustainability at these stages requires involvement of local stakeholders from multidisciplinary background to justify their role as producers, suppliers, consumers, and policy-makers, among others. Hence, understanding local community perception, knowledge, practices, and demands are crucial for management and best policy decisions [10,11]. Assessing various factors that might influence people's perception will further aid in designing effective nutrition-related programs and policy reformations [12]. Studies [13–17] have explored the association between various food sustainability parameters (including public perception) and socio-demographic factors, particularly, socio-cultural determinants (e.g., local food habits, practices and beliefs) [18–20]. Regional and local differences in such association pattern are also recognized [21]. The western world holds a lion's share of these studies, while the scenario in the eastern world is far beyond our complete understanding.

Sustainability challenges are colossal in populous countries, like India [22], with diverse social background and cultural practices, in addition to recent pandemic-created severe economic turmoil [23]. The government of India has ensured adequate food supply through its national food security act 2013. However, there is large regional data gap to boost national food policy because of diverse agro-ecology. Therefore, the support for sustainable food system should be augmented based on specific, regional agro-ecological needs rather than an all-India coordinated approach [24]. Moreover, varied regional geographic features together with other climatic and non-climatic drivers pose differential environmental challenges and consequent variation in productivity across the country [25]. Food policy should, therefore, be carefully formulated considering regional preferences and practices of the local community, as well as availability of local resources. In this regard, urban and rural India have different set up, priorities, and sustainability issues.

The Indian Himalayan region (IHR) covers 17% of total geographical area of the country, yet is supporting only 4% of population. Nearly 70% of the region is covered under rural set up [26]. Subalpine rural Himalayan settlements had a long tradition of subsistence farming and local resource sharing, which was sustainable. Agriculture had been the primary income source contributing about 45% of the total regional income. Overall, the region has seen a slower pace of development compared to the rest of the country; inaccessibility, fragility, and marginality of IHR directly affect the livelihoods of Himalayan people [27,28]. Additionally, deteriorating environmental resources, increased disasters, changing climate, rapidly eroding cultural fabric, and social values have become causes of concern since past few decades [29–31]. Sustainable agricultural practices are rapidly dwindling because of low productivity, climate uncertainty, and labor out-migration. Declining investments, diminishing key food crops, and volatile food prices are affecting mountain farming systems and associated supply chains. Moreover, poverty limits the nutritional value of diets in mountain households [32,33]. On the other hand, with increasing tourism, food demand is incremental, creating additional burden on production or import from external sources [34]. These issues need to be addressed immediately in an integrated and multi-dimensional way, particularly in pace with the carrying capacity of the Himalayan ecosystems.

Food sustainability concerns are, therefore, an emerging research area in IHR, especially in the state of Uttarakhand [35]. A handful of studies highlighted the importance of traditional crop diversity [36], indigenous practices [37], and other adaptive mechanisms towards holistic transformation of agriculture practices [26,33,38]. However, research focusing on sustainable food systems, associated factors, and future opportunities and challenges, as well as public perceptions, is lacking. Since sustainable food systems require coordinated effort of a range of local stakeholders from multiple backgrounds, this study aimed at:

- (1) Assessing current food sustainability perception and practices of the local community,
- (2) Identifying and ranking of local food sustainability constraints by the public, and

- (3) Testing the relationship between various socio-demographic factors (e.g., age, gender, education, socio-economy, socio-culture) and peoples' food sustainability perceptions and practices.

2. Materials and Methods

2.1. Study Site

The study region, Uttarakhand, is a distinct geographical and socio-cultural unit forming a part of central Himalaya (Figure 1). The Himalayan state lies between latitude 29°26' and 31°28' N and longitude 77°4' and 80°6' E; bounded by Indo-Chinese border in the north, Gangetic plains of Uttar Pradesh in the south, Tons-Yamuna rivers (bordering Himachal Pradesh) in the west and Kali-Sarda rivers (bordering Nepal) in the east. The geographical area (30,000 km²) ranges from 301 m a.s.l. at the foothills of the Himalayas to 7543 m a.s.l. at the snow-clad peaks of the Himalayan range, covering tropical, subtropical, subalpine, and alpine eco-climatic zones. Tropical and subtropical areas up to 1800 m a.s.l. have mean annual precipitation of 2000–3000 mm and mean annual temperature of 14–21 °C. Subalpine zones (1800–2500 m a.s.l.) are characterized by temperate climate with showery precipitation and mean annual temperature of 10–14 °C. At the alpine zone (above 2500 m a.s.l.), the climate is cold, with mean annual temperature of 4.5–10 °C and low annual precipitation with frequent and gentle showers. Although the effect of monsoon is common to the whole region, the local relief has given rise to peculiar thermal effects leading to several local and regional differences in the climatic condition [39]. The landform is largely comprised of rugged and fragile mountain ranges with narrow valleys and ravines, and a few small plains. Natural disasters, such as landslides and cloudbursts, are common in the region, especially during the rainy season. The region mainly supports natural vegetation, like tropical deciduous forests, sub-tropical pine forests, Himalayan temperate forests, and subalpine/alpine forests and grasslands, respectively, from lower to higher altitudinal gradient and across tropical to alpine eco-climatic zones [35].

Since more than 90% of the population in the hill districts of Uttarakhand are rural, as well as concentrated in the sub-alpine region, present study was conducted in two representative subalpine small to medium villages of Uttarakhand Himalaya, namely Ransi (30°35'35.7" N, 79°08'50.3" E, 1942 m a.s.l.) and Sari (30°38'98.9" N, 79°08'09" E, 1973 m a.s.l.). They are situated in the district Rudraprayag, in close proximity of the forests (forests substantially contribute to the subsistence and economy of the residents by providing fodder, fuel wood, and numerous other forest products). The combined population of the resident community of the two villages was estimated to be 216 belonging to a total of 74 families. Agriculture and allied activities (animal husbandry, fishing, forestry, etc.) contribute to the major share of local economy with majority having marginal (<1 hectare) and scattered landholdings. Cropping in the region is generally rain-fed. Details of regional cropping diversity have been described by Maikhuri et al. [36]. The infrastructural facilities, like roads, means of communication, schools, hospitals, etc., are available in limited capacity. While educational facilities (at least up to secondary level) are generally provided, health facilities are usually poor.

