*Original Research Article*

# DYNAMIC RELATIONSHIP BETWEEN VULNERABILITY TO CLIMATE CHANGE, LIVELIHOOD DIVERSIFICATION, PERCEPTION ON CLIMATE CHANGE AND INCOME OF THE FARMERS IN NORTH CENTRAL Nigeria


## ABSTRACT

**Aims:** Although a number of researchers have outlined the strategies farmers adopt to ensure stability of family income yet literature provides less understanding on the dynamic relationship between vulnerability to climate change, livelihood diversification, perception on climate change and income of the farmers. It is therefore the aim of this study to establish the relationship between these concepts.
**Study design:** Original research.
**Place and Duration of Study:** The study was conducted in North Central Nigeria in 2019.
**Methodology:** Multi-stage sampling technique was employed in the collection of primary data for this study. In the first stage, two (2) States were randomly selected from North Central Nigeria. In the second stage, five (5) Local Government Areas (LGAs) were randomly selected from the selected States, giving a total of ten (10) LGAs. In the third stage, sampling of farm households in each community were determined proportionately using Krejcie and Morgan (1970) formula. Data were collected from 483 farm households via questionnaire administered by trained enumerators. The data were analyzed using adaptive capacity index, vulnerability index and seemingly unrelated regression.
**Results:** Result of the seemingly unrelated regression revealed that increase in the number of livelihood activities and income of the farmer reduces vulnerability to climate change. More so, increase in the income of the farmer increases the number of livelihood activities the farmer engaged in and also increases the perception of the farmer on climate change.
**Conclusion:** farmers should diversify their sources of livelihood so as to reduce their vulnerability and improve resilience to climate change. The level of literacy among farm households and availability of social amenities should be looked into when formulating policies and developmental issues as they reduces vulnerability to climate change. Financial institutions should help facilitate access to credit by farmers so as to stimulate the adoption of climate smart practices.



*Keywords: Climate change; vulnerability index; adaptive capacity index; seemingly unrelated regression; North Central Nigeria.*


## 1. INTRODUCTION

Farmers' decisions on the choice of livelihood depend on numerous factors such as perception and vulnerability on climate change as well as income of the farmers. Farmers combine skills, abilities and knowledge with a variety of freely available resources to form activities that enable them to achieve the best possible livelihood outcomes, such as income [1]. Farmers' perception of climate change not only informs their farming decisions but also

determines the adoption of adaptation measures [2]; [3]. Climate change perception is a complex process that encompasses a range of psychological constructs such as knowledge, beliefs, attitudes and concerns about if and how the climate is changing [4]. Perception is influenced and shaped, among other things, by the individuals' characteristics, their experience, the information that they receive, and the cultural and geographic context in which they live. The perception of those that directly depend on the weather for at least part of their income, such as farmers, tend to be more accurate than others [5].

Livelihood activities derive from natural resources on which people depend directly or indirectly. There is therefore a strong link between livelihood diversification, climate variability and productivity of the natural resource base. Lending credence to this view, [6] pointed out that livelihoods activities depend on the environment in which the household functions. Livelihood in this research is in line with [7] which composed of a range of activities, both the access to assets and the use to which they can be put mediated by social factors (social relations, institutions, and organizations) and by exogenous trends (for example economic trends) and shocks (drought, disease, floods, pests). Climate change is evident in North Central Nigeria as [8] reported that farmers were mostly aware of increased/high temperature, soil erosion, soil infertility, high rainfall and disappearance of wildlife. As such, farm households form livelihoods amidst climate-induced changes.

Climate change has become a center point by researchers in livelihoods arrangement due its impacts on individuals and biological system functioning. Developing nations like Nigeria depend on climate-sensitive activities as a result encounters climate change impacts. Distinctive motivators and boundaries impact how individuals react to climatic change impacts such as their vulnerability, livelihood diversification, resources as well as income. [9] pointed out that households that depend on rain bolstered cultivation especially in Africa are confronted with the dangers in yearly income and shows how components of income change in reaction to variations in precipitation. Households hence attempt to diminish the result of income shock by diversifying in or out of agriculture or both. The assumption is that based on the views of [10] households with more spread livelihood sources are less helpless to the impacts of climate change.

