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RESEARCH PAPER

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# Climate change trends, impacts and adaptation of upland farmers in La Trinidad, Benguet, Philippines

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**Abstract**

This study analyzed the climatic trends and characterized the adaptation strategies in response to climatic change impacts to crop production, water resources and household economy of upland farmers in the Valley of La Trinidad, Benguet, Philippines. A total of 106 farmers were selected by getting the 20 present of the total number of farm households from the 4 selected barangays in La Trinidad. Climatic data was also taken into account to assess if there is change in the climate. Study showed that the mean annual minimum temperature revealed a significant increasing trend at an annual rate of 0.004 ± 0.002C from 1950 to 2017 and an increase of 0.21C in the mean that occurred from 1995 to 2017. The mean annual maximum temperature also indicated an increasing annual rate of 0.01 ± 0.003C and a significant increase of 0.67C in the mean that occurred in 1977 to 2017. In terms of rainfall, no significant trends and changes were detected in both means and variances. The result signifies that climate change took place in the area. Climate change impacts are currently negatively affecting the crop production, water resources and household economy of the farmers. To cope up with the climate change impacts, various adaptations strategies were developed by the farmers based on the knowledge they acquired from their years of experiences in farming. They employed this adaptation from their own material and financial resources.

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## Introduction

Climate change refers to the changes in climate parameters mean and/or the variability of its properties that persists for an extended or long period (IPCC, 2014). It has been firmly proven, with total probability of not less than 90% that this change within the last decades has been caused by anthropogenic increase in greenhouse effect (IPCC, 2007 as cited by Asmonov, 2008). Climate change is one of the major factors affecting the world today. They become real threats to the environment and to human systems specifically agricultural production, biodiversity and health are among others (IPCC, 2007 as cited by SEARCA, 2012). Climate change impacts on the environments and societies of Asia and the Pacific are now significant. For instance, climate change is likely to increase the vulnerability of farmers who already struggle with land degradation in Asia and Pacific (ADB, 2009). The Philippines is one of the developing countries in Southeast Asia expected to suffer most of the negative impacts of climate change (Jaranilla-Sanchez *et al.*, 2007). Given its geographical location, archipelagic formation, and population distribution the country is greatly vulnerable to the impacts of climate change (UNFCC, 2009). In the Philippines, majority of the upland areas are inhabited by farming communities. With minimal outside assistance, these upland communities are prone to climate-induced risks such as landslides (soil erosion), droughts, heavy rains, typhoons (tropical cyclones) and other calamities (Jaranilla-Sanchez *et al.*, 2007).

These become more striking in the Cordillera region with the periodic occurrence of typhoons, floods, landslides and drought. The Province of Benguet is located in the southernmost part of the Cordilleran region which is a major producer of temperate vegetables of the country. Any change in climate would therefore have many implications on farming practices, social organizations and community activities (Batani *et al.*, 2013). Climate change effects are now the biggest problem of many farmers in Benguet including the municipality of La Trinidad. The municipality is one of the major producers of vegetables, strawberry and cut flowers in Benguet. Based on the report of the Office of the Municipal Agriculture (OMAG) the municipality produced about 9,896.48 MT of vegetables, 912 MT of strawberry and 4,284,550.06 MT of cut flowers in 2016.

At present, most available climate change information and climate change model projections are of geographical scales. Data for this trends are mostly available in global or country scale which are sometimes not reliable to more specific areas. Thus, it is difficult to know what aspects of the present climate scenario are likely to change or continue in a particular region (Carter & Raps, 2008). Analysis of rainfall and temperature trends will help to validate the climate change impacts being felt by the community. The effects of climate change are also affecting the different adaptation strategies being applied by the farmers in different localities. Thus, the study is conducted to analyze the climatic trends and identify its impacts in La Trinidad, Benguet, Philippines. Also, to identify the adaptation strategies being applied by the farmers in the area to cope with the impacts of climate change.

## Materials and method

### *Study Site*

The study was conducted in La Trinidad, Benguet, Philippines from December 2017 to April 2018. Specifically, in the farming communities of La Trinidad in the Province of Benguet, Philippines. It is located 256 kilometers north of Metro Manila and its geographical coordinates are 16°21" north latitude 120°35" east longitude. The valley floor elevation is at 1,330 meters above sea level. La Trinidad has 8,273.80 ha total land area with a total of 129,133 population estimate (NSO Census of Population, 2015).

### *Data Collection*

The study used time series analysis for temperature and rainfall data to determine trends and change points that will indicate the local climate change. Sample survey method was carried out complemented by various data gathering techniques to provide ample description and understanding of climate change impacts and adaptations among farmers in La

Trinidad, Benguet with respect to crop production, water resources and farm household economy.

Data on the annual average rainfalls and temperatures from the year 1950 to 2017 were obtained by the researcher from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA), Baguio City. Interview questionnaires were used to gather the data to the farm households and Key Informants on field. Focus group discussions to farmers were also done by the researcher to validate the answers provided by the previous respondents. Field observations and photo-documentation were also undertaken to support the findings.

