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Farm-based climate adaptation dynamics: insights from the vegetable sector in the Western Highlands of Cameroon

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Abstract: Agro-based climate adaptation has gained traction in scholarly and policy circles, albeit with limited comprehensive empirical evidence on the pathways of crop sector-specific adaptation approaches in sub-Saharan Africa (SSA). To stem this knowledge gap, this study examines the evolution of farm-based climate adaptation practices in the vegetable subsector of Cameroon’s western highlands. Specifically, we (i) explore the different adaptation practices, (ii) estimate the determinants of farm-based adaptation, and (iii) determine the effects of farm-based adaptation on vegetable performance. Data were collected from a representative sample of farming households (N = 150) in two communities using a semi-structured questionnaire, complemented by key informant interviews (N = 10) and focus group discussions (N = 5). The Product Moment Correlation established an evolution from traditional practices to more modern scientific...
practices with changing climate, as vegetable farmers shifted from using local seeds to improved ones, intensified pest control strategies and adopted water pump-based irrigation practices. The binary logistic regression model revealed that belonging to farming groups, increase in income and access to credit significantly explained farm-based adaptation (p = 0.041). Furthermore, farm-based practices were significantly reflected in crop performance, mirrored through an increase in vegetable quantity (p = 0.003) and perceived quality (p = 0.046). The results suggest the need for further research to blend traditional and conventional adaptation approaches, and to create enabling environments to foster social capital (belonging to groups) and access to credit as key levers for climate-resilient vegetable production in the western highlands of Cameroon.

**Subjects: Development Geography; Social Geography; Environmental Geography**

**Keywords: climate adaptation; evolution; vegetable farmers; crop performance; determinants; Cameroon**

1. Introduction

The effects of climate change on the agricultural sector are no longer new in scientific literature, especially in sub-Saharan Africa’s rapidly transforming agrarian sector, earmarked as one of the most significantly affected globally (Borras., 2009). Consequently, studies on climate change adaptation have been extensively conducted in diverse parts of sub-Saharan Africa where rain-fed agricultural systems prevail (Abass et al., 2018; Tume & Kimengsi, 2021). Evidence shows that climate change impacts on agriculture place a huge economic burden on sub-Saharan Africa (SSA), given that her economy is largely agrarian (Calzadilla et al., 2014; Nhamo et al., 2019). Over 70% of all households in SSA depend on agriculture for livelihoods (Bisson & Hambleton, 2020); and agriculture contributes 15 to 40% to its GDP (World Bank, 2021). Given its importance, it is only natural for agricultural adaptation issues to draw high scientific and policy interest across this subcontinent; with special interest on evolution of these practices and their capacity to stimulate resilience (Kimengsi & Balgah, 2015). Understanding agricultural resilience within the context of an ever-changing climate holds enormous potentials to edify the co-evolution theory, and to buffer the negative effects of climate change on agriculture in SSA.

The co-evolution theory, as espoused by the socio-ecological co-evolution framework (Pretzsch et al., 2014) indicates the umbilical link between social systems (driven by man and his preferences and practices) and the natural system (such as land), where man draws resources from to satisfy his growing demands—agricultural produce in this case. The resource exploitation process occurs at an interface where management decisions and actions define the future ecological integrity of planet earth. The three spheres are mediated by institutions—rules that structure behaviour and practices (Kimengsi & Balgah, 2021; Ostrom, 1990). It is plausible therefore to indicate that management practices (climate adaptation strategies in this case) define the extent to which farmers would be able to climate-proof their development. This makes co-evolution a useful but yet to be fully applied framework, in assessing the evolution of agro-based climate adaptation pathways in SSA.

Agro-based climate adaptation practices have a long history in many parts of sub-Saharan Africa. For instance, the practice of using improved seeds, irrigation and pest control practices, mulching and crop diversification, among others, have been employed by farmers as adaptation measures to climate change (Amawa & Kimengsi, 2015; Balgah & Kimengsi, 2015). While these practices have evolved in SSA, the evolutionary process has witnessed a host of challenges including the failure to recognize the need to adapt, weak incentive mechanisms, and low adaptive capacity (Eriksen et al., 2021). These, putatively exacerbates sectoral vulnerability, particularly in
the agricultural sector. In addition, there are few attempts to address the structural contexts which sustain poor adaptation (Ikeme, 2003). Recent evidence in eastern and southern Africa shows that factors such as famine and poverty, significant reliance on the agricultural sector, and overall slow pace of socio-economic development constitute key militating forces against the evolution of agro-based climate adaptation (Rahut et al., 2021). This is further compounded by issues of poor governance (corruption) and weak investment capability (Rahut et al., 2021).

With more than two decades of science and policy emphasis on climate adaptation—especially in the agricultural sector, it has become germane to define and model future adaptation pathways. However, this step cannot be taken without a concise documentation of the different phases in the institution of climate adaptation practices in agricultural systems in sub-Saharan Africa. The study is justified on the following grounds: (i) rising food insecurity and climate change in rural agriculture require multi-level and multi-sector adaptation interventions—narrowing the 60% gap in agricultural production to address food insecurity by 2050, especially in SSA (FAO, 2008, Campbell et al., 2016), (ii) while 22% of cultivable land across the globe is expected to be negatively affected by climate change, SSA’s estimate is even higher: 56% (Campbell et al., 2016). Knowledge gaps with regard to the evolution pathways in crop-specific climate adaptation exist for SSA, despite ongoing efforts to address the negative short-term effects of climate change on farmers (Croft et al., 2018; Clay and King, 2019; Kimengsi et al., 2020; Nchu et al., 2019). This paper contributes to narrowing the knowledge gap, using the case of Cameroon.

Cameroon represents a classical case to understand the evolution of agro-based climate adaptation, given its agro-ecological diversity which calls for diverse adaptation practices. Climate change and all its concomitants are blamed as key factors which stalled progress towards the attainment of the Sustainable Development Goals in the country (Amawa & Kimengsi, 2015). Climate change manifestations vary across the different agro-ecological zones of Cameroon. Agriculture remains the backbone of the country’s economy and employs more than 70% of its population (Molua & Lambi, 2007). The effects of climate change on both subsistence and plantation agriculture have been sufficiently documented (Kimengsi & Muh, 2013; Kimengsi & Tosam, 2013; Molua & Lambi, 2007), including a few studies in the vegetable sector (Amawa & Kimengsi, 2015). Furthermore, indigenous adaptation practices have been studied (Kimengsi & Balgo, 2015, 2015; Nchu et al., 2019). However, comprehensive evidence on the evolution pathways of crop-specific adaptation practices, their determinants and effects on crop performance especially regarding production and productivity are lacking. This paper therefore seeks to (i) explore the adaptation practices in the vegetable subsector, (ii) identify the determinants of farm-based adaptation with emphasis on the vegetable subsector, and (iii) determine the effects of farm-based adaptation on crop performance. Knowledge in this regard will shed light on the dynamics of co-evolution in the realm of farm-based adaptation. Furthermore, it will shape policy levers geared towards blending traditional and conventional adaptation approaches, needed to create enabling environments to foster necessary conditions (such as social capital and access to credits) for enhancing climate-smart agriculture.

