





# Climate Change Adaptation among Smallholder Farmers: Evidence from Ghana

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## Abstract

Local discourses on climate change adaptation are very relevant to many developing countries which suffer the most of climate change impacts. Smallholder farmers are a backbone to the Ghanaian economy. However, the activities of smallholder farmers are threatened by climate-related risk increasing their vulnerability. This study aims to review knowledge on climate change adaptation for the ultimate goal of fostering climate-resilience among smallholder farmers. This paper uses purposive sampling to systematically review recent available literature on the theme “adaptation of smallholder farmers in Ghana”. In order to avoid the duplication of the information and track data sources for accuracy purpose, Mendeley version 1.19.4 software was used to incorporate articles while MS EXCEL Version 2019 was used to categorize the types and key examples of adaptation strategies used by smallholders. It was found that the most utilized adaptation types are farm management and technology (67%) and diversification on and beyond the farm (20.6%) with less adoption for knowledge management, networks and governance (5.4%); farm financial management (4%); government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population (3%). Although the strategies enlisted above help to adapt to climate change, challenges such as poor and unsustainable agricultural practices, socio-cultural constraints, institutional barriers and under-representation of other regions (except Northern Ghana) in the study of climate change adaptation of smallholder farmers in Ghana remain. The study therefore advocates for strengthening the link between research institutions and the extension officers and enhanced deployment of agricultural extension services to smallholder farmers in the rural areas among others.

## Keywords

Climate Change, Smallholder Farmers, Adaptation, Strategies, Systematic

## 1. Introduction

French scientist Jean-Baptiste Fourier in 1827 realized the warming effect of an enhanced greenhouse effect about 200 years ago which led to the recognition of climate change [1]. Further research was then conducted by Svante Arrhenius, a Swedish chemist in 1896 into this warming effect and predicted global temperatures could increase 5°C to 6°C if the atmospheric CO<sub>2</sub> doubles [2]. Various arguments have been engaged on the existence of climate change or not. However, in 2007, the Intergovernmental Panel on Climate Change (IPCC) settled on a 90% certainty of the existence of climate change as caused by anthropogenic factors initiating the Anthropocene [3]. Climate change has been a pertinent issue for over centuries now and most countries have been actively involved in its mitigation as the first-generation solution followed by adaptation measure. Climate change as a global phenomenon is a challenge that does not only affect the economic and physical development of states and communities but is largely a human right and social issue [4]. The agricultural sector remains one of the key sectors that is highly vulnerable to climate change due to its high risk and exposure to climatic variables such as precipitation, temperature and wind on which it depends [5]. The need for adaptation is thus very evident due to the level of vulnerability in this sector.

The twenty first century has been noticed as one of the historical era where the frequency magnitude of climate extreme events and impacts has increased exponentially. It has been found by [6] that, the increase in climate extreme events has impacted food security and terrestrial ecosystems which drive desertification and land degradation globally. This phenomenon is happening differently across continents due to their level of vulnerability. The African continent, especially West African Region which Ghana belongs to, is classified among the most vulnerable zones due to low level of adaptive capacity in the face of climate change. [7] reported that, in relation to the most vulnerable ecological zones (Sudan and Guinea Savanna zones), the most experienced climate change impacts are prolonged drought, erratic rainfall, reduction in crop yield and frequent flooding in Ghana while in the Northern, Upper East and Upper West regions are the most vulnerable to drought. With regards to these climatic threats, farmers, especially smallholder farmers have been noticed as one of the most vulnerable groups who need assistances. Therefore, technologies, especially Agroforestry Technologies (AT) have been developed by climate scientists/researchers and disseminated by development agencies for the purpose of supporting farmers to provide agricultural commodities in order to maintain food and nutrition security in Ghana. As found by [8], the top four adopted by the communities were farmland planting, livestock rearing, household plantings and fruit tree production as climate adaptation strategies. Moreover, a number

of socio-economic factors such as age, primary occupation, skill training, material support/incentives, membership to livelihood groups, number of farm-lands and access to extension services all significantly influenced the adoption of AT.

Although these tremendous efforts exist, farmers' expectations seem not to be achieved due to several constraints. There are several research works on adaptation strategies by farmers in specific geographical areas in Ghana, however, a one-stop countrywide view of adaptation strategies by smallholder farmers compiled across the country seems missing. Hence, a study to comprehensively document smallholder farmers' climate change adaptation at country level is pertinent as to help to critically examine available climate change adaptation strategies among smallholder farmers. This paper addresses this gap to find out challenges and suggests actions for successful adaptation strategies in the sector.

## **2. Theoretical & Conceptual Framework**

### **2.1. Climate Change Impacts on Agriculture**

Climatic variability and change affect agriculture in a wide range of ways. Climate change impacts crop production through direct impacts on the biophysical factors such as plant and animal growth and the physical infrastructure associated with food processing and distribution [9]. [10] study on "Implication of Climate Change on Crop Yield and Food Accessibility in Sub-Saharan Africa" opined that crop production is directly affected by climatic extreme events such as average temperature increase, drought, heat wave, flood, wildfire, change in rainfall amount and patterns, rising atmospheric concentrations of CO<sub>2</sub>, extreme change in climatic variability, seawater rise, etc. In fact, an increase of the earth's surface temperature of 1°C - 2°C is expected to lead to decreased crop yield in the tropical and subtropical regions [11] [12] as a result of increased evapotranspiration of plants and low available soil moisture content [13]. Moreover, climate change is anticipated to affect the intensity of rainfalls in some areas with effects on soil erosion and soil moisture, both of which are critical for crop yields [10]. Estimations by [11] for Sub-Saharan Africa would be a decrease in rainfall of about 20%. Such conditions will likely result in the loss of arable land due to decreased soil moisture, increased aridity and salinity, and groundwater depletion [10] among others.