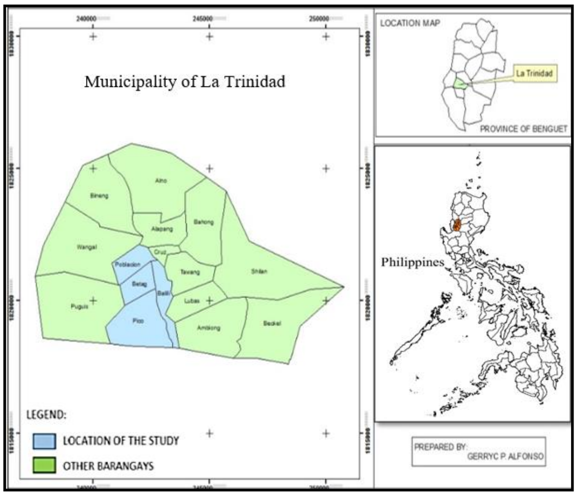



**Fig. 1.** Map showing the location of the study.

Purposive, convenience and snowball sampling was used to identify the respondents from the selected barangays. The total respondents were identified by getting the 20 percent of the total number of farm households per barangay. The study sites are as follows: Pico, Balili, Betag, and Poblacion of La Trinidad, Benguet. The selected sites were based on the criteria as follows: part of the major Valley of La Trinidad and area producing agricultural crops (vegetables and strawberry). Respondents were selected based on the following criteria: bonafide residents of the barangay, at least 45 years old and has 20 years' experience in farming based on the consideration that they are more knowledgeable and experienced in terms of change in climate and farming practices. Purposive sampling was employed to identify key informants based on the following criteria: at least 20 years of service in their offices, knowledgeable of the various programs and projects of various agencies, and at least 45 years old. In the case of local government units-barangay level, selected respondents were former or incumbent barangay officials, at least 45 years old and with farming experience. Respondents were 106 farm household heads representing the four barangays covered by the La Trinidad Valley. There were 36 respondents selected in Balili, 14 respondents in Betag and both 28 respondents in Poblacion and Pico. Nine key informants were selected from various offices, Office of Municipal Agriculture (OMAG), Municipal Environmental and Natural Resources Office (MENRO), Municipal Social Welfare and Development Office (MSWDO), La Trinidad Water District (LTWD) and the LGU's-municipal and barangay levels.

*Statistical Analysis*

Mean annual, minimum and maximum temperatures and average annual rainfall data were evaluated using descriptive statistics such as mean, standard deviation, minimum and maximum values. Trends were analyzed using five-year moving averages and simple regression. The entire time series were also subdivided into several periods and each were subjected to regression analysis. The significance of regression lines were evaluated employing F-test while detected trends were again assessed using Mann-Kendell test.

Changes were determined by comparing the means and variances in selected periods and was evaluated using t-test and F-test statistics, respectively. Significant change points for the entire time series were assessed using Pettitt's test. The results were augmented by narrative descriptions that were recalled by the respondents in terms of observed changes in climatic parameters that were generated from the farm households and key informant interviews.

Data gathered from the farm household's interviews were tabulated, classified, encoded and presented in appropriate charts.

In quantitative analysis, descriptive statistics such as mean, percentage and frequency were employed. On the other hand, qualitative analysis employed was included in the comparison of findings with theories and review of literatures, giving meanings to findings, and finally, deriving new insights from the study. The results of farm households and key-informant interviews, FGD's, field observations and analysis of secondary data were pooled and synthesized to identify and describe trends and changes in local climate and of its impacts. Also, to identify the adaptation strategies employed by the farmers to cope with the impacts of climate change.

**Results and discussion**

*Regression Analysis in Temperature and Rainfall*

Analysis showed significant regression lines for 1950-1961, 1961-1974 and 1974-2017 (Table 1). Overall, the regression for the entire time series was significant indicating an increase in the mean annual minimum temperature at a rate of 0.004 ± 0.002C per year (Fig. 2.). The results showed a significant change in the mean that occurred in 1993-2017 at 15.22C as compared to the 15.01C mean from years 1950-1993 that indicates a mean difference of 0.21C (Table 2).On the other hand, no significant change in variances were observed.

**Table 1.** Regression analysis of mean annual minimum temperature (1950-2017).

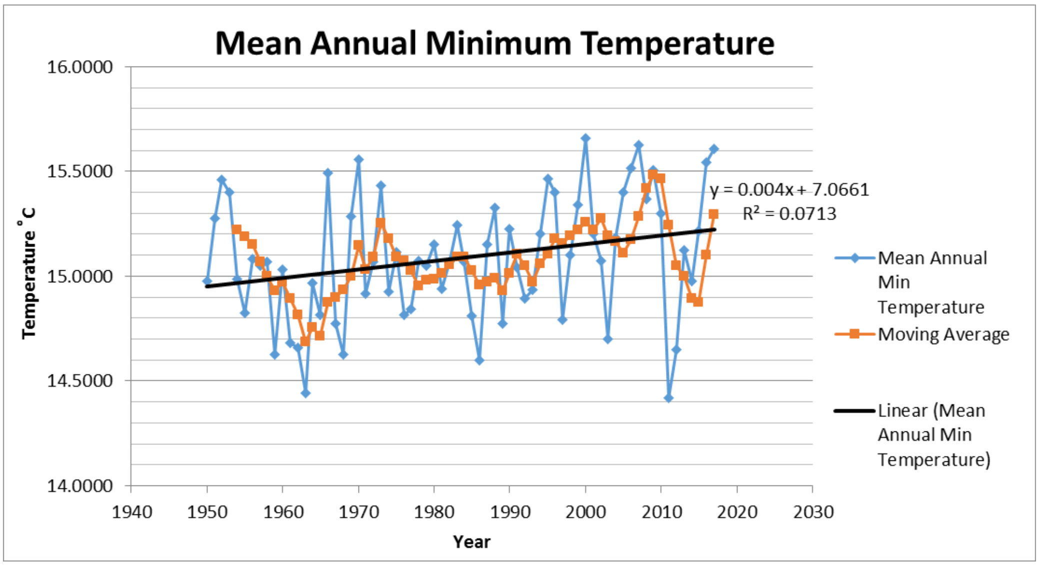
| Period | F-test for regression | Intercept ± S.E. | | Slope ± S.E. | | Trend |
|---|---|---|---|---|---|---|
| 1950-2017 | 5.06* | 7.07 | ± 3.56 | 0.004* | ± 0.002 | Increasing |
| 1950-1961 | 6.06* | 99.99* | ± 34.52 | -0.04* | ± 0.02 | Decreasing |
| 1961-1973 | 6.39* | -96.16 | ± 43.97 | 0.057* | ± 0.022 | Increasing |
| 1974-2017 | 4.97* | 0.42 | ± 6.59 | 0.007* | ± 0.003 | Increasing |

