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LIVELIHOOD SUSTAINABILITY UNDER ENVIRONMENTAL CHANGE: EXPLORING THE DYNAMICS OF LOCAL KNOWLEDGE IN CROP FARMING AND IMPLICATIONS FOR DEVELOPMENT PLANNING IN GHANA

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Abstract

The relationship between environmental change, local knowledge systems and livelihood sustainability has received increased scholarly attention over the past few decades. However, the inter-linkages and emerging dynamics of knowledge systems in response to environmental change is still a grey area. This paper explores the dynamics of local knowledge systems for adapting crop farming to environmental change in the Wa Municipality, northern Ghana. The study employed a mixed methods research approach to collect data from four farming communities. Qualitative data was collected through in-depth interviews of Key Informants and Focus Group Discussions (FGDs) with women, men and youth groups involved in farming. This was complemented by a household survey that targeted 200 farmers. The results show that farmers have resorted to integration of indigenous and new external knowledge systems for diversifying crop varieties and soil and water conservation strategies for adapting crop farming to environmental change, particularly, climate change and soil degradation. Drawing on the results, the paper advocates that Development Planning (DP) should emphasize an Endogenous Development (ED) approach and promote pro-poor approaches to crop diversification and integrated soil and water conservation for achieving inclusive environmental and livelihood sustainability in smallholder agriculture in the Wa Municipality and country at large.

Keywords: Environmental Change, Livelihood, Vulnerability, Local knowledge, Adaptation

1.1 Introduction

Environmental change is an issue of global concern given its effects on livelihoods (IPCC, 2012; Asante & Amuakwa-Mensah, 2015; Derbile, Jarawura & Dombo 2016). Events such as flooding, sea level rise, melting of the glaciers, insects' infestations, deforestation, rising desertification, high temperature, rainfall variability and drought are some evidences of its manifestation (World Bank, 2010; Lolig, Donkoh, Obeng, Ansah, Jasaw, Kusakari, Asubonteng, Gandaa, Dayour, Dzivenu, Kranjac-Berisavljevic, 2014; Abdulai, Ziemah & Akaabre, 2017). These occurrences have impacted negatively on local livelihoods, especially on food crops farming (Lolig et al., 2014; Abdulai et. al., 2017). Comparatively, the adverse impacts of environmental change on food crop production is much higher in Sub-Saharan Africa (SSA), where a higher proportion of the population are engaged in agriculture production (World Bank, 2010; Antwi-Agyei, Stringer & Dougill, 2014; Abdulai et al., 2017).

In Ghana, environmental stressors such as drought, rainfall variability, flood and soil infertility are noted to have impacted and continue to impact negatively on peoples' livelihood, particularly on food crop farming, which constitutes the major source of livelihood of rural people (Samaddar, Yokomatsu, Dzivenu, Oteng-Ababio, Adams, Dayour, Ishikawa, 2014; Antwi-Agyei et al., 2014; Abdulai et al., 2017). Within Ghana, the northern part of the country is perceived much vulnerable in the advent of environmental change stressors (Samaddar et al., 2014; Abdulai et al., 2017), due to the dependence on rain-fed crop farming (Antwi-Agyei, Stringer & Dougill, 2014), coupled with the incidence of poverty (Ghana Statistical Service, 2018). Studies indicate that crop farmers in north-west Ghana are severely vulnerable to environmental change (Samaddar et. al., 2014; Abdulai et. al., 2017).

In the midst of extreme environmental events, smallholder farmers have continuously devised and utilised their own knowledge system to respond to the changes in their environment (Derbile, 2010; Gyampoh & Asante, 2011; Bawakyillenuo et al., 2014) and diversifying their cropping (Dayour et al., 2015; Abdulai et al., 2017) to adapt to climatic shocks and stressors. These responses are unsurprising because, smallholder farmers are believed to hold good knowledge of their environment and surroundings to recognize and cope with any change (Egeru, 2012; Kirkland, 2012).

