<u>***Original Research Article***</u>

Household Food Diversity and Food Habits in Changing Climate of Western Bhutan

ABSTRACT

Household food diversity index (HFDI) is qualitative measure of food consumption that reflects household access to a variety of food groups. Food habit is the way people eat, which are influenced by various factors such as food quality, quantity, method to obtain food, discard food, learned behaviors, customs, etiquette, and eating-related problems. Impacts of climate change on food diversity and food habit poses threat on food security in agrarian Bhutanese. The study aims to analyze if household food diversity and food habits are affected by climate change in the three ecological zones. Household food diversity and food habits in Gasa, Punakha and Wangduephodrang districts (Dzongkhags) were compared and relationships were drawn. Household level data was collected using survey method form 368 randomly selected households, stratified into three agroecological zones, by administering pretested semi-structured questionnaire. The survey questions were designed using guidelines of Food and Agricultural Organisation (FOA). Food components consumed in the last 24 hours were recorded and grouped into 10 food groups. Food diversity indices are computed at the levels of household, Chiwog (village), Gewog (block), Dzongkhag (district), and at the whole study area. Spearman's correlation tests evaluated the relationship between household food diversity Index (HFDI) and Food habit with Climate Change and Elevation. Kruskal Wallis tests ascertain association among the same four sets of variables with three groups of Dzongkhag (district) as independent variable. In both sets of tests, the relationships were statistically significant. Climate change in the three agroecological zones are affecting food diversity and food habits. Introducing mass potato cultivation in Gasa, less water intensive rice variety in Punakha, and high yielding jersey cows for dairy are recommended for food diversity enhancement in the regions. Preserving traditional food culture like Aoolay from Gasa, and conserving biodiversity will contribute to mitigate impacts of climate change on food habits to achieve food security.

Keywords: Agroecological zones, food groups, inclusive supply chain, mitigate, traditional food

1. INTRODUCTION

Food diversity or household food diversity index (HFDI) or household dietary diversity score (HDDS) is qualitative measure of food consumption that reflects household access to a variety of food groups and is also the proxy for nutrient adequacy of the diet of individual [1]. Food habit is the ways people eat, which are influenced by various factors and motives such as what types of food are eaten, in what quantities, and when, as well as how people obtain, store, use, and discard food. Food habits also involve learned behaviors, customs, etiquette, and eating-related problems [2]. Climate Change (CC) is change in the pattern of weather, and related changes occurring over time scales of decades or longer [3]. Adapting and mitigating climate change towards agricultural practices are essential to maintain food diversity and preserving traditional food habits. Climate resilience in agriculture, conserve biodiversity, support small-scale farmers, promote agroecological approaches, and develop climate-smart food systems can contribute better food diversity and habits. Different geographical locations are differently influenced and affected by climate change affecting food diversity and food habits.

The study is carried out in the three ecological zones of western Bhutan. Gasa is in alpine zone with its elevation above 3600 m, Wangdue Phodrang is in cool-temperate zone from 2600 m to 3600 m, and Punakha in the dry sub-tropical zone at elevation of 1200 m to 1800 m [4]. Food diversity and food habits influenced by climate change in these three ecological zones of western Bhutan are compared and established relationships.

Bhutan presents significant challenges for the food production. Only 18% of arable wetlands are irrigated and 61% of dryland has no irrigation facilities. On agricultural inputs, 95% of all farm holdings use organic fertilizers, 25% use chemical fertilizers and slightly more than 9% of farm holdings use pesticides [5]. Farm mechanization is severely limited by steep landscapes and the small size of landholdings. To attain food security with food diversity and food habits in Bhutan, with just 3% of arable land for agriculture is a challenge. With the patchy agricultural land on mountainous terrain and rugged topography, half of the territory is on slopes prone to soil erosion. Soil erosion is estimated to 8.6 tons/hectare annually pushing Bhutan towards insecure food self-sufficiency [5]. Linking market to bring excess food for sell is yet another challenge for farmers. Some 37% of farmers used their food production only for self-consumption, 53% operated mainly for self-consumption with some sales, and only 10% take their production for sale [5]. With similar topography and location of the study site: Gasa is isolated from road access by about 30 km in the alpine region, high in the mountain, and major food to be imported. Wangdue Phodrang is prone to wild animals' attacks on crops and livestock, and poor market of cash crop (potato). Punakha has issue such as water scarcity and influence if junk food especially to young children. All these challenges hinder food production and thereby food diversity and food habit.

For food diversity, a study by [6] categorized food into 12 groups such as cereals, root and tubers, vegetables, fruits, fish and seafood, milk and milk products, meat and poultry, eggs, pulses/legumes/nuts, oil/fats, sugar/honey, and miscellaneous. Using the basis of [6], 10 food groups are framed to suit the Bhutanese dietary culture and practice. The ten food groups are cereals, vegetables, fruits, milk and its products, meat and eggs, pulses/legumes and nuts, oils and fats, spices and condiments, sweets and sugar, alcoholic and non-alcoholic beverages. The study of this kind in Bhutan on food diversity and climate change comparing different ecological zones will contribute to better understand the global climate change and food systems.

The objective of the study is to analyze if household food diversity and food habits are differently affected by climate change in the regions of Gasa, Punakha and Wangdue Phodrang. The comparisons will see relationships in terms of magnitude and direction. How is climate change impacting food diversity and food habits in the three regions is closely compared and reported. Accordingly, measures are recommended for action from relevant stakeholders. The issue is Bhutan has potential to expand as driver of food security, economic diversification and growth, create healthy society, and poverty alleviation through intervention in food and climate change [7]. The gap losing food habits, and food diversity needs to be narrowed for sustainable agrarian Bhutan.