Vulnerability to climate change is the degree to which a system is susceptible to, and unable to cope with adverse effects of climate change including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive [11]. There are two core considerations when thinking about the vulnerability context, and these are: the extent to which different groups are exposed to particular stresses and shocks; and the sensitivity of their livelihoods to these factors [12]. Over dependence on the climate sensitive sector, unsound land use practice and management, and lack of required capital in adaptation option practices worsen the livelihood vulnerability of rural farm households to climate change [13]. Climate change has altered livelihoods, leading to an increasing vulnerability, reducing the possibilities of securing livelihoods and poverty annihilation [14]. As such there is need to diverse every necessary means to reduce the impact of climate change.

Livelihood diversification has been recognized by researchers [15]; [16] to plays a crucial role in promoting economic growth, reducing rural poverty and environmental change in developing countries. This has to do with combining both agricultural and non-agricultural activities to survive and improve the standard of living of the rural populace [17]. Farm households are trying to diversify their sources of livelihood so as to reduce risks and cope with economic and environmental shocks [18]. In the same view, [19] opined that farm households engage in livelihood diversification due to uncertainty related to climate-sensitive occupations like farming as a major coping strategy for various economic and environmental

challenges. Lending credence to this, [20] affirmed that increase in income from diversified livelihood sources allows farmers to enhance their adaptive capacity to cope with climate risk. In the light of the foregoing, this study seeks to provide answer to this pertinent research question; what is the dynamic relationship between vulnerability to climate change, livelihood diversification, perception on climate change and income of the farmers in North Central Nigeria. It is on the view that livelihood diversification would serve as coping strategy to the effects of climate change and as a result, the income generated could be used by the farmers to adapt to different adaptation strategies which would invariably reduce their vulnerability to climate change as well as increase their perception on climate change. The objective of this research is to determine the dynamic relationship between vulnerability to climate change, livelihood diversification, perception on climate change and income of the farmers in North Central Nigeria.

## 2. METHODOLOGY

The study was conducted in North Central Nigeria. The States that make up the North Central zone are Benue, Kogi, Kwara, Nasarawa, Niger, Plateau and Federal Capital Abuja. Central Nigeria covers a total land area of 242, 425.00 sq kilometres and lies between Latitude $4^0$ and $14^0$ North of the equator and Longitudes $3^0$ and $14^0$ East of the Greenwich meridian. The area has an estimated population of 20, 266, 257 people [21].Going by the population growth rate of 2.5% [22], the population was projected to 29, 351, 574 people. Multi-stage sampling technique was employed in the collection of primary data for this study. In the first stage, the two (2) States were randomly selected from the North Central Nigeria. In the second stage, five (5) Local Government Areas (LGAs) were randomly selected from the selected States, giving a total of ten (10) LGAs. In the third stage, sampling of farm households in each community were determined proportionately using [23] formula.

$$S = \frac{X^2 NP(1-P)}{d^2(N-1)+X^2P(1-P)} \quad (1)$$

Where: S = The required sample size; $X^2$ = Table value of chi-square for 1 degree of freedom at the desired confidence level (1.96); N = Population size; P = Population proportion (assumed to be 0.80); $d^2$ = Degree of accuracy expressed as a proportion (0.05). Data for this study were collected using structured questionnaire. The primary data were obtained through administration of structured questionnaire and interview schedule to elicit information from 483 farmers, on all the information needed to achieve the stated objective. The questionnaires were administered by trained enumerators supervised by the team of researchers.

The data were analyzed using Seemingly Unrelated regression model. The empirical Seemingly Unrelated regression model is specified in equation (2)-(5):

$$Y_1 = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}Y_2 + \beta_{15}Y_3 + \beta_{16}Y_4 + e_1 \quad (2)$$

$$Y_2 = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}Y_1 + \beta_{15}Y_3 + \beta_{16}Y_4 + e_2 \quad (3)$$

$$Y_3 = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}Y_1 + \beta_{15}Y_2 + \beta_{16}Y_4 + e_3 \quad (4)$$

$$Y_4 = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}Y_1 + \beta_{15}Y_2 + \beta_{16}Y_3 + e_4 \quad (5)$$

Where in equation (2)-(5): $Y_1$ = vulnerability to climate change (index); $Y_2$ = livelihood diversification (Number of different livelihood activities); $Y_3$ = perception on climate change (weighted mean); $Y_4$= Income of the farmer (NGN); $X_1$ = Age of the farmer (years); $X_2$ = Household size (Number); $X_3$ = Educational status of the farmer (Number of years spent in school); $X_4$ = Livestock diversification (Tropical Livestock Unit); $X_6$ = Crop diversification (Number of different crop grown); $X_7$ = Credit use (NGN); $X_8$ = Farm size (hectares); $X_9$ = Availability of social amenities (Number); $X_{10}$ = Membership of association (Number); $X_{11}$ =