At the international level, local knowledge has gained recognition (Samaddar et. al., 2014; Derbile et. al., 2016), and perceived as a strategic resource and driver of innovations for

sustainable development (Nii, Codjoe, & Burkett, n.d.; UN/ISDR, 2008; Gyampoh, Amisah, Idinoba & Nkem, 2009; Derbile, 2010; IPMPCC, 2011; Kirkland, 2012; Armah, 2012; Egeru, 2012). The Intergovernmental Panel on Climate Change (IPCC)(2007) in its Fourth Assessment Report acknowledged indigenous knowledge as an invaluable basis for developing adaptation and natural resource management strategies in response to environmental change and other forms of changes. This recognition was reaffirmed at the 32nd Session of the IPCC in 2010: justifying its usefulness for coping and adapting to environmental change. It is perceived as cost-effective, participatory and sustainable (IPCC, 2010). Besides, the Cancun Adaptation Framework (CAF), adopted by Parties at the 2010 United Nations Framework Convention on Climate Change (UNFCCC) Conference in Cancun, has as a guiding principle, the need for adaptation to be "based on and guided by the best available science and, as appropriate, traditional and indigenous knowledge" (Nakashima, et al., 2012).

Although many studies have recognized the importance of local knowledge for development, the dynamics of local knowledge and how it contributes to coping and adaptation of livelihoods under environmental change is seldom explored. Most scholarly contributions on environmental change and local knowledge in northern Ghana either focused on communities' concerns of existing risks and the adaptation measures (Samaddar et al., 2014), the impact of climate change on the livelihoods of rural people (Abdulai et al., 2017), review and projections of climate change impacts (Asante & Amuakwa-Mensah, 2015), local coping and adaptation strategies (Antwi-Agyei, Stringer & Dougill, 2014; Abdulai et. al., 2017), perceptions, causes and effects of climate change (Lolig et. al., 2014), how local calendar and climate events can inform climate change communication to farmers in rural communities (Anaafo, 2018), and an evaluation of the potentials and limitations of local knowledge for climate change adaptation (Derbile, et al., 2016).

This paper has a dual purpose. First, it explores the dynamics of local knowledge for enabling adaptation of crop farming to environmental change in the Wa Municipality of Ghana. Secondly, it examines the policy implications for Climate Change Adaptation Planning (CCAP) in the Municipality and Ghana at large. The paper is structured in five parts. The ensuing section provides an overview of environmental change and livelihood vulnerability. Section three examines local knowledge as a resource for adapting to environmental change. The study area and methodology are presented in sections four and five, respectively. Section six presents the results while section seven focuses on discussion. The paper is concluded in section eight.

1.2 Literature Review

1.2.1 Environmental Change and Livelihood Vulnerability

Environmental change is one of the daunting development challenges of the 21st Century, worsening the plight of less advanced economies, especially in the global south. Environmental change is defined as a change or disturbance of the environment caused by human influences or natural ecological processes (Johnson et al., 1997; Rosenzweig & Tubiello, 2007;). It is further perceived as the deteriorating environmental conditions that lead to environmental shocks, stressors and perturbations that negatively affect people's livelihoods. Rainfall variability, drought, deforestation, land degradation, and or soil degradation all represent environmental change (Dolman & Verhagen, 2003; Adger & Brooks, 2003, cited in Debile, 2010).

Drawing on the above definitions, this paper perceives environmental change as a negative change in the quality of the natural environment, resources and conditions induced by human activities or ecological processes that adversely affect the livelihoods of persons who depend on the natural environment for a living. The incidence of rainfall variability, drought, rainstorm, flash floods, bushfires, sand winning and charcoal burning constitute dimensions of environmental change in this regard. The impact of environmental change on livelihood is well-known globally, with West Africa being the hardest hit and the results manifested in declined food crop yields (Eguavoen; 2013; Asante & Amuakwa-Mensah, 2015).