2. Materials and methods

2.1. Study area
Cameroon is fondly called Africa in miniature, as its agro-ecological diversity mirrors the sub-Saharan African reality. Its poverty rate of 54% exceeds SSA’s average by 24 percentage points (Kimengsi et al., 2020; World Bank, 2010). The country broadly has four agro-ecological zones; the southern rain forests (East, Centre, Littoral, and South West regions), the central savannah (southern part of the North region and Adamawa), the northern arid region (the Far North region and the northern part of the North region), and the western highlands (North West and West regions; Nji et al., 2019). The Western Highlands is considered the most densely populated zone of Cameroon.
(128.5 inhabitants per km$^2$). Peasant farming, including the cultivation of vegetables and other market gardening crops is dominant (Amawa & Kimengsi, 2015; Jiotsa et al., 2015).

Within the Western Highlands, Tubah municipality was selected due to its rich history and experience in vegetable cultivation. Tubah municipality is located between Latitudes 4°50’—6°05’ North of the Equator and Longitude 9°95’ and 11°59’ East of Greenwich Meridian (Angong, 2005). The area has two distinct seasons: the wet season which runs from mid-March to mid-October, and the dry season from November to February. With a surface area of about 361 square Km (Cameroon, 2001), it is made up of four villages: Bambili, Bambui, Kedjom Keku (Big Babanki) and Kedjom Ketinguh (Small Babanki; Figure 1). For this study, two communities were selected, namely Bambili and Babanki Tungo (Table 1), as they host the highest volume of vegetable production activities in the municipality.

2.2. Data collection
This paper forms part of an on-going mixed methods research on climate adaptation and natural resource management in Cameroon. After a purposive selection of the two study sites (Bambili and Babanki Tungo), a random sampling of 150 farming households in both villages was performed. To achieve this and with the aid of community members, a transect walk was first carried out. During this process, we adopted an ad-hoc farm household numbering approach. Having assigned numbers to the identified vegetable farming households, we used pieces of paper to write down the household number. Raffle draws were then repeatedly performed to randomly select numbers corresponding to some of the vegetable farming households. The selected numbers during the raffle draw guided us to locate the exact vegetable farming household for questionnaire administration. In each of the two villages therefore, random sampling was done until the 75th vegetable

![Figure 1. Location of study communities (Source: National Institute of Statistics, Yaounde).](image)

![Table 1. Study sites and sample](table)

| Villages           | Vegetable farming population | Number of vegetable farming households | Number of households per study site |
|--------------------|------------------------------|----------------------------------------|-------------------------------------|
| Bambili            | 4343                         | 869                                    | 75                                  |
| Kedjom Ketinguh    | 7525                         | 1254                                   | 75                                  |
farmer was selected for data collection. In cases where some household members were absent, we further performed the raffle draws to replace such initially selected numbers, from the remaining farmers, who were all in the replacement sample. These procedures culminated in a total sample of 150 vegetable farming households. In both communities, more than 5% sampling fraction was attained. This proportionate random sampling approach ensured that vegetable farming households from the selected villages are equally represented in the final sample. This approach has been employed in previous studies in the Western Highlands of Cameroon (Kimengsi et al., 2022a, 2022b; Kimengsi & Silberberger, 2022).

Three key research instruments were used to include: key informant interview (KII) guide, focus group discussion (FGD) guide and a semi-structured questionnaire. These instruments were designed and validated in October 2020. The interview guide had a set of eight pre-determined questions, focusing on the typology of climate adaptation interventions, the phases of adaptation, farmers’ response to adaptation interventions, and on the challenges linked to promoting crop-specific adaptation. The focus group discussion (FGD) was developed to capture six questions linked to farmers' understanding of the different adaptation interventions, household level forces that shape adaptation, and on the challenges linked to crop-specific climate adaptation practices. A total of 10 interviews and 5 FGDs were conducted, involving farmers, agricultural extension officers, Common Initiative Groups and NGO representatives, as they are the fundamental actors in the vegetable farming sector in the study site. The average size of each FGD ranged from 8–12 participants. The interviews lasted between 45 to 60 minutes, while the FGDs lasted between 50 and 75 minutes. Informed by such interviews, the semi-structured questionnaire was further refined before being administered. A semi-structured questionnaire (40 items) was developed for the household survey. The first section (section “A”) of the guide elicited demographic information, section “B” was based on the dynamism of climate change adaptation practices, section “C” centered on the determinants of dynamic climate change adaptation practices, while section “D” focused on the effects of climate change adaptation practices on vegetable performance. The last part (section “E”) placed emphasis on the challenges linked to climate change adaptation and the possible recommendations. The semi-structured questionnaire was pre-tested in Nkwen: a neighboring community (N = 10) and further refined. A research assistant was recruited and trained to assist with the data collection using the semi-structured questionnaire. The data collection took place between the months of October and November 2020.

2.3. Data processing and analysis
Qualitative data from FGDs and KIIs were analyzed using thematic and narrative analyses. The quantitative data set was analysed through the SPSS version 20. The first part of quantitative analysis was to conduct descriptive statistics of adaptation practices in the vegetable subsector. Inferential statistics were performed as the second part of quantitative analysis. Inferential statistics were done using the binary logistic regression analysis, to assess the determinants of farm-based adaptation practices. Table 2 presents the list of variables used in the analysis.