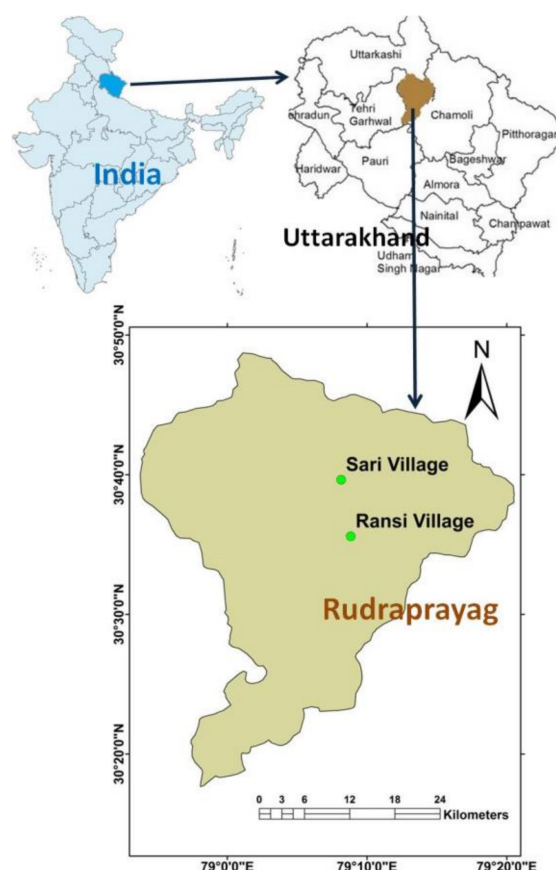


Figure 1. Location map of the study area.

2.2. Design of Questionnaire

Structured questionnaire was developed, comprised of two sections. Table S1 (Section A) (containing 30 questions) was designed to find out local respondents' perception related to economic, social, and environmental aspects of sustainable food system (from production to consumption), as well as awareness on relevant policy, schemes/facilities, and legislation initiatives undertaken by the Government. This section also contained questions to assess individual's participatory willingness in development of future sustainable food system. Therefore, section A had five specific subsections: (i) economic perception (6 questions), (ii) social perception (5 questions), and (iii) environmental perception of sustainable food system (7 questions), as well as (iv) awareness of government food policy (4 questions) and (v) public participatory willingness (8 questions). Table S1 (Section B) contained 25 questions framed to understand peoples' choice and practices related to food sourcing, quality, production, post-production processing, marketing, and consumption. The five specific subsections under Table S1 (Section B) were (i) food sourcing (3 questions), (ii) choice of quality (3 questions), (iii) food production (9 questions), (iv) post-production processing and marketing (6 questions), and (v) food consumption practices (4 questions).

All these questions had equal weightage and were multiple choice type with response options set at a scale of '0–5'. Scores, 1 and 5, respectively, indicated the lowest (least sustainable/negative) and highest (most sustainable/positive) degree of 'sustainability or positive response', while 0 represented responses of 'Do not know or Not applicable'. The validity of the questionnaires was confirmed using Cronbach's Alpha (SPSS v.16, IBM, United States), and the observed values ranged between 0.86 to 0.91 (Cronbach's Alpha > 0.7 implies high internal reliability) [40].

In addition, semi structured interviews with open-ended questions were conducted to explore socio-demographic background of the respondents based on their age, gender, level of education, socio-economy (i.e., level of income, land ownership, total number of

family members, number of earning members and their occupations), and socio-culture (i.e., involvement in farming, livestock rearing, gardening, beekeeping, dependence on forests for fuel/fodder, dependence on local plant and animal products during festivals/rituals, dependence on local medicinal plants, dependence on local aquatic resources, etc.).

2.3. Collection of Data

Data collection was done during December 2018 in a four-stage process. The first round of data collection involved selection of respondents from the two villages. A total of 62 respondents were selected randomly to increase the probability of sampling both genders; however, they were limited to the age range between 16 to 55 years (who would be the ones maximally involved in food system business), as well as representing different (covering every possible variety) educational, socio-economic, and socio-cultural background. Semi structured open-ended questions were used to extract details of respondents' age, gender, education, socio-economy, and socio-cultural activities. In order to ensure that the responses were independent and unbiased, we selected only one member per household.

At the second stage, the structured questionnaire was used to gather data on local community's perception and practices related to food sustainability. Prior to the questionnaire survey, purpose of the visit was explained; verbal consent was secured from all respondents for interviews and photographs, and they were promised of identity nondisclosure. It took nearly 45 min to complete one interview.

The third round comprised of group discussions held at both villages. We interacted with all the respondents (32 in Ransi and 30 in Sari) in some common meeting places. The respondents were asked to enlist their perceived or observed constraints (economic, social, and environmental) towards sustainable food system. At the same time, they were asked to jot down all possible ways of contributing to future food sustainability. We then prepared a final list by incorporating the five most common (validity duly crosschecked) economic, social, and environmental challenges towards developing sustainable food system in the locality. Similarly, a final list of five most preferred options for participating in food sustainability practices was developed. Accordingly, the respondents were instructed to rank these five economic, social, and environmental constraints, as well as participatory options, based on their personal preferences.

At the fourth and final stage, peoples' responses related to food sustainability practices and constraints were crosschecked by undertaking informal discussions with other villagers and, in some cases, further data verification by literature/report review or actual field checks.

2.4. Analyses of Data

2.4.1. Socio-Demographic Profiling of the Respondents

Other than gender-based segregation of the respondents as 'male' or 'female', they were categorized into four age groups, namely (i) 'early young aged' (16–25 years), (ii) 'young aged' (26–35 years), (iii) 'late young aged' (36–45 years), and (iv) 'middle aged' (46–55 years).

Based on level of education, people were divided into four groups: (i) 'primary-educated': those who pursued general education (primary level) up to 5th standard or less; (ii) 'secondary-educated': those who pursued general education (secondary level) between 6th and 10th standard; (iii) 'intermediate-educated': those who pursued 'stream specific' education (intermediate level) between secondary and college level, i.e., 11th and 12th standard; and, finally, (iv) 'high-educated group': those who pursued highly specialized education (Graduation and above level).

The respondents were categorized as belonging to 'advanced', 'intermediate', or 'backward' socio-economic classes. Such categorization was determined based on possession of assets (house, vehicle, landholdings, etc.), as well as types of occupation/livelihood and monthly average per capita family income, depending on the number of earning members, summation of their monthly income, and total number of family members. For example,

socio-economically ‘advanced’ respondents had more than two assets (including landholdings) and monthly average per capita income of more than Rs. 10,000. ‘Intermediate’ group had one or two assets, along with monthly average per capita income between Rs. 5000 to Rs. 10,000. ‘Backward’ group had no assets, and their monthly per capita income was less than Rs. 5000.