This work will establish the relationships between the parameters and with that an informed decision on appropriate food system policy and climate resilience can be adopted for specific communities with specific food habits. The problem is to establish a study focus on examining the relationship between climate change, food diversity, and food habits in the three agro-ecological zones. It aims to understand how shifts in climate patterns, including temperature, precipitation, and extreme weather events, influence the availability and diversity of food crops in different regions and how people adapt to their food culture accordingly. The research seeks to explore the potential consequences of climate change on agricultural systems, local food cultures, and nutritional diversity. Through this study the question like how climate change affects the production and availability of diverse food crops in different agro-ecological zones, what are the specific climate-related challenges faced by farmers of Gasa, Punakha and Wangdue Phodrang in maintaining and enhancing food diversity and food culture. Further it will recommend strategies and adaptations to be developed to promote food diversity and resilience in the face of climate change and potential implications of reduced food diversity on nutrition, human health, and socio-economic well-being in different agro-ecological zones.

This work is presented in a logical manner using the major variables of study. Socio demographic profile of respondents are collected and computed for the readers understanding of respondents. Major food grown and consumed are categorized into 10 food groups to learn food diversity. Food diversity index is computed at various levels using the standard rule adopted by [1]. Different food habits and food culture are collected from all three regions and compared. Climate change is overarching phenomenon to compare with across the parameters.

2. METHODS

2.1 RESEARCH DESIGN

Through both designs of comparison and building relationships, the study adopted cross-sectional research. Cross-sectional research design in the three agroecological zones enabled to collect data from a single point of time from a wide range of respondents with a wide range of variables considered. For food diversity and food habits, food groups consumed in last 24 hours, food barter, food types, production to buy ratio, perception to climate change, copong mechanisms to climate change and food production, and impacts of climate change and food were variables to develop the relationships and to make comparisons. It is suitable to establish relationships and for comparison through analysis of association as in climate change with food diversity and food habit in different agroecological zones [8]. The quantitative approach of collecting data using semi structured questionnaire was adopted. Data was collected from surveying any one member from the household farmers using a semi-structured questionnaire to make sure randomness as well as inclusiveness of the respondents from within the household of the study site.

The study provided a snapshot of the present food diversity status and food habit in the three districts of Gasa, Wangdue Phodrang and Punakha during the time of November 2022 to February 2023. An assessment of plant diversity in home-gardens in three ecological zones was studied in Nepal with similar approach adopted [9].

2.2 STUDY AREA

The study site has been divided into three agro-ecological zones [4]. Gasa falls into Alpine zone with above 3600 meters above sea level. Wangdue Phodrang is under cool-temperate zone at 2600 to 3600 meters. The lowest agro-ecological zone (Punakha) is dry sub-tropical zone within 1200 to 1800 meters. Since the study was to see if different ecological zones have diversity in food and the food habits, the zoning provided a convenient way to compare them with each other. As shown in the figure 1, the study collected data from three zones of alpine, cool temperate and dry sub-tropical zones from three districts of Gasa, Wangdue Phodrang and Punakha respectively. Gasa had one Sub District as Laya with four villages namely Chongro, Lungo, Nelu and Pazi. Wangdue Phodrang District had two sub districts namely Gangtey with Gogona and Kumbu villages and Phobji with Gangphel and Drangha. Similarly, Punakha District had two sub districts namely Kabisa with Angona-Zabisa and Petari villages and Dzomi with Gubji-Tsekha and Tana-Uesa villages.

The three zones are different in terms of rural or urban setting: Laya in Gasa is far away in remote setting with walk distance of 30 km from the end of vehicle road. Wangdue Phodrang District having Gangtay and Phobji sub-districts are away from national highway connected with narrow and unstable farm roads as semi-rural communities. Punakha district with Dzomi and Kabisa sub-districts are next to National highway with urban town within 5 km from the communities.