The vulnerability of West African countries to environmental change is partly attributed to its physical and socio-economic characteristics (World Bank, 1998; Niasse et al., 2004; FAO, 2008; Molua, 2010). For instance, Lagos and Wirth (2009) posited that environmental change increases risk, particularly for those who rely on the weather patterns, soils, waters and other natural resources for their livelihoods. In West Africa, the masses (58.6%) that live in the countryside depend on rain-fed agriculture for their livelihoods (Benson & Clay, 1998; IPCC, 2012). Unlike the wealthy, these people are mostly peasant farmers who lack access to alternative services and this predisposes them to more environmental risks such as droughts, floods, rainfall variability, land degradation and deforestation, and famine (Niasse et al., 2004).

The worst vulnerability prevails in West Africa. According to the International Panel on Climate Change (2007), the adverse impacts of climate change on agriculture will occur predominantly in the tropics and subtropics and in sub-Saharan Africa. As a corollary, yields from rain-fed agriculture in some African countries are projected to fall by 50 percent by 2020 (IPCC, 2007).

This vulnerability in Africa and West Africa in particular is attributed to land degradation, low level of capital investment, population pressure, and policies that reduce farmer support services (ECA, 1989; Yaker, 1993; IPCC, 2007). The vulnerability to environmental change also affects natural and economic trees and thus, affecting women and young girls the most given that they fetch fuel wood and harvest economic trees to meet basic family needs (Niasse et al., 2004; EPA, 2011; Yaro, 2013; World Bank, 2014). Besides this, other evidence of environmental change in West Africa points to temperature. Records show that West Africa is warmer than it was in 100 years ago (Hulme et al., 2001). According to Hulme et al., (2001) warming in Africa and for that matter West Africa in the 20th Century was at the rate of about 0.05 Degree Celsius per decade, with slightly larger warming in June, July, August and September-November seasons than in December, January, February and May (Hulme et al., 2001).

The vulnerability of the economies of West African countries to environmental change is attributed to rainfall driven agriculture production, which drive their economies. Ghana's economy depends on rain-fed agriculture is similar to many other West African countries (Antwi-Agyei et al., 2012; Asante & Amuakwa-Mensah, 2015). In Ghana, about 54.2% of the country's population depend on rain-fed agriculture for their livelihoods (World Bank, 2010; Ghana Statistical Service, 2013;). Evidence of environmental change pointed to declining rainfall pattern and increasing temperature in recent times (World Bank, 2010; Cameron, 2011; Eguavoen, 2013). Annual mean temperature in Ghana is predicted to increase by 0.6 ^{o}C, 2.0 ^{o}C and 3.9 ^{o}C by the years 2020, 2050 and 2080 respectively, whilst rainfall pattern is estimated to decrease by 2.8%, 10.9% and 18.6% for the same periods (EPA, 2007; Ministry of Environment Science and Technology, 2010). The World Bank (2010) temperature projections also affirmed warming temperature over the period 2010 to 2050 in all regions of Ghana with the highest temperature in the Northern, Upper East, and Upper West Regions. Based on these projections, it is possible that, temperature in future has the tendency to causing more impairment to food crops yields in Ghana.

It is asserted that the defenceless nature of farmers in Northern Ghana to environmental stressors (drought, bushfires, flooding, etc.) is due to less available useful/profitable diversifications mechanisms, poverty and insufficient job opportunities created by state policies and globalization (Yaro, 2013; Asante & Amuakwa-Mensah, 2015). Livestock rearing previously dominated in Northern Ghana as assets and insurance for households' upkeep. However, in recent times the outbreak of livestock diseases, and declining grazing areas has resulted in decline

of the number of households keeping livestock, placing farmers in the position of captive vulnerability (Derbile, 2010; Yaro, 2013). Antwi-Aygei et al. (2012) found that the Upper East and Upper West regions of Ghana are the most sensitive in terms of exposure to drought and the effect of drought on crop yields, particularly, maize, sorghum, rice, yam and millet.