Extension contact (Number); $X_{12}$ = Poverty status (poor =1, non-poor = 0); $X_{13}$ = Adaptive capacity (index); $\beta_{0i}$= constant term to be estimated; $\beta_1$ - $\beta_{16}$ = Parameters to be estimated; $e_1$ - $e_4$ = error terms. The vulnerability index was calculated using three indicators of exposure, sensitivity and adaptive capacity with sub indicators following [24]. Perception on climate change was calculated using five point Likert type scale to generate the weighted mean. Adaptive capacity index was calculated using eight indicators of knowledge, use, availability, accessibility, consultation, affordability, benefit and sources of information on each adaptation strategies adopted by the farmers on a Likert type scale following [25].

## 3. RESULTS AND DISCUSSION

Result of the Seemingly Unrelated regression model on the dynamic relationship between vulnerability, livelihood diversification, perception on climate change and income of the farmers is presented in Table 1. The R Square ($R^2$) revealed that 67% of the variations in vulnerability, 40% in livelihood diversification, 32% in perception on climate change and 61% in income of the farmers' models were explained by the variables included in the models. The likelihood ratio statistics as indicated by Chi$^2$ ($\chi^2$) statistics of 1012.72, 415.70, 313.63 and 961.84 for vulnerability, livelihood diversification, perception on climate change and income were statistically significant at 1% probability levels, (Prob. > Chi = 0.0000) suggesting that the models have strong explanatory power. In the vulnerability model, crop diversification (0.012) and poverty status (0.061) significantly increases vulnerability to climate change at 10% and 1% probability levels respectively. The possible reason for this might be that farmers' engagement in crop production which could be under rain-fed and being poor increases the sensitivity of the farmers to climate change and as result increases their vulnerability. While a year increase in the level of education (-0.007), an increase in the tropical livestock ownership unit (-0.004), an increase in access to functional social amenities available in the area (-0.019), an increase in the membership of association the farmers belong (-0.034), an increase in the adaptive capacity of the farmers (-0.459), an increase in livelihood diversification (-0.042) and a naira increase in the income of the farmers (-0.019) significantly reduces vulnerability to climate change at different probability levels. The implication of a negative relationship between livelihood diversification and vulnerability to climate change is that engagement in different livelihood activities reduces farmers' vulnerability to climate change which could serve as coping strategy. The possible reason for a negative relationship between income of the farmers and vulnerability to climate is that as the farmers income increases the possibility of adopting climate smart agricultural practices increases. This result is line with the views of [26]; [27] who pointed out that lacking financial assets, moo educational level, and constrained technology and infrastructure decline farm households' level of vulnerability to climate change. This result is also in accordance with the findings of [28] affirmed that climate vulnerability level of the farmers are significantly influenced by education, credit, membership of farmer based organization, unemployed household members, non-farm income, environmental warning and droughts.

In the livelihood diversification model, an increase in the household size (0.019), would push the farmer to engage in other activities so as to offset household expenses. A year increase in educational level of the household head (0.016), would provide an opportunity to be employed in different livelihood activities due to the knowledge and skill acquired. A unit increase in the livestock ownership (0.006), which is a form asset can serves as coping strategy that could be reinvested in other businesses. A naira increase in credit accessed by the farmers (0.015), gives the farmers the opportunity to invest in off-farm business. A unit increase in the extension contact accessed by the farmers (0.025), might bring about increase in yield as well as farm income which could be used to establish other businesses. An increase in the adaptive capacity of the farmers to climate change (1.089), increases their adaptation to climate change and so also their income. A naira increase in the income

of the farmers (0.328) significantly increases the number of livelihood diversification the farmers engaged. The positive effect of income of the farmers on the livelihood diversification might be that there would be more money to invest in different businesses. Whereas household vulnerability index (-0.697) significantly decreases the number of livelihood diversification of the farmers at 1% probability level. The possible reason for this, is that the vulnerable households might lack the resources to diversify into different activities. This result is consistence with the findings of [29] who opined that there are several factors such as educational level, number of livestock ownership, farming experience, etc., that affect diversified diversification.

