Climate Resilient Livelihoods in Dagana Dzongkhag: An Action research on Promotion of Change Resilient Livelihood Options

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Abstract

Climate change impacts on rural farming system and adaptation practices have not been formally studied and thus the adaptive capacity of rural community remained poorly understood in Bhutan. The action research on climate change and adaptation was carried out in four *gewogs*: Goshi, Kana, Geserling, and Khebisa of Dagana Dzongkhag with the objective to help build adaptive capacity and resilience of the communities through capacity building and awareness trainings. This study assessed changes in adaptive capacity and resilience of the farming communities after adaptation interventions by comparing baseline and end line survey data. A total of 210 respondents were randomly selected from the households surveyed during the baseline study conducted in the four *gewogs* in 2014. Household surveys, focus group discussions, key informant interviews, field observations, *gewog* level and household level indicators were used for the final evaluation. The study found that the interventions had improved communities' farming practices and adaptive capacity, thereby scaling up resilience. Five indicators at the *gewog* level: planning; rule of law; water management; biodiversity; and environment improved, although not significantly, in almost all four *gewogs*. Similarly, household indicators such as energy and livestock (t (210) = -4.429, p =.000) and health and sanitation (t (210) = - 5.005, p =.000) showed significant improvement after the interventions.[1]The rate of improvement over household indicators differed significantly (p = .004) between the four *gewogs*. Post intervention saw increased households availing credit opportunities and engaging in off-farm activities all geared towards climate resilient livelihoods practices.

Keywords: Adaptation, adaptive capacity, livelihoods, resilience, vulnerability

Introduction

Bhutan, a small country counted among the LDCs, is located in a fragile ecological zone in the Himalayas. This leaves Bhutan highly vulnerable to the effects of climate change. Climate change threatens Bhutan's biodiversity and increases the likelihood of natural hazards such as glacier lake outburst floods (GLOFs), flash floods, droughts, and forest fires (Wangdi *et al.,* 2013; Alam & Tshering, 2004). The rapid melting of Bhutan's Himalayan glaciers affects key development sectors such as hydropower, agriculture, tourism, and forestry at large (Ahmed & Suphachalasai, 2014).

Climate researchers have reported that climate change is causing negative impacts on farming systems, visibly or invisibly, that are likely to be exacerbated in the near future (Habibur & Alam, 2016). In Bhutan, subsistence farmers are directly affected by temperature changes and monsoon patterns that are less predictable as a result of climate change. This is because they depend on agriculture and forestry, both sensitive to increasing temperature and water availability (Alam & Tshering, 2004; Davies *et al.,* 2008).

The most probable impacts of climate change are due to rising temperature, erratic rainfall, flooding, wind storms, and inadequate water for irrigation that negatively affects rural farming system in Bhutan (Alam & Tshering, 2004; Ning *et al.,* 2013). Moreover, a majority of our farmers are poor and illiterate and do not have the capacity to cope with the impacts of climate change (Namgyal, 2003; Meenawat &.Sovacool, 2010). Neil *et al.* (2003) stated that understanding of processes that shape farmers' adaptation to climate change is critical to identifying vulnerable entities and to develop well targeted adaptation policies. However, climate change impacts on rural farming system and adaptation practices have not been formally studied, and thus, the adaptive capacity of rural community remained poorly understood in Bhutan. Given our poor knowledge of the interplay

between the impacts of climate change and rural farming system and the imminent threats to rural livelihoods arising from changing climate, an action research to improve adaptive capacity and resilience of farming communities in Bhutan is not only timely, but also necessary.

In this study, based on the action research on climate resilient livelihood option undertaken in four *gewogs* of Dagana Dzongkhag: Goshi, Kana, Khebisa, and Geserling, we present first-hand information on the adaptive capacity of these farming communities, as effect of adaptation interventions, which would help to outline future adaptation efforts for rural communities in Bhutan.

Materials and Method

Study area

The study was conducted in four *gewogs* of Dagana Dzongkhag: Goshi, Kana, Khebisa, and Geserling. Each *gewog* was comprised of five *chiwogs*. There were a total of 20 *chiwogs* in the study area.

Sample size

Sample size was calculated based on the sample size calculator with 10% confidence from each *chiwog* of the *gewog*. The households in each *chiwog* were randomly selected to represent 50-60 respondents from each *gewog*.

Data collection and analysis

Focus group discussion and household interviews were conducted using semi structured questionnaires. The *gewog* level indicators and household level indicators were used to assess the performance of each household or *gewog* in terms of adaptation strategies towards building climate resilience. An adaptive capacity of a household, for instance, was assessed based on five broad parameters namely greenery and trees; energy and livestock management; health and sanitation; water management; and agriculture and food security. The status of each parameter was assessed in regular intervals using the indicators. Similarly, *gewog* level indicators were used to assess the extent and quality of institutional processes and mechanisms for addressing various climate-related risks and hazards in each *gewog*. Each *gewog* was assessed in eight thematic areas, using indicators which were mostly quantitative variables. Each indicator had a maximum score of 4 and was scored as 0, 2, 3, 4, corresponding to its achievement level against the set criterion of 'perfect', 'nearly', 'more than 50%' or 'less than 50%'. Each theme had a maximum score of 16, meaning that a *gewog* can be assessed at regular intervals to see how its climate related risks management performance is changing against each indicator.

Microsoft Excel was used to calculate the scores of the indicators and radar charts were made to represent the performance of each parameter in different households and *gewogs*. Paired Sample *t* test and an Analysis of Variance (ANOVA) were conducted to compare the performance between different the *gewogs*.

Results and Discussion

Profile of Respondents

It was found that 52.85% of respondents (*n* = 111) were male, whereas 47.14% of respondents (*n*=99) were female (Table 1). The age range for active farm workers was between 21 to 68 years old. Only 25% of the respondents reported as literate. The 19% of the respondents (*n* = 39), at the time of the study, were a member of Farmer Self Help Group in the community. The majority (57%) of the respondents (*n* = 92) had a farming experience of 20-30 years.