1.2.2 Local Knowledge and Adaptation to Environmental Change

Local knowledge is synonymous with traditional knowledge, traditional ecological knowledge, ancestral knowledge, indigenous knowledge, indigenous knowledge systems, indigenous technical knowledge, indigenous science farmers' knowledge, folk knowledge, and rural people's knowledge (Derbile, 2010; Kirkland, 2012; Nakashima et al., 2012). Although each term carries its own connotations, there is a substantial overlap (Kirkland, 2012). According to Nakashima et al. (2012: 29) the terms "indigenous, traditional or local knowledge' make reference to knowledge and know-how accumulated across generations, which guide human societies in their innumerable interactions with their surrounding environment". Similarly, Grenier (1998) defines indigenous knowledge as "the unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area". For this paper, Local Knowledge (LC) is used in reference to the knowledge people use in their daily life to irk a living. This knowledge system could either originate from within the community itself and/or is knowledge that originates from outside the community and is adapted to local conditions for meeting needs of local populations (Cohen & Levinthal, 1990; Derbile, 2010).

Local knowledge focuses on elements of significance for local livelihoods, security and well-being, and as a result is essential for climate change adaptation (Nakashima et al., 2012). Many studies have revealed that rural communities are using local knowledge to somewhat respond positively to climatic shocks (e.g. Chambers & Conway, 1991; Derbile, 2010; Kirkland, 2012). These responses are, in a certain sense, unsurprising, in that, indigenous communities have lived in the same environment for thousands of years, and have developed a wealth of knowledge about their surroundings (Kirkland, 2012). It is, therefore, natural that, when their livelihoods are on the touchline, they would draw on local knowledge as much as possible for irking a living. According to Kirkland (2012: 4), local knowledge is important because it adds cultural context, is often appropriate, increases community buy-in and promotes equity, efficiency, and the environment and finally, because it increases communication and understanding. Kirkland

(2012) views the importance of traditional knowledge in climate change adaptation effort in two specific ways. First, those indigenous communities can help scientists understand current and expected climate change impacts. Second, that indigenous knowledge can provide the tools for managing climate change. Thus, indigenous knowledge in the form of weather prediction strategies, crop varieties, agricultural practices, water storage methods, building techniques and so on can help communities maintain their quality of life even in the face of climate change impacts. Nyantakyi-Frimpong (2013) also asserts that the incorporation of indigenous knowledge in climate change adaptation policies would make programmes cost effective, participatory and sustainable.

This paper draws on the Sustainable Livelihood Approach (SLA) of Chambers and Conway (1991) as an overarching theoretical framework for exploring the role of local knowledge for adapting livelihoods to environmental change. According to them, "livelihood comprises of capabilities, assets (tangible and intangible) and activities required for a means of living" (Chambers and Conway, 1991:9). Chambers and Conway asserted that, livelihood sustainability is socially and environmentally embedded. Thy argue that a livelihood is socially sustainable when it is able to withstand shocks and stressors and maintains its assets and access, and environmental sustainable when the livelihood of the people can uphold and boost local assets in which the livelihood of the people depends on. Hence, both the social and the environmental elements are crucial for sustaining the livelihoods of smallholder farmers under environmental change.

Local knowledge is conceptualized as an intangible asset of livelihood which smallholder farmers draw on to adapt to environmental change stressors and shocks. The pioneering work of Chambers and Conway (1991) has been acknowledged and or extended in several other applications (Downie, Dearden, & King, 2016; Derbile, 2010; Downie et al., 2016; Olivier, 2018; Apine, Turner, Rodwell, Bhatta, 2019; Bhushan, Singh, Telidevara, & Kumar, 2019; Su, Wall, Wang, & Jin, 2019). The SLA has been adapted in the following studies: analysis of livelihood sustainability of small-scale fisheries (Downie et. al., 2014) and smallholder farmers (Olivier, 2018; Bhushan et al., 2019), livelihood sustainability of residents in rural tourism communities (Su et. al., 2019), and local knowledge and livelihood sustainability under environmental change (Derbile, 2010).