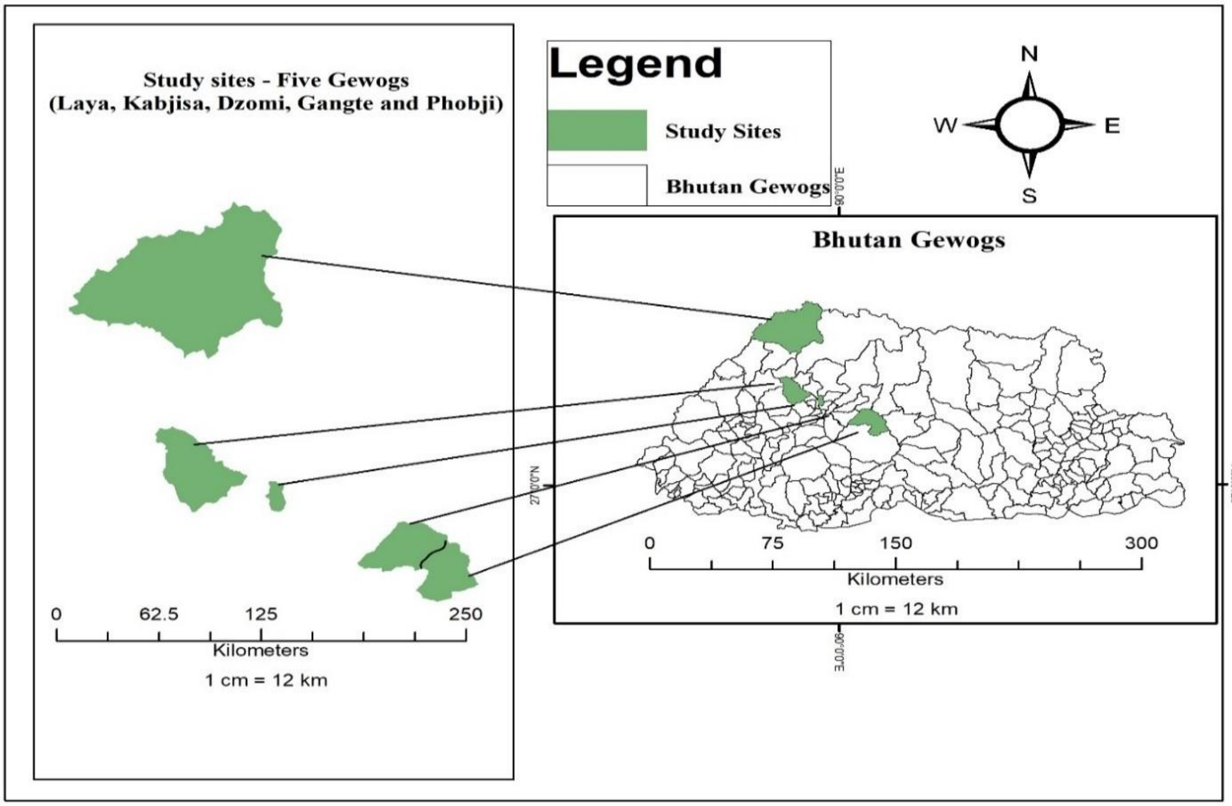

Figure 1: Study area, three ecological zones

2.3 SAMPLE SIZE

The target population was instrumental in order to have a scope and coverage of the study. Since the aim of the study was to determine household level of food diversity and food habit, household was the unit of parameter and of statistics. A respondent had to be a member of household, from the farming community, staying in the village, and practicing farmer. The initial list of 1822 was provided by the five *Gups* (the heads of the local government). However, some households without members staying in the village had to be excluded. After subtracting 21 households without members doing farming, the final list had 1801 households in the population was confirmed.

To determine the minimum sample size, Cochran's formula was used [10]. For the desired level of precision, desired confidence level, and estimated proportion of attribute present in the population, the Cochran's formula helped to calculate an ideal sample size. With relatively large population as in this case, Cochran's formula is considered appropriate. The formula is shown in the equation 1 as follows:

(Equation 1)

Where: Z = confidence level of 95% (1.96)

E = margin of error (0.05)

P = proportion of the population (0.5)

Q = 1 – p (0.5)

= Cochran's sample size recommendation

Fitting the above information in Equation 1, the minimum required sample size was 385 households of farmers. However, Cochran's formula can be adjusted for a smaller population, as shown in Equation 2.

(Equation 2)

Where: N = population size (1801 households)

n = adjusted sample size

Considering the target population of 1801 households, the minimum adjusted sample size was calculated as 360 farmers. Under each stratum (agroecological zone) 120 households are to be taken. However, the actual data collection was from the field was from 368 households. Exactly 120 households from Gasa district, 120 households from Wangdue Phodrang district and 128 from Punakha district. Therefore, the results presented in this study are based on the analyses of data collected from 368 farmers.

2.4 SAMPLING TECHNIQUE

The detailed procedure of sampling is illustrated in Figure 2. Three districts were purposely selected to ensure the three ecological zones. Dividing the total 360 households into three ecological zones, each district/zone gets 120 households.

In the second stage, minimum one Gewog (sub district) in each selected district were chosen. The selection of two gewogs was also purposive, based on the elevation of the ecological zones. This study covered a total of 12 villages under five sub-districts of three districts. The procedure of having a proportionate sample from each village is given in the Table 1.

Table1: Sampling Procedure

Sl. Number	Screening Procedure	Number of households respondents
1	Initial list of population from the three agroecological zones	1822 households
2	Exclusion of non-farming households	1801 households
3	Three districts stratification	120*3 = 360 households
4	Five sub-districts stratification	(120*1 + 60*4) = 360 households
5	12 villages (four villages from each district) stratification	30*12 = 360 households
6	Actual number of households administered for data collection	368 households

At the final stage, stratified sampling was employed. The selection of household was completely randomized [11]. The random function in Microsoft Excel 2019 "=RANDBETWEEN()" has been a handy tool to get the sample households when they were listed in serial number of alphabetic order of the names of head of household. The household list of the 12 villages each time was put into serial number before random number were generated. Every village gets an equal share of 30 (8.33%) households. Stratified sample is shown in the Table 2.

Table 2: Stratified random sampling (number; % in parenthesis)

Dzongkhag	n (%)	Gewog	n (%)	Chiwog	n (%)
Gasa	120 (33.33)	Laya	120 (33.33)	Lungo	30 (8.33)
				Pazhi	30 (8.33)
				Naylu	30 (8.33)
Wangdue Phodrang	120 (33.33)	Gangtey	60 (16.66)	Chongro	30 (8.33)
				Gogona	30 (8.33)
		Phobji	60 (16.66)	Jangchu-Kumbu	30 (8.33)
				Drangha	30 (8.33)
Punakha	120 (33.33)	Kabjisa	60 (16.66)	Gangphel	30 (8.33)
				Petarı	30 (8.33)
		Dzome	60 (16.66)	Angona-Zabesa	30 (8.33)
				Gubjı-Tseyka	30 (8.33)
				Tana-Uesa	30 (8.33)

2.5 SURVEY QUESTIONNAIRE

Designer solutions of Computer Assisted Personal Interviews (CAPI) as an open-sourced material from World Bank Groups was used to administer survey questionnaire in the study [12]. The same survey method was adopted by [6] in measuring food household dietary diversity index in USA and in investigating multiple households water sources [13]. This study adopted the semi-structured questionnaire consisting of closed and open-ended questions. The semi-structured questionnaire allowed to capture additional information that arose during data collection and to be used in validating the quantitative data. There are four sections in the questionnaire. Section one collected data on the demographic profiles of the household. Section two collected food diversity information, including types of food grown, area of food grown, and food groups consumed in the last 24 hours. Section three consisted food habits and food culture related questions and section four captured climate change as broad variable.