Respondents' Perception on Climate Change and its Impacts

Of the surveyed respondents, 95% (*n* = 199) stated that the climate is changing, describing what they believe to be signs of climate change, such as erratic rainfall, thunder storms, rise in temperature, and changes of weather patterns. Furthermore, 75% of the respondents (*n* = 157) were aware of the causes of climate change and its impacts. This result can be partly attributed to adaptation interventions provided to them. A

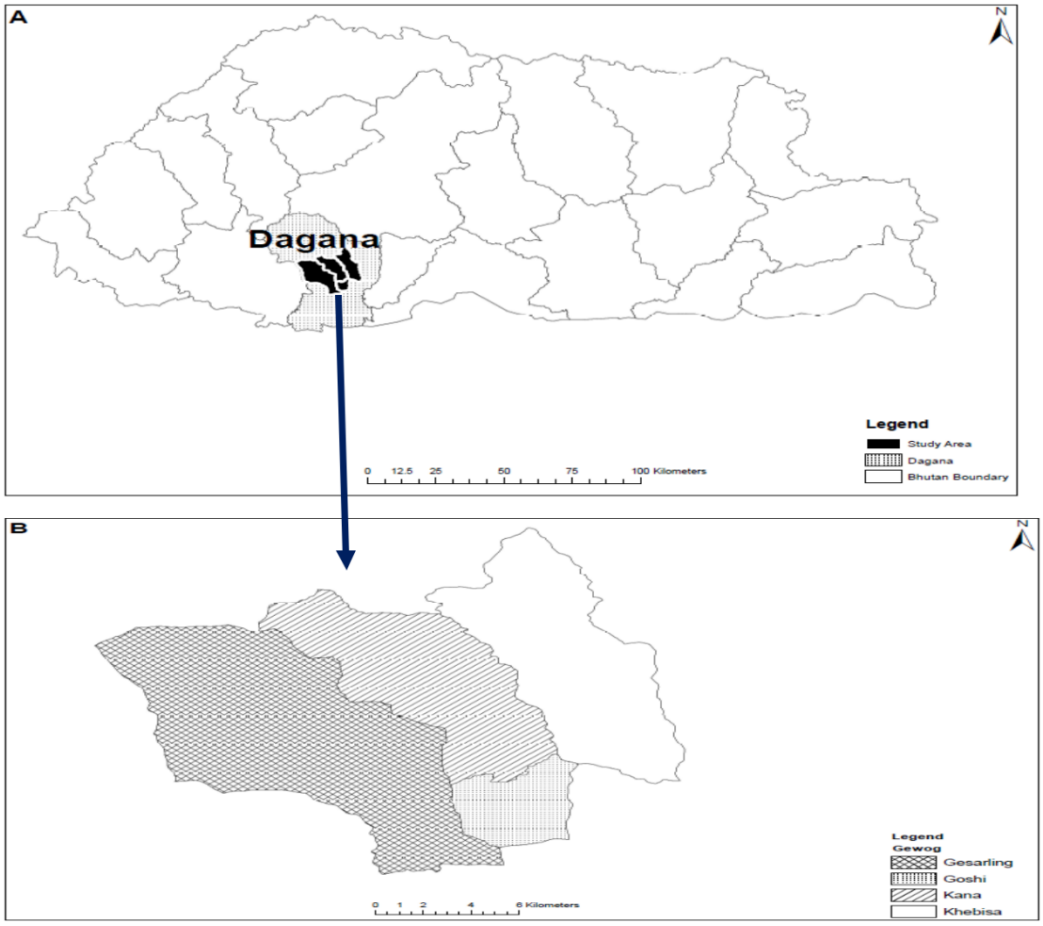

Figure 1. A) Location of Dagana Dzongkhag and study site B) Four *gewogs* of the study site

majority (71%) of the respondents (n = 149) felt that water/streams/spring are decreasing yearly due to rise in temperature and erratic rainfall. They believed that the decreasing trend of spring water and stream has negatively affected agriculture production. More than 50% of the respondents in each *gewog* believed that the increase of pest and disease as the direct impact of climate change. People reported a high incidence of pests, such as ants in potatoes, trunk borers (in rice and wheat), fruit flies, and diseases such as citrus greening in citrus plants. Communities feel the need for adaptation measures at household levels to reduce these negative impacts.

Overall Performance on Household level Indicators

Statistical results showed significant differences between the baseline and end line scores in the areas of energy and livestock (t (210) = -4.42, p =.000), and health and sanitation (t (210) = -5.0, p =.000). This indicates the positive impact of community awareness and capacity building programs to help communities implement adaptation measures for health and hygiene and energy systems at the local level (Birkmann, 2006). More people were aware of health implication from poor sanitation and hygiene. Similarly, people were aware of the benefits of a safe and clean energy system. Safe and clean energy improves health security by emitting less smoke while also contributing to the reduction of greenhouse gases. There was a slight increase in the number of household access to LPG and biogas energy use. However, the post intervention survey found no real breakthrough in three other household parameters.

Table 1. Respondents' details

Gewog	Sample size	No. of respondents	Male	Female
Khebisa	67	54	20	34
Kana	79	50	22	28
Goshi	74	56	37	19
Geserling	62	50	32	18
Total	**282**	**210**	**111**	**99**

No significant difference was observed in greenery and trees (t (210) = 1.57, p =.117), water management; (t (210) =1.03, p =.302), and agriculture and food security (t (210) = 2.78, p =.006) (Table 2). The decline or no change in greenery and trees does not mean that there was no improvement, but instead it can be reasoned by the fact that planting trees, such as fruit trees and medicinal plants, takes considerable time to show real change (Grist, 2015).

In all four *gewogs*, water infrastructure developments are still at the planning stage, and no advancement in water management was observed at the household level. Post intervention saw improvement in agriculture and food security at the household level, although, not significantly. For example, there was no significant increase in the number of 'farmer groups' and 'trained progressive farmers' in the *gewogs*. For sustainable agriculture practices, farmers need to be trained. For instance, organic farming and sustainable land management require adequate farm knowledge and skills. Unlike the food security indicators, awareness program had made real impacts at the household level to scale up health and hygiene. Finally, livestock management and energy production significantly improved in many households across four *gewogs*.

Household level Performance between the Gewogs

Households in Khebisa Gewog performed relatively well in three household indicators: health and sanitation, livestock management, and agriculture and food security (Figure 2). There was an improvement in health and sanitation at the household level when compared to the baseline survey conducted by Chhetri in 2014 (End line: M = 16.1, SD = 2.4, Baseline: M =13.5, SD = 2.2). This result can be attributed to awareness program on safe drinking water and their practice at the household level. There was only slight improvement in energy and livestock management (End line: M =10.2, SD = 2.46, Baseline: M = 9.9, SD = 2.8) and agriculture and food security (End line: M =13.4, SD = 2.0, Baseline: M = 13.3, SD = 2.6). Indicators on greenery and trees showed a slight decline in score (End line: M = 10.77, SD = 3.5, Baseline: M = 12.3, SD = 3.3). This result can be attributed to the fact that trees and greenery take considerable time to show visible impacts. Household indicators on water management also showed a decline (End line: M = 11.8, SD = 2.56, Baseline: M = 12.6, SD = 3.1). This is because major water infrastructures such as water tanks/storage are still under construction in the *gewog*.