The Pearson product-moment correlation coefficient was also used to assess the relationship between the evolution of climate adaptation practices in the past and presently. Farm-based practices (improved seeds, crop diversification, increased use of fertilizer, irrigation and intensified pest control) and non-farm-based practices (belonging to farming groups, seeking early warning, insuring farms, shifting planting and harvesting dates) were correlated to analyse the trend of climate adaptation evolution. Furthermore, the binary logistic regression model was used to analyse the association between climate adaptation practices and socio-economic determinants (Gujarati & Porter, 2003). The model is specified as:

$$Y_i = \eta + \beta_i \sum Z_i + \epsilon_i$$

(1)
**Table 2. List of variables used during data analysis**

| Explanatory variable                  | Description                                      | Measurement |
|---------------------------------------|--------------------------------------------------|-------------|
| Demographic                          | Age                                              | Years       |
|                                       | Sex                                              | Male = 1 Female = 0 |
|                                       | Marital Status                                   | Single = 0 Married = 1 Widowed = 2 Divorced = 3 |
|                                       | Family size                                      | Small, Moderate or Large |
| Evolution of adaptation practices     | Phase of creating awareness to adapt             | Years       |
| Phases of adaptation                  | Phase of making preparation to adapt             | Years       |
|                                       | Phase of adaptation implementation               | Years       |
|                                       | Phase of moving towards adaptive management and monitoring | Years |
| Farm-based adaptation practices       | Mulching                                         | Before and currently |
|                                       | Type of seeds                                    | Before and currently |
|                                       | Crop diversification                             | Before and currently |
|                                       | Increased use of fertilizer                      | Before and currently |
|                                       | Irrigation                                       | Before and currently |
|                                       | Intensified pest control                         | Before and currently |
|                                       | Crop management practices                        | Before and currently |
|                                       | Avoidance of flood prone areas                   | Before and currently |
| Non-farmed based adaptation practices | Diversified into other businesses                | Before and currently |
|                                       | Belonging to farming groups                      | Before and currently |
|                                       | Seeking early warning information                | Before and currently |
|                                       | By insuring farms against risks                  | Before and currently |
|                                       | Shifting harvesting period                       | Before and currently |
|                                       | Shifting planting dates                          | Before and currently |
|                                       | Land management practices                        | Before and currently |
|                                       | Livelihood strategies                            | Before and currently |
| Determinants of adaptation strategies | Age                                              | Years       |
| Socio-Cultural determinants           | Gender                                           | Sex         |
|                                       | Education up to class six and above              | Numbers     |
|                                       | Farming experience                               | Number of years farming |
|                                       | Membership of social organizations               | 1 if access, 0 otherwise |
|                                       | Extension contact (at least three visits with training annually) | 1 if access, 0 otherwise |
|                                       | Either mixed farming or cropping                  | 1 if practice, 0 otherwise |
| Economic determinants                 | Farm income                                      | FCFA        |
|                                       | Farm size                                        | Acres       |
|                                       | Sources of Credit                                | Financial institutions |
|                                       | Phone access (owning a phone)                    | 1 if access, 0 otherwise |
|                                       | Credit access                                    | 1 if access, 0 otherwise |
|                                       | Access to labour force                           | 1 if access, 0 otherwise |
|                                       | Non-farm income                                  | FCFA        |
|                                       | Access to market                                 | 1 if access, 0 otherwise |
|                                       | Degree of dependence on agriculture              | Numbers     |
|                                       | Availability of roads                            | Km          |

(Continued)
| Explanatory variable | Description | Measurement |
|----------------------|-------------|-------------|
| Physical determinants | Perception on reduction in rainfall | 1 if reduce, 0 otherwise |
|                      | Weather information access        | 1 if access, 0 otherwise |
|                      | Soil fertility                     | 1 if stress, 0 otherwise |
|                      | Perception on increase in temperature | 1 if increase, 0 otherwise |
|                      | Access to pest and disease control | 1 if stress, 0 otherwise |
|                      | Availability of water              | 1 if stress, 0 otherwise |
|                      | Availability of weather forecasting technologies | 1 if stress, 0 otherwise |
|                      | Conducive relief                  | Slope height |
|                      | Abundant agricultural land        | Hectares |
| Climate adaptation and the performance of vegetable production | Increased in quality of vegetables | 1 if increase, 0 otherwise |
| Changes in vegetable productions | Increased in quantity of vegetables | 1 if increase, 0 otherwise |
|                               | Increased in the varieties of vegetables | 1 if increase, 0 otherwise |
|                               | Changes in the perceived quality of vegetables (size of leaves and freshness) | 1 if increase, 0 otherwise |
| Periods of harvestings | Everyday                           | Number of times |
|                        | Weekly (twice or thrice)          | Number of times |
|                        | Monthly (twice or thrice)         | Number of times |
|                        | After every three months          | Number of times |
| Outcomes of vegetable production | More income                      | 1 if increase, 0 otherwise |
|                               | Increased wellbeing              | 1 if increase, 0 otherwise |
|                               | Reduced vulnerability            | 1 if reduce, 0 otherwise |
|                               | Improved food security            | 1 if increase, 0 otherwise |
|                               | More livelihood assets            | 1 if increase, 0 otherwise |
|                               | More sustainable use of Natural Resource base | 1 if increase, 0 otherwise |
|                               | Security                          | 1 if increase, 0 otherwise |
|                               | Health                            | 1 if increase, 0 otherwise |

Where:

$Y_i$ is a probability of deciding the adoption practices (the dependent variable captured as $1 = \text{yes}$, if the farmer reported using at least one listed practice, $0 = \text{no}$ when no practice was reported), $\eta$ is the intercept. $\beta_i$ are the parameters (regression coefficients), while $Z_i$ are the explanatory variables.

The dependent variables (adaptation practices) were binary and their values were 1 for a vegetable farmer who used at least one of the listed practices and 0 for a farmer who used none. A vegetable farmer in Tubah municipality was considered to have adapted to climate change if he/she has employed at least one of the adaptation strategies such as mulching, crop diversification, irrigation, increased use of fertilizer and intensified pest control. The determinants of climate change adaptation practices ($Y_i$) were categorized into three. The first categories are social determinants of age, gender, membership of social organisation, contact with extension agents and participation in training with values of 1 if yes, and 0 otherwise. The second is economic determinants of farm size, income, credit, labour force, access to market and landholding with values of 1 if yes, and 0 otherwise. The third is environmental determinants of climate, soil fertility, location of farm and relief with values of 1 if response is yes, and 0 otherwise. This binary logistic regression model was used because the outcome
variables showed binary outcomes that can be used to predict log odds of a particular variable (Long & Freese, 2006) and its socio-economic determinant on the respondents’ decision to adopt an adaptation practice (Marie et al., 2020). The binary logistic regression model was used because it allows one to analyze decisions and determine the associated probabilities for the choice of a particular adaptation practice separately and independently (Ketaren & Sianturi, 2017).

