

Status of Field Crops Diversity in Dewathang and Orong Geogs, Samdrupjongkhar

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ABSTRACT

Status of on-farm diversity of field crops was assessed in Dewathang and Orong geogs under Samdrupjongkhar dzongkhag (district) by Samdrupjongkhar Initiative (SJI) to document and understand the status of field crops diversity, reasons for maintaining agro-diversity, farmers perception on emerging issues like climate change, and crop production constraints and challenges faced by the farming communities. A total of 131 households were randomly sampled and surveyed using a structured questionnaire. The change in a number of households cultivating the different field crops that comprised cereals, legumes and some underutilized crops were compared 20 years before and now to compute the percent change. Paired t-test was used to analyze the data to assess the change in on-farm agro-biodiversity. This study revealed that the overall percentage of households cultivating different field crops has reduced by 27% in the span of twenty years. Paired t-test analysis of the data shows that there is a significant change ($P < 0.01$) in the number of households cultivating different or field crops 20 years before and now. Three critical reasons assigned by farmers for cultivating different crops and varieties were for food security and livelihood (53%), to meet different needs (28%) and meet religious needs (18%). Three most important challenges on the cultivation of different crops listed by respondents were farm labour shortage (26%), human-wildlife conflict (24%) and pest and disease attack (17%). Some 44% of the respondents observed that climate change has occurred over the last twenty years. This study indicates that the on farm-agro diversity plays a very critical role for food security and livelihood. To help the communities to sustainably maintain the in-situ conservation, linking on farm agro-diversity to other income generating enterprises like agro-tourism, organic production and value addition of products for income generation should be pursued. Findings from this study were used as baseline to design interventions to address community's challenges in field crops conservation, development and utilization.

Keywords: *Agro-biodiversity, On-farm, Conservation, Community, Decline, Climate change*

1. Introduction

Agro-biodiversity is a sub-set of biodiversity. It is a result of natural selection processes and the careful selection and inventive development of farmers, herders and fishers over millennia. Many

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people's food and livelihood security depend on the sustained management agro-biodiversity (FAO, 1999). Agro-biodiversity refers to interaction between agricultural management practices, farmers' resource endowments, bio-physical resources, and species (Brookfield & Stocking, 1996). Agricultural biodiversity, includes harvested crop varieties, livestock breeds, fish species and non-domesticated (wild) resources within field, forest, rangeland including tree products, wild animals hunted for food and in aquatic ecosystems ; Non-harvested species in production ecosystems that support food provision, including soil micro-biota, pollinators and other insects such as bees, butterflies, earthworms, greenflies; and non-harvested species in the wider environment that support food production ecosystems (agricultural, pastoral, forest and aquatic ecosystem) (FAO, 1999).

Agro-biodiversity can contribute to food and agriculture in several different ways. Experiences and research have revealed that agro-biodiversity among many other benefits is very vital for increasing productivity, food security, and economic returns of the farmers; helps to reduce the pressure of agriculture on fragile areas, forests and endangered species and can help make farming systems more stable, robust, and sustainable (Thrupp, 1997). Agro-biodiversity continues to serve as the source of livelihood for local communities in the different agro-ecosystems such as the drylands, high elevation areas and low-lying humid tropical areas (Abdelali-Martini, et al., 2008). In Bhutan where subsistence farming is still dominant, agro-biodiversity plays a pivotal role for meeting household food security and poverty alleviation (Katwal, et al., 2015). In the Bhutanese self-sustaining, integrated and subsistence agricultural production system, agro-biodiversity is the cornerstone for household food security and livelihood. Bhutanese farmers continue to cultivate many traditional crops and varieties and preserve their seeds using their own seed selection criteria which help in the conservation of on-farm agro-biodiversity. In Nepal, Upreti and Upreti (2002) have recorded that farmer' indigenous knowledge is one of the major factors contributing to conservation of agro-biodiversity.

Generally, Bhutanese farming system and diet is dominated by nine important cereals (*Dru-na-gu*) which are the main source of energy and nutrition (NBC, 2016). The nine different cereals or *Dru-na-gu* are also essential for religious rituals (*rimdos*) and annual religious ceremony (*loche*) that are integral part of the culture and tradition of the Bhutanese people (Lhendup, 2008).