2.6 DATA ANALYSIS

Preliminary data from the field were downloaded from Survey solutions of CAPI and checked in detail for any missing, incomplete, or inconsistent responses. In case of any problematic response, the data was rectified via phone calls. The responses were incorporated in the data set, cleaned and coded in the Microsoft Excel spreadsheet version 2019 as exercise of data management. The cleaned data set was then imported to IBM SPSS Version 25 for further analysis. Data were analyzed descriptively using mean, standard deviations, frequency, and percentage in the first section. Results were mostly presented in tables, graphs and radars. For inferential purpose, data were tested for normality. The variables to be tested were non parametric. Spearman's Corrilation and Kruskal Wallis tests were administered to see the relationships and association. With three ecological zones having more than two groups of variables, Spearman correlation and Kruskal Wallis tests were conducted using variables as household food diversity index, food habit, elevation, and climate change perceptions.

3. RESULTS AND DISCUSSION

3.1 SOCIODEMOGRAPHIC PROFILE

The socio demographic profile of respondents is presented in Table 3. Gender as men and women, age group, family size, marital status, education levels, and dependency ratios were computed.

Table 3: Profiles of the survey respondents from the three agroecological zones, (Gasa, Wangdue Phodrang and Punakha (number; % in parenthesis)

Characteristics	Gasa	Punakha	Wangdue Phodrang	Total
Gender				
Male	51 (42.50)	58 (45.31)	32 (26.67)	141 (38.32)
Female	69 (57.50)	70 (54.69)	88 (73.33)	227 (61.68)
Total	120 (100)	128 (100)	120 (100)	368 (100)
Age				
≤ 45 years	72 (60.00)	68 (53.13)	78 (65.00)	218 (59.24)
> 45 years	48 (40.00)	60 (46.87)	42 (35.00)	150 (40.76)
Marital Status				
Married	91 (75.83)	102 (27.72)	94 (78.33)	287 (77.99)
Unmarried	15 (12.50)	9 (7.03)	9 (7.50)	33 (8.97)
Divorced	5 (4.17)	5 (3.91)	14 (11.65)	24 (6.52)
Widowed	9 (7.50)	11 (8.59)	3 (2.50)	23 (6.25)
Separated	0 (0.00)	1 (1.00)	0 (0.00)	1 (0.27)
Family Size				
≤ 4 members	39 (32.50)	35 (27.34)	41 (34.17)	115 (31.25)
> 4 members	81 (67.50)	93 (72.66)	79 (65.83)	253 (68.75)
Education				
Literate	53 (44.17)	65 (50.78)	56 (46.67)	174 (47.28)
Illiterate	67 (55.83)	63 (49.22)	64 (53.33)	194 (52.72)
Dependency Ratio				
National DR= 47.0 (PHCB, 2017)	46.64	64.98	76.04	62.18

Women respondent 61.68% and 38.32% of men from 368 respondents. Gasa had 57.50% women and 42.50% men, Punakha had 54.69% women and 45.31% men and Wangdue Phodrang had 73.33% of women and 26.67% of men. Men work in the fields and women take care of the household chores.

Because the house was visited for household survey, the probability to have women respondents was high. The women respondents from Wangdue Phodrang were exceptionally higher 73.33% than men 26.67%. This was since data collection months were December and January during which most men go to bordering town of Phuentsholing with their loads of potato to sell in auction to Indian merchants. Though in the national population ratio men are more than female people staying in the rural villages is mostly women. According to National Statistics Bureau population ratio in 2017 was 109.74 men, which says there were about 110 males for every 100 females in the population of Bhutan [14]. It is the women folks, especially in rural farming population, who stay at the homes so that the men can go to the field to work. Similar findings was shown in a study of Nepalese farmers coping with food insecurity where household structure like gender composition and age structure are decisive factors for food security in rural settings [15].

Age of working population is critical especially in agriculture. With categorizing median age of the respondents at 45 years, all regions showed higher population below 45 years old with average of $\leq$ 45 years (59.24%) and > 45 years (40.76%). Overall, there are more respondents in the category of 31 to 45 years. Age group of 46 to 60 years had constant number across the three districts (Gasa 24, Punakha 25 and Wangdue 26 respondents), while least respondents were from age group above 60 years.

The respondents of the study fit in the economically productive age group, or prime age for farming. Population between 31 to 45 years fall in the median of working population and are those farmers who can do most of the farming activities as they are in their prime age to do physical work.

The size of the family indicates number of members staying in the household and participating in farming [16]. The family size was categorized into two groups with $\leq$ 4 (31.25%) members and > 4 (68.75%) members. There were 13.86% of households with only one to three members. The largest group was with 56.25% of respondents in the category of four to six members. With seven to nine members 22.01% and more than nine members had 7.88% of respondents.