3. Results

3.1. Socio-demographic characteristics of farmers

This study was conducted in two farming communities in Tubah sub-division. A total of 150 participants were sampled in the survey. Socio-demographic characteristics of the sampled vegetable farmers (Table 3).

Females [84 (56.0%)] and farmers aged 45–59 years [71 (47.3%)] constituted a significant proportion of the vegetable farming population (Table 3). Married participants were observed to have the highest participation rate [90 (60.0%)] than those with any other marital status. Most of the participants had attended primary school [101 (67.3%)] and farming was their main occupation [119 (79.3%)]. A large population of females and married farmers suggests that vegetable production is likely to be subsistence—based, with family members providing the bulk of labour in vegetable cultivation. This may have implications for adapting labour-intensive climate-adaptation practices in vegetable production.

3.2. Evolution pathways in climate adaptation practice

3.2.1. Endogenous adaptation practices

In both study sites, the study observed two phases in climate adaptation practice: In Babanki Tungo, phase one began from 2000–2010 while phase two started from 2011 to 2020. Adaptation practices of using improved seeds (83%), intensified pest control (83.3%), and irrigation practices (86.4%) were observed to have evolved significantly while the practice of mulching, crop diversification and the use of fertiliser remained fairly constant (Figure 2).

A significant evolution was also reported for Bamhili as the adaptation practices of using improved seeds (68.7%), intensified pest control (90%), and irrigation practices (58.2%) were observed to have evolved significantly while the practices of mulching, crop diversification and the use of fertilisers remained constant (Figure 3).

These practices exhibit challenges linked to their scale of operation and limited resources to sustain such efforts. For instance, practices such as the use of improved seeds, fertilisers and pest control require financial resources for the purchase and/or storage of these farm inputs. Additionally, the knowledge and know-how to apply some of these farm inputs are still lacking. Worse still, the limited number of agricultural extension workers implies that the extension service coverage is not adequate to ensure significant knowledge dissemination.

3.2.2. Exogenous adaptation practices

The exogenous adaptation practices adopted in Babanki Tungo were observed to have changed significantly: Practices such as belonging to farming groups, and the shifting of harvesting and planting dates evolved more than other practices (Figure 4). In Bamhili, exogenous practices such as business diversification, belonging to CIGs, shifting of planting and harvesting dates witnessed a significant change when compared to their counterpart (Figure 5).

Exogenous adaptation strategies such as belonging to CIGs and farming groups, the shifting of planting and harvesting dates, and business diversification, are characterized by a host of challenges. For instance, belonging to a farming group does not automatically guarantee improved access to climate adaptation packages. Additionally, with poor climate records and forecasts, even
Table 3. Socio-demographic characteristics of vegetable farmers in the study sites

| Parameters | Babanki N (%) | Bambili N (%) | Total N (%) | Parameters | Primary N (%) | Secondary N (%) | Degree N (%) |
|------------|---------------|---------------|-------------|------------|---------------|----------------|--------------|
| Participation | 80 (53.3) | 70 (46.7) | 150 (100) | Education | 101 (67.3) | 26 (17.3) | 18 (12.0) |
| Sex | Male 66 (44.0) | Female 84 (56.0) | | Professional | 5 (3.3) | | |
| Age groups (years) | < 15 0 | 16–29 12 (8.0) | 30–44 58 (38.7) | 45–59 71 (47.3) | 60+ 9 (6.0) | | |
| Marital status | Single 19 (12.7) | Married 90 (60.0) | Divorced 18 (12.0) | Widowed 23 (15.3) | Family size | < 4 children 84 (56.7) | 5-9 children 43 (28.7) | ≥ children 2 (1.3) | Childless 0 (0.0) |

Note: N = indicate total number of cases recorded.

The adjustment of planting and harvesting dates are sometimes faulty and ill-informed. Additionally, business diversification requires resources to assure diverse business operations.

The empirical analysis for Babanki Tungo (Table 4) revealed that there was a significant increase in the adoption of farm-based practices like improved seeds [59 (83.1%), $\chi^2 = 28.517, p = 0.038$], intensified pest control strategies [65 (83.3%), $\chi^2 = 207.324, p = 0.02$] and irrigation practice [55 (84.6%), $\chi^2 = 84.476, p = 0.039$] currently (2011–2020) than in the past (2000–2010; Table 4). However, we observed that farmers shifted from local irrigation techniques to the use of improved methods like sprinklers. Results show that other farm-based practices such as mulching, crop diversification, and crop management were not significantly different from the past (Table 4). On the other hand, there was a significant increase in the adoption of non-farm-based practice of membership in farm groups [55 (84.6%), $\chi^2 = 84.476, p = 0.039$] and business diversification [59 (83.1%), $\chi^2 = 28.517, p = 0.038$] currently (2011–2020) than in the past (2000–2010). In Bambili, the

Figure 2. Evolution pathways of endogenous climate adaptation practice in Babanki Tungo.
analysis showed that there was a significant increase in the adoption of farm-based practices of improved seeds (69.7%, \( \chi^2 = 1.055, p = 0.304 \)) and irrigation practices (70, \( p = 0.044 \)) and non-farm-based practices of belonging to farming group (73.5%, \( \chi^2 = 824.125, p = 0.032 \)) and business diversification (68.4%, \( \chi^2 = 57.000, p = 0.438 \)) in the recent phase (2011–2020) than in the past (2000–2010).

### 3.3. Changes in the typology of adaptation practices

In Babanki Tungo, it was observed that the rate of irrigation (90%), pest control (92%) and the shift in planting dates (70%) increased while the other practices remained the same (Figure 6).

In Bambili (Figure 7), a 1% increase in fertiliser use was observed. Furthermore, irrigation increased from 40% to 60%, pest control also increased to 85%. Additionally, the practice of shifting planting dates increased to 87%, while those for harvesting dates increased to 77%.