The Intergovernmental Panel on Climate Change (IPCC) [3] [13], projects for Africa a warming of 0.2°C - 0.5°C per decade, which could significantly affect climate sensitive crops like maize, sorghum, cassava, yam, cowpea in the West Africa sub-region. Climatic changes have always had, and continue to exert, impact on local agricultural production: from the 1960s to the 1990s, West Africa encountered a particularly dry period, with terrible droughts in the Sahel and the semi-arid Guinea-Savannah, in the late 1970s and early 1980s, although rainfall averages have since recovered [14]. It is worth mentioning that water scarcity limits agricultural production as irrigation facilities are costly. In the long run,

this would carry physical and socio-economic suffering to smallholders in the region. In some parts of West Africa (The Gambia, Senegal and Gulf of Guinea), climate induced-sea-level rise resulting from the global temperatures increase affects already coastal and low-lying agricultural lands factoring in impacts such as inundation, soil salinization [15] [16] [17] leading to a loss of agricultural land, loss in farmers' income and food supply systems [10].

Several studies projected serious climate concerns for food production and agriculture in general. [18] indicated that for a country like Ghana an average temperature increase in its sub-humid region of 1.45°C by 2050. Equally, [19] and [14] reported a likely increase in the inter-annual rainfall variability, an increase in the rainfall intensity with a decrease in the number of rainy days. Such variability entails a shift in the country's rainfall pattern that had serious consequences on rain-fed agriculture [18] [20] [21] of the country. Agriculture goes beyond crop production. For crops to be produced, important human labor and capital investment are needed for successful farming. For instance, in Ghana, under poor climatic conditions, smallholder farmers are heavily affected. They depend largely on rainfall for their livelihood [22]-[27]. For [28], the adverse effect from climate change in the form of reduction of agricultural production ends up slowing down the growth of countries in Africa, since a great proportion of their national income comes from agriculture. Therefore, climate change has direct impacts on smallholders as they are not able to make their living through food crop production, and their ability to have the capital to access food is affected [29].

## 2.2. Climate Change and Adaptation in Africa

Africa is a continent with high potential in natural resources and has diverse climatic zones due to its size and its location but also considered as one of the most vulnerable due to its low adaptive capacity in the face of climate change which can differ from one country to another [30]. Africa's vulnerability is the function of a high degree of sensitivity to water, food, and health; exposure to natural disasters (droughts, floods, and storms), climate variability; and a weak socio-economic profile related to assets, livelihood strategies, agriculture, and social network [31]. In sub-Saharan rural areas of Africa, the employment share related to agriculture is 98% with a poverty rate shifted from 64.9% in 1998 to 61.6% in 2008, which is still double the prevailing average in developing countries [32] [33]. Any slight change in rainfall is highly likely to impact the livelihood of the African communities at an alarming rate. The combination of those factors is threatening Africans' livelihood in multidimensional and multi-sectoral ways. Agricultural production is likely to drop by 10% - 50% by 2050 in most of the African zones linked to the decline and poor rainfall under prevailing farming practices with 70% of Africa's population dependent on rain fed agriculture [34]. In addition, functional changes are happening in all terrestrial ecosystem types in Africa, including deserts, grasslands and shrublands, savannas and

woodlands, and forests with major causes related to climate change [33].

“Moreover, climate change and climate variability are likely to jeopardize agricultural potential, food security and nutrition in most African regions; as well as aggravate the water stress currently faced by some countries, while some countries that never experienced water stress will become at risk” [35]. West Africa is expected to face severe impacts on food production, including a decline in oceanic productivity, with high risks for food security and negative repercussions for human health and employment [34]. In the face of that challenge, scientists with local farmers are elaborating on the multiple benefits of crop diversification practices such as using varietal diversity in monocultures, mixing crops with non-crop vegetation, crop rotations, poly-cultures (including wild varieties), agroforestry and mixed landscapes, water and soil conservation technique such as *half-moon*, *Zai*, *stone lines*, especially in Sub-Saharan Africa. Benefits derived from these strategies include pest and disease reduction, increased production, increased production stability, and climate stress buffering as climate adaptation strategies [36].

Although efforts have been deployed, these technologies are likely not to be efficient in the nearest future based on the climate projected scenarios. There is a need to systematically establish the influence of African traditional worldviews on climate change risk perception, development of adaptive strategies, and policy formulation and implementation in participatory and involvement approaches [37].

### **2.3. Smallholder Farmers in Ghana**

According to [38], about 475 million smallholder farmer households come from two-thirds of the 3 billion rural people living in the developing world. A critical defining factor of a smallholder farmer is one who operates on less than 2 hectares of agricultural land [39] [40]. This definition, though widely accepted due to the characterization of the word “smallholder”; presents certain generalizations as the productivity and use of resources of two farmers both operating on less than 2 hectares of land may present different results [41]. The unique dynamics of smallholder farmers in Ghana will, however, be discussed considering their unique adaptive capacities in the discussion section. In Ghana, about 90% of farm holdings are small scale in nature, mostly less than 2 hectares [40]. The food crop sub-sector houses the majority of the smallholders in Ghana who employ traditional methods of farming using the hoe and the cutlass as farming tools. There is little mechanized farming among smallholder farmers. Agricultural production is dependent on natural and climatic factors thus farming yields are reliant on precipitation, temperature, and nature of the soil. [42] has elaborated that a Ghanaian farmer’s adaptive capacity subject to exposure of risk and available resources also plays a crucial role in the overall productivity of the farmer. Most food crop farms are intercropped. Mono cropping is mostly associated with larger-scale commercial farms as it is currently being done under the block farms.