For the farming purpose, the size of the family is adequate in the study. According to the population and housing census of Bhutan 2017, the average family size of the households in Bhutan, as per the Population and Housing Census of Bhutan (PHCB) 2017, was 3.9 members [14]. The national level of family size closely matched with the respondents from this study. It was shown in the study of [16] that large family size of five to eight members showed negative food security. So more the merrier do not hold water in the study as well as other studies.

On education front, 47.28% of the population were literate with any form of education (primary, non-formal, secondary, or tertiary levels) and 52.72% of the respondents were without any form of education. With more than half of respondents were illiterate, their income from farming is negatively affected. It was found in a study in China by [17] that financial literacy is significantly related to farmers' income.

Using the standard dependency ratio, over all the dependency ratio of the research area was 62.18, while of Gasa was 46.64, of Wangdue Phodrang was 76.04 and of Punakha was 64.98. Each of the ratios were hugely different.

a)
b)
c)

The national dependency ratio as of 2017 was 47.0 [14] which coincides with that of Gasa's dependency ratio. However, the total dependency ratio of all the three ecological zones was higher that national average at 62.18. Similarly, that of Wangdue Phodrang (76.04) and Punakha (64.98) are higher than the national average with big margin. With higher dependency ratio there will be more children and elderly population to be fed by the working population. This indicates that the food availability, food production, food import and food diversity will be negatively affected by high dependency ratio. Similar finding was reported that the household's dependency ratio is major determinant effecting food security and food diversity in Pakistan [18].

3.2 FOOD TYPES AND FOOD GROUPS

It was found that the farmers generally grow mixed crops. However, Gasa and Wangdue Phodrang had more traditional crops than Punakha district. Punakha district had mostly mixed crops types as given in Table 4.

Table 4: Types of food crops grown in the study area

	n (%)		
Dzongkhag	Traditional crops	Modern crops	Mixed crops
Gasa	64 (53.33)	1 (0.83)	55 (45.83)
Punakha	7 (5.47)	18 (14.06)	103 (80.47)
Wangdue Phodrang	60 (50.00)	3 (2.50)	57 (47.50)
Total	131 (35.60)	22 (5.98)	215 (58.42)

Traditional Crops locally called Dru-Na-Gu, (Nine Cereals) are Rice (Bja), Maize (Gayza), Wheat (Ka), Barley (Nah), Buckwheat (Bjo), Millets (Memja), Pulses (Sem), Oil seeds (Peka), and Amaranths (Zimtse). The modern crops are those introduced by the ministry of agriculture after 1970s such as broccoli, carrots, tomatoes, onions, and quinoa, oats. The mixed crops consist of both modern and traditional crops [19].

In terms of food groups, when major food groups been tabulated, reflected in Table 5, it was found that vegetables were common for all the three sites, while Punakha grows 100% of cereals. For Gasa, turnip and radish are grown for feeding horses and yaks in winter. Wangdue Phodrang grows potato at commercial scale. Punakha rice as main cereals so the valley is also termed as the rice bowl of Bhutan [20].

Table 5: Major food groups grown in the three ecological zones

Dzongkhag	n (%)					
	Cereals	Vegetables	Fruits	Dairy	Meat/Eggs	Oil Seeds
Gasa	100 (83.33)	120 (100)	0 (0.00)	42 (35.00)	20 (16.66)	7 (5.83)
Punakha	128 (100)	125 (97.65)	78 (60.93)	99 (77.34)	30 (23.43)	55(42.96)
Wangdue	71 (59.16)	120 (100)	2 (1.66)	114 (95.00)	10 (8.33)	16 (13.33)
Total (368)	290 (78.80)	365 (96.73)	80 (21.73)	255 (69.29)	60 (16.30)	78 (21.19)

The food diversity was tabulated and found that the food groups grown is limited to what all the farmers consume. For instance, fruits are not grown in Gasa, and just 1.66% in Wangdue Phodrang. However, when questioned if they consume fruits, it was learnt that they buy all food that do not grow in the farmland. That make us to believe that the import of food groups is enormous especially in the mountainous regions. Food import is shown below in the Table 6.

Table 6: Essential food items imported for consumption

Dzongkhag	n (%)						
	Rice	Flour	Noodles	Pulses	Fruits	Vegetables	C.Oil
Gasa	120(100)	78(65.17)	78(65.17)	70(58.03)	95(79.46)	89(74.10)	108(90.17)
Punakha	7(5.14)	66(51.47)	81(63.23)	121(94.85)	23(17.64)	28(22.05)	105(82.35)
Wangdue Phodrang	110(91.66)	62(51.66)	83(69.16)	84(70.00)	70(58.33)	68(56.66)	105(87.50)

When eight essential food groups commonly consumed after import were tabulated it was found that 67.41% of them were imported by Gasa respondents, 62.19% by the Wangdue Phodrang participants and 44.94% by the respondents of Punakha district. This indicates that high altitude people do not grow better mix of food and therefore depend more on food imports. For instance, Gasa imports 100% of rice. Rice is essential today for Gasa people also. When it must be fully imported and is a must food commodity, the community is vulnerable if situations like covid-19 arises. Rice grown in Bhutan is for domestic consumption, and not been able to meet the demand from local production. Import of rice is the only alternative to meet the shortage. In 2013, Bhutan consumed 6,259 tons of rice with per capita consumption of 135.5kg/year [19].

3.3 LIVESTOCK FOR FOOD DIVERSITY

Wangdue Phodrang has 99.16% of households rear cows/ox mostly for dairy and manure. Gasa has 93.33% of horse owners. In terms of diverse livestock rearing, Wangdue Phodrang is having most of the livestock. Horses are used for transportation of incense (Sangzey) products as plant products and cordyceps (*Cordyceps sinensis*) from mountains to road point. Punakha has 91.40% of households rearing cows/ox illustrated in Table 7.