There was a significant increase in the rate of adopting farm-based adaptation practices like fertiliser application (73.5%, \( \chi^2 = 57.000, p = 0.438 \)) and non-farm-based practices like the shifting planting dates (68.4%, \( \chi^2 = 136.035, p = 0.061 \)). Most farms were mulched once (78.8%) a year between...
2000 and 2020. The irrigation techniques significantly changed but the rate of irrigation per day remained the same. It was observed that most farmers significantly irrigated (81.3%) their farms once in a day while few irrigated twice (18.8%). The rate of pest control significantly increased. Most farmers were applying pest control measures on average thrice a month (57.7%), while some apply pest control measures only twice a month (37.2%), with just 5% applying it once a month. Also, most farmers shifted their harvesting periods once [20(46.5%), others twice [18(41.9%)] \( \chi^2 = 69.156, p = 0.313 \). In Bambili, there was a significant increase in the rate of farm-based practices like the use of fertilizer [67 (95.7%), \( \chi^2 = 98.065, p = 0.027 \)] and non-farm-based practices like the shifting of planting dates [44 (81.4%), \( \chi^2 = 17.021, p = 0.046 \)]. Most vegetable farmers in Bambili mulch their farms once (95.7%) in a year from 2000 to 2020. While irrigation techniques changed, the rate at which they practice irrigation per day remained the same. The rate of pest control significantly increased in a month, as most farmers apply pest control practices thrice a month (66.2%). Most farmers shifted their harvesting periods once [44 (81.4%)]; this surpassed those who shifted harvesting dates twice [31(5.6%), \( \chi^2 = 17.021, p = 0.046 \)]. The results show that the scale and types of climate adaptation practices have evolved from traditional to more modern approaches. Climate adaptation practices were observed to have evolved through two phases. Phase one started from 2000 to 2010 with mostly traditional practices (78.3%). The second phase began from 2011 to 2021 with practices that have been modernised. Overall, the findings demonstrate co-evolution theory of vegetable production systems and climate change.

### 3.4. Determinants of adaptation strategies applied by vegetable farmers

This paper reports that belonging to the age group 30–44 years \( OR = 0.301, p = 0.039 \) and obtaining an education \( OR = 1494.526, p = 0.001 \) were significant social determinants of climate adaptation. Furthermore, belonging to a Common Initiative Group \( OR = 0.301, p = 0.039 \) and having contact with extension agents \( OR = 3.564, p = 0.041 \) all significantly determined climate change adaptation practices (Table 6). In addition, having high incomes \( OR = 3.564, p = 0.041 \), multiple income sources \( OR = 3.564, p = 0.041 \) and large farm sizes \( OR = 0.301, p = 0.039 \), were significant economic determinants of climate adaptation practices. Vegetable farmers whose farm labour was provided by farming groups \( OR = 3.564, p = 0.041 \) and obtain information about climate change adaptation through radio, TV agricultural programs \( OR = 3.564, p = 0.041 \) as well as farmers with inadequate access to water \( OR = 39.546, p = 0.046 \) significantly influenced the dynamism of climate change adaptation practices (Table 5).

On the relationship between the evolution of climate adaptation practices and changes in vegetable production, the Pearson product-moment correlation coefficient showed a strong, positive and statistically significant correlation between an increase in the quantity of vegetables
| Type of climate change adaptation practice | Location | Sig. level | Location | Sig. level | Location | Sig. level |
|------------------------------------------|----------|------------|----------|------------|----------|------------|
| Farm based | Mulching | 80 (100) | 80 (100) | $\chi^2 = 18.367, p = 1.000$ | 70 (100) | 70 (100) | $\chi^2 = 18.498, p = 0.987$ |
| Use improved seeds | 12 (16.9) | 59 (83.1) | $\chi^2 = 28.517, p = 0.038$ | 20 (30.3) | 46 (69.7) | $\chi^2 = 1.055, p = 0.304$ |
| Crop diversification | 80 (100) | 80 (100) | $\chi^2 = 18.367, p = 1.000$ | 70 (100) | 70 (100) | $\chi^2 = 18.498, p = 0.987$ |
| Increased use of fertilizer | 80 (100) | 80 (100) | $\chi^2 = 18.367, p = 1.000$ | 70 (100) | 70 (100) | $\chi^2 = 18.498, p = 0.987$ |
| Irrigation | 10 (15.4) | 55 (84.6) | $\chi^2 = 84.476, p = 0.039$ | 5 (7.1) | 65 (92.9) | $\chi^2 = 70, p = 0.044$ |
| Intensified pest control | 13 (16.7) | 65 (83.3) | $\chi^2 = 207.324, p = 0.02$ | 41 (41.8) | 57 (58.2) | $\chi^2 = 61.021, p = 0.823$ |
| Crop management | 80 (100) | 80 (100) | $\chi^2 = 18.367, p = 1.000$ | 70 (100) | 70 (100) | $\chi^2 = 18.498, p = 0.987$ |
| Non-farm based | Business diversity | 12 (16.9) | 59 (83.1) | $\chi^2 = 28.517, p = 0.038$ | 13 (26.5) | 36 (73.5) | $\chi^2 = 824.125, p = 0.032$ |
| Belong to farming groups | 10 (15.4) | 55 (84.6) | $\chi^2 = 84.476, p = 0.039$ | 18 (31.6) | 39 (68.4) | $\chi^2 = 57.000, p = 0.438$ |
| Seeking early warning | 6 (42.8) | 8 (57.1) | $\chi^2 = 47.561, p = 0.712$ | 6 (25) | 18 (75) | $\chi^2 = 41.321, p = 0.668$ |
| Insuring farm against risks | 3 (25) | 9 (75) | $\chi^2 = 53.463, p = 0.567$ | 1 (16.7) | 5 (83.3) | $\chi^2 = 71.012, p = 0.089$ |
| Shifting harvesting period | 29 (44.6) | 36 (55.4) | $\chi^2 = 301, p = 0.079$ | 38 (54.3) | 32 (45.7) | $\chi^2 = 18.367, p = 0.053$ |
| Shifting planting dates | 29 (44.6) | 36 (55.4) | $\chi^2 = 301, p = 0.079$ | 38 (54.3) | 32 (45.7) | $\chi^2 = 18.367, p = 0.053$ |
| Land management | 80 (100) | 80 (100) | $\chi^2 = 18.367, p = 1.000$ | 70 (100) | 70 (100) | $\chi^2 = 18.498, p = 0.987$ |