This paper draws on an integrated analytical framework (Figure 1) that integrates local knowledge and environmental change into the SLA approach (Derbile (2010). Environmental

change is taken as the starting point and local knowledge an asset for moderating environmental shocks, stressors and perturbations, especially in crop farming. Environmental change, as in deforestation, land and soil degradation, and rainfall variability adversely impact livelihoods as in Northern Ghana and elsewhere. In this framework, environmental change and its associated shocks, stressors and perturbations may trigger instability of local livelihoods requiring response to adapt to the change. The framework posits that households devise ways of dealing with these risks in their livelihoods by drawing on their local knowledge systems coping and adaptation.

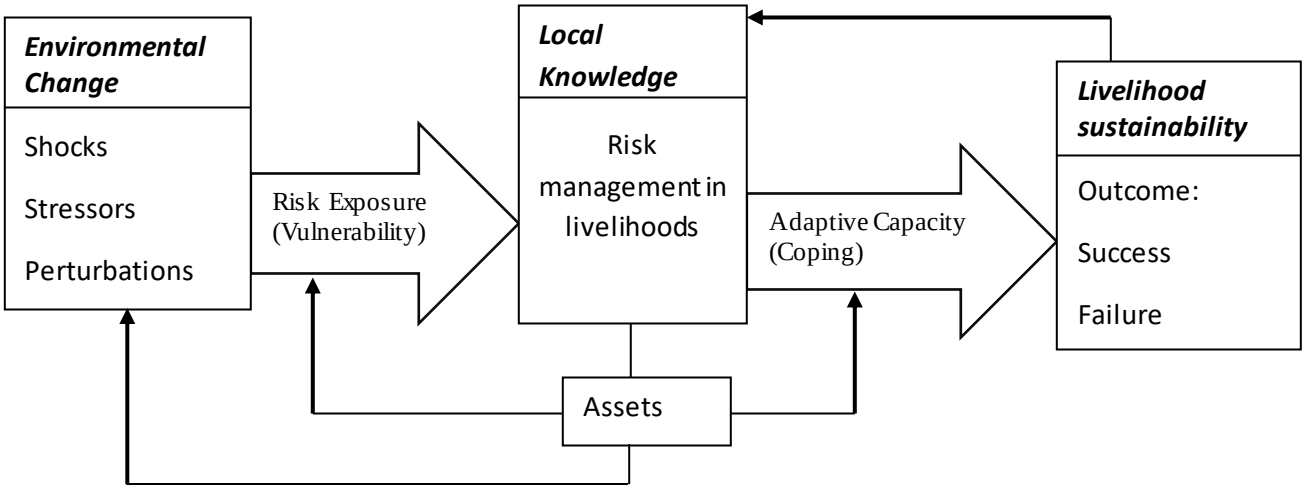

Figure 1: Conceptualizing environmental change, local knowledge and livelihood linkages (Adapted from Derbile, 2010).

In this context, households may draw on wide ranges of localized farming knowledge systems and techniques, strategic management of productive assets and kinship and social mechanisms of support to adapt to environmental change (Derbile 2010). Chambers and Conway (1991) underscored the importance of local knowledge systems in irking a livelihood. They asserted that the ability of farmers to cope or adapt to environmental change stressors and shocks depend on the adaptive capacity, thus, the magnitude of the risks or level of exposure to the risk, and the assets available (tangible and intangible assets) for managing their livelihoods in the midst of the shocks and stressors. However, the outcomes could either be successful or a failure to the households involved. In this context, its outcome becomes a success where the households or farmers involved are able to withstand shocks and stressors and maintain their access and assets to sustain livelihoods and a failure, the inability to sustain livelihoods due to the environmental stressors (Derbile, 2010). This process is cyclical and continuous, enabling households and farmers to draw on lessons of their experimentations with local knowledge systems and alter

such knowledge applications if necessary, for the purpose of constantly improving capacity for adaptation to environmental change.