Considering the important role of on-farm agro-biodiversity, the Samdrup Jongkhar Initiative (SJI) a local community based organization initiated the assessment of the status of field crops diversity in Dewathang and Orong geogs. The SJI operates under the umbrella of the *Lhomon* Society (LMS), a registered civil society organization that aims to promote community development in keeping with the principles of Gross National Happiness. The conservation, development and utilization of field crops was initiated in 2016 with support of the Global Environment Facility (GEF) Small Grant Project (SGP) of the UNDP. In order to establish a baseline for the GEF project, a household survey to document the status of field crops was carried out by the SJI.

The objectives of the survey was to document and understand the status of field crops diversity, challenges faced by the farming communities in crop production, and establish and use the baseline data to design relevant interventions to address challenges faced by farmers in crop production and conservation. This survey documented the status of field crops diversity, crop production issues and challenges faced by farmers. Further, some of the interventions initiated and challenges for crop rehabilitation, conservation and utilization programs are also discussed.

2. Materials and Methods

A simple random sampling was done to collect data using a structured questionnaire survey. To ensure that an individual has equal opportunity of being selected for the interview from the target population we decided the sample size using standard deviation(σ), margin of error (E) and confidence level with known population ($N= [(z_{\alpha/2})^2 * \sigma^2] / E^2$). There are six villages with 310 households. From total households the standard deviation was 29.2. Thus, at confidence level of 95%, we sampled 131 household. Based on the objective of the study, a structured questionnaire was prepared and field tested at Gayzor village. Primary data was collected through personal interview with the farmers of different villages using structured questionnaire. Data collected through the household survey was compiled using Microsoft Excel 2013 and analyzed using SPSS (Statistical Package for the Social Sciences) version 23.

3. Results and Discussion

3.1. Demographic profile of study sites

There are 870 households in Dewathang and Orong geogs and from the total households 131 households were randomly sampled and surveyed for this study. The numbers of households surveyed in each chiwogs are presented in Table 1. Of the total 131 respondents 87 were female and 44 male.

Table 1. Number of respondents by geog and chiwogs

Geogs	Chiwogs	Number of Respondents
Dewathang	Bangtsho	13
	Martang	24
	Domphu	14
	Rekhey	23
Orong	Mencheri	17
	Philuma	40
Total		131

3.2. Status of field crops diversity in Dewathang and Orong geogs

Dewathang and Orong geogs largely fall under the dry and wet sub-tropical agro-ecology. Farmers of two geogs have grown different cereals crops since time immemorial. The major field crops cultivated in the two geogs are rice, maize, wheat, barley, buckwheat, millets, oilseeds, legumes and some underutilized crops. Farmers mostly practice subsistence farming and continue to grow different crops and varieties in their farms to meet their household food security and livelihood. The extent of cultivation of different was assessed by comparing number of households cultivating the field crops 20 years before and the percent change was estimated for each crop. The overall decline in the number of household cultivating different field crops in Dewathang and Orong geogs compared to 20 years before is 27%. The highest percentage of households who have discontinued the cultivation was for wheat and barley (Figure 1). Paired T-test analysis of the data shows that there is a significant change ($P<0.01$) in number of household cultivating different or field crops 20 years before and now (Table 2). The analysis indicates that the number of households cultivating rice, wheat, barley, buckwheat, millet, and mustard has significantly declined. The increase in the number of households cultivating the crop is only in maize but the change is not significant (Figure 1).