Note: N: Number of participants
Table 5. Frequency of climate adaptation practices

| Type of climate change adaptation practice | Location | Frequency of practice in Babanki | Frequency of practice in Bambili | Sig. level |
|-------------------------------------------|----------|----------------------------------|---------------------------------|------------|
|                                           |          | Once n (%) | Twice n (%) | Thrice n (%) |          | Once n (%) | Twice n (%) | Thrice n (%) |          |
| Farm based                                |          |            |            |              |            |            |            |              |          |
| Mulching                                  |          | 80 (100)   | 0          | 0            | ND         | 70 (100)   | 0          | 0            | ND        |
| Increased use of fertilizer               |          | 63 (78.8)  | 10 (12.5)  | 7 (8.8)      |           | 67 (95.7)  | 3 (4.3)    | 0            |          |
| Irrigation                                |          | 65 (81.3)  | 15 (18.8)  | 0            |           | 29 (41.4)  | 41 (58.6)  | -            |          |
| Intensified pest control                  |          | 4 (5.1)    | 29 (37.2)  | 45 (57.7)    |           | 10 (15.4)  | 12 (18.5)  | 43 (66.2)    |          |
| Non-farm based                            |          |            |            |              |            |            |            |              |          |
| Shifting harvesting period                |          | 20 (46.5)  | 5 (11.6)   | 18 (41.9)    |           | 44 (81.4)  | 3 (5.6)    | 7 (13.0)     |          |
| Shifting planting dates                   |          | 48 (72.3)  | 10 (15.2)  | 8 (12.1)     |           | 70 (100)   | 0          | 0            | ND        |

n: Number of participants
ND: not determined, test redundant.
Source: Field work 2021
Figure 6. Changes in the typology of adaptation practices in Babanki Tungo.

Figure 7. Changes in the typology of adaptation practices in Bambili.

(\(r = 0.76, n = 150, p = 0.003\)), the quality of vegetables (\(r = 0.58, n = 91, p = 0.046\)) and climate change adaptation practice (Table 7).

4. Discussion
Agro-based climate adaptation continues to receive significant attention in scholarly and policy spheres, thus validating the need for further evidence on crop-sector specific adaptation, especially in agriculture-dependent sub-Saharan Africa (SSA). We contribute to shed light on this, by (i) exploring the different adaptation phases in the vegetable sector, (ii) estimating the determinants of farm-based adaptation with emphasis on the vegetable sector, and (iii) determining the effects of farm-based adaptation on crop performance.
### Table 6. Binary logistic regression results on the determinants of climate adaptation practices

| Determinants of climate adaptation practices (Independent variables) | Dependent variable: Climate change adaptation practices (Yes/No) | Beta | S.E. | df | Sig. | Odd Ratio (OR) 95% C.I. for OR Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|
| | Age (16–29 years) | Reference | | | | | | | |
| | 30–44 years | −1.199 | 56.532 | 1 | 0.039 | 0.301 | 0.112 | 0.986 |
| | 45–59 years | 12.313 | 29.105 | 1 | 0.965 | 2.319 | 1.956 | 4.235 |
| | ≥ 60 years | −11.587 | 26.945 | 1 | 1.000 | 0.000 | 0.000 | - |
| | Sex (females) | Reference | | | | | | | |
| | Males | 3.443 | 191.477 | 1 | 0.657 | 3.273 | 0.985 | 4.365 |
| | Education (Profession) | Reference | | | | | | | |
| | Primary | −0.850 | 32.478 | 1 | 0.786 | 0.427 | 0.012 | 4.365 |
| | Secondary | −23.513 | 10.787 | 1 | 1.000 | 0.000 | 0.000 | - |
| | Degree | 25.730 | 570.322 | 1 | 0.001 | 1494.529 | 0.000 | 1500.000 |
| | Farm Knowledge (Medium) | Reference | | | | | | | |
| | High | 9.167 | 11.440 | 1 | 0.472 | 95.572 | 61.356 | 102.365 |
| | Member of social organization (cooperative societies) | Reference | | | | | | | |
| | CIG | −1.199 | 56.532 | 1 | 0.039 | 0.301 | 0.112 | 0.986 |
| | Farmer’s association | 35.783 | 54.413 | 1 | 0.999 | 3471.500 | 0.000 | 0.000 |
| | Ordinary Social Club | 19.501 | 201.190 | 1 | 0.999 | 294.308 | 0.000 | 0.000 |
| | Contact with extension agent (Had no contact) | Reference | | | | | | | |
| | Had contact | −4.202 | 841.932 | 1 | 0.041 | 3.564 | 1.874 | 6.325 |
| | Income (>91 000FCFA) | Reference | | | | | | | |
| | 31 000–60 000FCFA | 21.976 | 30.331 | 1 | 0.999 | 3471.500 | 0.000 | 0.000 |
| | 61 000–90 000FCFA | −4.202 | 841.932 | 1 | 0.041 | 3.564 | 1.874 | 6.325 |
| | Farm_size (> 2.0 ha) | Reference | | | | | | | |
| | ≤ 1.0 ha | 9.097 | 681.934 | 1 | 0.756 | 31.396 | 12.596 | 36.652 |
| | 1.1–2.0 ha | −1.199 | 56.532 | 1 | 0.039 | 0.301 | 0.112 | 0.986 |
| | Credit sources (Njangi group) | Reference | | | | | | | |
| | Friends and relations | −4.202 | 841.932 | 1 | 0.041 | 3.564 | 1.874 | 6.325 |
| | Bank | 7.361 | 71.353 | 1 | 0.896 | 173.649 | 0.000 | 0.000 |
| | Microfinance | −38.991 | 129.507 | 1 | 1.000 | 0.000 | 0.000 | 0.000 |
| | Cooperatives | 9.123 | 61.946 | 1 | 0.999 | 962.247 | 0.000 | 0.000 |
| | Personal savings | −7.016 | 187.342 | 1 | 0.001 | 0.112 | 0.000 | 0.896 |
| | Source of labour force | Reference | | | | | | | |
| | Provided by family | −25.558 | 38.578.851 | 1 | 0.999 | 0.000 | 0.000 | 0.000 |
| | Hired Labour | 36.934 | 417.246.157 | 1 | 1.000 | 10.000 | 0.000 | 0.000 |
| | Farming group | −4.202 | 841.932 | 1 | 0.041 | 3.564 | 1.874 | 6.325 |
| | Friends | −9.335 | 76.363.142 | 1 | 1.000 | 0.000 | 0.000 | 0.000 |
| | Individually | −36.290 | 226.040.593 | 1 | 1.000 | 0.000 | 0.000 | 0.000 |
| | Information influencing adaptation measures (Social media/internet) | Reference | | | | | | | |
| | Access to market information | −4.693 | 93.383 | 1 | 0.896 | 0.009 | 0.000 | 0.023 |
| | Information on weather forecasting | −24.390 | 5.717 | 1 | 1.000 | 0.000 | 0.000 | - |