Socio-cultural categories (e.g., ‘good’, ‘average’, or ‘poor’) of the respondents were determined based on their degree of involvement/dependence on various traditional socio-cultural activities, which include farming, gardening, livestock rearing, beekeeping, collection of fuelwood and fodder from forests, harvesting local medicinal plants, using local animal or plant products during festivals/rituals, and dependence on local aquatic resources. People involved in six or more such activities were socio-culturally ‘good’, while those pursuing three to five of these traditional practices were ‘average’. Those culturing none or up to two of these activities were considered as socio-culturally ‘poor’.

2.4.2. Scoring Food Sustainability Perception and Practices

Since response options for each questions (belonging to sections A and B) were set at a scale of ‘0–5’, respondents were assigned scores of 1 to 5 (a score of 0 was excluded due to non-validity) based on their choice of response against each question. Choices of response for each kind of score in case of majority individual questions (Table S1 for further details) were as follows:

- 0.5–1.4 (=score 1) for choosing—‘Never/Not at all/Very low/Worst’;
- 1.5–2.4 (=score 2) for choosing—‘Rarely/A little/Low/Bad’;
- 2.5–3.4 (=score 3) for choosing—‘Sometimes/Partly/Moderate/Neutral’;
- 3.5–4.4 (=score 4) for choosing—‘Often/Mostly/High/Good’;
- 4.5–5.4 (=score 5) for choosing—‘Always/Fully/Very high/Excellent’.

However, for a few questions (where more positive response indicated more negative impact on food sustainability), order of the response scores was reversed (i.e., score 1 indicated highest degree, while score 5 indicated lowest degree).

The scores for all 30 questions of section A were averaged to obtain the final score for food sustainability perception of each respondent. Subsequently, the perception scores of all the respondents were averaged to compute the perception score of the community. In general, a perception score ranging between

- 0.5–1.4 (=score 1) indicated ‘Negative’ perception,
- 1.5–2.4 (=score 2) indicated ‘Partly negative’ perception,
- 2.5–3.4 (=score 3) indicated ‘Neutral’ perception,
- 3.5–4.4 (=score 4) indicated ‘Partly positive’ perception,
- 4.5–5.4 (=score 5) indicated ‘Positive’ perception.

Similarly, the scores for all 25 questions of section B were averaged to obtain the final score for food sustainability practices of each respondent. The practice scores of all the respondents were then averaged to calculate sustainability practice score of the community. In general, a practice score ranging between

- 0.5–1.4 (=score 1) indicated ‘Unsustainable’ practices,
- 1.5–2.4 (=score 2) indicated ‘Less sustainable’ practices,
- 2.5–3.4 (=score 3) indicated ‘Moderately sustainable’ practices,
- 3.5–4.4 (=score 4) indicated ‘Highly sustainable’ practices,
- 4.5–5.4 (=score 5) indicated ‘Most sustainable’ practices.

In a similar manner, subsection-wise score under each section was computed and compared for understanding food sustainability perception and practices of the local community in further detail. It is evident that higher perception and practice scores of respondents indicated more positive perception, as well as better sustainability practices.

2.4.3. Rank-Based Quotient (RBQ) Analysis for Identifying Sustainability Constraints

The respondents were asked to rank (from the final list of food sustainability constraints and participatory options) the (i) economic, (ii) social, and (iii) environmental

challenges related to sustainable food systems, as well as (iv) their preferred participatory options individually in order of preference. Data collected by such preferential ranking technique were then compiled together and Rank-Based Quotient (RBQ) of each constraint/option was computed following the formula of Sabarathnam [41].

$$RBQ = [\sum f_i(n + 1 - i)/(N \times n)] \times 100, \quad (1)$$

where f_i = Number of respondents reporting a particular constraint under i th rank, N = Number of respondents, i = Number of the rank, and n = Number of constraints identified.

In every case (economic, social, and environmental sets of sustainability constraints), RBQ values against each of the five constraints were then compared. The one with the highest RBQ value was considered as the most important among the listed constraints. Priority for rest of the four constraints decreased according to their corresponding RBQ values in descending order. Similarly, the most preferred participatory option was also determined based on the highest RBQ value.

2.4.4. Statistical Analyses of Data

Descriptive statistics, such as percentages averages and frequencies, were used to analyze the socio-demographic variables (e.g., age, gender, education, economy, and socio-culture) of the respondents. Descriptive statistics was also used to characterize details of public perception and practices (of individual respondents, as well as community as a whole) related to food sustainability. Furthermore, the perception and practices scores were correlated to check consistency and coherence between individual's responses on sustainability perception and practices. Crosstab analysis and Pearson's Chi-squared tests were performed to analyze whether there was significant association between the socio-demographic factors, namely respondents' gender, age, level of education, socio-economic status, and socio-cultural background and the response variables, like overall food sustainability perception and practices of the respondents. Similarly, the influence of these factors on economic, social, and environmental perception of food sustainability, awareness on government policy, and public participatory willingness, as well as practices, like food sourcing, quality choice, production, post-production processing, and consumption, were also tested. Kruskal–Wallis test was used to find out if there were significant differences in respondents' food sustainability choice and constraints ranking response across their age, education, socio-economy, and socio-cultural background. All descriptive and statistical analyses were performed using Microsoft Excel (2007) and SPSS ver. 16.0 (IBM, United States) for the Windows. Statistical significance was tested at 5% levels of significance.

3. Results

3.1. Socio-Demographic Profile of the Respondents

The respondent sample ($n = 62$) comprised of 52% females and 48% males. Most of the respondents belonged to early young (16–25 years; 31%) or young (26–35 years; 32%) age categories. Education level was mostly intermediate (38%) to primary (24%). Respondents were almost equally distributed across the three broad socioeconomic classes, namely advanced (34%), intermediate (35%), and backward (31%). The majority (42%) of the respondents scored average in terms of socio-cultural practices. Figure 2a–e presents a detailed overview of the socio-demographic profile of the respondent population.

Our survey revealed that agriculture was the most trending socio-cultural practice (adopted by 77% of the respondents), followed by gardening (71% respondents). More than half of the respondent population were involved in collection of fodder and fuel wood from forests and livestock rearing, as well as depended on local animal/plant products for rituals and festivals (Figure 3).