Table 7: Different animals reared in the three ecological zones

Dzongkhag	n (%)					
	cows/ox	Yaks	Horses	Pigs	Poultry	Sheep/Goats
Gasa	1 (0.83)	42 (35)	112 (93.33)	0 (0.00)	0 (0.00)	0 (0.00)
Punakha	117 (91.40)	0 (0.00)	0 (0.00)	1 (0.78)	42 (32.81)	0 (0.00)
Wangdue Phodrang	119(99.16)	3 (2.50)	9 (7.5)	0 (0.00)	1 (0.83)	1 (0.83)

The common purpose of rearing any type of livestock is for manure. It has been found that the poultry earing got reduced as the farm specialization overtook the locally rearing of a few local chickens. Yaks in Laya has been reduced as cordyceps became more lucrative after the legalization of cordyceps collection. Yak farming in Bhutan is experiencing an increased pressure to sustain due to ineffective one blanket-policy [21]. So is the case with cows, piggery, poultry, and sheep/goat farming need to be treated differently at policy level for integrated and sustainable food systems. Livestock products enhance food diversity as meat, eggs, and dairy products. Moreover, on Bhutan manure from livestock is the major supply for food corps growing. A similar finding was reported by [22] which says that livestock farming is important for crop production as animal products account for approximately one-third of global human protein consumption.

3.4 HOUSEHOLD FOOD DIVERSITY INDEX

It is globally accepted to eat diverse types of foodstuffs for a healthy diet. There is disagreement to define and measure healthy food in the literature. Nutritional studies often use count indices to quantify food diversity. However, a comparison with selected traditional diversity measures showed that the new indicator more accurately reflected healthy food diversity [23]. Household food diversity index of the three district, five sub-districts and 12 villages is provided in the Table 8.

Household food diversity index (HFDI) or also termed as household dietary diversity score (HDDS) indicates as the measure of food consumption that reflects household access to a variety of food groups [1] Food diversity is also proxy to measure nutrient adequacy of a community, country, or region. Household food access is the ability to acquire sufficient quality and quantity of food to meet all household members' nutritional requirements for healthy and productive lives [6]. All the diverse food consumed were grouped under 10 groups. At the district level, Gasa's HFDI was 7.54, Wangdue Phodrang was 7.80 and of Punakha was at 7.90. With elevation increasing, there is decrease in HFDI.

Table 8: Household Food Diversity Index (HFDI) at all levels

Dzongkhag	HFDI	Gewog	HFDI	Chiwog	HFDI
Gasa	7.54	Laya	7.54	Chongro	7.60
				Lungo	7.87
				Neylu	7.77
Wangdue Phodrang	7.80	Gangtey	7.75	Pazi	6.93
				Gogona	8.10
				Janchub-Kumbu	7.40
		Phobji	7.85	Drangha	7.80
				Gangphel	7.90
Punakha	7.90	Dzomi	7.82	Gubji-Tseykha	7.97
				Tana-Eusa	7.67
		Kabisa	7.99	Angona-Zabisa	7.65
				Petari	8.32
HFDI of three Dzongkhag Average			7.75		

Food diversity can be best when there is access to diverse food groups. It was clear that those far-flung places which are not accessible to motorable road had scored lesser than those relatively accessible places. Here this study compares three groups of respondents divided by elevation. In the study of [1] they do not compare different groups but using similar food groups with different groups of people like women group, children, or other age groups. Pearson correlation between HFDI and concerned to climate change has been computed and HFDI was correlated with average altitude (elevation) as illustrated in table 9 and 10 respectively.

3.5 FOOD HABIT

In the food culture, a question was asked as to what factor determine food culture. Economic factor (38%) is most detrimental factor as compared to environmental (30%) and socio-cultural factor (32%) for food habit determination as shown in Figure 3.

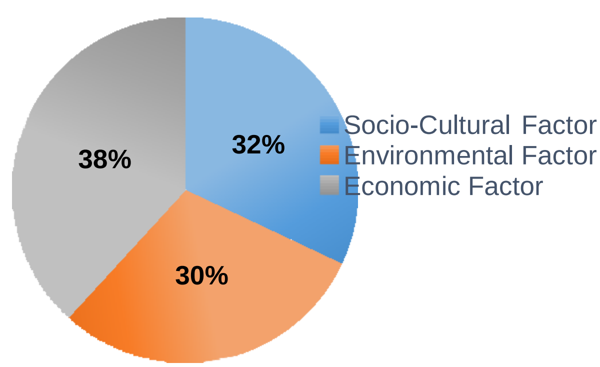

Fig. 3: Factors that determine food habit

Respondents were saying if only there is money other two factors will fall in place. However, the other two factors also environmental factor like going vegetarian and socio cultural like Aooley (food festival) in Gasa is still practiced which was there since 1650s. In the paper on transparency of the meat chain in the light of food culture and history by [24] meat preference value was universal. On sustainable consumption of meat products, people sensitive to animal welfare increased in avoiding to buy meat or by preferring organic meat indicating social factor been more influential than economic factor.

3.6 CLIMATE CHANGE

Farmers perspectives on climate change has been computed. Radar diagram in Figure 4 indicated causes of climate change. According to farmers' opinion human activities like waste and automobiles effluents are the main cause of climate change. Natural cause is another leading cause of climate change. Unappeased deities and religious reasons were rated low in all the three agroecological zones.