* Significant at 5% level

**Table 2.** Comparison of mean values for two selected periods from the entire series of mean annual minimum temperature (1950-2017).

| Periods | 1950 to 1993 | 1994 to 2017 |
|---|---|---|
| N | 44 | 24 |
| Mean | 15.01 | 15.22 |
| Difference | 0.211 | |
| t (Observed value) | 2.935** | |
| p-value (one-tailed) | 0.002 | |

** Significant at 1% level




Mean= 15.087 C Standard deviation= 0.300 C Minimum= 14.42 C Maximum= 15.658 C

**Fig. 2.** Five-year moving average and regression line for mean annual minimum temperature from 1950-2017

The analysis for the entire time series showed a highly significant trend at increasing rate of 0.01C ± 0.003C per year in mean annual maximum temperature (Fig. 3). Regression analyses of smaller periods (1950-1963, 1963-1972, 1972-1991 and 1991-2017) were significant. In general the smaller periods within the year 1950-2017 shows a recurring significant increasing and decreasing trends for the entire period (Table 3). The means and variances of the mean annual maximum temperature for the two selected period revealed highly significant increase from 23.23C during 1950-1976 to 23.91C during the period 1977-2017 showing a mean difference of 0.67C (Table 4).

**Table 3.** Regression analysis of mean annual maximum temperature (1950-2017)

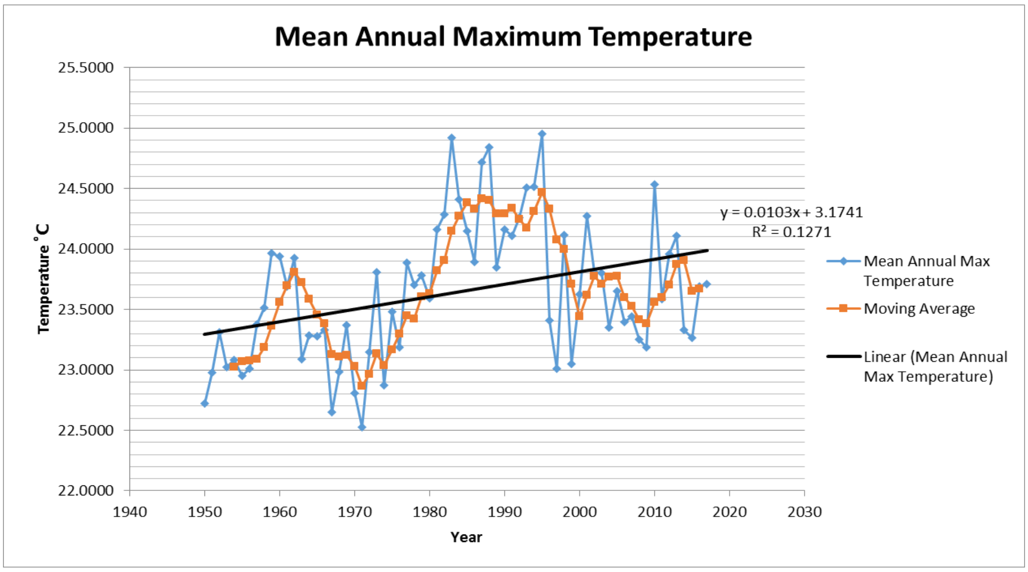
| Period | F-test for regression | Intercept ± S.E. | | Slope ± S.E. | | Trend |
|---|---|---|---|---|---|---|
| 1950-2017 | 9.61** | 3.17 | ± 6.60 | 0.01** | ± 0.003 | Increasing |
| 1950-1963 | 35.16** | -164.02** | ± 31.50 | 0.09** | ± 0.02 | Increasing |
| 1963-1972 | 8.02* | 219.54* | ± 66.16 | -0.09* | ± 0.03 | Decreasing |
| 1972-1991 | 17.42* | -116.01** | ± 33.53 | 0.07** | ± 0.02 | Increasing |
| 1991-2017 | 4.63* | 71.64** | ± 22.24 | -0.02* | ± 0.01 | Decreasing |

* Significant at 5% level **Significant at 1% level

**Table 4.** Comparison of mean values for two selected periods from the entire series of mean annual maximum temperature (1950-2017)

| Periods | 1950 to 1976 | 1977 to 2017 |
|---|---|---|
| N | 27 | 41 |
| Mean | 23.23 | 23.91 |
| Difference | 0.67 | |
| t (Observed value) | 5.796** | |
| p-value (one-tailed) | <0.0001 | |

** Significant at 1% level




Mean= 23.64 C Standard deviation= 0.572 C Minimum= 22.53 C Maximum= 24.95 C

**Fig. 3.** Five-year moving average and regression line for mean annual maximum _temperature from 1950-2017

Based on this increasing trend, by year 2020, La Trinidad mean annual minimum temperature is about 15.102C ± 0.002C while its mean annual maximum temperatures is about 23.67C ± 0.003C. This indicates that temperature in La Trinidad is significantly increasing but the computed mean annual minimum and maximum temperature in La Trinidad is lesser than the Philippine temperature projections of NCCA (2011) and Cinco *et al.* (2013) that the mean annual minimum and maximum temperature in the country will raise by 0.9 to 0.11 respectively in 2020. Based from the computed temperature from 1950 to 2017 the average mean annual minimum and maximum temperature is 15.09C and 23.34C respectively. If we add the projections of NCAA (2011) and Cinco *et al.* (2013) of 0.9 and 1.1 to the prevailing temperature of La Trinidad by year 2020, its minimum and maximum temperature will be 15.99 C to 16.19C and 24.54C to 24.74C respectively which is higher than the result of the trend analysis in the maximum and minimum temperature of La Trinidad which is 15.094C ± 0.002C to 23.67C ± 0.003C. This lower temperature is attributed to the higher elevation and mountainous location of La Trinidad Valley.