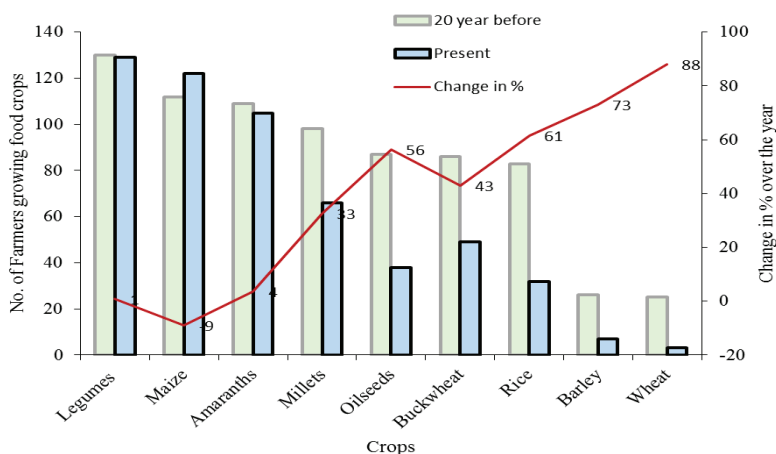


Figure 1. Different field crops cultivated and percent change in numbers of farmers cultivating 20 years before and now.

The survey found that the community of two geogs cultivates all the nine traditional crops (the *Dru-na-gu*) that are prevalent and recognized in the farming systems. The nine crops are rice, maize, wheat, barley, buckwheat, millets, legumes, mustard oilseeds and amaranth. The successful cultivation of all the nine crops is an indication of the agricultural suitability of a farming community (NBC, 2016). Amongst the field crops, maize and rice is the most popular crop cultivated by maximum number of households. Farmers cultivated different traditional

varieties and have assigned local names to the crops and varieties cultivated by them (Table 3). The main reasons for the increase in the number of households cultivating maize are attributable to maize being a staple food, its good adaptation in the dry land rain fed farming system of both the geogs, and availability of seed of good varieties promoted by the Department of Agriculture (DoA). In maize, out of six varieties currently cultivated, five are farmer's traditional varieties. This is a very good sign of farmers still maintaining their traditional varieties. However, as farmers have raised pest and disease incidence as the third important challenges for crop production (Fig. 4), traditional varieties could be vulnerable to diseases like Gray Leaf Spot (*Cercospora zea maydis*). Katwal et al., (2013) have reported that traditional maize varieties are highly susceptible to Gray Leaf Spot.

Rice is also the main staple in some chiwogs of Dewathang and Orong geogs. This study found that farmers cultivate rice under irrigated rice and upland rice ecosystem. This study showed that the household cultivating rice in the Dewathang and Orong geogs has decreased by 61 % (Fig. 2) over the past twenty years. The cultivation of upland rice referred locally as *Pangbara* is slowly declining in both the geogs. Currently there are three varieties of upland rice cultivated by farmers which are *Sambara*, *Zerbar* and *Khetsala bar* (Table 4). The reasons for decline of upland rice cultivation are attributed to legislation on the ban on slash and burn system (*Tseri*), wild animals attack and labour shortage.

Table 2. Paired t-test on the number of respondents growing major food crops before 20 years and now in Dewathang and Orong geogs, 2017

	Test	Mean	N	Std. Error Mean	P value
Rice	Before 20 years	.634 ^a	131	.0423	
	Present	.244 ^b	131	.0377	**
Maize	Before 20 years	.855 ^a	131	.0309	
	Present	.855 ^a	131	.0309	ns
Wheat	Before 20 years	.191 ^a	131	.0345	
	Present	.023 ^b	131	.0131	**
Barley	Before 20 years	.198 ^a	131	.0350	
	Present	.053 ^b	131	.0197	**
Buckwheat	Before 20 years	.656 ^a	131	.0416	
	Present	.374 ^b	131	.0424	**
Millet	Before 20 years	.748 ^a	131	.0381	
	Present	.504 ^b	131	.0439	**
Mustard	Before 20 years	.664 ^a	131	.0414	
	Present	.290 ^b	131	.0398	**
Amaranth	Before 20 years	.832 ^a	131	.0328	
	Present	.802 ^a	131	.0350	ns
Legumes	Before 20 years	.992 ^a	131	.0076	
	Present	.985 ^a	131	.0108	ns

ns = not significant **highly significant at $P < 0.01$

Wheat (Bong) is one of the components of dru-na-gu. Wheat flour is used making tormas (idols or images of local deities). Cultivation of this crop has drastically declined mainly due to lack of farm labour. The extent of barley cultivation (Phemong) has also significantly declined. According to the farmers, such decline is attributed to the change in the food consumption pattern as rice is preferred over wheat and barley. Farmers cultivate sweet and bitter buckwheat. Sweet buckwheat is called Brema or Guntshung while bitter buckwheat is called Khala. Buckwheat is consumed in the form of cooked dough (Bokpe) and noodles (Putu).