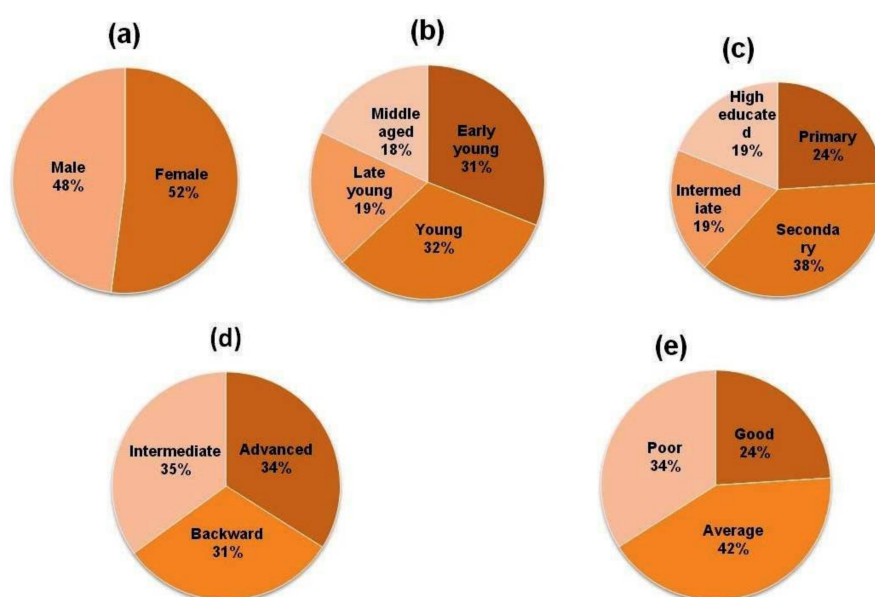


Figure 2. Socio-demographic profiling of the respondents' (a) gender, (b) age, (c) education, (d) socio-economy, and (e) socio-culture.

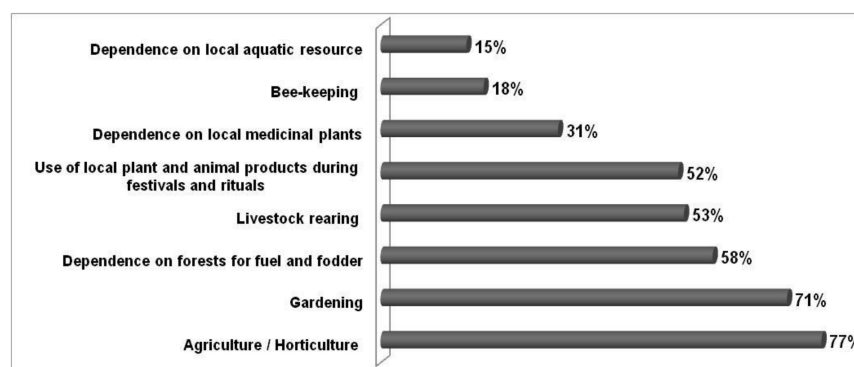


Figure 3. Respondents' involvement in various socio-cultural practices.

3.2. Food Sustainability Perception and Practices of the Local Community

By and large, local community (68% respondents) had a 'neutral' perception (Mean score 2.9; Table S1) towards food sustainability, while, 23% of the respondents were 'partly negative' (Figure 4a). People were 'neutral' about relevant economic aspects since they rated scope for economic viability, yield, local value addition, and supply of external inputs/ labor under current food system as 'moderate' (Figure 5a; Table S1). They were also 'neutral' about the future prospects of agricultural sector in the locality. However, they affirmed that farmers were 'rarely' connected to higher value export markets. Respondents were largely 'neutral' about social aspects, like food affordability, equal access, and their involvement in relevant traditional socio-cultural practices. Their rating of food in terms of animal welfare, as well as public health and nutrition, were 'good'. Nevertheless, they were 'partly negative' about the impact of current food system on local socio-cultural tradition (Table S1). Overall public perception on environmental aspects of food system was 'neutral', particularly in the context of land degradation, water quality, biodiversity loss, deforestation, climate change, energy crisis, etc. They were, though, 'partly negative' about the food system activities in relation to pollution and toxicity (Table S1). Public perception on government efforts and participatory willingness were generally 'neutral' (Figure 5a). However, perception regarding willingness to participate in sustainable food system was 'partly positive' in terms of future involvement in various relevant awareness

programs, availing new technology packages, local knowledge sharing, and trainings on capacity building (Table S1).

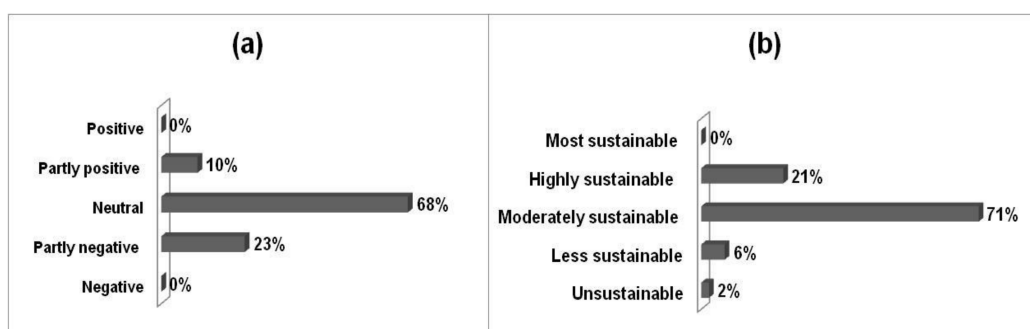


Figure 4. Status of respondents' (a) perception and (b) practices related to food sustainability in the study area.

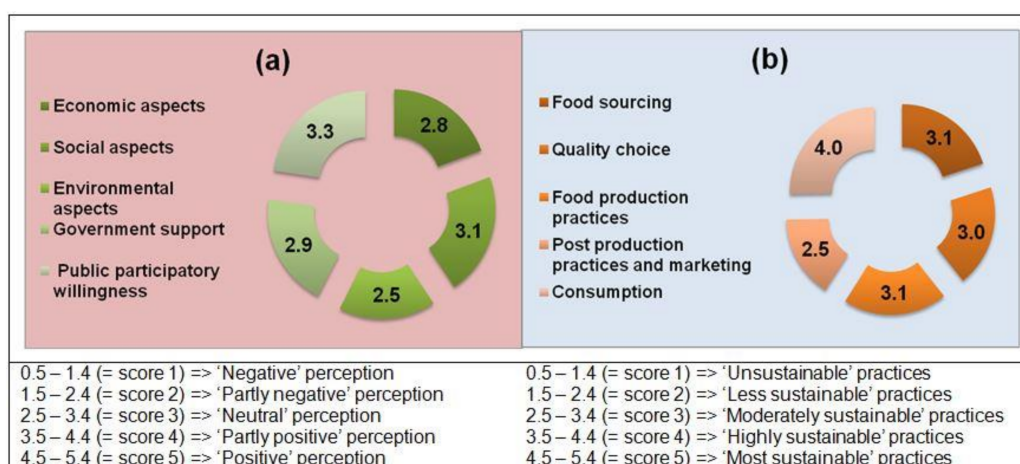


Figure 5. Subsection-wise scores of local community (a) perception and (b) practices related to food sustainability.