Regression analysis shows that there are no significant changes in the average annual rainfall of the entire time series. All the observed trends are insignificant. The same is true to the periods (1950-1966 and 1966-2017) where means and variances are compared. The Mann Kendall test also suggests that there are no trends in the time series. Pettit' test also suggest that no change of point have been observed from year 1950 to 2017. The result suggests that increase and decrease of mean annual rainfall within the series are not significant.

These findings substantiated the report of Villafuerte II *et al.* (2014) that the high temporal and spatial variability of rainfall in the Philippines may affect the result of rainfall trend in a specific area. In case of Tropical Cyclone, it was highlighted by PAGASA (2011) that there are no significant trends in total number of annual tropical cyclones and rainfall patterns. IPCC (2007) also projects that in the early to mid-21$^{st}$ century that there will be increase of heavy precipitations and stronger tropical cyclones.

*Changes in Local Climate as Observed and Experienced by the Respondent*

Based on the respondent's observations and experiences, majority (53.77%) of the respondents revealed that climate change occurred in the locality in the 1990's. On the other hand, many claimed (33.02%) that climate change occurred in years 2000 and above (Table 5). Table 6 shows the top 10 changes in climatic conditions and other related phenomena as observed and experienced by the respondents since 1977. Almost all (87.74%) of the respondents observed that the temperature had become warmer especially on summer months and 82.08% said that they experienced longer dry season. This observed change in temperature corroborates with the study of Batani *et al.* (2013) in Benguet that almost all of her respondents (85.2%) agreed with the said temperature change.

According to the farmer respondents, during the previous years they can work whole day on their farms but now because of increased temperature some of them cannot. Nowadays a great majority (63.21%) of the farmers in La Trinidad Valley works only from 6:00-10:00 am and continue working on 3:00 pm onwards. Few respondents (9.43%) experienced also intense heat at 9:00 in the morning until 4:00 in the afternoon.

This scenario were also being experienced in Dingle, Iloilo where farm laborers ceased to work at 10:00 am in the morning and resume at 4:00 in the afternoon Landicho *et al.* (2016). With the observations of the warming temperature in La Trinidad, the older respondents said that from 1970's to late 80's seen and experienced "amog" (ice crystals) on the grasses in the morning but as the year enter 1990's this specific phenomena were no longer observed. Moreover, unpredictable climatic weather pattern was highly observed (77.36%) by the respondents.

The other changes in climatic conditions greatly observed by the farmers are as follows: decreasing occurrences of long monsoon rain (67.92%); fewer typhoons but their intensity is stronger (64.15%); decreasing rainfall frequencies after rainy season (58.49); and early onset of summer (42.45%). On the other hand, fewer respondents observed lesser occurrences of hailstorm, unpredictable number of typhoons, decreased amount of rainfall, stronger intensity of rain, longer duration of cold season and late onset of summer.

**Table 5.** Period in time since 1977 where changes in climate were observed and experienced by farmers

| Year observed changes | Frequency | Percentage |
|---|---|---|
| 1980-1989 | 14 | 13.21 |
| 1990-1999 | 57 | 53.77 |
| 2000 and above | 35 | 33.02 |
| Total | 106 | 100 |

**Table 6.** Top 10 changes in climatic conditions observed and experienced by the respondents in La Trinidad Valley

| Observed changes in climatic conditions | Frequency | Percentage |
|---|---|---|
| 1. Temperature become warmer especially in summer months | 93 | 87.74 |
| 2. Prolonged or longer dry season | 87 | 82.08 |
| 3. Climatic/Weather pattern is no longer predictable | 82 | 77.36 |
| 4. Decreasing occurrences of long monsoon rain | 72 | 67.92 |
| 5. Fewer typhoons but their intensity is stronger | 68 | 64.15 |
| 6. Decreasing rainfall frequencies after rainy season | 62 | 58.49 |
| 7. Early onset of summer | 44 | 42.45 |
| 8. Delayed onset of rainy season including typhoons | 44 | 42.45 |
| 9. Shorter duration of rainy season | 28 | 26.42 |
| 10. Lesser occurrence of hailstorm events | 9 | 8.49 |

Of these observed changes by the respondents, some coincide with the abnormal climatic conditions observed in the Philippines due to El Niño southern oscillation (ENSO) phenomenon reported by PAGASA (1997) as cited by Laruan (Unpublished) namely; delayed onset or early termination of rainy season; weak monsoon activity and less tropical cyclone entry in the country. In addition PAGASA (2006) as cited by Philippine Institute for Development Studies (PIDS) (2007) rated magnitude of more than 1.5°C Oceanic Niño Index (ONI) value in years 1997 to 1998 indicating strong El Niño phenomena in the said years. According to PAGASA (2015), the strongest El Niño phenomena occurred in year 1997-1998 with an ONI value of 2.4 followed by years 1982-1983 with ONI value of 2.2. Also year's 1991-1992 and 2009-2010 was rated as strong both with ONI value of 1.6. These reports support the increase of temperature observed by the respondents in La Trinidad Valley especially on the 1990's. Respondent's observation such as fewer typhoons but intensity is stronger and decreasing rainfall frequency is substantiated by the report of Cruz *et al.* (2013) that the rainfall extremes indicate an increasing trend in the number of days without rain; and Cinco *et al.* (2016) also disclosed that there is no significant trend of cyclones forming in the Philippine Area of Responsibility (PAR).