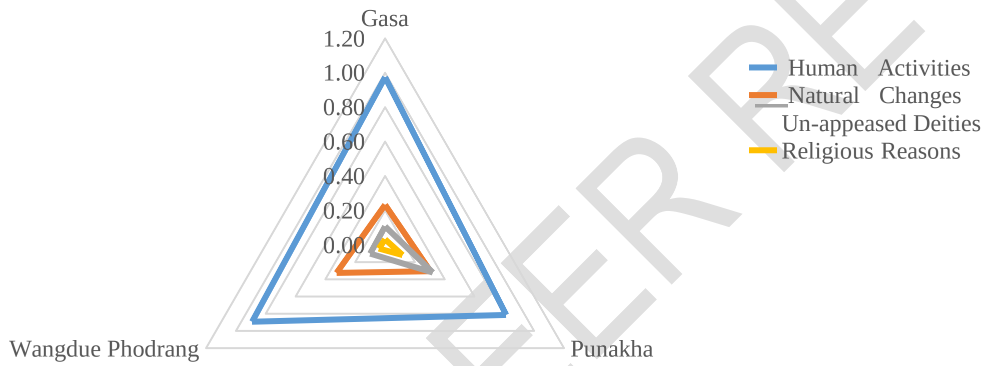

Fig. 4: Farmers views on cause of climate change

Climate change imposes challenges to the world's ability to meet food for all. Food systems are highly sensitive to climate, as they are both sufferer and initiator of the effects of climate variability and climate change [26]. Human cause of climate change is therefore having detrimental impact on food systems in all the three regions. However, respondents from Gasa say the most cause is due to climate change, further indicating the degree of cause is different at different agroecological zones.

Television is the most favorable source through which information on climate change is received (Figure 7) especially in Wangdue Phodrang and Punakha. In Gasa however, radio is the main source through which people receive climate related information. On the other hand, flyers and posters are the least preferred source farmers choose to avail information on climate change.

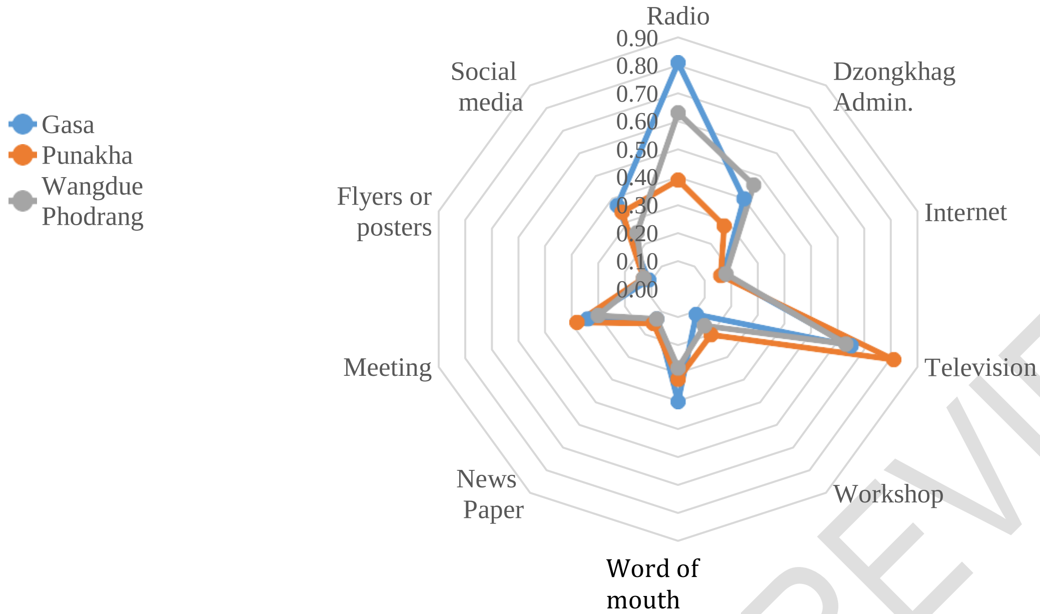

Fig. 5: Radar showing the medium of information on climate change is received by the farmers

Farmers obtaining information must be from authentic source and timely, especially to farmers who work to produce food for themselves and urban dwellers. Similar analysis was reported by [27] which revealed that the farmers' experience, education, land area, credit, and climatic information from the relevant source were important factors that influenced farm household adaptation to climate change.

Table 9: Spearman's Correlation of Household Food Diversity Index (HFDI) with Climate change and Elevations, and Spearman's Correlation of Food Habit with Climate change and Elevations.

			HFDI	Climate Change
Spearman's rho	HFDI	Correlation Coefficient	1	-.285**
		Sig. (2-tailed)	.	0
		N	368	368

** Correlation is significant at the 0.01 level (2-tailed).

			HFDI	Elevation
Spearman's rho	HFDI	Correlation Coefficient	1	-.115*
		Sig. (2-tailed)	.	0.027
		N	368	368

* Correlation is significant at the 0.05 level (2-tailed).