Table 2**.** Paired sample *t* test on the scores of household parameters

Parameter	Mean *(SD)*		*t*	*df*	*sig. (2 tailed)*
	Baseline	End line			
Greenery and trees	13.00 (3.9)	12.50 (4.01)	1.576	210	0.117
Energy and livestock	9.74 (3.24)	10.80 (3.09)	-4.429	210	0.000
Health and sanitation	15.01 (3.32)	16.07 (3.18)	-5.000	210	0.000
Water management	13.05 (3.45)	12.78 (3.01)	1.030	210	0.302
Agriculture and food security	12.40 (3.23)	11.65 (3.28)	2.780	210	0.006

SD = Standard deviation

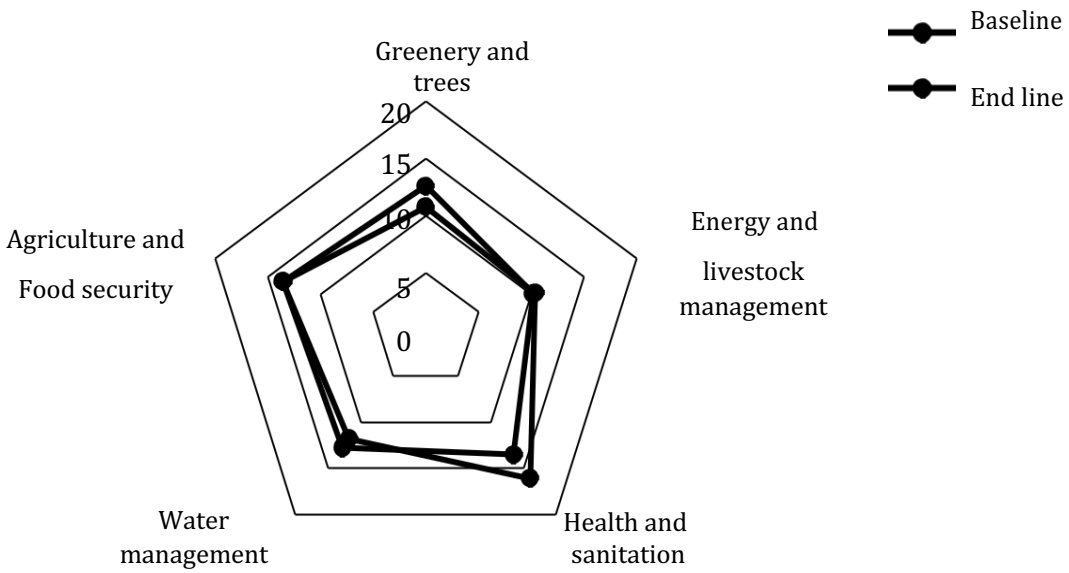

Figure 2. End line and baseline comparison of the household indicators in Khebisa Gewo

The households in Kana Gewog performed better in two indicators: energy and livestock management (End line: *M* = 10.63, *SD* = 2.5, Baseline: *M* = 9.4, *SD* = 2.9) and health and sanitation (End line: *M* = 15.3, *SD* = 2.9, Baseline: *M* = 14.9, *SD* = 2.3). The improvement in health and sanitation can be attributed to public awareness on safe drinking water and its practice at home. Many households have a toilet and separate kitchen waste dumping site. Similarly, an improvement in energy and livestock management can be attributed to increased access to safe and clean

energy systems. It was found that the number of households' access to electricity and biogas increased over the course of two years. Household indicators on greenery and trees (End line: *M* = 12.2, *SD* = 3.3, Baseline: *M* = 12.3, *SD* = 3.7) and agriculture and food security (End line: *M* = 12.02, *SD* = 2.9, Baseline: *M* = 12.3, *SD* = 3.1) showed trivial signs of improvement over the course of two years. Furthermore, there was no improvement on the water management at the household levels (End line: *M* = 12.5, *SD* = 2, Baseline: *M* = 12.8, *SD* = 2.9) (Figure 3). Many households in the *gewog* were poor in water conservation system. Few households own water tanks or practice rain water harvesting. The household level indicators of Goshi Gewog showed improvement in two parameters as shown in Figure 4: health and sanitation (End line: *M* = 17.13 *SD* = 1.6, Baseline: *M* = 16.9, *SD* = 2.6) and energy and livestock management (End line: *M* = 11.8, *SD* = 2.5, Baseline: *M* = 10.6, *SD* = 2.8). There was a drop, however, in agriculture and food security (End line: *M* = 10.35, *SD* = 3.0, Baseline: *M* = 12.2, *SD* = 2.7). Farmers of Goshi Gewog were deeply concerned about the growing irrigation water scarcity, erratic weather patterns and rampant wildlife depredations. Improvement in health and sanitation can be attributed to public awareness on safe drinking water. Many households had toilet and washrooms. An improvement in energy and livestock management can be attributed to increased access to safe and clean energy systems, such as electricity and biogas. There was a slight decline in the score for greenery and trees (End line: *M* = 13.8, *SD* = 3.9, Baseline: *M* = 13.8, *SD* = 3.9) and water management (End line: *M* = 14.0, *SD* = 2.0, Baseline: *M* =14.5, *SD* = 2.27) over the period of two years. This result can be attributed to poor access to safe drinking water and non-existence of water harvesting practices in the village. Geserling Gewog showed good performance in terms of implementing adaptation measures as shown in Figure 5. There was improvement in two parameters: energy and livestock management (End line: *M* = 10.4, *SD* = 4.2, Baseline: *M* = 8.9, *SD* = 4), and health and sanitation (End line: *M*= 15.5, *SD* = 4.7, Baseline: *M* = 14.5, *SD* = 4.5). This is reflected in improved livestock diversity. The improved health and sanitation was due to awareness programs that emphasized on promoting better health by cleaning their surroundings. Only slight improvement was seen in water management (End line: *M* = 12.6, *SD* = 4.4, Baseline: *M* = 12.0, *SD* = 4.6), reflecting the households' poor access to safe drinking water and non-existence of water harvesting practices in the village. There was a slight drop in indicators of agriculture and food security (End line: *M* = 10.9, *SD* = 4.0, Baseline: *M* = 11.6, *SD* = 4.1), and greenery and trees (End line: *M* = 13.2, *SD* = 4.6, Baseline: *M* = 13.6, *SD* = 4.7). This results indicate that there was not enough food year round. Greenery and trees, again, show limited improvement over a short span of time.