(Continued)
Table 6. (Continued)

| Determinants of climate adaptation practices (Independent variables) | Dependent variable: Climate change adaptation practices (Yes/No) |
|---|---|
| | Beta | S.E. | df | Sig. | Odd Ratio (OR) | 95% C.I. for OR |
| Agricultural extension service | -43.525 | 56.873 | 1 | 0.999 | 0.000 | 0.000 | . |
| Radio/TV agricultural programs | -4.202 | 841.932 | 1 | 0.041 | 3.564 | 1.874 | 6.325 |
| Water availability | Reference |
| Lack of water | 12.770 | 58.072 | 1 | 0.046 | 39.546 | 10.356 | 83.254 |

S.E: Standard error, df: degree of freedom, C.I: Confidence level: OR: Odd ratio

Table 7. Correlation between the evolution of climate adaptation practices and changes in vegetable production

| Changes in vegetable production | Climate change adaptation practice |
|---|---|
| | Cases | Correlation coefficient (r) | Significance level |
| Increase quantity of vegetables | 150 | 0.76 | 0.003 |
| The varieties of vegetables | 87 | 0.32 | 0.061 |
| Quality of vegetables | 91 | 0.58 | 0.046 |

4.1. Evolution pathways for climate adaptation practices

On the evolution pathways, a shift from traditional practices to more modern practices was reported. For instance, vegetable farmers in the study communities moved from using local seeds to improved ones (88.1%), intensified pest control strategies (83.3%) and adopted the water pump irrigation practice (82%). Both endogenous and exogenous practices are characterized by several challenges including limited financial resources to purchase and/or store farm inputs, poor knowledge and know-how on the application of farm inputs and the limited number of agricultural extension workers. Additionally, some farming groups and CIGs are poorly managed, while business diversification requires resources to assure diverse business operation. Nevertheless, there is ample empirical evidence supporting evolution pathways for climate adaptation by farmers in SSA, even if the strategies tend to be context-specific. A similar study in rural Ghana by Dumba et al., (2021) reveals that farmers engaged in the (re)location of their farms on riverine areas as an agro-based climate adaptation strategy. Kimengsi and Balgah (2015) contend that such shifts could either be carried out unconsciously and/or consciously. In the forest zone of Cameroon, Bele et al. (2013) showed that farmers embraced opportunities presented by climate change, by employing strategies such as the growing of maize and vegetables in dried swamps, the diversification of crop production and changing food regimes in which groundnuts gradually replaced by njansang and soya bean. According to Bate et al. (2019), farmers embraced both rainfall-related and temperature-related adaptation approaches in South West Cameroon. In parts of the western highlands, specifically in the Bui Plateau, Tume and Kimengsi (2021) found that adoption and adaptation were skewed towards traditional approaches, with farmers making use of local seeds more than improved ones. This trend is also observed in our study. The key traditional approaches as reported for instance, by Abid et al. (2015) comprises knowledge of (a) the seasons; (b) historical storm patterns; (c) the colour of rain-bearing clouds; and (d) wind patterns, including direction and wind types such as the North-East trade winds that bring the dry season and the South-West Monsoon winds that bring the
rains. Indigenous knowledge is evolving and is continually influenced by internal innovation and experimentation involving local culture and interaction with other areas (Tume et al., 2019). It constitutes a resource which enables people to respond to climate change. The modern adaptation phase in the study communities took place between 2011 and 2020. In recent years, there has been a general shift from traditional practices to modern scientific practices. In Tubah for instance, the channel irrigation system was abandoned; farmers now use energy-driven water pumps and sprinklers to irrigate farmlands. Francisco and Silva (2009) revealed that as farmers recognized the inadequacy of their indigenous knowledge to cope with climate change, they now integrated suitable scientific tools and technologies into their plans for adapting to climate change and variability.

4.2. Determinants of climate change adaptation practices

Belonging to a farming association strongly influenced climate change adaptation in the study communities. Farmers’ organizations in Tubah include Common Initiative Groups (58.5%), farmers’ association (19.2%), and Ordinary Social Clubs (23.3%). This finding is in line with the works of Armé (2015) who reported that farmers’ organizations are effective channels of communicating information to farmers. Furthermore, in Southern Mali, Diallo et al. (2020) reported that farmers who belong to an association reaped positive benefits in climate adaptation. This specifically concerned the adoption of short-duration maize varieties as an adaptation strategy. Membership in local associations by local farmers enhances their adaptation to climate change. The information obtained from such associations assists vegetable farmers in Tubah to increase their farming knowledge and skill on climate change adaptation. In addition, groups provide ample sources of labour which can facilitate the implementation of labour-demanding adaptation strategies, such as adopting modern irrigation schemes. Groups can also generate capital for climate adaptation through rotary savings and credit schemes (Mitter et al., 2019).

Regarding access to extension services, this study revealed that some farmers had contacts with extension workers more than six times in a year, others less than six times in a year and some once in a year. Those that had more contacts with extension workers modernised their adaptation practices as they learned new techniques on land and crop management. Some vegetable farmers did not have the possibility to benefit from the services of extension agents due to the on-going crisis and the drastic reduction in the number of extension workers in Tubah. Studies in other parts of the western highlands such as the Bui plateau showed that insufficiency in the number of qualified extension workers, as well as the limited resources at their disposal, constrain effective adaptation practices. In this regard, there has been very limited evolution in agro-based climate adaptation as mirrored through limited innovation (Tume & Kimengsi, 2021). However, Tingem et al. (2009) showed that more modern approaches such as the development of late-maturing cultivars are effective in agro-based climate adaptation, while assuring productivity increases, where extension services are active. Dahal et al. (2019) revealed that agricultural extension agents greatly influenced the dynamic nature of climate change adaptation practices, while Arimi (2014) held that poor extension services hinder farmers’ access to necessary information on climate change adaptation. In parts of South West Cameroon, Nchu et al. (2019) reported that tenure insecurity and inequality (not access constraints to extension services) amplifies agricultural systems vulnerability to long- and short-term climatic change, while constraining adaptation. It is plausible to assume that the effectiveness of extension services to support farmers’ climate adaption is contingent on other critical factors in agriculture, such as tenure security. Farmers with usufruct land rights are likely not to engage in climate adaptation strategies, compared to those with full property rights (Maddison, 2007).