Our results revealed overall 'moderately sustainable' practices (Mean score 3.1; Table S1) towards food sustainability; as voted by majority (71%) of the respondents (Figure 4b). On average, people were 'moderately sustainable' in terms of food sourcing, quality preference, production, and post-production practices (Figure 5b). Food sourcing was often dependent on subsistence farming products, as well as locally processed/outsourced products, while people sometimes procured food from local forests, gardens, streams, and rivers (Table S1). Rating of food quality was largely 'good'; however, only 10% of all the respondents did actually check for safety standards and shelf life of purchased processed food products (Table S1). Food production practices mostly involved traditional sustainable agricultural techniques (including agro-waste management, resource recycling, natural pest control and non-application of synthetic chemicals, fertilizers, and pesticides), as well as livestock rearing. However, cultivation of local indigenous variety was not frequently practiced (Table S1). In case of post-production practices, people mostly adopted traditional post-harvest storage practices, as well as maintained high yielding seed bank. Respondents were not well aware of modern techniques of food processing and packaging, rather, using natural food processing and preservation techniques whenever required. They rated food distribution infrastructure as partially available (Table S1). Local food consumption practices were characterized by minimum food wastage at all stages of production to consumption and were, therefore, 'highly sustainable' (Figure 5b; Table S1).

People firstly preferred to contribute to sustainable food system by directly involving in food production, processing, and packaging practices as per prescribed sustainable standards (RBQ = 73.55; Table 1). Secondly, they liked to engage in boosting various economic

aspects (local value addition, financing, marketing, investment, export activity, connectivity and infrastructure, etc.) related to sustainable food system (RBQ = 68.06; Table 1). Strong correlation ($r = 0.77$) between perception and practice scores suggested good sync between food sustainability perception and practices of the respondents (Figure 6).

Table 1. Ranking of constraints and mode of contribution to sustainable food system by the respondents.

S. No.	Constraints/Mode of Contribution to SFS as Identified by the Respondents	RBQ Values	Final Rank Based on RBQ Values	% of Respondents Assigning Rank to Individual Constraint				
				I	II	III	IV	V
1.	Economic constraints to SFS							
(a)	High production cost of local food product due to various externalities, like land degradation, climate uncertainty, loss in biodiversity and ecosystem services, etc.	79.03	I	39%	27%	24%	10%	0%
(b)	Low and inconsistent productivity	70.65	II	27%	29%	19%	18%	6%
(c)	Insufficient government support, lack of facilities, like modern technology and incentives	62.90	III	10%	26%	37%	24%	3%
(d)	Market uncertainty	59.35	IV	23%	16%	16%	26%	19%
(e)	Unequal distribution and affordability of market-based foods	28.06	V	2%	2%	3%	23%	71%
2.	Social constraints to SFS							
(a)	Loss of traditional food systems	63.87	III	32%	18%	11%	15%	24%
(b)	Constraints due to small land holding	83.23	I	40%	42%	13%	3%	2%
(c)	Migration for alternate jobs and, therefore, lack of laborers	74.84	II	24%	31%	40%	5%	0%
(d)	Cheap, calorie rich, low nutritious foods are introduced to the market to increase supply and lower production cost	40.97	IV	2%	6%	26%	27%	39%
(e)	Lack of adequate infrastructure for setting up and monitoring food safety standards	37.10	V	2%	3%	10%	50%	35%
3.	Environmental constraints to SFS							
(a)	Climate uncertainty	82.58	II	44%	31%	21%	5%	0%
(b)	Constraints due to rough terrain, irrigation issues, and land degradation, as well as labor intensive watershed management for soil and water conservation	86.77	I	45%	44%	11%	0%	0%
(c)	Tourism and pollution	59.03	III	10%	21%	37%	19%	13%
(d)	Overexploitation of natural resource	34.19	V	2%	5%	15%	21%	58%
(e)	Loss of indigenous variety and biodiversity in general	7.42	IV	0%	0%	16%	55%	29%
4.	Preferred mode of contribution to SFS							
(a)	Directly involving with sustainable food production, processing and/or packaging practices as per prescribed standards	73.55	I	45%	16%	13%	13%	13%
(b)	Participating and/or promoting training and awareness programs on opportunities, challenges, and capacity building related to sustainable food system	68.06	III	15%	40%	23%	16%	6%
(c)	Contributing to boost social aspects of sustainable food system, e.g., practicing sustainable food sourcing, equal sharing, prevent food wastage, conserving local socio-cultural tradition, adhering to food safety standards and consumer rights, etc.	51.94	IV	13%	13%	16%	37%	21%
(d)	Contributing to boost economic aspects of sustainable food system, e.g., local value addition, financing, boosting market demands and networking, investment, export activity, connectivity and infrastructure, etc.	71.29	II	27%	21%	35%	13%	3%
(e)	Contributing to boost environmental aspects of sustainable food system, e.g., soil, water and biodiversity conservation, preventing deforestation, land use planning and restoration of degraded land, reducing GHG emission, pollution control, energy efficiency, etc.	35.16	V	0%	10%	13%	21%	56%

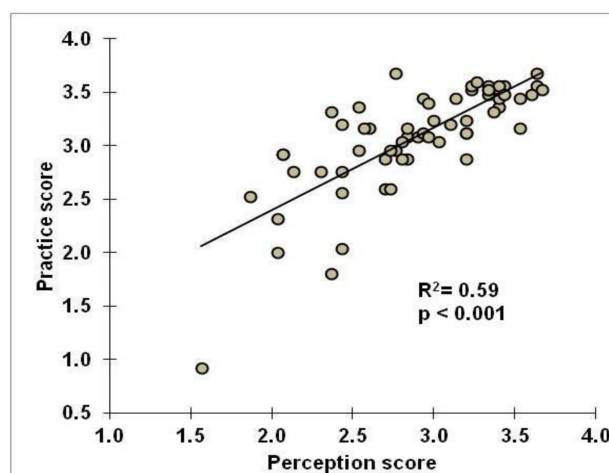


Figure 6. Correlation between perception and practice scores of the respondents.