Economically, the smallholder farmer can be likened to an entrepreneur who makes efforts at managing his enterprise by raising capital from various sources and investing in productive assets—assets even as basic as a hoe or bicycle [38]. Risk decisions geared at making some profit are also taken by the smallholder farmer. Decisions usually come in the form of what to plant, what implements to use, how much of the harvest to keep for one's household consumption, and how much to sell [38]. These are important decisions that confront smallholder farmers daily. Smallholder farmers in Ghana as in other African countries, contribute immensely to sustaining the food basket of the country. This has contributed to a lot of efforts being made to improve and upscale their activities, especially in the face of climate change.

#### **2.4. Climatic Conditions in Ghana**

Ghana lies between Latitude 4.5°N and 11.5°N north of the equator and Longitudes 3.5°W and 1.3°E. According to the Koppen Classifications, Ghana is within the tropical climatic zone and has two main climatic seasons known as the dry season and the wet or rainy season [43]. Ghana is divided into three (3) climatic zones namely the Southern Savanna climatic belt which coincides with Northern Ghana characterized with a single rainfall season from the end of May to September and drought from mid-October to mid-May; the tropical forest in the south-west with 2 rainy seasons throughout the year – April to July and September to November and dry season August and December to February and finally the Accra Plains which coincides with the coastal savannah zone which records the least annual precipitation. The Ghanaian Agricultural sector is made up of five (5) main sub-sectors namely Crops (excluding Cocoa), Cocoa, Fisheries, Forestry, and Livestock [43].

#### **2.5. Climate Change and Smallholder Farmers in Ghana**

The fight against malnutrition, hunger, poverty, and disease in Africa has become more challenging in the face of climate change due to its effects on agricultural productivity and the bedrock of the people's livelihood [44]. [45] and [46] hint that the agricultural sector employs about 60% of the workforce and contributes an average of 30% to Gross Domestic Product (GDP) in Africa. Ghana like many other Sub-Saharan African countries has agriculture as a major contributor to the economy; however, in recent times, there has been a major decline in the contribution agriculture is making to Ghana's GDP. The Ghana Statistical Service [47] reported that the major contributor to the economy now in terms of GDP is the Services sector at 46.3% while Agriculture lags behind the Industrial sector with 19.7%. The decline in the agricultural sector's contribution to GDP is a result of a multiplicity of factors of which climatic stressors such as late-onset and early cessation of rain, increased temperature, and long periods of drought cannot be ignored. Various adaptive and coping mechanisms thus exist among smallholder farmers in order to address these challenges.

### 3. Materials and Methods

#### 3.1. Study Area

Ghana is located between Latitude 4.5°N and 11.5°N north of the equator and Longitudes 3.5°W and 1.3°E on the west coast of Africa with a total land coverage of 238,540 km<sup>2</sup>. Favorable land mass for agriculture is estimated to be 10 million ha, which is 42% of the total land of the country. Ghana has an average annual rainfall of 1187 mm, mean temperature from 26°C to 29°C and the daily ranges only some 6°C to 8°C along the coast and some 7°C to 17°C in the north. Average relative humidity ranges from nearly 100% in the south to 65% in the north. The annual water evaporation is estimated as ranging between 1350 mm in the south to about 2000 mm in the north. It has been found by [48] that the evaporation rate depends on the combination factors of water availability, vegetation cover and prevailing weather conditions, among others. The mean annual precipitation is between 1020 and 1400 mm, but there is a marked moisture deficit because of the long, intensely dry season that follows [49]. Ghana is facing climate change through: 1) increases in temperatures, 2) erratic rainfall distribution, 3) rising sea levels and 4) weather extremes and climate related disasters. According to [50], the mean annual temperature has increased 1°C in the last 30 years. Main rural income is derived from agriculture and its related activities for livelihood support. As reported by [48], bad rainfall distribution has led to crop failures, especially in the northern part of the country where agriculture is mostly practiced. The country has a population of about 29.6 million [51] and a youthful structure, with a broad base consisting of large numbers of children and a small number of elderly persons [52].

#### 3.2. Methods

This paper adopts the systematic review approach and uses both quantitative and qualitative methods. According to [53] and [54], a systemic review allows for replicability of results through the use of specific steps. [55] [56] [57] as cited in [58], shows that systematic review method generally comprises a number of formal methodological steps that a researcher follows to identify and analyze literature. These are: 1) define the research question and scope of the study, 2) document selection, including development of inclusion and exclusion criteria, 3) critical appraisal of study quality, 4) analyze and synthesize evidence, quantitative and/or qualitative, and 5) present results.