Amongst the oilseed crops, mustard (Memba) is most popular. Farmers of Dewathang and Orong geogs grow two types of mustards locally known as Memba serbu (yellow seed colour) and Memba tshalu (red seed colour). Mustard is mainly grown by the farming communities for the extraction of oil for the house hold consumptions, and is the major source of cooking oil. The primary challenge faced in mustard cultivation is the lack of suitable oil expellers.

Different types of millets are cultivated by the farmers. The finger millets are commonly called Kongpu. Millets are grown to meet the supplementary dietary requirements. It is consumed in the form of cooked dough made from its flour. It is also used for brewing local alcoholic drinks (Bangchang and Ara). Compared to other cereals, majority of the farmers continue to cultivate this crop in remote areas and marginal lands. There are two types of finger millet grown by farmers in Dewathang and Orong. They are compact and loose type. According to the respondents, these millets are less prone to damage by wild the animals and infection by pest and diseases.

Fox-tail millet (Yangra) literally means the essence of prosperity or being precious. This is because foxtail millet is ready for harvest during the lean-food season. Some varieties of this crop help address household food needs during the lean season. Farming communities of Dewathang and Orong geogs cultivate five varieties of foxtail millet, namely Khang Yangra, Danishampi Yangra, Rongshong Yangra, Yangra Changlu and Pusoktang/Busum Yangra. This study revealed that cultivation of all five varieties has declined compared to the last twenty years.

The little millet or common millet is quite a popular crop in the study site. Two varieties of little millet cultivated are Chera Balingbu and Chera Tshalu. Farmers grow little millet mainly for household consumption and according to their local belief, the little millet is considered offensive in making offerings during religious ceremony and other special events. There are two types of amaranth varieties grown by the farming communities which are Lhasomo and Sharang mo. Lhasomo are of two types, Lhasmo Tsalu and Lhasomo Balingbu (red and white varieties). Amaranth is grown in very small quantities in small patches of land by almost all the household. It is consumed in the form of roasted snacks with tea. It is also used for making local brews called Changkoey/Nagpa.

Different types of legumes and pulses are cultivated by the farming communities of Dewathang and Orong geogs. Grain legumes are mostly grown on dryland; however, it can be grown in wetland and kitchen gardens. Most farmers grow traditional varieties and maintain their own seeds. Respondents mentioned that they cultivate grain legumes for food, as source of income,

and for maintaining soil fertility. Compared to other cereals, there is also very little change in the extent of grain legume cultivation between 20 years before and now (Figure 1). Farmers continue to cultivate different 10 traditional varieties of beans which are listed in Table 4. Brokchey oray is the most common beans grown by the farmers in the locality while Ngangshing Orey is the least cultivated variety. Farmers also cultivate different types of pulses. The pulses cultivated are mostly the varieties of Vigna species which are locally known as Gagpu Changlu, Gagpu Tshalu, Gagpu Yanglu and Gagpu Singay. Additionally, farmers also grow soybean and peas in small areas. Soybean is grown to make traditional fermented soya cheese. The cultivation of different legumes by the farmers is a good practice for sustainable soil fertility management. There is also a very good scope for commercial cultivation of legumes and pulses for income generation.

Table 3. Varieties of rice, maize, millets and amaranth cultivated at the study site

Crops								
Rice	Maize	Wheat &Barley	Foxtail Millet	Little Millet	Buckwhea t	Oilseed	Amaranth	
Pang	Yangtsep	Bong	Khang	Chera	Brema/Gu	Memba	Lhasamo	
Bara	a Ashom		Yangra	Balingbu	ntshung	Serbu		
Sam	Betpai	Phemong	Dani	Chera	Khalla	Memba	Sharang	
Bara	Ashom		Shampi	Tshalu		Tshalu	Mo	
			Yangra					
Zerbara	Barma		Rongshong				Lhasa Mo	
Var.	Ashom		Yangra				Tshalu	
Khetshal	Baipo		Yangra				Lhasamo	
a Bara	Ashom		Changlu				Balingbu	
Bhur	Zetpo		Pusoktang					
Kamja	Ashom		Yangra/Bu					
			sung					
Khangm	Baipo-							
a Maap	zetpo							
	Ashom							

Table 4.Types and traditional varieties beans cultivated in Dewathang and Orong geogs.