*Climate Change Impacts to Crop Production, Water Resources and Farm Household Economy*

*Impacts on Crop Production*

More than half (50.94%) of respondents revealed that due to changes in climatic conditions estimated damages range from 25-50 percent of the total volume based on normal production from previous cropping years (Table 7) . On the other hand, 43 (40.57%) of the respondents said that their crop production volume were damaged by 51 to 75%. According to some respondents, damages from climate change were more observed in farm household cultivating strawberries. Despite the shorter life span of strawberries as experienced by the respondents still almost half (48.49%) cultivates strawberry as their major crops (Table 8).

**Table 7.** Estimated damage to volume of crop production due to climate change.

| Estimated damage to the volume crop production due climate change | Frequency | Percentage |
|---|---|---|
| (1) no damages | 0 | 0.00 |
| (2) less than 25% | 7 | 6.60 |
| (3) 25-50% | 54 | 50.94 |
| (4) 51-75% | 43 | 40.57 |
| (5) more than 75% | 2 | 1.89 |
| Total | 106 | 100 |

The primary impacts to crops on the observed changes in climatic conditions by the respondents are as follows: water stress problems; susceptibility to pest and diseases infestation; poor growth and development; and wilting of crops (Table 9.). All participants in the FGD mentioned various impacts of climate change to their crops that are similar to the answers of respondents in the interview. They also claimed that even using adaptations such as increasing application of fungicide and pesticide cannot not stop the intensifying pest and disease infestations in their crops.

**Table 8.** Major crop produced by farm households.

| Major crop produced by farm households | Frequency | Percentage |
|---|---|---|
| Vegetables | 44 | 41.51 |
| Strawberry | 62 | 58.49 |
| Total | 106 | 100 |

**Table 9.** Impacts of observed changes in climatic condition on crop production.

| Observed changes in climatic conditions | Primary impacts | Intermediate impacts | Concluding impacts |
|---|---|---|---|
| 1. Temperature become warmer especially in summer months<br>2. Prolonged or longer dry season<br>3. Decreasing occurrences of long monsoon rain<br>4. Decreasing rainfall frequencies after rainy season<br>5. Shorter duration of rainy season<br>6. Late onset of rainy season including typhoons | • Exposure to heat<br>• Water stress<br>• Limited water supply<br>• Faster evaporation rate of water at the soil surface and water sources<br>• Faster transpiration | • Poor growth and development of crops<br>• Stunted growth of crops<br>• Wilting of crops<br>• Plants become more susceptible to Pest and diseases infestation | • Decreased Yield<br>• Reduce quality of crops<br>• Total or partial crop failure<br>• Increased production cost<br>• Increase use of farm inputs |
| 7. Fewer typhoons but their intensity is stronger | • Exposure to intensive rain<br>• Physical damage such as cuts leading to susceptibility to pest and diseases infestation<br>• Wilting and rotting leading to susceptibility to pest and diseases infestation<br>• Disturbed growth and development | • Total or partial crop failure<br>• Reduced quality and quantity of crops<br>• Increase application of farm inputs | • Decreased yield<br>• Total or partial crop failure<br>• Increase productions cost<br>• Decreased net income |
| 8. Early onset of summer; delayed onset of rainy season<br>9. Variability of the duration and onset of rainy season, typhoon events and rainy season<br>10.Variability of temperature in a day from extreme to extreme | • Exposure to variable climatic events<br>• Exposure to hot temperature<br>• Water stress | • Disturbed growth and development<br>• Shorter life span of crops<br>• Stunted growth of crops<br>• Wilting of crops<br>• Plants become more susceptible to pest and diseases infestation | • Decreased yield<br>• Total or partial crop failure<br>• Increase productions cost<br>• Reduce quality of crops<br>• Longer period of production |

*Impacts on Water Resources*

The main source of farm irrigation used by the respondents are creeks, springs and river. Table 10 shows that majority (73.58%) of the respondent's water sources are from creeks and springs. The respondents are not dependent on rainfall to support their farming operations. As for the distance of water sources, almost all of respondent's (82.08%) water sources were located 5 to 50 meters from their farms. Diversion of water from the dammed creeks to their small irrigation canals are commonly practiced by the respondents.

According to key informants from LGU, they have projects on water impounding but are more focused in rural areas such as barangays Alno, Beckel and Bineng. On the other hand, current impounding project of the DA and LGU already started its Phase I at barangay Pico that will be continued until barangay

Betag. So far, this is one of the biggest irrigation project that was implemented in La Trinidad Valley. Further, respondents near the concrete impounding facilities mentioned that they might benefit on it but not all the farmers. This might cause commotion to farmers if the scheduling is not properly regulated.

**Table 10.** Sources and distance of water for farm use.

| Sources of water | Frequency | Percentage |
|---|---|---|
| Spring | 22 | 20.75 |
| Creek | 78 | 73.58 |
| River | 6 | 5.66 |
| Total | 100 | 100.00 |
| Distance of water sources | Frequency | Percentage |
| 5-50m | 87 | 82.08 |
| 51-100m | 5 | 4.72 |
| 101-300m | 14 | 13.21 |
| Total | 100 | 100.00 |

Moreover, all respondents agreed that climate change impact is negatively affecting the quantity and availability of water for irrigation in the Valley. Respondents perceived that the sources of water are being depleted because of the conversion of lands to built-up areas. Table 11 shows the assessment of the impacts of climate change on the quantity, quality and availability of water resources for farm use. A great majority of the respondents (59.43%) said that the quantity of water for farm irrigation decreased by 26-50 percent while few respondents (19.81% & 18.87%) assessed that it decreased by 11-25 and 51-75 percent respectively. In terms of water availability, majority of the respondent (55.66%) mentioned that water for irrigation are just enough while many (35.85%) responded that it is becoming scarce. As for the water quality, majority (54.72%) of the respondents said that the quality of the water is more or less fit for irrigation.