Overall Performance on the Gewog level Indicators

The indicators on water management improved in all four *gewogs* as compared to baseline as shown in Figures 6, 7, 8 and 9. The highest score on the indicator was seen in Geserling (9.3 to 14), followed by Kana (12.5 to 14), Goshi (8.5 to 13), and Khebisa (11.5 to 13). These results indicates that the respective *gewog* administrations have formulated plans, or have started implementing the existing plans for rural water project (both irrigation and safe drinking water supply) based on the recommendations of the baseline study. Similarly, indicators on biodiversity and environment showed improvements in three *gewogs*. The highest score on biodiversity was found in Kana (11.5 to 15), followed by Khebisa (12 to 14) and Geserling (11.6 to 13) (Figures 7, Figure 6 and Figure 9, respectively). Environmental indicators showed good progress in Geserling (8 to 12), Khebisa (9.5 to 12), and Kana (11 to 12). These results support the present scenarios of those *gewogs* which are on the processing of establishing community forest. Rich environment supports diverse species for vibrant local ecosystems, which in turn help enhancing nature's capacity to buffer the impacts of climate change. However, both the indicators on biodiversity (10) and environment (10.5 to 10) showed no significant improvements in Goshi (Figure 8). This result indicates that Goshi Gewog lacked strategic planning for environment and biodiversity. The gewog indicators on rule of law and planning showed improvement across all

four *gewogs* (Figures 6, 7, 8, & 9). The highest score on the indicator of rule of law was found in Goshi (14), followed by Kana (13), Khebisa (12), and Geserling (12).

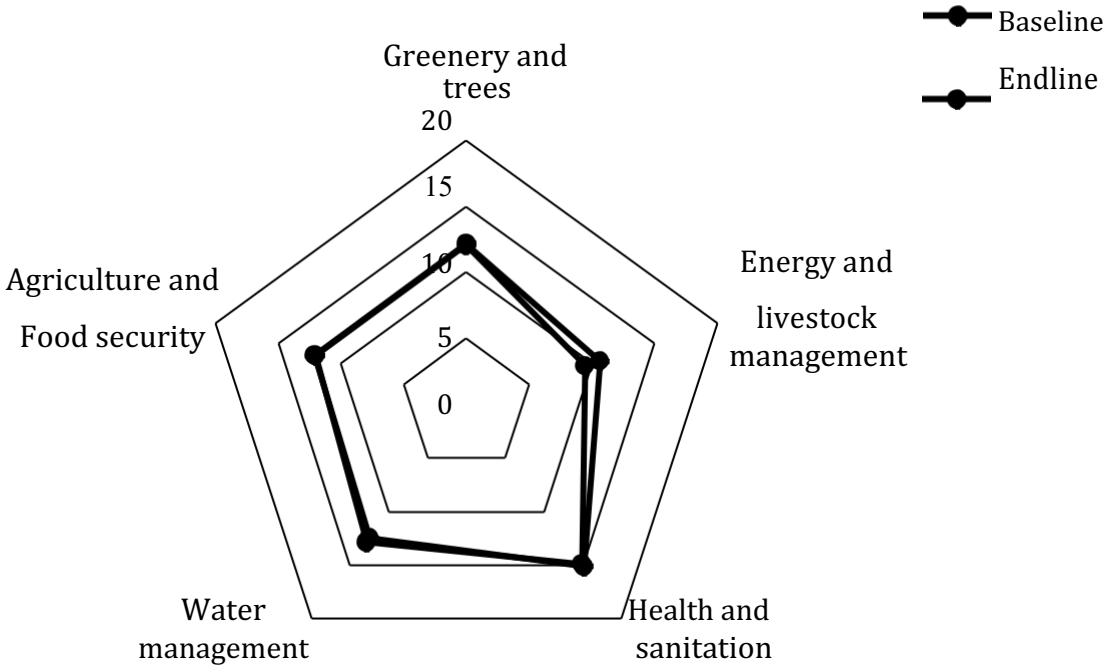

Figure 3. End line and baseline comparison of the household indicators in Kana Gewog

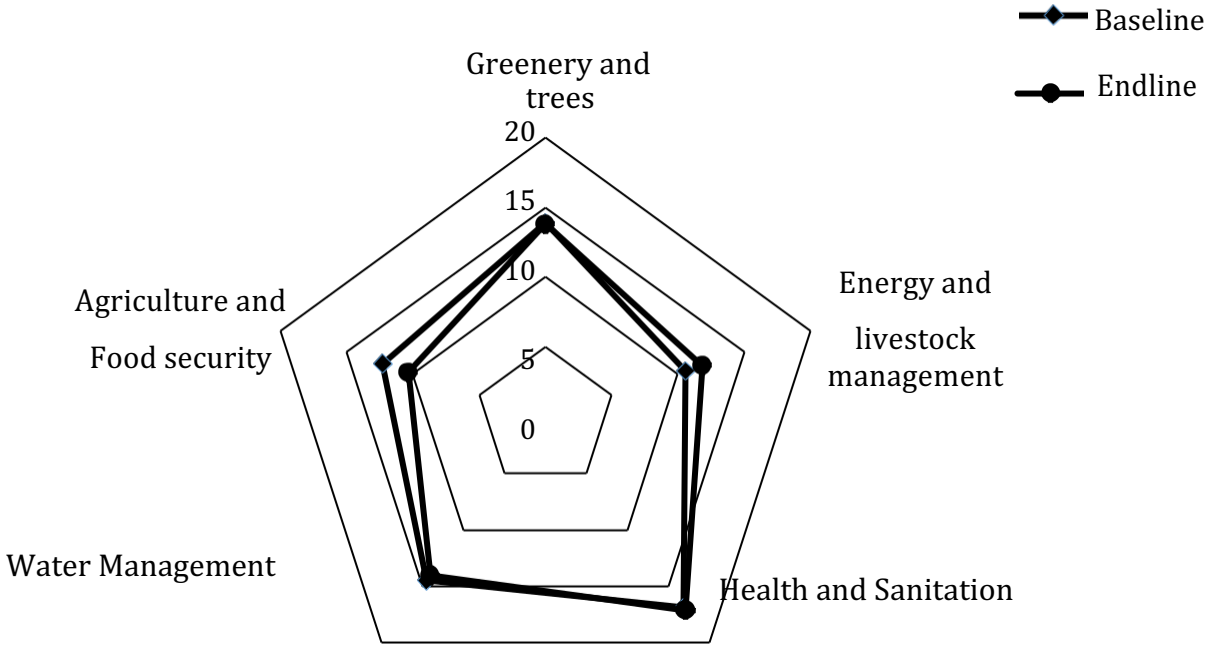

Figure 4. End line and baseline comparison of the household indicators in Goshi Gewog