Based on this method, we selected 500 prominent climate change adaptation thematic articles published and accessible online to document adaptation of smallholders in the country. The review covers three areas, namely: 1) smallholder adaptation strategies in Ghana; 2) Challenges of smallholder to adapt to climate change and 3) Factors influencing adaptation of smallholder farmers in Ghana. Quantitative methods are used for numerical values, figures and percentages while qualitative methods focus on the meanings and interpretations of the

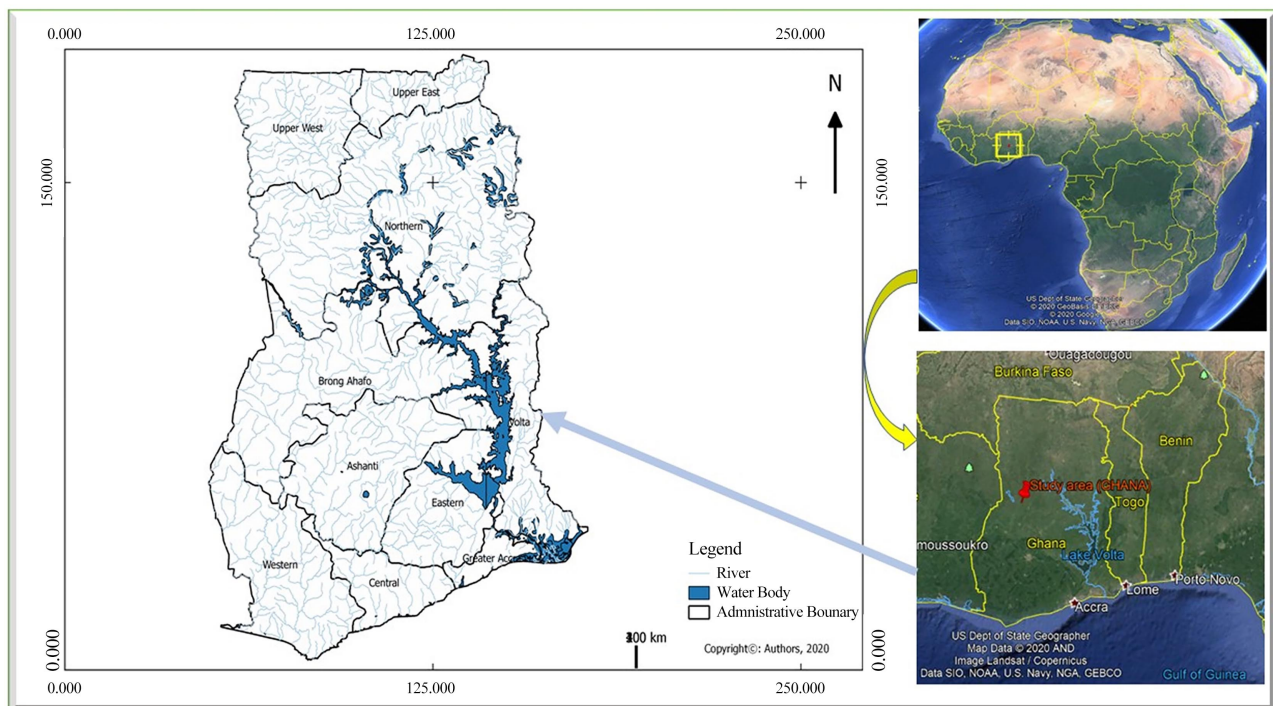
literature reviewed.

### 3.3. Data Collection

The literature search was done through the use of the academic search engine Google Scholar with keywords or sentences such as “climate change, farmers and adaptation; smallholder farmers and adaptation; smallholder farmer adaptation in Ghana”. The first step of this review had results imported into Mendeley, bibliographic management software to remove duplicates. Secondly, a decision framework adapted from [59] was created and tested to exclude sources that were not published with climate change adaptation and smallholder farmers in Ghana as focus (**Figure 1**). The second step on the decision framework narrowed down publications to articles on climate change and farmers in Ghana. All publications not within this category were excluded. The exclusion moved on to publications on climate change and smallholder farmers in Ghana. Finally, publications on climate change adaptation and smallholder farmers in Ghana were used for this review.

### 3.4. Sampling

Purposive sampling was used to sample out articles from the search results in Google scholar. An initial sample size of 500 publications or research papers were sampled within the last decade (2010-2020) on the preferred topic. Preferences were also given to articles or research papers published in high impact journals and also with high citations. This initial sample size was narrowed down to 50 based on the decision framework adapted from [59].