1.2.3 Study Area

The Wa Municipality is one of the eleven (11) District/Municipal Assemblies that make up the Upper West Region (UWR) of Ghana (Figure 2). The Municipality shares administrative boundaries with Nadowli District to the North, Wa East District to the East and South, and Wa West District to the West and South. It lies within latitude 9º32′ to 10º20′N and longitude 1º40′ to 2º45′W, with an area of approximately 234.74 square kilometres, about 6.4% of the region's land area (Wa Municipal Assembly, 2010). According to the 2010 Population and Housing Census (PHC), Wa Municipal has a total population of 107, 214, with 50.6% being females while the rest were males (Ghana Statistical Service, 2013). The majority (66.3%) of the population live in Wa, the only urbanized town in the Municipality (Ghana Statistical Service, 2013). The Municipality lies in the Savannah high plains, which is generally, gently undulating with an average height of 160m to 300m above sea level (Wa Municipal Assembly, 2010). The gentle rolling nature of the landscape implies that the topography is suitable for agriculture. The soil type in the Municipality is largely that of the Savannah ochrosols, shallow texture but supportive of the growth of a variety of crops including millet, sorghum, maize, rice, cowpea and groundnut.

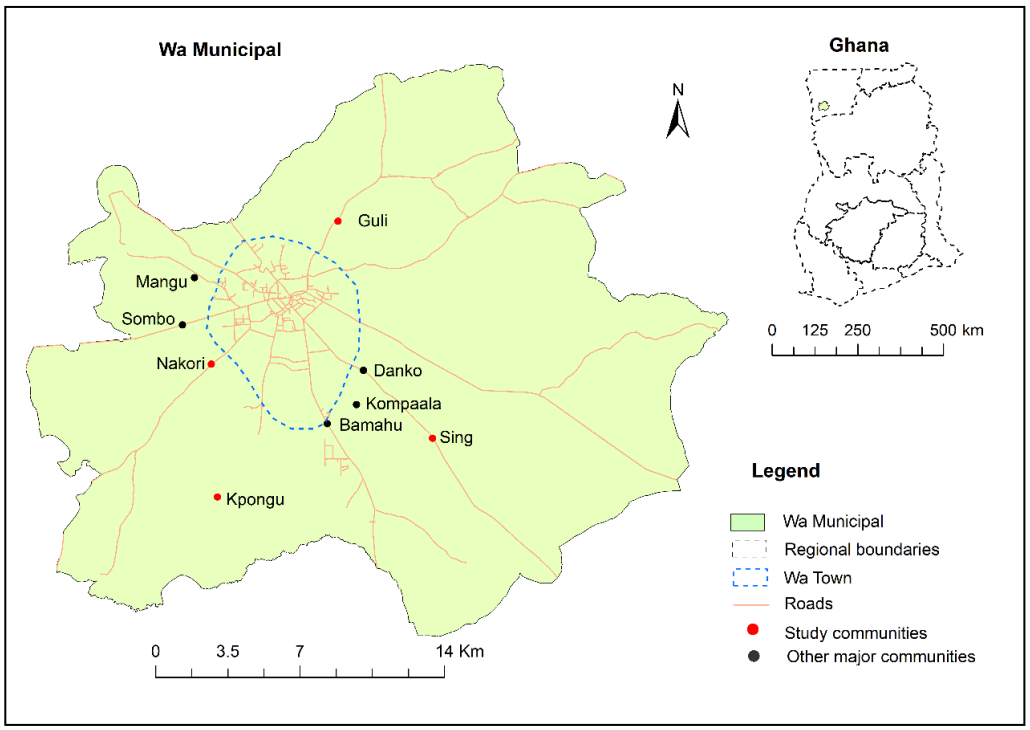

Figure 2: Location of study area
Source: Wa Municipal Assembly (2010)