			Food Habit	Elevation
Spearman's rho	Food Habit	Correlation Coefficient	1	-.227**
		Sig. (2-tailed)	.	0
		N	368	368

** Correlation is significant at the 0.01 level (2-tailed).

			Food Habit	Climate Change
Spearman's rho	Food Habit	Correlation Coefficient	1	.134**
		Sig. (2-tailed)	.	0.01
		N	368	368

** Correlation is significant at the 0.01 level (2-tailed).

Spearman's rank correlation was computed to assess the relationship between house food diversity index and climate change. There was a negative correlation between the two variables, $r(366) = -.29$, $p = .00$. Spearman's rank correlation was computed to assess the relationship between house food diversity index and elevation. There was a negative correlation between the two variables, $r(366) = -.12$, $p = .02$. Spearman's rank correlation was computed to assess the relationship between house food habit and elevation. There was a negative correlation between the two variables, $r(366) = -.23$, $p = .00$. Spearman's rank correlation was computed to assess the relationship between house food habit and climate change. There was a positive correlation between the two variables, $r(366) = .13$, $p = .01$. All the factors show statistically significant relationships to each other. With increase in climate change there is decrease of household food diversity index (HFDI). With increase in elevation/altitude there is decrease in HFDI. With increase in elevation, there is decrease in food habit and with increase in climate change there is increase in food habit. Putting the relationships together, there is significant change brought about by climate change in the three ecological zones on food diversity and food habit.

It indicates that food culture decreases with increase in elevation. Places with modern infrastructure like roads and access to market, which are at lower elevation have higher food diversity. While those far-flung villages, especially highlanders without road access and leading humbler lives are having poorer understanding of food habit. Laya people living as pastoralists have food cultural events like Awooley and Bumkor practiced annually which is declining as per the test showing negative relationships with altitude. In a study on social and cultural implications of food and food habit by [25], introduce a food habits for better health, one should have knowledge of the people's beliefs, attitudes, knowledge and behavior before attempting to introduce any innovation into an area. This was particularly so because social science must work with health science to become less 'culture bound,' and requires a major reorientation of health partners with social partners. In 1960s, eggs were not fed to African women because they tend to be licentious. Further, it was uneconomical to eat an egg that would later hatch and become a chicken so egg eating was regarded as a sign of greed. Similarly, milk was forbidden to married women if the milking cow was not gifted by her parents when she is married. In this study, men from Gasa, Punakha and Wangdue Phodrang do not carry manure in their backs. It was believed that if men carry manure in their back, they will take nine more rebirths before getting to human form.

Table 10: Kruskal-Wallis's test for finding the association in the non-parametric variables

Test Statistics[a,b]

	HFDI	Elevation	Climate Change	Food Habit
Kruskal-Wallis H	5.689	328.403	24.048	28.612
df	2	2	2	2
Asymp. Sig.	0.050	0.000	0.000	0.000

a. Kruskal Wallis Test

b. Grouping Variable: Dzongkhag

The Kruskal-Wallis's test for median as the measure of central tendency for the non-parametric data has been administered. Comparing three independent groups as the three districts (Gasa as alpine zone, Wangdue Phodrang as. The testing variables were Household Food Diversity Index (HFDI), climate change, elevation and food habit. Since the p-values for HFDI =0.050, for Climate Change = 0.000, for Elevation = 0.000 and for Food Habit = 0.000 which were all less than .05, it is evident that a statistically significant difference exists in the three districts (Dzongkhags) namely Gasa (alpine zone), Wangdue Phodrang (cool temperate zone) and Punakha (dry sub-tropical zone).

4. CONCLUSION AND RECOMMENDATIONS

Household food diversity represents the range of different foods that are regularly included in the meals and diets of individuals or families within a home. Food habits encompass various aspects, including what people eat, how they eat, when they eat, and why they make certain food choices. Food habits are shaped by a combination of factors, including cultural, social, economic, environmental, and individual influences. Local climate change has been established to have significant relation to local food diversity and food habit. Building climate resilience in the food sector, particularly towards food diversity and food habit is of utmost importance for Bhutan in order to achieve sustainable food security for the people. This study assessed how climate change is affecting the food diversity and food habits in the regions of Gasa, Punakha and Wangdue Phodrang. Food culture and habit showing an inverse relationship with elevation in the three ecological zones. With increase in elevation from Punakha to Wangdue Phodrang and to Gasa, food culture is increasing. However, food diversity is decreasing with elevation in the three ecological zones. Also, it is found that impacts of climate change are felt increasingly with elevation. Therefore, the study strongly recommended to have better climate resilient approach to have diverse food. Capacity development in climate smart agriculture will improve food diversity and food habit. One intervention is sustainable greenhouse in high altitudes. Adopting organic kitchen gardening, drip irrigation for efficient water management are other climate adaptation strategies for food security.

In order to preserve and promote the declining food habits and food culture, especially in the lower altitudes, government must intervene with encouraging programs of competitions and access for enabling farmers to showcase food cultures and thereby promoting food diversity also. Economic benefits to farmers when adopting to have diverse local food need to be in place. Premium price for food grown locally need to be in place at the policy level itself. Policy adoption and implementation is weak. Farmers say even if the rules exist, actual application is limited. We are all kits and kins to impose rules is the attitude of enforcing agencies which make all the flexibility to follow rules. Addressing climate change and promoting sustainable agricultural practices are essential for maintaining food diversity and preserving traditional food habits. Efforts to build climate resilience in agriculture, conserve biodiversity, support small-scale farmers, promote agroecological approaches, and develop climate-smart food systems can all contribute to mitigating the impact of climate change on food diversity and habits. Introducing mass potato cultivation in Gasa, less water intensive rice variety in Punakha, and high yielding jersey cows for dairy are recommended for food diversity enhancement in the regions. Preserving traditional food culture like Aoolay from Gasa, and conserving biodiversity will contribute to mitigate impacts of climate change on food habits to achieve food security.

Since food diversity is a cross-sectional study during winter months, similar study must be conducted to capture the such situation at different instance of time, for instance, during summer to have a comprehensive outcome incorporating longitudinal relation.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the authors.

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