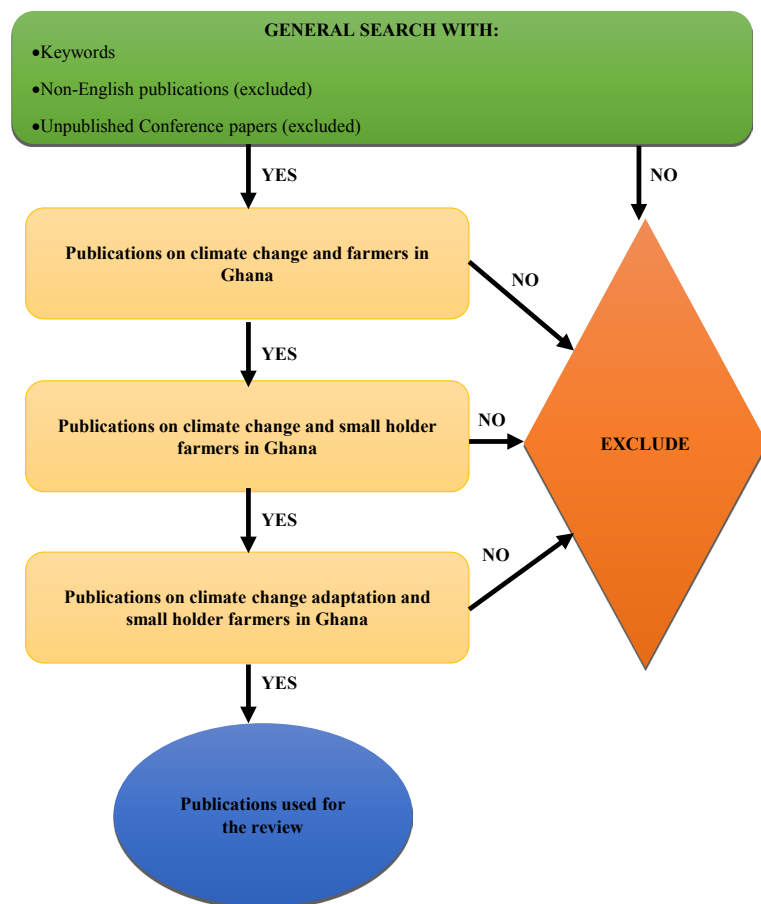


**Figure 1.** Map of study area. Source: Google Earth (2020).



### 3.5. Data Analysis

Both content and comparative data analyses were performed based on themes adopted from [60] on the classification and characterization of agricultural adaptation options specific to small-scale farmers. The methodology adopted from [60] used in the “Discussion Paper of the International Food Policy Research Institute” was found to suit the objectives of this paper as it builds on the review of selected literature on micro-level practices to adapt to climate change for African small-scale farmers. The methods used a detailed classification or characterization of agricultural adaptation options specific to small-scale farmers and came up with five categories which are not mutually exclusive (Table 1): 1) Farm management and technology (FMT); 2) Farm financial management (FFM); 3) Diversification on and beyond the farm (DBF); 4) Government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population (GIRRD); and 5) Knowledge management, networks, and governance (KMNG). The identified adaptation strategies in the literature will be put under each category. Descriptive statistics, especially frequencies are used to generate the proportion of the adaptation strategies to seek out the most-mentioned practices. Figure 2 presents a decision framework used to determine the sampled papers for this study.



**Figure 2.** Decision framework for sample size determination. Source: Adapted from [59].

**Table 1.** Categorization and characterization of adaptation strategies.

| N. | Adaptation strategies   | Characteristics  |
|----|---|--|
| 1. | Farm Management and Technology (FMT)  | FMT includes adjustments in land use and livelihood strategies that go beyond the usual agricultural practices available for coping with constantly varying biophysical and socioeconomic conditions.  |
| 2. | Farm Financial Management (FFM)   | FFM encompasses “farm-level responses using farm income strategies (both government supported and private) to reduce the risk of climate related income loss” [61] as cited in [60].   |
| 3. | Diversification on and Beyond the Farm (DBF)  | DBF comprises both nonagricultural livelihood strategies that are carried out on the farm, such as the sale of non-timber forest products, and activities deployed by farm families beyond the farm, such as petty trade or seasonal migration, etc.   |
| 4. | Government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population (GIRRD) | GIRRD refers to all the institutional responses to the risks associated with climate change. It primarily addresses issues involving infrastructure, health and public employment, and welfare programs. This category of strategy has the potential to strongly influence farmers’ risk management strategies.  |
| 5. | Knowledge Management, Networks, and Governance (KMNG)   | KMNG consists of both macro-level practices such as all sorts of practical trainings for farmers and agricultural extension officers, and such micro-level practices as the use of decision support systems and weather forecasts, wild plants and animals as bellwethers of ecosystem variability or change, and generally increased experimentation by farmers and other stakeholders. |

Source: Authors (2020), Adapted from [60].

## 4. Results and Discussion

### 4.1. Smallholder Farmer’s Adaptation Strategies

The application of the decision framework trimmed down publications treating smallholder farmers adaptation in Ghana to 30 recent articles published within the last decade (2010-2020). Based on [60] classification model, smallholder farmers’ adaptation strategies found in the literature were classified into the following five categories (which are, of course, not mutually exclusive):

- Farm management and technology (FMT);
- Farm financial management (FFM);
- Diversification on and beyond the farm (DBF);
- Government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population (GIRRD);
- Knowledge management, networks, and governance (KMNG).

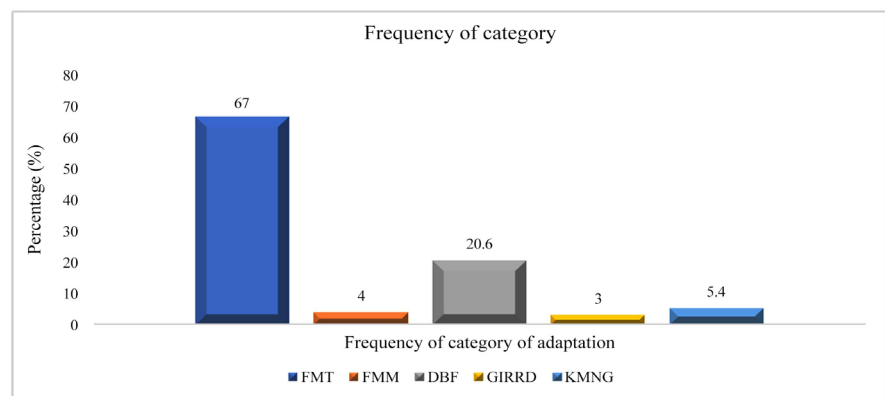
Using descriptive statistics, the adaptation strategies by smallholder farmers were found and described as follows in **Table 2** and **Figure 3** respectively. **Table 2** details the number of smallholder farmer’s adaptation strategies mentioned per each adaptation strategy. Whereas **Figure 3** shows the frequency of each category of adaptation strategy plotted in bar charts.

In term of frequency, we found that farm management and technology represents the dominant strategy of adaptation in the literature, used by smallholder farmers in Ghana with 67%; followed by diversification on and beyond the farm with 20.6%; which is followed by knowledge, management, networks, and governance 5.4%; farm financial management with 4%; and government interventions in rural infrastructure, rural health care services, and risk reduction for the rural population with 3%.