Type	Name of Local Variety of Beans
Climber	1. Brok`chey oray
	2. Ngangshing oray
	3. Martshala oray
	4. Pengkulung oray
	5. Wangchelingpa oray
	6. Pheshanpu oray
	7. Ney-nga oray
	8. Jog oray
Dwarf	1. Choktor oray
	2. Brokchey oray

Other less popular or underutilized crop cultivated by the communities included Perilla (*Perilla frutescens*) or locally known as known as Nam. Unlike other crops, Nam is adapted to various elevation and climatic conditions. It is used as ingredient to prepare traditional Bhutanese tea and Ezey (Pickle). There are two types of Perilla, namely Nam balungbin (white Perilla) and Nam changlu (black perilla).

3.3. Seed flow pathways at the study sites

The farming communities of the two geogs continue to depend on formal and informal seed systems. The seed flow diagram (Figure 2) indicates that seed exchanges occur within and outside the communities. The informal seed system continues to play a critical role in perpetuating on-farm diversity but the management of informal seed system is left to the farmers alone. To preserve the seed and facilitate the seed exchange of traditional crops and varieties, SJI has started a Community Seed Bank (CSB) in Dewathang geog.

The implementation of Plant Genetic Resources for Food and Agriculture (PGFRA) emphasizes the need to strengthen the local seed supply system and germplasms currently available in the national gene bank or in the community seed banks (NBC, 2012). Farmers report Dzongkhag Agriculture office as one of the main source of new seeds.

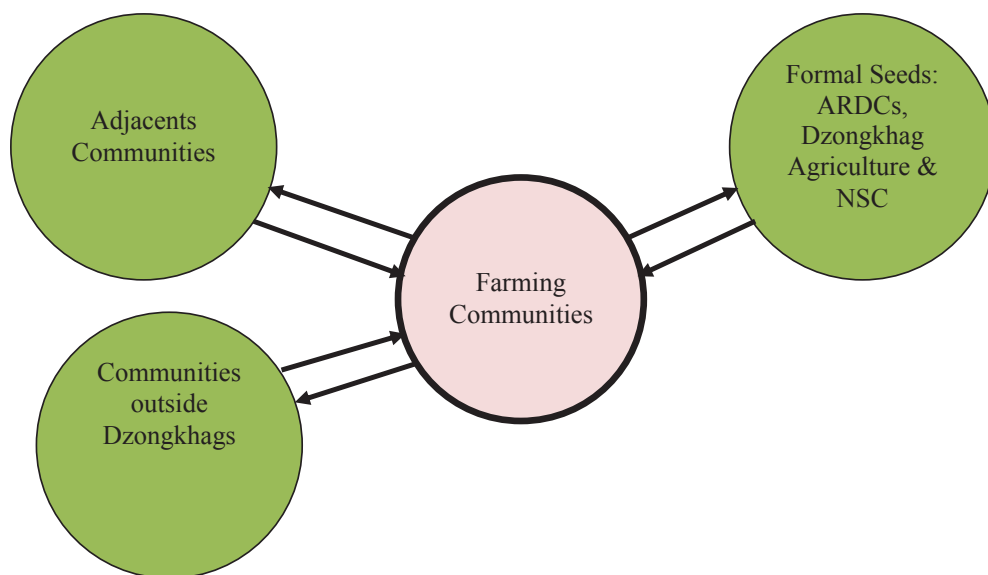


Figure 2. Seed flow diagram prepared by respondents

3.4. Reason for cultivating different crops

Majority of the respondents agree that they cultivate different crops for food security and livelihood. Three critical reasons assigned by farmers for cultivating different crops and varieties are for food security and livelihood (53%), to meet different needs (28%) and meet religious needs (18%). A similar study that assessed the farmers reason for maintain on-farm agro-biodiversity in Bhutan found that an overwhelming 93% of the respondents manage and use agro-biodiversity for household food security and livelihood (Katwal et al, 2015). Many resource-poor farmers in Nepal and Vietnam adapted crop varieties to serve as the main resource to meet their needs and secure livelihood (Sthapit, Rana, Eyzaguirre & Jarvis, 2008) Farmers cultivate different field crops as one of the coping strategies against crop failures through on-farm crop diversity, and to meet their religious and cultural needs (Figure 3).