*Impacts to Household Income*

The impacts to crop production and water resources greatly influence the respondent's household economic conditions. All respondents experienced decline in their farm income from vegetables production though mentioned that it depends on how lucky they are to hit the fluctuating high price in the market. Furthermore, almost all (80.19%) of the respondents mentioned that farming a parcel of lot with an area of 500 square meter is insufficient to support their households needs. This explains why farmers in La Trinidad rent other private lands to cultivate for additional household income. In contrast, few respondents (19.81%) revealed that a 500 square meter of land is sufficient and allow their household to save and use this to finance their next cropping season. These problems being experienced by the farmers led them to borrow money from relatives, cooperatives, and middle men.

**Table 11.** Assessment of the impacts of climate change on the quantity, quality and availability of water resources for farm use.

| Impacts of climate change to water resources | | Frequency | Percentage |
|---|---|---|---|
| Quantity of water for farm use volume of water decreased by: | | | |
| (1) <10% | | 2 | 1.89 |
| (2) 11-25% | | 21 | 19.81 |
| (3) 26-50% | | 63 | 59.43 |
| (4) 51-75% | | 20 | 18.87 |
| (5) >75% | | 0 | 0.00 |
| | Total | 106 | 100.00 |
| Availability of water for farm use | | | |
| Scarce | | 38 | 35.85 |
| Just Enough | | 59 | 55.66 |
| Oversupply | | 9 | 8.49 |
| | Total | 106 | 100.00 |
| Quality of water | | | |
| not fit for irrigation | | 28 | 26.42 |
| more or less fit for irrigation | | 58 | 54.72 |
| fit for irrigation | | 20 | 18.87 |
| | Total | 106 | 100.00 |

Furthermore, more than half (69.81%) of the respondent pointed out that their children's education is primarily constrained when crop production is affected by climate change impacts. Respondents mentioned that children in college are the most affected, because of the expensive tuition and miscellaneous fees plus expensive school requirements. In worst case, unsuccessful farmer respondents mentioned that they no longer send their children to college because of their low net income from farming. Interestingly many (87.13%) respondents admitted that their basic needs are not affected by lower income from crop production. This is may be explained by the nearer farm areas in La Trinidad Valley to the markets and tourist areas where they easily sell their crops.

Generally, even with the low increase of temperature recorded in La Trinidad, this still have various negative impacts as observed by the farmers to their crop production, water resources and farm household economy. World Bank (2007) stated that climate change have both negative and positive impacts which contradicts with the result of study, that all respondents observed only negative impacts. The result was substantiated also by the study of Pulhin and Tapia (2016) that climate change impacts on agriculture and water sectors are more localized, cutting across provincial to municipal level and affects more farmers as compared to other climate change stressors.

*Climate Change Adaptations on Crop Production, Water Resources and Household Economy*

*Adaptation on Crop Production*

The experienced climate change impacts led the farmers to use plastic tunnels and polyethylene mulch to protect their crops (Table 12). These adaptations now allow the farmer to continue crop production during the months of June, July and August; though flooding is still a problem during typhoon events.

**Table 12.** Adaptations to cope with the impacts of observed changes climatic conditions to crop production.

| Observed changes | Adaptation | Frequency | Percentage |
|---|---|---|---|
| • Temperature become warmer especially during summer months | • Increase frequency of watering | 90 | 84.91 |
| • Prolonged or longer dry season | • Increase use of insecticides, fungicides and pesticides | 73 | 68.87 |
| • Delayed onset of rainy season | • Increase use of fertilizer | 53 | 50.00 |
| • Decreasing rainfall frequencies after rainy season | • Multiple cropping / mix cropping | 28 | 26.42 |
| | • Change crop or variety of crop | 43 | 40.57 |
| • Shorter duration of rainy season | • Use of black polyethylene mulch | 88 | 83.02 |
| • Early onset of summer; Late onset of rainy season including typhoon | • Increase frequency of watering | 90 | 84.91 |
| | • Mini greenhouse “Tunneling” | 86 | 81.13 |
| • Variability duration and onset of rainy season, typhoon events and dry season | • Use of black polyethylene mulch | 88 | 83.02 |
| | • Raised beds or plots | 6 | 5.66 |
| | • Greenhouse | 6 | 5.66 |
| • Fewer typhoons but intensity is stronger | • Mixed cropping and raised beds or plots | 3 | 3.33 |

**Table 13.** Adaptations to cope with the impacts of observed changes in climatic condition to water resources.

| Observed changes | Adaptation | Frequency | Percentage |
|---|---|---|---|
| • Temperature become warmer especially during summer months | • Deeper irrigation canals | 87 | 82.08 |
| | • Divert water from household waste water (water cycling) | 71 | 66.98 |
| • Prolonged or longer dry season | • Less frequent watering of crops | 62 | 58.49 |
| • Delayed onset of rainy season | • Secure alternative sources of water or maintain two source of water | 61 | 57.55 |
| • Decreasing rainfall frequencies after rainy season | • Observe watering schedule or sharing among neighbors | 50 | 47.17 |
| | • Reduce volume of water when watering | 25 | 23.58 |
| | • Construction of water storage facilities | 12 | 11.32 |
| • Shorter duration of rainy season | • Plant drought resistant crops or shift to other crops | 23 | 21.70 |
| | • “Wait and see” “Timing” | 7 | 6.60 |
| | • Transfer or rent other farm lots with sufficient irrigation | 6 | 5.66 |

When temperature becomes warmer and the duration of dry season becomes longer, around (84%) of the respondents cope with the impacts of climate change by increasing the frequency of watering their crops. Before, as mentioned by the respondents they can water their plants twice a week but now it became more frequent (thrice a week or every other day). Other adaptations include, as follows: use of black polyethylene mulch (88%), increasing application of fungicide, insecticide and pesticide (68.87%), increasing use of fertilizer (50%) and changing crops or variety of crops (40.57%). Change of crops or crop variety can be in terms of using hybrid or resistant varieties, short term crops, crop requiring minimal farm inputs and drought-tolerant crop varieties.