**Table 2.** Number of smallholder farmer's adaptation strategies mentioned per category.

| Category of adaptation  | Number of different strategies mentioned | Number of strategies mentioned, including multiple answers (found repetitively in many studies) |
|---|--|---|
| Farm management and technology (FMT)  | 12                                       | 87  |
| Farm financial management (FMM)   | 3  | 5   |
| Diversification on and beyond the farm (DBF)  | 11                                       | 27  |
| Government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population (GIRRD) | 2  | 4   |
| Knowledge management, networks, and governance (KMNG)   | 3  | 7   |
| Total   | 27                                       | 130   |

Source: Authors' compilation from reviewed literature (2020).



**Figure 3.** Frequency of category of adaptation strategy. Source: Authors' compilation (2020).

**Figure 3** only shows the most preponderant adaptation strategies in use by smallholder farmers in Ghana to offset the negative impacts of climate change on their livelihoods; neither is it an indicator of the relative importance of one strategy over others nor indicates the best of the strategies in terms of adaptation. Different adaptation strategies are used in different ecological, cultural settings and even farming type. Therefore, it is imperative to analyse and choose an appropriate adaptation strategy which best suits a situation. However, general lessons can be learnt from all 5 adaptation strategy categories presented by [60] irrespective of unique setting of a farmer. **Table 3** gives some details of some smallholder adaptation strategies and some practical examples for better comprehension.

Farm management and technology and diversification on and beyond the farm was found to be the most used adaptation strategies by smallholder farmers as they are farmer-centered options (solely depend on them) where farmers take up initiatives to cope with climate change impacts and sustain their livelihoods. The initiatives by the farmers do not require huge investments as their farm sizes are usually less than 2 hectares [39] [40] and as such, farmers are able to handle their home-grown farm management technology and diversification themselves. The food crop sub-sector in Ghana is held by 90% of small-scale farmers who

employ traditional methods of farming using the hoe and the cutlass as farming tools [40]. The other types of adaptation (knowledge management, networks and governance; farm financial management; and government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population) require more infrastructure and financial investments which are out of the reach of smallholder farmers' capacity. The efforts of institutions (state and non-state stakeholders in farming) are usually required in advanced farm management technology.

For clarification on the specific adaptation strategies employed by smallholder farmers in Ghana, practical examples are further discussed below.

**Table 3.** Some Details of smallholder farmers adaptation strategies.

| N. | Category                             | Adaptation Strategies                    | Practical examples found in the literature  |
|----|--------------------------------------|--|---|
| 1. | Farm management and Technology (FMT) | Diversify to indirect farming activity   | “Gari” processing and petty trading [62] [63], animal production and expansion to animal production   |
|    |                                      | Increasing farm size for food production | Expansion of farm size [64]   |
|    |                                      | Improved crop varieties                  | Use of improved crop and breeds including high yielding crops, early maturing varieties, drought tolerant and improved breeds [62] [E.g. A typical example of improved maize used by farmers is <i>Obaatampa</i> [63] and short duration crops  |
|    |                                      | Soil and water conservation techniques   | Indigenous irrigation for crops [65]: construction of mounds, ridges, bunds or drainage channels [62] [63]; mulching, small scale dam in the farm, hand dug trenches, and intentionally leaving out of big trees on the farm [66]<br>Manual digging of well in the farms for irrigation [63]<br>Farmers who farm close to water (about 46 % of the respondents) rely heavily on the water bodies for manual irrigation [63] but these water bodies dry out during the dry season.<br>Rainwater harvesting [67]<br>Zero tillage [66] |
|    |                                      | Crop diversification                     | Tree planting and agro-forestry [66]<br>Intercropping maize with cassava, cocoyam, plantain or vegetables for instance [63]; intercropping cereals with leguminous [66], especially groundnut and maize [68]  |
|    |                                      | Changing planting dates and periods      | Changing planting dates and densities [24] [64] [69] [70] [71]); early or late planting and timing of the onset of the rainy season [62] [72] Apply sawdust and other organic materials (e.g. compost) to improve crop yield, agroforestry [66] [73]<br>Bush fallow, crop rotation, [22] [62] [64]; Seed preservation, Tractor/Animal ploughing [22]<br>Integrated soil fertility management technologies [74]  |
|    |                                      | Soil and plant related strategies        |   |
| 2. | Farm financial management (FFM)      | Financing farms for sustainability       | Female farmers form groups and take loans together for capital to invest in farms. The male farm heads sell livestock to be invested in crop farming [71]   |

**Continued**

|    |   |   |   |
|----|---|---|---|
| 3. | Diversification on and beyond the farm (DBF)  | Livelihood diversification  | Petty trading, charcoal or fuel-wood, timber sales [75], temporal and permanent migration to urban areas in search of non-existing jobs [69] [76] [77] Selling of household assets, undertake alternative business [67]   |
|    |   |   | Starting fisheries, sheanut and groundnut processing. Home-garden agriculture, food stuff trading, sand mining, “table-top” or “small kiosk” businesses, wage-employment popularly called “By-Day” [68] [78] Shift towards cash crop production [E.g. cashew from [66] [79]; mangoes and cashew from [66]   |
| 4. | Government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population (GIRRD) | Farmers receive subsidized inorganic fertilizers and credits from the government, | Food vending, sale of sachet water and baking [79] Movement into animal farming/production [64] Adopting of fertilizer/pesticide application [22] [63] [68] [80]  |
| 5. | Knowledge management, networks, and governance (KMNG)   | Capacity development programs   | Capacity development in (Northern) Ghana driven by international donors focuses on knowledge and awareness and dissemination of improved technologies [e.g. the West Africa Agricultural Productivity Programme (WAAPP) [81] Information about weather patterns and agric practices for better adaptation [82]. Agric extension officers creating awareness about changes in climate [83] Education through radio [63] [67]; text messages from NGOs [67] |

Source: Authors' compilation from reviewed literature (2020).