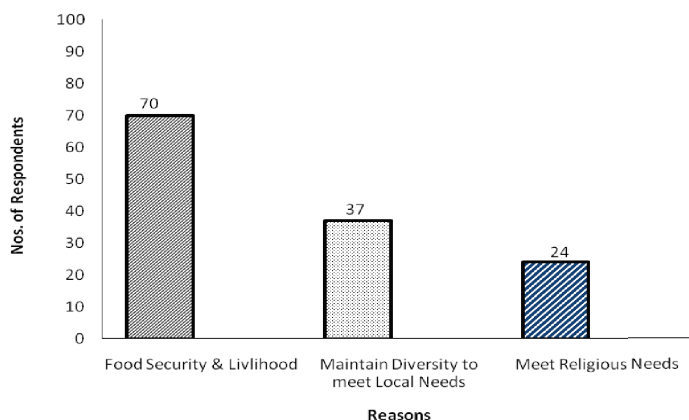


Figure 3.Reasons for cultivating different field crops

3.5. Challenges faced by Farmers in Cultivation and Conservation the Field Crops

Farmers listed numerous challenges they faced in crop production. The three most important challenges listed by respondents are farm labour shortage (26%), human wildlife conflict (24%) and pest and disease attack (17%). Crop damage caused by wildlife is seen as serious threats to livelihood and crop diversity loss, as communities tend to give up crop cultivation in wildlife prone areas (NBC, 2014). Introduction of new seeds is seen as the least important challenges faced in field crops cultivation and conservation in Dewathang and Orong. This study is in-line with the finding of Katwal et al (2015) that the threat of displacement of the traditional crops and varieties by introduction of new seeds is very minimum. However, NBC (2012) reported that displacement of land races by new and genetically uniform cultivars has been recorded as a major threat for PGFRA in Bhutan.

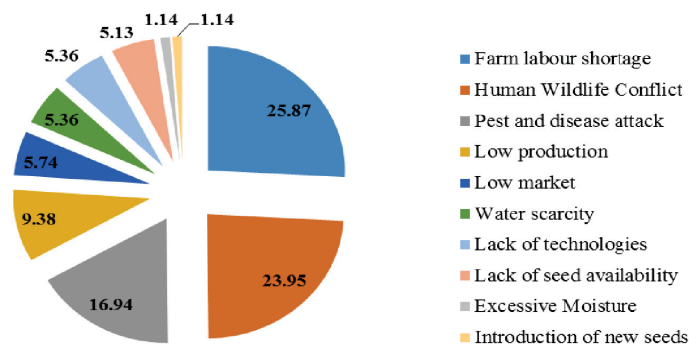


Figure 4.Different challenges listed by respondents for field crops cultivation and conservation

3.6. Farmers perception on local climate

Farmers consider rainfall as the most important weather parameter which affects their livelihood. About 44% of the respondents felt that there was high variation in the rainfall pattern while 41% felt that there was no change in the rainfall pattern. Remaining 19% observed changes in rainfall pattern (Figure 5). In general farmers' understanding and awareness on climate change is poor. A survey done in 2010 to document the impact of climate change on biodiversity reported that community's understanding on impacts of climate change and preparedness on any potential impacts is poor (MoAF, 2011).

Majority of farmers in the two geogs have dryland based rainfed cropping system and depend on rainfall for production of crops and hence timely rainfall is very critical. Majority of the respondents (83%) reported that they have not observed significant changes in the sowing and harvesting pattern of the field crops. Adjusting sowing time in relation to the changes in rainfall pattern could be a good adaptation strategy for farmers to cope against the observed variation in rainfall pattern.