The variability of duration on the onset of rainy season, typhoon months and dry season became a problem to the farmers. Because of these climatic changes, some farmers establish their adaptation by raising the plots or beds, installation of green houses and tunnel (mini green house) during rainy season. As mentioned by the respondents, normally the plastic tunnels (mini green house) from the farms will be removed during December because they expect that no rain events may occur. However, because of the rain occurrence during December and summer some farmers maintain the use of mini green house during those months to avoid damages to the flowers and fruits of strawberries or Vegetables. Furthermore, the respondents said that strong typhoons have still great impact to their crops. Accordingly, the adaptations such as tunnel and raised plots or beds become less effective if strong typhoon strikes the Valley. Strong winds during typhoons can still destroy their tunnels and crop even grown in raised plots or beds.

**Fig. 4.** Mini Green House.

*Adaptation to Water Resources*

Almost all (66.98%) respondents divert water from creeks and springs to an interconnected irrigation canals.

The irrigation canals allow the passage of water from farm to farm which led respondents to schedule the diversion of water from sources to their own irrigation canals. Majority (82.08%) of the respondents also dig their irrigation canal deeper to accommodate more volume of water to be stored. These allow farmers to have a reserved water supply for at least two watering period equivalent to four (4) days.

The farmers mentioned that before year 2000 water coming from the springs of Barangay Pico and Puguis was enough to supply water for irrigation to Barangay Betag, but it became limited as year reaches early 2000. At present the irrigation canals that were used to divert water to Barangay Betag is being controlled already by the farmers in Barangay Pico and Puguis resulting to decreased water supply. This might be the reason why respondents from Barangay Pico said that their water for irrigation is still enough or oversupply. A great majority (66.98%) also of the respondents admitted that water coming from residential areas are being diverted to their farm to irrigation. According to the respondents, water for irrigation during rainy season is cleaner as compared to summer because during rainy season water is flowing regularly.


**Fig. 5.** Water pump used to pump water from creeks to irrigation canals.

Furthermore, Majority (58.49% and 57.55%) of the respondents respectively practiced less frequency of watering crops and securing two sources of water supply. Two sources of water allow farmers to have alternative sources whenever water is no longer accessible in their irrigation canals. These alternative water sources range from 100-500 meter distances. As a resort, farmers use portable water pumps to pump water from creeks to their irrigation canals or to directly water their crops (Fig. 5.). Almost half (47.17) of the respondents said that they observe scheduling of water with their neighbors to avoid conflict.

In addition, few (11.32%) respondents also constructed water storage facilities. The design of these depends on the available financial resources and ownership of farm lot cultivated by the farmers. Many respondents do not own the land that they cultivate, so as a result farmers cannot construct concrete or permanent water storage facility on their farm.

Some (21.70%) respondents revealed that they plant drought resistant crops or shift to other crops. Farmers plant crop species depending on how they assess their surrounding and predict the price of crops when they harvest it. On the other hand, respondents do not have any adaptations to improve the water quality for irrigation. The "ikap" (joint cleaning activity) according to the farmers is not really contributing to the improvement of the water quality. This activity is purposely done to remove litters on their water sources and irrigation canals to provide a better view of their farms to tourist. According to MENRO, they also conduct monthly clean-up drive on the said creeks as part of the DENR Adopt-an-Estero program. Aside from the MENRO activity, the joint efforts of the local Government Unit (Provincial, Municipal, and Barangay), BSU, Benguet Provincial Irrigation Office (BPIO), BSU Strawberry Farmers Association Inc. (BSFAI) and LTWD constructed a single water filtration facility in barangay Betag amounting to Php.1,527,448.43.00 that was completed in 2008. This water filtration project aims to improve the quality of irrigation water. According to respondents this water filtration project was functional only for a few months after its implementation but suddenly stopped because it filtered water that is not enough to sustain the irrigation water supply needed by the farmers.

*Adaptations on Farm Household Economy*

In Table 14, almost all the respondents (91.51%) revealed that they employed various scarcity adjustment measures in their household to cope with the impacts of climate change. Majority of the respondents (51.81%) rent some parcels of land to cultivate. Respondents within Benguet State University (BSU) property are only given an area of 500 square meter, with this small area, farmers rent other land to farm within BSU or Private properties to cultivate. According to some farmers, 500 square meter of farmland cannot sustain their household need. As a result farmers are forced to bid land to cultivate because other farmers also have the same strategy. Farmers with adequate financial resources are bidding with higher amounts to rent certain land areas.

As mentioned by almost half (47.17%) of the respondents, they give up their lands and engage to contract growing or they obtain loans to finance their household needs. Contract growing of farmers continue until they can again afford to buy their own farm inputs. In worst scenario, some farmers go back in their own "ili" (place of origin) to farm, work in small scale mining or become laborer to their neighbor farmers. In this case, the education of their children are affected, their children are forced to go home with them or left to continue their schooling but with limited allowance. Less than half (46.23%) of the respondents are engaged into some short-term wage employment such as to worker to other strawberry farms as seller, tourist caller or seller of neighbor's uncontracted vegetable crops or driver within the locality. Moreover, many (39.62%) respondents are engaged to other livelihood activities to sustain their household needs. These livelihood activities are small scale animal raising (9.43%), stores (12.26%), propagation of ornamental crops (2.83%), buying and selling of vegetables crops (3.77%) and strawberry product making (11.32%).