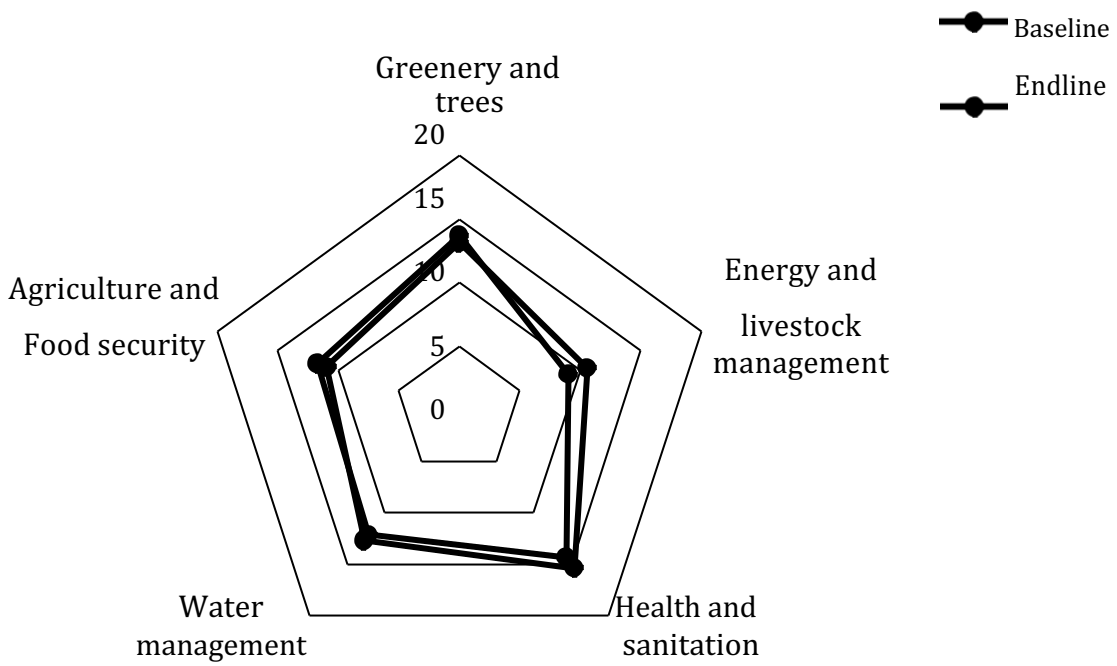

Figure 5. End line and baseline comparison of the household indicators in Geserling Gewog

Three *gewogs*, Goshi, Kana, and Geserling had the same score (16) on indicator of planning. Khebisa scored (15) on the same indicator. This result indicates that the *gewogs* have been successful in up-holding the rule of law. As previously mentioned, the rule of law improves livelihoods security by promoting a disciplined community that minimizes human induced hazards at the community level (Jacobs *et al.,* 2015). There was no significant difference in the score of the indicators between the *gewogs*. Improvement on these indicators can be attributed to the impact of capacity building programs offered by the intervening group on community planning to *gewog* administrators.

Gewog indicators on agriculture showed good progress in Goshi (10 to 13) and Geserling (13.6 to 15), whereas Khebisa showed a slight decline (15 to 14); Kana showed no change (14) (Figure 8, Figure 7, Figure 9 & Figure 6, respectively). After the intervention, agriculture extension services and farming practices have seen improvements in many *gewogs*, however, the number of 'farmer's groups' and 'trained farmers' has remained the same. Nonetheless, *gewog* administrators support the idea of going organic and increasing food production to enhance livelihood security.

Gewog indicators on energy showed a slight decline in three *gewogs*; Khebisa (9 to 8), Kana (11.5 to 11), and Goshi (9.5 to 9) (Figure 6, Figure 7 and Figure 8). This was despite the fact that many *gewogs* make use of improved stove, which improve health security by less smoke intake, and none supported traditional energy use methods. Geserling, however, showed improvement (6 to 8) (Figure 9).

Gewog indicators on disaster risk management showed a slight drop in Goshi (9 to 8) and Geserling (6.3 to 6) (Figure 8 and 9). This result validates the lack of disaster focal person and disaster management committee in those two *gewogs*. The result also contradicts MoAF's report (2015) which says that the Department of Disaster Management

of Ministry of Home and Culture Affairs (MoHCA) is spearheading the National Risk Management Framework in preparing communities to avoid disasters in every *gewog*. However, Kana (7 to 12) and Khebisa (7.5 to 11) showed improvement. Some *gewogs* have failed to identify disaster prone areas and there were no proper rules or norms for building construction in these *gewogs*. Disaster risk management is crucial for livelihood security. It safeguards communities from environmental and climatic hazards created by climate change. This year, Bhutan experienced torrential floods in its southern *dzongkhags* which claimed many properties and even a few lives. The monsoon flash floods and landslides wrecked public infrastructures, such as roads and bridges, across the country (Kuensel, 2016). The disaster is a reminder to all Bhutanese that more work remains to be done in terms of bolstering the nation's preparedness to tackle disasters of bigger scales.

Out of eight, seven *gewog* indicators showed improvements, although not significantly. Statistical tests showed that there was a significant difference between the mean of the total score of baseline *gewog* indicators (M = 85.62, SE = 5.86) and end line (M = 98.75, SE = 6.02); t (4) = -7.26, p = .005). This result suggests that the community-based awareness program and capacity building were effective in improving the adaptive capacity of the people in general. And it confirms the postulation of Jacobs *et al.* (2015) who asserted that the capacity building is the key element to enhance adaptive capacity of farming communities.

Gewog Wise Performance on the Indicators

There was no significant difference (p >.05) in indicator scores between the *gewogs*. This indicates that each *gewog* is performing equally well in terms of setting future plans, implementing existing plans, and programs for improving the adaptive capacity of the community.