3.3. Identification and Ranking of Local Food Sustainability Constraints

Rank-based quotient (RBQ) analyses identified various social, economic, and environmental constraints towards food sustainability (Table 1). As ranked by the respondents, major and second major economic challenges were ‘high production cost of local food product due to various externalities’ (RBQ = 79.03) and ‘low and inconsistent productivity’ (RBQ = 70.65), respectively. Top ranked social challenges include ‘constraints due to small land holding’ (RBQ = 83.23), followed by ‘migration for alternate jobs and, therefore, lack of laborers’ (RBQ = 74.84). ‘Constraints due to rough terrain, irrigation issues, and land degradation, as well as labor intensive watershed management for soil and water conservation’ (RBQ = 86.77), was the most voted environmental challenge, while ‘climate uncertainty’ (RBQ = 82.58) was the second most important constraint identified by the respondents (Table 1).

3.4. Effect of Various Socio-Demographic Factors on Food Sustainability Perception and Practices

Chi square analyses revealed that socio-culture was the most important socio-demographic factor to influence people’s practices and perception related to sustainable food system. Education level and gender were other important factors. Supplementary Table S2 presents detailed chi square values and level of significance of all the analyses. Overall food sustainability practice score was significantly associated with socio-cultural score of the respondents ($\chi^2 = 45.6$; $df = 30$; $p < 0.05$; Figure 7a). More precisely, respondents with higher socio-cultural score were significantly more sustainable in terms of food sourcing ($\chi^2 = 39.9$; $df = 10$; $p < 0.001$; Figure 7b) and showed more positive economic ($\chi^2 = 50.7$; $df = 30$; $p < 0.05$; Figure 7c) and social ($\chi^2 = 38.7$; $df = 24$; $p < 0.05$; Figure 7d) perception, as well as higher participatory willingness ($\chi^2 = 63.8$; $df = 42$; $p < 0.05$; Figure 7e). Gender was significantly associated with food sourcing practices ($\chi^2 = 13.1$; $df = 5$; $p < 0.05$; Figure 8), and female respondents (mean score: 3.2) were more dependent on sustainable food sources than the males (mean score: 2.7). Education level significantly influenced their choice and rating of food quality ($\chi^2 = 31.1$; $df = 18$; $p < 0.05$; Figure 9). Ranking of the most important economic and social constraints, as well as choosing the best way to contribute to food sustainability, significantly differed across the socio-cultural categories (the only factor among the tested demographic parameters) of the respondents, as determined by Kruskal–Wallis test (Table 2).

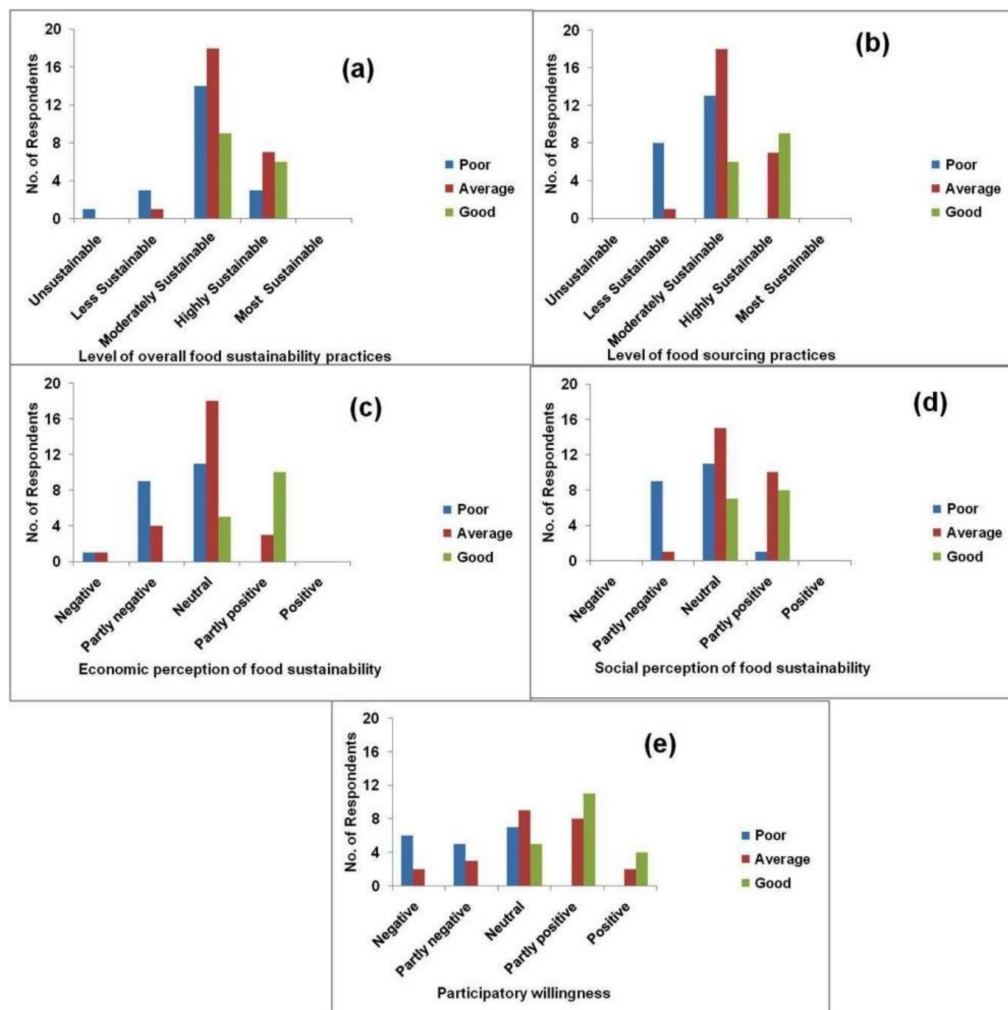


Figure 7. (a) Overall food sustainability practices, (b) food sourcing practices, (c) economic perception, (d) social perception, and (e) participatory willingness across the socio-culturally 'Poor', 'Average', and 'Good' respondents.