### ***Farm management and technology***

A study by [24] identified crop diversification and shifting the planting date to be the major adaptation strategies to a warmer climate. In fact, this strategy is used by smallholder farmers in response to declining precipitation (E.g. in Sekyedumase district of Ashanti region). It has also been found by [84] that 95% of the respondents in the Bongo, Kassena Nankana West (KNW) and Kassena Nankana East (KNE) districts in north-east Ghana use changing planting dates as climate change adaptation measure. Recently, it has been noticed that, farmers have adjusted their planting dates or cropping calendar due to unpredictable weather condition. Most of the farmers have adopted this measure because of its cost-effectiveness. This measure does not need much resource (technical and financial) for adoption.

From another angle, it is been commented that northern Ghana farmers use mixed cropping and switching to the cultivation of crops like millet and sorghum that are less affected by drought stress. In the Lawra district of Ghana, for instance, 41% of farmers use crop diversification practices such as mixed crop-

ping as climate change adaptation measure [85]. Migration has been strongly used as an adaptation strategy but most of the migrants are males because of the cultural settings. Although some strategies are adopted by farmers little attention is paid to technologies such as composting and mulching, and season gardening which could help in supporting food security and improve the livelihood of farmers under climate change.

Recent findings suggest that farmers in Northern Ghana, for example, still prefer to plant traditional crop varieties—as opposed to hybrid or synthetic ones—because they are better suited to local conditions. In maize farming systems, farmers' use of the improved seed variety such as “*obatanpa*” is common [86]. This variety is appreciated by farmers due its high resistance to drought. In a recent survey, 85% of households still use local varieties of maize because they are perceived to taste better, require no fertilizer inputs and are more easily accessed and stored [87].

Particularly, it is noted that soil and plant-related strategies such as use of organic fertilizers, including compost, animal/tractor ploughing are very minimal. In fact, this could be explained by the fact that organic sector in Ghana currently occupies only 0.2% of agricultural land [88] implying minimal adoption of the practice. In addition, animal/tractor ploughing is capital intensive; hence not at reach for many smallholders.

#### ***Farm financial management***

On adaptation strategy through farm financial management, [71] assessed the preferred institutional adaptation support of heads of farm households in adapting to future projected impacts in the Guinea Savanna agro-ecological zone in Ghana. Findings showed that as a coping measure, female heads of farm households relied on village savings and groups loans as source of fund for their enterprise. The male counterparts, due to their access to other resources could offer them money for their farm needs. The resources mostly sold were livestock. Although the case presented was found in the Guinea Savana agro-ecological zone of Ghana, it is likely to be the case in the other ecological zones. Farmers forming groups for loans give them increased access to loans which help them to finance their farming challenges and therefore coping in unfavourable climatic times [24].

#### ***Diversification on and beyond the farm***

According to [89], diversification in Ghana is a strategy where smallholders manage risk and gain extra income to secure their livelihoods. Studies of [76] and [77] have both reported evidence of increase diversification among resource poor households especially those in Northern Ghana. Cropland diversification or on-farm diversification strategies are very common phenomenon among the rural households in Northern Ghana. The reason is the introduction of the fertilizer subsidy programme by the government of Ghana [80] which served as a catalyzer to pull most rural households into the farming sector [68] and venture in other types of farming. National figures from the Ghana Statistical Service al-

so signpost that 46% (3 million) of all rural households in Ghana run or own a non-farm enterprise, with women working 72% of these business ventures [90]. Women in rural Ghana especially Northern Ghana, usually initiate agro-processing businesses. Thus, women process groundnuts, sheanuts, cotton ginnery, rice and trade food stuff, whereas men often engaged in transportation services, repair services and temporal migration to the South in search of blue color job [5] [91]. [92] stressed that crop diversification is one of the traditional strategies that help farmers to cope with the effects of climate change. It is observed livelihood diversification among resource poor households especially those in Northern Ghana [68]. It has been found by [7] in four agro-ecological zones (Semi-Deciduous Forest, Forest-Savanna Transition also known as Transitional zone, Guinea Savanna and Sudan Savanna) of Ghana that 30.2% of famers use crop diversification in order to adapt to climate change negative effects on their production.

#### ***Government interventions in rural communities (GIRRD)***

Among GIRRD, access to credit in promoting climate change adaptation strategies has been seen as crucial. According to [24], increased access to credit enable farmers to purchase improved hybrid seeds (e.g. *Obaatanpa* and *Dorke* for maize cultivars), and inputs such as fertilizers to boost crop production and hence reduce the negative impact of climate change on food production. In addition, [63] found that some smallholder farmers in rural households of central region of Ghana receive inorganic fertilizers at a subsidized rate from government to enable them adapt to climate change and improve their productivity.

#### ***Knowledge management, networks, and governance.***

Access to extension services from state actors like Ministry of Agriculture is a catalyzing factor for good adaptation. It is believed that access to extension services has a positive and significant impact on adaptation to climate change [22]. In fact, farmers received advices on how to reduce the impacts of climate change on crop yield. Figures show that 10% of farmers in the country are receiving extension services [63]. Married women in the Guinea-Savannah agro-ecological zone have better access to information than their unmarried counterparts as information on weather patterns and adaptive strategies are communicated through husbands [82]. It is further asserted that men have better access to knowledge as they own radios where information on climate adaptation is channeled through and also because men travel more to towns where information is more accessible. [81] asserts that, increasing knowledge and awareness of women in the Northern region of Ghana can help for better adaptation since most women are into farming.