Farming knowledge is a key determinant for adopting dynamic climate change adaptation practices. Vegetable farmers had different levels of farming knowledge, skills and ability. A majority of the farmers reported that their market gardening knowledge was moderate (39%), some it was high (43%) and for others it was low (18%). Those with high and moderate market gardening knowledge were more dynamic with their climate change adaptability than those with
low market gardening knowledge. Farming knowledge is acquired through experience and education (Abid et al., 2015; Ali & Erenstein, 2017), and through the activities of extension services (Dahal et al., 2019). The aged are more experienced and have the capacity to adapt to changes in climate. However, Ali and Erenstein (2017) maintained that young farmers have a longer planning horizon and the ability to take up long-term adaptation measures such as irrigation and mixed crop-livestock systems. Oyekale and Oladele (2012) found that younger farmers are more capable to adopt dynamic adaptation practices compared to their older counterparts possibly due to their innovative character and keen desire to try new technologies and methods to improve agriculture. Other studies in sub-Saharan Africa have emphasized the role of farm practices in enhancing adaptation. For instance, using three crops (maize, sorghum and Bambara groundnut) Tingem et al. (2009) showed that changing sowing dates could prove ineffective in climate adaptation. This is attributed to the narrow rainfall band which strictly determines the timing of farm operations. In rural Zimbabwe, Tui et al. (2021) reported that the most promising agro-based climate adaptation practices included soil fertility improvement, the diversification of farm production using legumes, and investment in conducive market environments.

The binary logistic regression model revealed that belonging to farming groups, increase in income and access to credit significantly explained farm-based adaptation. Studies across sub-Saharan Africa have showed that several beyond-the-farm factors still progress towards agro-based climate adaptation. For instance, Descheemaeker et al. (2016) revealed that spatial and organizational factors such as poor community organization and mal-functional extension services truncate information flow, knowledge and skills in relation to climate adaptation. Besides the motivation to belong to groups, cultural beliefs define agro-based climate adaptation (Niang et al., 2014). Furthermore, a majority of vegetable farmers in Tubah sub-division had natural assets (87%), financial and economic capital (64%), farm tools (92%) access to market (75%) and own phones (95%). Financial resources and access to markets enabled vegetable farmers in Babanki and Bambili villages to buy improved seeds, new irrigation technologies and other important inputs needed to change their adaptation practices. According to Armi (2015), farmers with lower income are more conservative in adopting new practices because they usually consider their family welfare and situation before embarking on spending money on new adaptation practices like improved production technologies such as modern water pumping machines for irrigation, chemical fertiliser and improved seeds, for improving productivity. Maddison (2007) equally reported that tenants and farmers cultivating on leased land adopted the least adaptation practices compared with those cultivating owned and family lands. This is because they were unwilling to invest in long term adaptation practices like the construction of water tanks and also they are more conscious about their farm income and rents to be paid hence they will adapt less to climate change to keep their gross revenue above total cost. Ojo and Bajyegunhi (2018) revealed that household assets have a great influence on the adoption of farm technology.

Households that have access to off-farm income are likely to adapt to climate change. Farmers who engage in off-farm activities can purchase chemical inputs, invest in conservation of soil and also improved varieties as their financial constraints may be overcome by being involved in off-farm income activities. In rural Ghana, Dumba et al. (2021) showed that the practice of diversifying from farm to non-farm livelihood strategies enhanced agro-based climate adaptation. Source of credit is an important factor that influences adoption of dynamic climate adaptation practices in the study communities. Vegetable farmers usually obtain most credit facilities from friends and relations (60.1%), banks (4%), micro-finance (11%), personal saving (3.2%) and Saving Groups (12.8%). Nabikolo et al. (2012) revealed that credit sources enabled farmers to acquire all the necessary modern inputs such as improve seeds, sprinklers and large hectares of farmland. Armi (2015) justified that poor access of farmers to credit facilities may discourage adoption of appropriate climate change adaptation technology as most farmers will not be able to procure necessary inputs such as improved seeds and herbicide. In semi-arid parts of Ghana, Batung et al. (2022) found that households with access to credit from informal sources reported improved adaptation interventions as compared to those
without credit access. Nabikolo et al. (2012) supported the fact that access to credit increases financial resources of farmers, reduces cash constraints and allows farmers to purchase inputs. Similar findings have been reported for instance, by Djoumesi et al. (2018) for smallholder vegetable farmers in the Southwest region of Cameroon, and Alhassan et al. (2020) for farmers in Ghana.

5. Conclusion
This paper sought to explore the phase-based adaptation practices of vegetable farmers in the Western Highlands of Cameroon, drawing from a random sample of 150 households. Based on the analysis, the following conclusions are drawn: Firstly, climate adaptation practices in the vegetable crop sector have witnessed an evolution from traditional practices to more modern scientific practices. While both approaches have strengths and demerits, it is germane for research and policy interventions to explore pathways for an effective integration of both approaches in order to improve future agro-based adaptation interventions. For instance, policy should focus on identifying points of potential convergence between traditional and modern, scientifically-based practices. This should be accompanied by the application of effective policy instruments such as functional extension services for effective knowledge transfer, incentives, and access to affordable credit, to enable the effective uptake of this hybrid approach. Scientifically, conditions, under which both approaches could converge and be effectively embraced by vegetable farmers should be explored in subsequent studies. Secondly, both endogenous and exogenous evolutionary patterns were observed in the study site. Endogenous practices such as mulching, crop diversification and the use of organic manure have remained unchanged over the years, while exogenous ones such as business diversification and the belonging to CIGs have witnessed an evolution. It therefore holds that endogenously-rooted climate adaptation practices are more stable over time than exogenous ones. These should be starting points for long term climate adaptation strategies. Irrespective of form, changes in vegetable production practices in response to climate change support the ideology embedded in the co-evolutionary theory. Thirdly, socio-economic factors continually trigger agro-based climate adaptation, albeit in varying proportions. Further conditions under which these determinants could engender the convergence of traditional and modern adaptation practices need to be clarified. Also understanding why some socioeconomic variables favour climate adaptation strategies and why others do not, and if these patterns are consistent over space, time and agricultural sector can provide insights for generalization. Finally, the evolution of both exogenous and endogenous farm-based adaptation practices contributes to an improvement in agricultural performance. This is reflected through an increase in vegetable quantity and quality. Studies to uncover the respective contributions of endogenous and exogenous approaches to crop performance should be prioritized in future. Furthermore, the creation of an enabling environment to foster social capital (membership in groups) and access to credits is required. Our findings suggest that climate change influences adaptation strategies in the vegetable sector in Cameroon. However, it is plausible that other factors such as yields, market access could act as compounding factors in shaping farmers’ adaptation decisions. Further research is necessary to identify the level to which factors other than climate change could have informed decision making in the vegetable sector analyzed in this study.

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The data that support the findings of this study are available upon reasonable request.

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