In the perception on climate change model, a unit increase in livestock ownership (0.014), an hectare increase in farm size (0.031), a unit increase in extension contact (0.015), could give the farmers the ability to keep track of climate variability as well as their perception on climate change. Whereas, being poor (-0.145), significantly reduces farmers' perception on climate change, probably the farmers might not to be well informed about climate change which could be from different medium. A unit increase in the adaptive capacity (0.506) and a naira increase in the income of the farmers (0.278) significantly increases the farmers' perception on climate change. The possible reason for a positive relationship between the farmers' income and perception on climate change could be that higher income might give room for large social network and access to climate change information. This is in accordance with the findings of [30] who ascertained that residents' education level and household size are the main factors that affect the perception of climate change.

In the income model, a year increase in the level of education (0.025), a naira increase in credit accessed by the farmers (0.016), a unit increase in access to functional social amenities in the area (0.311), a unit increase in the membership of association the farmers belongs to (0.248), a unit increase in extension contact accessed by the farmers (0.026), a unit increase in adaptive capacity of the farmers to climate change (0.436), increase in livelihood diversification of the farmers (0.412) and perception on climate change (0.566) significantly increases income of the farmers at different probability levels. While poverty status (-0.916) and household vulnerability index (-0.386) significantly reduces income of the farmers at 1% and 10% probability levels. The possible reason for the negative relationship between household vulnerability and income of the farmers is that vulnerability is also associated with poverty. The positive relationship between livelihood diversification and income of the farmers is that engaging in different activities gives room for better wealth accumulation. Farmers with high perception on climate change carefully adapt to different strategies so as to reduce the impact of climate change on their income. This result is in line with the findings of [31] who confirmed the important role of education, different employment activities, fixed assets in improving household income.

**Table 1: Estimates of dynamics between vulnerability, Livelihood diversification, perception and income of the farmers in North Central Nigeria**

| Variables | Vulnerability Coefficients | Livelihood diversification Coefficients | Perception on climate change Coefficients | Income Coefficients |
|---|---|---|---|---|
| Age | -0.001 | -0.004 | 0.004 | 0.004 |
| | (-1.64) | (-1.31) | (1.57) | (1.45) |
| Household size | 0.002 | 0.019*** | -0.006 | 0.008 |
| | (1.40) | (2.66) | (-1.12) | (1.07) |
| Education | -0.007*** | 0.016** | 0.001 | 0.025*** |
| | (-4.94) | (2.54) | (0.16) | (3.66) |
| Tropical Livestock | -0.004*** | 0.006** | 0.014*** | 0.001 |

| | | | | |
|---|---|---|---|---|
| Units | (-6.04) | (2.25) | (6.77) | (0.22) |
| Crop diversification | 0.012* | -0.006 | -0.006 | 0.049 |
| | (1.71) | (-0.21) | (-0.27) | (1.53) |
| Credit | -0.002 | 0.015*** | -0.005 | 0.016*** |
| | (-1.42) | (3.03) | (-1.36) | (2.89) |
| Farm size | -0.005 | -0.027 | 0.031** | 0.009 |
| | (-1.19) | (-1.54) | (2.26) | (0.50) |
| Social amenities | -0.019** | -0.043 | -0.025 | 0.311*** |
| | (-2.54) | (-1.43) | (-1.08) | (10.80) |
| Membership of association | -0.034*** | 0.061 | -0.046 | 0.248*** |
| | (-2.86) | (1.26) | (-1.20) | (4.68) |
| Extension contact | -0.003 | 0.025*** | 0.015** | 0.026*** |
| | (-1.42) | (3.30) | (2.52) | (3.17) |
| Poverty status | 0.061*** | -0.092 | -0.145** | -0.916*** |
| | (3.37) | (-1.24) | (-2.50) | (-13.23) |
| Adaptive capacity | -0.459*** | 1.089*** | 0.506*** | 0.436** |
| | (-12.16) | (6.49) | (3.76) | (2.24) |
| Household vulnerability index | - | -0.697*** | 0.079 | -0.386* |
| | | (-3.76) | (0.54) | (-1.85) |
| Livelihood diversification | -0.042*** | - | -0.009 | 0.412*** |
| | (-3.76) | | (-0.24) | (8.31) |
| Perception on climate change | 0.008 | -0.014 | - | 0.566*** |
| | (0.54) | (-0.24) | | (9.04) |
| Income | -0.019* | 0.328*** | 0.278*** | - |
| | (-1.85) | (8.31) | (9.04) | |
| Constant | 0.871*** | 4.296*** | 0.798* | 9.844*** |
| | (6.34) | (7.56) | (1.80) | (23.38) |
| $R^2$ | 0.6766 | 0.4071 | 0.3251 | 0.6156 |
| RMSE | 0.1235 | 0.5085 | 0.3998 | 0.5794 |
| $Chi^2$ | 1012.72 | 415.70 | 313.63 | 961.84 |
| Prob>$Chi^2$ | 0.000 | 0.000 | 0.000 | 0.000 |