Off-farm Activity

The number of households owning off-farm equipment increased after the intervention. There was a slight increase in income from off-farm activities. However, there was no significant difference (p >.05) in the number of households engaged in off-farm activity before and after the interventions (Table 3). Respondents said that many households from Kana and Goshi Gewog were engaged in Daga Chhu Hydro Project for last three years. Off-farm income generation helps to compensate for poor agriculture harvests, minimizing climate related threats to food security and overall livelihood. Wangdi *et al.* (2013) recommended that small-scale industries be promoted as a means to provide off-farm income generating opportunities to supplement the community's livelihoods in the event of climate disasters (early/late rains, pest damage, frosts, hail storms or droughts) in Bhutan. Off-farm activities would serve (Synnott, (n.d) as means to promote resilience at times of devastating events induced by climate variability.

Household assets such as car, mobile phone, radio, and television had not significantly increased after the intervention in all *gewogs*. Television coverage increased to 80.47% against 76.60% at baseline. Television and mobile phone are important for information dissemination; they are crucial for rural farmers to make informed decisions. Daily weather forecasting is done by the Department of Hydro Met Services in Thimphu. The information is transmitted through local radio stations and Bhutan's national television channel to all the farmers so that they can make informed decisions for farm activities by setting ideal dates to sow or harvest particular crops. A mobile phone, for instance, can be used to acquire quick and relevant information about agri-business in terms of obtaining accurate information of commodity prices at any point of time. This is important to avert possible economic losses. Access to proper information also provides communities with an early warning system in order to react quickly and reduce negative impact during extreme climate events (Meenawat & Sovacool, 2010).

Access to Basic Facilities

The number of households with access to Community Centers (CC) increased by 42.83%, whereas access to credit facilities increased by 40.00%, which are both significant (p<.005) (Table 4). This finding can be attributed to the

government's recent effort to expand Bhutan Development Bank Limited (BDBL) branches to *gewog* levels to improve access to rural credits. A respondent from Trashithang Village under Geserling Gewog said, "now I do not have to travel to BDBL office in Dagapela, which is a day's distance from my village, to avail financial facility as I can now do it in my own *gewog*."

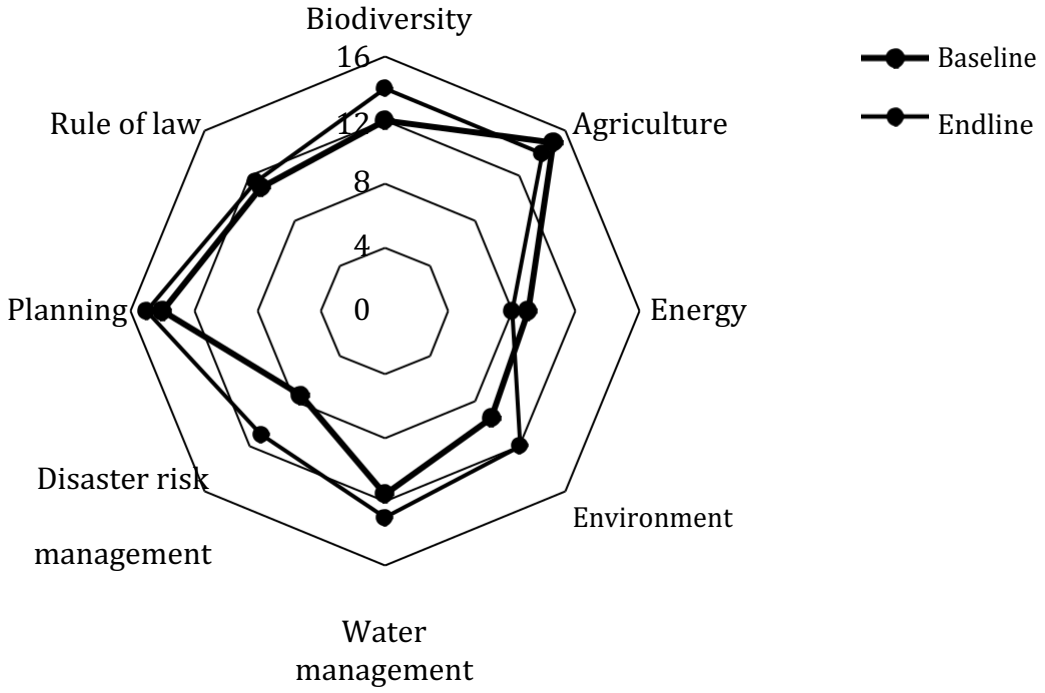

Figure 6. Comparison of the *gewog* indicators of baseline and end line in Khebisa