## **4.2. Challenges or Constraints**

#### ***Some poor and unsustainable agricultural practices***

Expansion of farm size for food production has potential implications for deforestation, which will in turn exacerbate climate change. Although this strategy seems to be common in the case studied communities, it is not sustainable as

continuous expansion of farm lands results in further clearing of the forest [79]. Moreover, the adoption of cashew crop may seem a good adaptation strategy as cashew can be suitable in the changing weather patterns because of its drought-resistant nature. However, cashew is reported by researchers to impoverish the soil; hence to have about severe consequences on food security of the farmers [93].

#### ***Socio-cultural barrier in adopting climate adaptation strategies***

As migration is considered as an adaptation option, due to the socio-cultural norms most of the migrants are male. Although women are considered among the most vulnerable group in the face of climate change and contribute significantly to household food security, they are constrained to migrate in looking for alternative source of income in order to adapt to climate change. Only males are allowed to migrate, especially in dry season to look for an alternative source of livelihood. For example, men often have the power to decide who migrates and who stays in semi-arid Ghana [67]. This is considered as a gender barrier due to socio-cultural believes threatening migration as an adaptation option by female [94]. Moreover, gender insensitive adaptation planning, gender insensitive agriculture implements coupled with traditional belief systems [67] impede on the adaptive capacity of smallholder farmers, especially women. In fact, women are often left behind when adaptation programmes are implemented. Some government-led adaptations are mostly focused on cash crops producers which are the monopoly of men (e.g. cocoa, etc.) [75].

[95] stated that, crop farming is one of the key sources of income for the majority of households in northern communities, which share common features regarding population, ethnicity and ecological problems. With regards to that, promoting strategies which go in line with farmers' livelihood improvement may probably solve most of socio-cultural, economical and even environmental issues. Moreover, indigenous knowledge consideration in adaptation implementation could contribute with significance to the cost-effectiveness and the sustainability of the technologies to be diffused. [96] stated that, it is important to understand and take into consideration indigenous perceptions of climate change and their preferences of strategies towards adaptation in Ghana although they may have some shortcoming to be corrected.

#### ***Institutional barriers***

It has been commonly believed that institutions play key roles in capacity building in the face of climate change. Most Ghanaian farmers believe that the limited institutional support is a setback to the adoption of some suitable adaptation strategies. A study conducted by [95] reported that 33% of households in northeast Ghana reported that a lack of institutional capacity to facilitate agricultural adaptation served as an important barrier. Studies of [65] highlighted the following detailed institutional challenges faced by smallholder farmers in Ghana: lack of government support in terms of relevant information on climate change, poor agricultural extension service delivery, high cost of irrigation facilities, lack of support from government, credit constraints, limited incomes, high



cost of farm inputs, land constraint, etc.

Further, statistics shows that the lack of sufficient extension coverage prevents from effective adaptation of smallholder farmers. In reality, the ratio of agricultural extension agent to farmers is 1:2500 [63]. This situation is worse in some districts in the Northern region where the ratio is estimated to be 1:3000 [97] [98].

#### ***Ecological Imbalance***

Based on the reviewed literature, it can be seen that more than 80% of the publications on climate change adaptation in Ghana is based on the northern savanna belt of Ghana [22] [68] [72] [81] [95]. The Northern savanna belt of Ghana has been a target for climate change studies due to the extreme climatic conditions being experienced in the region. However, there is an incident of similar extremes in the other zones of Ghana in recent times and it will be interesting to know the dynamics of climate change adaptation taking place in the other ecological zones [24] [75]. This is important because the generality of climate change adaptation strategies in Ghana which is mostly found in literature from the north may not suffice in the other ecological zones of Ghana.

## **5. Conclusions**

The literature on adaptation of smallholder farmers in Ghana offers a large number of climate change adaptation strategies. The review of studies covering data across Ghana revealed different practices relevant to climate change adaptation by smallholder farmers. The number of practices mentioned per study varies from one to another, but a constant remains, which is, the practices address a wide range of adjustments in the behavior of farmers, state and non-state institutions, as well as in the use and change of technologies. They comprise fundamental changes in the natural resource management system, but also more delicate and less visible tunings to ancient farming practices, such as mix cropping, intercropping and agroforestry, among others. Constraints to smallholder farmer's adaptation to climate change in the country include poor and unsustainable practices, socio-cultural barriers, institutional barriers as well as the underrepresentation of other ecological zones in adaptation studies and programs. Hence, the following recommendations could be made to address climate change adaptation issues in the country:

- The link between research institutions and the extension officers should be strengthened by the relevant institutional body;
- make agricultural extension services largely available to smallholder farmers in the rural parts of Ghana;
- dissemination of climate forecast information via suitable medias (TV and radio programs);
- Government must ensure that smallholder farmers have access to affordable credit, affordable irrigation facilities and other farm inputs;
- Climate changes adaptations strategies decision making should take into con-

- sideration gender barriers;
- Socio-cultural aspect should be factored in designing climate change adaptations strategies framework;
  - Need to promote composting, mulching and season gardening in a scalable framework (taking into consideration cost-effectiveness);
  - The focus of research is skewed to the northern part of Ghana. There is a need for more research that highlights smallholder farmer's adaptation to climate change in the other ecological zones of the country.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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