Values in parentheses are the t-values. *** P<0.01, **P<0.05 and *P<0.10.
Source: Field survey, 2019.



## 4. CONCLUSION

Increase in livelihood diversification and income of the farmer reduces vulnerability to climate change. More so, increase in the income of the farmer increases livelihood activities the farmer engaged in and also increases the perception of the farmer on climate change. Based on the findings, the study therefore recommended that farmers should diversify their sources of livelihood so as to reduce their vulnerability and improve resilience to climate change. The level of literacy among farm households and availability of social amenities should be looked into when formulating policy and developmental issues as they reduces vulnerability to climate change. Financial institutions should help facilitate access to credit by farmers so as to stimulate the adoption of climate smart practices and also break the vicious cycle of poverty among farmers.

## REFERENCES

1. Nsubuga FNW, Mearns KF, Davis NC, Kalumba AM, Komen K. Exploring the influence of climate change and capital assets on livelihood formations in central region of Uganda. Environmental, Development and Sustainability. 2020;1(1):1-20.
2. Meldrum G, Mijatovi´c D, Rojas W, Flores J, Pinto M, Mamani G, et al. Climate change and crop diversity: Farmers' perceptions and adaptation on the Bolivian Altiplano. Environmental Development Sustainability. 2018;20(1):703–730.
3. De Matos Carlos S, Da Cunha DA, Pires MV, Do Couto-Santos FR. Understanding farmers' perceptions and adaptation to climate change: The case of Rio das Contas basin, Brazil. Geo Journal. 2020;85(1):805–821.
4. Whitmarsh L, Capstick S. Perceptions of climate change, in psychology and climate change: Human perceptions, impacts, and responses. Editors S. Clayton and C. Manning (Academic Press). 2018;13–33.
5. Whitmarsh L, Capstick S. Perceptions of climate change, in psychology and climate change: Human perceptions, impacts, and responses. Editors S. Clayton and C. Manning (Academic Press). 2018;13–33.
6. Nsubuga FNW, Mearns KF, Davis NC, Kalumba AM, Komen K. Exploring the influence of climate change and capital assets on livelihood formations in central region of Uganda. Environmental, Development and Sustainability. 2020;1(1):1-20.
7. Sallawu H, Tanko L, Coker AAA, Sadiq MS. (2016). Livelihood and income diversification strategies among rural farm households in Niger State, Nigeria. Asian Journal of Agricultural Extension, Economics & Sociology. 2016;11(4):1-11.
8. Sallawu H, Oha E, Barnabas C, Oyebisi KL, Oyelami SO, Mohammed US, et al. Levels and drivers of vulnerability to climate change by IFAD-VCDP farmers in North Central Nigeria. Nigerian Journal of Agricultural Economics. 2020;10(1):75-91.
9. Kinsey BH. (2002). Survival or growth? Temporal dimensions of rural livelihoods in risky environments. Journal of Southern African studies. 2002;28(3):651–629.
10. Antwi-Agyei P, Dougill AJ, Fraser EDG, Stringer LC. (2012). Characterising the nature of vulnerability: empirical evidence from two regions of Ghana. Sustainability Research Institute. 2021. Pp.37.
11. European Environment Agency (EEA). Climate change, impacts and vulnerability in Europe 2012. An indicator-based report No. 12/2012.
12. Miller F, Bowen K. Questioning the assumptions: the role of vulnerability assessments in climate change adaptation. Impact Assessment and Project Appraisal. 2013;31(1):190–197.
13. Asrat P, Simane B. Characterizing vulnerability of crop-based rural systems to climate change and variability: agro-ecology specific empirical evidence from the Dabus watershed, North-West Ethiopia. American Journal of Climate Change. 2017;6(4):643–667.
14. Aniah P, Kaunza-nu-dem MK, Ayembilla JA. Smallholder farmers' livelihood adaptation to climate variability and ecological changes in the savanna agro ecological zone of Ghana. Heliyon. 2019;5(1):1-25.
15. Loison SA. Household livelihood diversification and gender: Panel evidence from rural Kenya. Journal of Rural Studies. 2019;69(1):156–172.
16. Roy A, Basu S. Determinants of livelihood diversification under environmental change in Coastal Community of Bangladesh. Asia-Pacific Journal of Rural Development. 2020;30(1):7-26.
17. Pritchard B, Rammohan A, Vicol M. (2019). The importance of non-farm livelihoods for household food security and dietary diversity in rural Myanmar. Journal of Rural Studies. 2019;67(1):89–100.
18. Baird TD, Hartter J. Livelihood diversification, mobile phones and information diversity in Northern Tanzania. Land Use Policy. 2017;67(1):460–471.
19. Bhatta GD, Aggarwal PK, Shrivastava AK, Sproule L. (2015). Is rainfall gradient a factor of livelihood diversification? Empirical evidence from around climatic hotspots in Indo-Gangetic plains. Environment, Development and Sustainability. 2015;18(6):1657-1678.