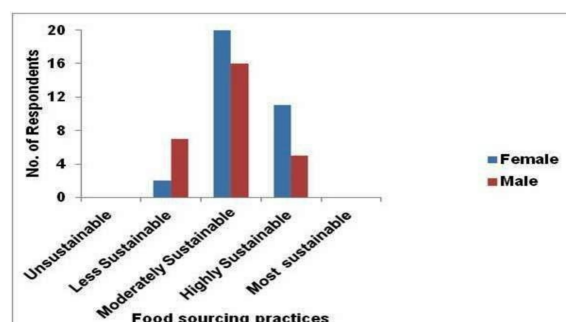


Figure 8. Gender-wise food sourcing practices of the respondents.

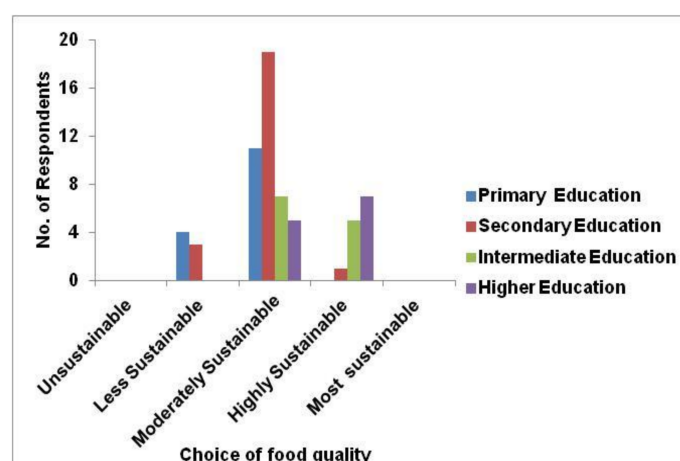


Figure 9. Education-wise food quality choice and rating of the respondents.

Table 2. Variation in respondents' food sustainability constraints ranking response and chosen mode of contribution across their socio-cultural background.

Sl No.	Variables Tested	Kruskal–Wallis Mean Rank for Various Socio-Cultural Category			Chi-Square	df	p Value
		Poor (21 Respondents)	Average (26 Respondents)	Good (15 Respondents)			
1.	Ranking the most important economic constraint to food sustainability	23.8	31.0	43.2	11.25	2	0.004 *
2.	Ranking the most important social constraint to food sustainability	36.9	33.3	20.8	8.31	2	0.016 *
3.	Ranking the most important environmental constraint to food sustainability	31.6	35.1	25.0	3.64	2	0.162
4.	Choice of the best way to contribute to food sustainability	44.0	29.8	17.0	22.67	2	0.000 **

Note: * denotes significant ($p < 0.05$ & 0.01); ** denotes highly significant ($p < 0.001$).

4. Discussion

Globally, sustainable food system is one of the most important agenda of sustainable development goals [42] and is becoming more urgent with every passing year. Studies available in India, particularly IHR, have hitherto focused on food security [32] rather than food sustainability. While food security ensures physical, social, and economic access to preferred food in sufficient quantity and quality; food sustainability safeguards long term food security and its associated economic, social, and environmental resource bases. Maximizing food sustainability might require changes in everyday practices related to food sourcing, quality choice, and consumption pattern, as well as food production and post-production approaches, which varies significantly region-wise and even locality-wise [10].

Present study indicated that local people in general adopted moderately sustainable practices related to food systems, particularly, food sourcing, quality preference, production and post-production processes. In earlier days, agricultural practices adopted by the local

people in the studied area through age-old trial and error basis were most sustainable [36]. This traditional sustainability in food sourcing is currently compromised partially because dependence on subsistence farming and local forests, gardens, or aquatic resource-based products have to some extent been replaced by local market-based and/or outsourced products. However, transport infrastructure and network were yet to be improved enough to support the local community in exporting their local produce to national and international markets for achieving a stable economic base as was also reported by Dhasmana and Dhoundiyal [35]. Additionally, the region is facing a series of environmental and socioeconomic challenges causing decline in agricultural productivity, fragmentation of land resource, and consequent food insecurity for the burgeoning population [30].

The younger population mostly rated food quality as 'good'. However, older respondents admitted that quality of local produce has deteriorated over time, along with loss of many indigenous varieties. Therefore, choice options for preferable locally grown good quality food were shrinking. Similar findings were highlighted by Maikhuri et al. [36], who advocated the importance of various locally grown traditional crops in developing food sustainability in the region. They suggested that traditional crops could be promoted as health foods and organic produce, together with value addition and better agro-climatic suitability in face of changing climate, to increase their market potential, as well as revive their consumption to acceptable level. Interestingly, our findings revealed that only 10% of all the respondents did actually check for safety standards and shelf life of purchased processed food products. Given that there was no food quality testing and monitoring facility in the area, nutritional values of those market-based/outsourced food products, as well as their comparative superiority over locally grown food, were questionable. This is clear indicator of the fact that local people were not actually well conscious of the quality of food they were consuming. While many studies across the world are today emphasizing on the importance of sustainability labels on food products [43,44], people in this region were hardly aware of such a concept. Overall, rating for food adequacy and variety was moderate. Tiwari and Joshi [32] observed that food adequacy and variety were limited mainly by poor supply facilities and low purchasing power (mostly due to poor economic condition) of the local community.

The majority respondents stated the level of agricultural intensification and livestock rearing as 'high', while studies [32,33,45] confirmed a significant downfall in the present day agricultural scenario. Older people were better aware of traditional agricultural practices than younger residents. A handful of studies [35,36] have attempted to document the common traditional agricultural practices adopted by local community, as well as suggested new pattern of future farming (both economically and ecologically sustainable) focusing primarily on choice of crops, cropping pattern, land use management, and yield. Few studies [37,38] recorded important social and cultural practices for conservation and promotion of traditional crop diversity, protection of seed materials/food grains, and preservation of indigenous knowledge. Others [45,46] reported the role of climate induced changes on agricultural systems, food sustainability, and livelihood. Our study assessed food system related perception, knowledge, and practices of the local community in the context of current environmental issues of the region (e.g., pest control, agro-waste management and resource recycling, application of synthetic chemicals and other advanced agricultural techniques, etc.) for developing more comprehensive pragmatic approach towards sustainability. In addition, present study revealed overall 'moderately sustainable' post-production practices adopted by the local community. Yet, their food consumption pattern was appreciably sustainable with minimum food wastage.