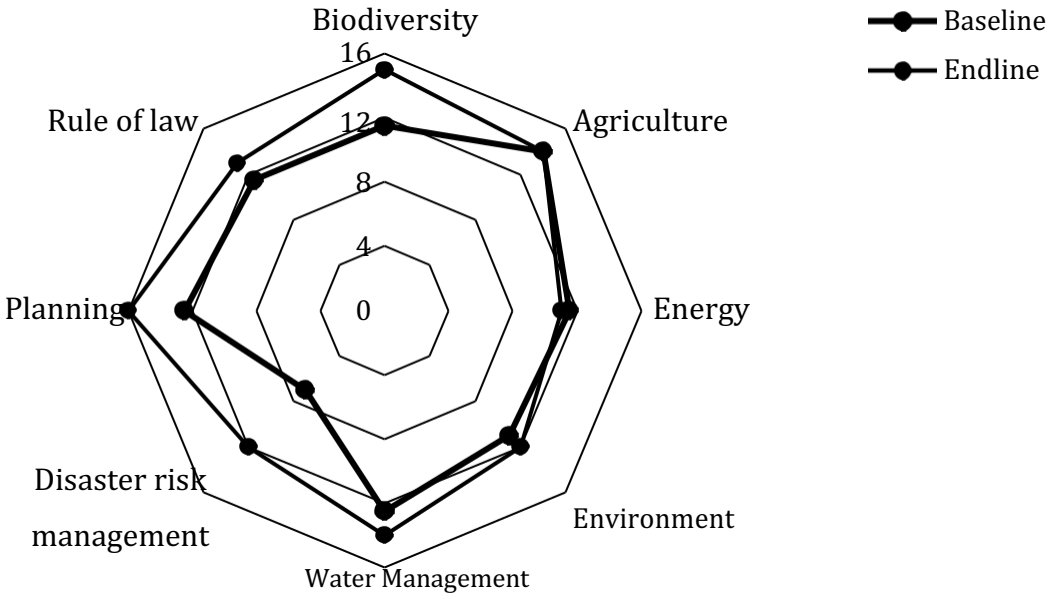

Figure 7. Comparison of the *gewog* indicators of baseline and end line in Kana

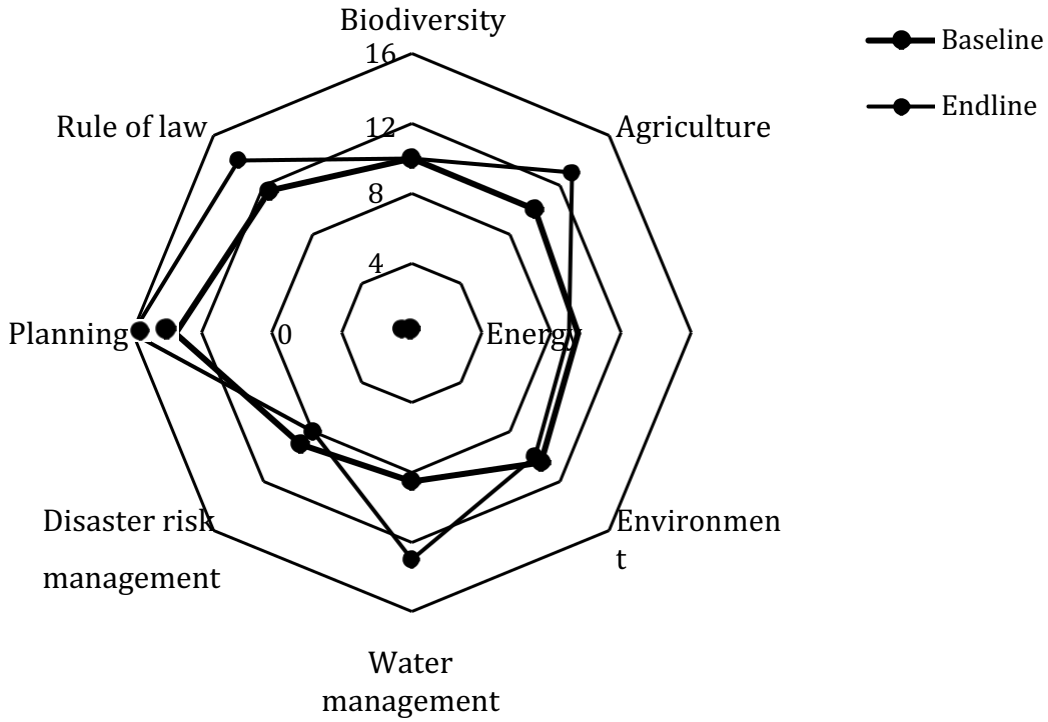

Figure 8. Comparison of the *gewog* indicators of baseline and end line in Goshi

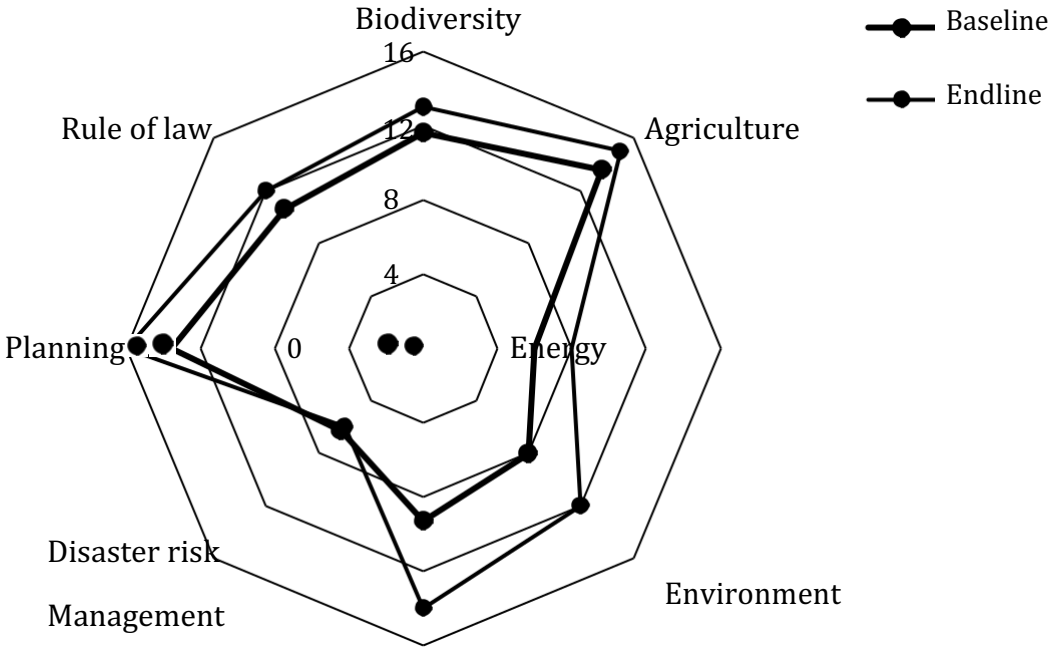

Figure 9. Comparison of the *gewog* indicators of baseline and end line in Geserling

This statement is close to what Osbahr *et al.* (2010) have suggested that for people to be climate resilient, they should have access to credit facilities for both lending and saving money. It is reported that currently, many Bhutanese farmers take loans from BDBL at a high interest rate of 10% per annum (MoAF, 2015; MoAF, 2016). In Bhutan, the concept of micro-credit is new and its scope and accessibility were limited until very recently. Bhutan lacks other rural micro credit providers such as Credit Union, Credit Cooperatives and Cooperative Banks (MoAF, 2016). Tanner (2014) stated that rural credit is crucial for rural development as it provides alternative livelihood options for farmers to withstand moments of crisis. Farmers in Bhutan avail loans mainly to invest in new agricultural technologies (power tillers, saw chain, truck etc.) or to set up a rural enterprise. This credit scheme provides one seminal means to avert food insecurity when there is lower return from the farm. Access to health facility in all four *gewogs* was found to be improving. A Basic Health Unit (BHU) was found located in a distance less than 90 minutes from individual households. This result supports the NEC (2016) report, which stated that 90% of the population had access to basic health care services in Bhutan. However, the quality of services depends on the availability of health workers and medical facilities in the BHU.

Every *gewog* has a separate RNR office to provide extension services related to agriculture, livestock, and forestry. The RNR extension services provide the country impetus to achieve self-reliance through inclusive green socio-economic development.

Livestock Management

The income generation from dairy farming increased by 9% after the intervention. This indicates improvement in livestock management among the communities. Although variation exists between different gewogs, livestock management significantly improved after the intervention.