20. Tripathi A. (2017). Socioeconomic backwardness and vulnerability to climate change: evidence from Uttar Pradesh state in India. Journal of Environmental Planning and Management. 2017;60(2):328-350.
21. National Population Commission (NPC). Population Data in Nigeria. 2006. Accessed on February 20, 2022. Available at: http://www.population.gov.ng/population-data-in-Nigeria.
22. National Bureau Statistics (NBS). Demographic statistics bulletin. 2018. Accessed on 11th March, 2022. Available at: https://nigerianstat.gov.ng.
23. Krejcie RV, Morgan DW. Determining sample size for research activities. Educational and Psychological Measurement. 1970;30(1): 607-610.
24. Sallawu H, Oha E, Barnabas C, Oyebisi KL, Oyelami SO, Mohammed US, et al. Levels and drivers of vulnerability to climate change by IFAD-VCDP farmers in North Central Nigeria. Nigerian Journal of Agricultural Economics. 2020;10(1):75-91.
25. Sallawu H, Nmadu JN, Coker AAA, Mohammed US. Adaptive capacity of IFAD-value chain development programme farmers to climate change risks in North Central Nigeria. Nigerian Agricultural Policy Research Journal. 2019;6(1):1-10.
26. Amare A, Simane B. Climate change induced vulnerability of smallholder farmers: agro-ecology based analysis in the Muger sub-basin of the upper Blue-Nile basin of Ethiopia. American Journal of Climate Change. 2017;6(4):668–693. Accessed on 12 March, 2022. Available at: https://doi.org/10.4236/ajcc.2017.64034.
27. Gebreegziabher Z, Mekonnen A, Bekele RD, Bane J, Zewdie SA. Mapping vulnerability to climate change of the farming sector in the Nile Basin of Ethiopia: a micro-level perspective. In Agricultural Adaptation to Climate Change in Africa. 2018;28(54), 28-54. Routledge, England, UK.
28. Adzawla W, Azumah SB, Anani PY, Donkoh SA. Analysis of farm households' perceived climate change impacts, vulnerability and resilience in Ghana. Scientific African. 2020;8(1): 1-11.
29. Akhtar S, Li GC, Nazir A, Razzaq A, Ullah R, Faisal M, et al. Maise production under risk: The simultaneous adoption of off-farm income diversification and agricultural credit to manage risk. Journal of Integrative Agriculture. 2019; 18(2):460–470.
30. Jinjia W, Jiansheng Q, Hengji L, Li X, Hongfen Z, et al. (2018). What Affects Chinese Residents' Perceptions of Climate Change? Sustainability. 2018;10(47):12-22. Accessed on 19th February, 2022. Available at: www.mdpi.com/journal/sustainability.
31. Tran-Quang T. Socio-Economic Determinants of Household Income among Ethnic Minorities in the North-West Mountains, Vietnam Croatian. Economic Survey. 2015;17(1): 139-159.
32. Aryal S, Cockfield G, Maraseni TN. Vulnerability of Himalayan transhumant communities to climate change. Climatic Change. 2014 Jul;125(2):193-208.
33. Mekonnen Z, Woldeamanuel T, Kassa H. Socio-ecological vulnerability to climate change/variability in central rift valley, Ethiopia. Advances in Climate Change Research. 2019 Mar 1;10(1):9-20.