Neutral perception towards food sustainability, especially economic, social, and environmental aspects was indicative of insufficient knowledge of the residents on modern day global concept of food sustainability. Nevertheless, people, in general, were positive about direct involvement in activities, as well as awareness and training programs relevant to sustainable food system. Again, partly negative perception on the influence of present food system on traditional socio-cultural practices suggested that people had a more realistic

approach on these aspects. Probable reason could be a deep-rooted connection between various socio-cultural practices and their day to day lifestyle [38,45]. Another reason behind the neutral and mixed response could be various socio-economic and mindset changes among the respondents brought about by recent trend of rural out-migration in Uttarakhand Himalaya [31]. This also helped majority of the local people to identify and rank various food sustainability constraints. A few studies in Uttarakhand Himalaya acknowledged and researched some of the top ranked socio-economic and environmental constraints, including climate change, livelihood, and environmental challenges [30,45]. Dhasmana and Dhoundiyal [35], therefore, emphasized on the importance of considering public opinion and participation, along with sincere and consistent effort from the government's end in decision-making and policy-planning, to establish long term sustainability in the region. The authors also pointed out that, despite introduction of certain food security schemes, training, and awareness programs by the local governance, people did not seem to be much hopeful or aware of them primarily due to ineffectiveness of the extension network. Moreover, any kind of centralized coordinated planning for the entire Uttarakhand Himalayas has little scope due to altitudinal, climatic, and soil variations [35], as well as differences in socio-environmental vulnerability level of the local community [47] across the region. It is, therefore, advisable to design appropriate awareness program covering the utilitarian value of food sustainability, particularly its economic, social, and environmental dimensions and their interrelatedness, in a local context.

If the local community is to engage in livelihood business, policy decisions, and healthy initiatives related to food sustainability, understanding how various demographic factors affect their perception and practices is imperative. Nevertheless, understandings of public perception regarding food sustainability are poorly researched. Our results contributed to filling up such knowledge gap in the studied area. Among the five tested demographic factors, socio-culture emerged as the most important factor to influence people's practices and perception of food sustainability. People with higher socio-cultural score had more positive perception and greater sustainability practice score, as well as higher participatory willingness. Ranking of various sustainability constraints, as well as choosing the best way to contribute to food sustainability, significantly differed across socio-cultural categories of the respondents. Worldwide studies have recognized a deep link between socio-cultural norms and food choice, consumption pattern, food security, and health promotion [18,19,48] irrespective of urban or rural context. In fact, food choices and dietary patterns (e.g., food preferences, preparation methods and consumption) represent a vital facet of human social and cultural diversity [49]. The consideration of the social resources and constraints in making dietary choices not only takes into account health related concerns but also involves social, economic, and environmental sustainability [50]. Furthermore, current status of socio-cultural activity of the local community of the studied area indicated that people, especially the younger generation, were at in transition of leaving their age old practices and adopting the modern commercial food systems. Increasing tourism, as well labor out-migration, in Uttarakhand also aggravated the situation [31].

Apart from socio-cultural factors, we found that education level significantly influenced choice of food quality. Studies suggested that educational programs, cultural transitions, lifestyle change, and public policy planning interventions notably affect food systems [20,51]. Female respondents being more dependent on sustainable food sources than the males indicated gender as another important factor in regulating food sustainability practices. Women being the center point of majority socio-cultural practices play significant role in development of local food sustainability [7]. Gender equality and women empowerment were, therefore, advocated for establishing and maintaining effective sustainability practices. In this case study, public response was independent of their socioeconomic background; therefore, food choice, production, or consumption practices did not differ much across affluent and poor respondents. This could be explained by their general lack of consciousness on health and sustainable development, as well as lack of awareness of the economic potential of sustainable food system [7]. On the contrary, socio-economy

is an important control at global scale since food sustainability problems are rooted in imbalances and inequities [52], thereby necessitating assurance of requirement-specific production and adequate supply, as well as sufficient affordability and access. Again, role of respondents' age was not a prominent factor in determining food sustainability despite older population revealed better knowledge of traditional local food culture. This could be due to the fact that age distribution of the respondents (appropriately representative of the resident population) was more skewed towards younger generation (covering 63% of the population). Younger people expressed more inconsistent perception and practices than the older ones. Absence of significant relation between age and food sustainability perception was also reported by Bosona and Gebresenbet [17]. However, in our case, increasing the number of respondents by covering more villages, as well as involving a greater number of elderly respondents, would have better validated the finding; future research is open to such question.

5. Conclusions

To conclude, our study revealed overall moderately sustainable practices towards food sustainability, particularly food sourcing, quality choice, adequacy, and variety, production and post-production processes, etc. Consumption pattern with minimum food wastage, as well as awareness on current status of traditional food culture, showed marked signs of sustainability. On the other hand, people's general perception was neutral indicating poor awareness of modern day theoretical concept of global food sustainability. Specifically, people were not well aware of food sustainability related social, economic, and environmental perspectives and available government support, as well as advanced food processing and packaging techniques. It was, thus, evident that people were neither completely independent of traditional sustainable food system, nor were they fully prepared and equipped to adopt modern commercial food system. In general, local community showed positive participatory willingness regarding involvement in future sustainable food system. Some of the most important sustainability constraints identified by the respondents were higher local food production cost, small landholdings, labor migration, challenging land and water management issues, and climate uncertainty. Socio-cultural score of the respondents was the most important factor governing food related practices and perception, as well as ranking of various sustainability constraints. People with higher socio-cultural score had more positive perception and greater sustainability practice score, as well as higher participatory willingness. Additionally, education level and gender were other important factors influencing food sustainability practices.

In nutshell, this study has highlighted the importance of public opinion and participation for extracting finer details that, in turn, would support better decision-making and policy-planning. Appropriate awareness program covering the utilitarian value of food sustainability, particularly its economic, social, and environmental dimensions and their interrelatedness in a local context, would be highly effective. Promoting gender equality and women empowerment would enhance food sustainability to a significant extent. Additionally, holistic pragmatic approaches are required to address various sustainability constraints faced by the local community. We encourage direct involvement of socio-culturally active people and conducting extensive outreach programs (inclusive of promoting government schemes, training facilities, etc.) for future sustainable local food system in the vulnerable Himalayan valleys.

Supplementary Materials: The following are available online at <https://www.mdpi.com/article/10.3390/su13137060/s1>, Table S1: Food sustainability survey questions and public response in the two subalpine Himalayan settlements and Table S2: Association between food sustainability perception/practices and various socio-demographic factors as determined by Chi squared analyses.

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