**Table 14.** Adaptation to cope with the impacts of observed changes in climatic -conditions to farm household economy.

| Observed changes in climatic conditions | Adaptation | Frequency | Percentage |
|---|---|---|---|
| • Temperature become warmer especially during summer months<br>• Prolonged or longer dry season<br>• Delayed onset of rainy season<br>• Decreasing rainfall frequencies after rainy season<br>• Shorter duration of rainy season<br>• Early onset of summer; Late onset of rainy season including typhoons<br>• Variability duration and onset of rainy season, typhoon events and dry season | • Scarcity adjustment | 97 | 91.51 |
| | • Rent some parcels of the farm | 55 | 51.89 |
| | • Obtain loans or engage in contract growing | 50 | 47.17 |
| | • Engage in short-term wage employment<br>-Work hand in other farms or become contractual laborers<br>-Driver<br>-Tourist caller for strawberry picking<br>-Seller of neighbors not contracted crops | 49 | 46.23 |
| | • Engage in other livelihood<br>-Small scale animal raising<br>-Store<br>-Propagate ornamental<br>-Buy and sell of vegetables<br>-Strawberry product producer | 42 | 39.62 |
| | • Subject farm to strawberry picking area | 23 | 21.70 |
| | • Family will work to government or private agency | 17 | 16.04 |
| | • Home gardening | 17 | 16.04 |
| | • Family member is working abroad | 4 | 3.77 |

Some (21.70%) respondents, subject their farms as strawberry picking area.The low volume production of strawberry fruits led other respondents with areas near the road or selling area to subject their strawberry and vegetable farms to tourist picking. Accordingly, this adaptation allow other respondents to have better net income as compared to selling their crops to middle men. The price of a strawberry per kilo ranges from 1.5$ to 4.5$ depending on the peak season.

On the other hand, tourist strawberry picking per kilo ranges from 8.5$ to 9.5$ which double the price of strawberry as compared to its price per kilo. As mentioned by the respondents, this give them more opportunity to earn money to be used for their capital and farm inputs after the strawberry cropping. Competition among farmers hosting strawberry picking is now problematic because many of them subject their farms to picking. In addition, vegetable are now being subjected by respondents to vegetable picking for the tourists also.

Moreover, few (16.04%) respondents revealed that some of their family member works to a government or private agency. Farmers with family working in government or private agency are those who have more adequate financial resources that allows them to cultivate more land and implement crops and water resources adaptations as compared to other farmers. This result coincide with the study of Peras *et al.* (2008) that adaptation practices vary among different socio-economic groups depending on the nature of their occupations and availability of resources. Few respondents also (16.04%) revealed that they practice home gardening. This adaptation as mentioned by respondents ensures their daily meal and at the same time a source of additional income allotted to their children's daily allowances when they sell it to their relatives or to their neighbors. Lastly, few (3.77%) respondents mentioned that a family member work abroad just to cope with the impacts of climate change. As observed, this adaptation is the least choice of adaptation among others.

In summary, the farm households applied unique and various adaptations to minimize the impacts of climate change in their lives. The result corroborated with the statement of Gurung and Bhandari (2009) that addressing climate change impacts, adaptations should be diverse to reduce risk. In La Trinidad Valley, it appears that no less than seven (7) adaptations were employed by the respondents.

Household economy adaptations of the study were also supported by the report of UNFCC (2007) that local communities build their resilience, including adopting appropriate technologies while making the most of traditional knowledge and experiences, and diversifying their livelihoods to cope with current and future climate change impacts. It indicates that La Trinidad Valley farmers are more able to cope with the climate change impacts. This proves that every agricultural region varies differently and requires various context and localized adaptations to cope with climate change impacts (Cameron, 2014; Israel and Briones, 2012 as cited by Pulhin and Tapia, 2016). Moreover, results of the study substantiated the report of IPCC (2007) that societies across the world have a long record of different various adaptation practices to cope with the impacts of weather and climate related events such as floods, droughts and storms.

The adaptation in crop production and water resources in La Trinidad Valley, are in some ways similar with the identified adaptations in Asia as studied by Cruz *et al.* (2007) like increased farm inputs (fertilizer, pesticide and insecticides) and the waste water recycling for irrigation.

**Conclusions**

The statistical analysis of mean annual, minimum and maximum temperature for the past 68 years in La Trinidad showed a significant increased trend and was validated by the respondent's experiences and observation on changes in climatic conditions. All Farmer respondents confirmed that observed changes in climatic condition had negative and multiple impacts to their crop production, water resources and household economy. Its impacts to agriculture areas, farming households and water resources should be disseminated by concerned institutions. Since impacts of climate change to quality and quantity of the water for irrigation were identified by the farmers of La Trinidad, the LGU, NIA, DA and other related institutions should now provide irrigation support to farmers of La Trinidad.

Various and multiple adaptations were practiced by the farmer respondents in La Trinidad to cope with the impacts of the observed changes in climatic condition to their crop production, water resources and household economy. These adaptations were implemented by the respondents from their own experiences, knowledge and financial resources. DA, NIA, LGU and BSU should synchronized their projects and programs to create sustainable, holistic, environmental friendly and low cost adaptations. Further Study on the assessment of the effectiveness and acceptability of Adaptation strategies in the area is desirably to identify the specific institutional needs of Upland Farmers in the Area.

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