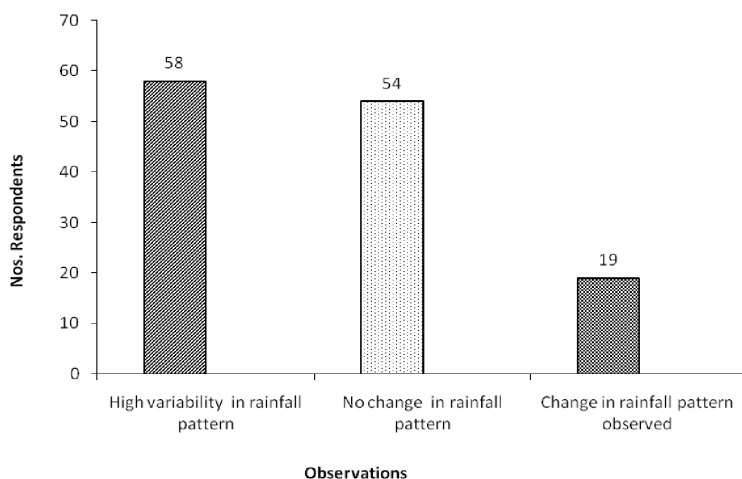


Figure 5. Farmers Perception on rainfall pattern

4. Conclusion and Recommendations

This study has established that farmers in the two geogs continue to depend on agro-biodiversity for food security and livelihood. Farmers still cultivate different cereals, pulses and some underutilized species like amaranth and perilla. Farmers produce, maintain and exchange seeds within and outside their geogs. They continue to cultivate many traditional crop varieties and the rate of displacement by other new crops and seed is very minimum. Apart from maize, legumes

and underutilized crops like amaranth, the percentage of households cultivating different crops is significantly declining. Growing different crops and varieties that can adapt well under marginal environment continues to be the only sustainable coping strategy of farmers against potential risks of crop failures. It is apparent that farmer's awareness and understanding on the potential impacts of climate change on agriculture is very poor.

There are many challenges for the sustainable of *in-situ* conservation of field crops in the two geogs. Making *in-situ conservation* programs more sustainable, remunerative and attractive to the communities is challenging. Low yield of traditional crops and varieties makes them vulnerable to crop displacement by other improved varieties and commercial crops. Managing pest and diseases in a sustainable manner without the use of agro-chemicals and increasing shortage of farm labour needs to be addressed to ensure the continuity of current on-farm agro-biodiversity. Crop damage by wild animals and birds is forcing farmers to leave their land uncultivated. Limited understanding of the communities on the long-term value of on-farm agro-biodiversity and inability to link agro-biodiversity to other important remunerative enterprises like agro-tourism and organic farming are urgent issues that have to be addressed. Mainstreaming CSO lead initiatives on agro-biodiversity with government agencies for recognition and support is currently weak.

The SJI has initiated work on rehabilitation of traditional crops and varieties from 2012 with the support of GEF SGP project, and is closely working with Agriculture Research and Development Center (RDC), Wengkharr through six lead farmers in Dewathang geog with the support of International Fund for Agriculture Development (IFAD) project. Some of the potential interventions to enhance the conservation, development and utilization of on-farm agro-biodiversity are through value addition and marketing of traditional crops and their products for income generation. There is a need to focus on product development, diversification, and marketing of local produce to sustain farmer's livelihood through income generation. There is an urgent need to explore and promote labour saving devices to address the needs of small subsistence farmers and women farmers in particular – who are the actual custodians of seed. Sustainable on-farm agro-biodiversity conservation initiatives will require designing women and youth-focused enterprises. Linking of agro-biodiversity to other important rural enterprises such as agro-tourism, organic seed production and production of organic fertilizers has good potential for long-term sustainable on-farm conservation of field crops.

Participatory and voluntary approaches for the conservation, development, and utilization of agro-biodiversity and its benefits through a long term community visioning and participation has to be initiated. Further, mainstreaming of community-based agro-biodiversity programs initiated by CSOs like SJI with the National Bio-diversity Center, Dzongkhag Agriculture Sector and Research and Development Centers will lead to more sustainable *in-situ* conservation.

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