The improvement in livestock management also means increased household income. A case study conducted on smallholder dairy farming in three Agro-Ecological Zones of Bhutan showed that smallholder dairy farming contributed to 18% of the household annual income (Bhujel & Sonam, 2014). The respondents considered rearing of dairy cattle as a source of easy income both through dairy products and live animal sales during times of financial need. However, there was no significant difference in the diversity of livestock reared before and after intervention ($p > .05$).

Agricultural production and rearing of livestock are foundational to the livelihoods for people living in rural Bhutan. It is reported that the livestock sector is an important means of improving family income, food security, and nutritional status. Dairy cattle contribute (Neuhoff *et al.,* 2014; Bhujel & Sonam, 2014) to a healthy environment by maintaining soil fertility, as the dung is utilized for the production of organic fertilizer. Respondents mentioned that dairy cattle play an important role in the production of farmyard manure for their mixed crop-livestock farming system. The study found increased use of cattle dung for biogas production. Adoption of biogas will contribute to forest conservation and human health.

Energy Management

There was significant improvement in energy management after the adaptation intervention ($p < .05$). The number of households with access to clean and safe energy systems, especially electricity, LPG, and biogas, slightly increased from the baseline. Percentage of households using LPG and biogas increased by 3% and 1.30%, respectively. While the percentage of households using kerosene or diesel fuel declined from 32% to 29%, there was no change in the percentage of

electricity use, firewood, and solar cells. The frequency of electricity and LPG use increased by 9% and 4%, respectively, although the overall number of households using electricity did not increase over the years. This indicates that farmers were aware of the benefits of using safe energy systems. Bhutan is known to have the highest fuelwood consumption in the region, perhaps in the world, with an annual per capita fuelwood consumption of a staggering 1.2 tons (NEC, 2016). Similarly, in Nepal, firewood accounts for approximately 90% of the biomass energy consumed. Firewood is not a sustainable source of

Table 3. Paired sample *t* test on the number of households engaged in non-farm

Non-farm activity	Activity mean *(SD*		*t*	*df*	*sig. (2 tailed)*
	Baseline	End line			
Government Services	14.2 (3.77)	13.30 (3.65)	1.66	3	0.194
Private employee	2.0 (2.30)	1.75 (0.50)	0.24	3	0.824
Business	6.5 (3.10)	8.50 (5.70)	-1.47	3	0.236
Contractor	6.7 (4.27)	5.80 (3.69)	-2.04	3	0.133
Power saw operator	2.2 (1.70)	8.00 (3.10)	-4.17	3	0.025

Table 4. Paired sample *t* test on the number of households' access to basic facilities

Facility	Mean (*SD*)		*t*	*df*	*sig. (2 tailed)*
	Baseline	End line			
Access to credit	35.50 (4.79)	46.00 (4.89)	-16.2	3	0.001
Access to Community Center	21.75 (15.19)	36.75 (9.35)	-4.8	3	0.017
Access to extension services	46.75 (0.50)	50.75 (2.80)	-2.8	3	0.006

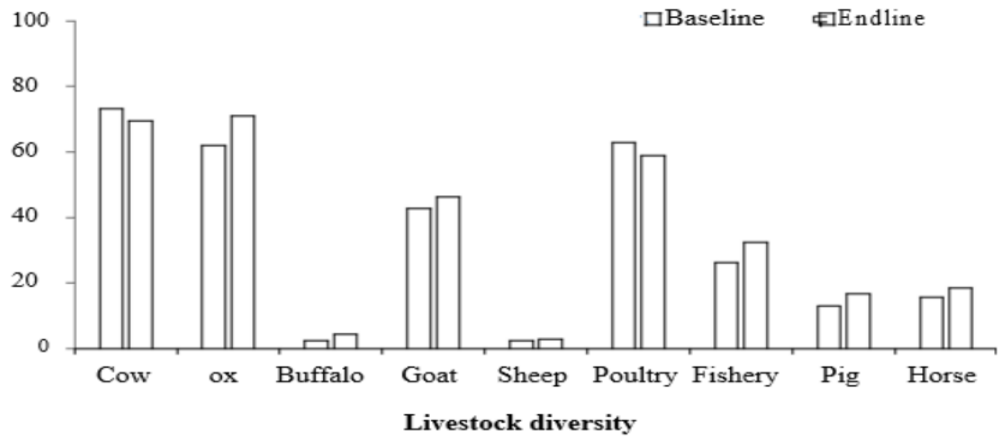

Figure 10. Livestock diversity owned by households before and after intervention

energy because once it is burned, it cannot be cycled back into the farming system. Reduction in firewood consumption can help promote agroforestry which can contribute to greenhouse gas mitigation by sequestering carbon in trees and soil. The demand for fuelwood in Bhutan, however, appears to be declining, and between 2008-2015, the total quantity of fuelwood supplied declined steadily from 109,416.6 m^3 to 67,589.74 m^3 (NEC, 2016). Integrating trees and agroforestry into farming systems helps to improve overall soil health through reducing soil erosion. Addressing the threat of climate change requires maximizing inherent energy and productivity potential by enhancing biodiversity and recycling energy.

Conclusion

The study found that community-based adaptation intervention had improved rural farming practices and heightened sustainable livelihoods. The result showed that the advocacy and behavioral changes, at the household level, have significantly improved, especially in the practice of health and sanitation, and energy and livestock management. Similarly, strengthening the capacity of the local institution has helped to mainstream adaptation strategies into *gewog* development plans and programs.

The number of households' access to Community Centers for availing basic facilities such as micro-credit, banking, and other Government to Citizens services (G2C) has increased after the intervention. The diversification of livelihoods, both within agriculture and non-agriculture was observed in most *gewogs*.

The number of households engaged in non-agricultural activities, like business, power saw operation, and carpentering had also increased in post intervention, thus, driving towards resilient livelihoods.

However, there were challenges that confront rural households in implementing adaptation strategies. The majority of farmers lack adequate knowledge on farm economics and sustainable agriculture practices. Farmer's current coping strategies at the household level need to be strengthened. Additional trainings are required in sustainable land management, organic farming, and crop diversification.

The present study provides useful information on the adaptive capacity of rural communities, as an effect set of adaptation interventions, which would help to outline future adaptation efforts. This would enable the implementation of evidence-based adaptation strategies to improve adaptive capacity and resilience of rural communities in the face of climate change. Similar studies are required in different agro-ecological zones in Bhutan to acquire a holistic understanding on the dynamics

of climate change impacts and rural farming systems. This could help to develop sound climate change policies and a long term adaptation strategy to address climate change in Bhutan.

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