The vegetation type in the Municipality is Guinea Savannah grassland. It is made up of short trees with little or no canopy and shrubs of varying heights and luxuriance. Commonly occurring economic trees are Shea, Dawadawa, Kapok, teak and Baobab. Cashew and Mango are exotic species, which also grow well in the area. The Municipality is located in the tropical continental climate with two main seasons - wet and dry seasons. The South-Western Monsoon winds from the Atlantic Ocean bring rains from May and September, whilst the North-Eastern Trade winds from the Sahara Desert bring the long dry season from October to April. The mean annual rainfall varies between 840mm and 1400mm (Wa Municipal Assembly, 2010). Most of the rainfall occurs, between June and September, and is generally low and unreliable. The long dry season and the erratic rainfall pattern hinder year-round farming.

Subsistence agriculture is the main source of livelihood in the Municipality. It is relied on by 70 to 80% of the population (UNDP, 2011), with the major activity being crop farming. Food crops, farmers cultivate include millet, sorghum and maize, yams, groundnuts, rice and beans (GSS, 2014). Besides crop farming, many households are also into livestock rearing with few into fish farming. Farming is largely done with hoe and cutlass. Very few farmers can afford the use of tractors or even animal traction (UNDP, 2011). Agriculture in the Municipality is rain-fed.

Over the years, human activities have contributed to environmental degradation and change. Poor farming practices, rapid infrastructural development, bush burning, cutting of fuel wood overgrazing, mining, global pollution of the ecosystem and over exploitation of the natural reserves have combined to bring about environmental change. In 2007, 2008 and 2009, floods inundated homes, crops and property in several parts of the Upper West Region including parts of the Wa-Municipality (Wa Municipal Assembly, 2010). The major environmental changes in the Municipality that are putting a strain on livelihoods are drought, high sunshine, flood, rainfall variability, desertification and erosion.

1.3 Methodology

The study adopted a mixed method research approach to explore the dynamics of local knowledge in crop farming under environmental change. This approach was found useful for building complementarity, synergy and triangulation of results (Creswell; 2009; Schoonenboom and Johnson, 2017). The Wa Municipality was purposively selected due to the increasing incidence of floods, rainstorms and droughts in the past five years. The study was conducted in

four (4) out of 30[1] farming communities in the Municipality as part of a project implemented in the Municipality, the Research for Resilience Preparedness Programme. The four communities, comprising Nakori, Kpongu, Guli and Sing (Figure 2) were selected through simple random sampling and the limit to four was part of the project design.

Primary data collection was organised in two phases in line with sequential mixed research method (Berman, 2017). The first phase involved a qualitative study in June 2016[2], followed by a household survey[3] in July 2017. The qualitative study was conducted in Nakori and Kpongu as part of project design. Qualitative data was collected through in-depth-interviews of key informants (Assembly members, chiefs, earth priests, chief farmers and women leaders) and Focus Group Discussions (FGDs) with already existing farmer groups as follows - adult males (> 35 years), adult females (>35 years) and youth (25-35 years). In all, fourteen (14) in-depth interviews and six (6) FGDs were conducted in the two communities. FGD guide and interview schedule were used to guide the interviews and FGD sessions, respectively. These sessions were recorded using audio recording devices, transcribed and manually analysed through identification of keywords, patterns and relationships.

A household survey, aimed at generating basic descriptive statistics on the application of local knowledge systems for adaptation was also conducted. Findings from the qualitative phase informed the design of the survey instrument. The survey was conducted among 200[4] farmer-households across all four sampled communities (Nakori, Kpongu, Sing and Guli). The 200 farmer-households were distributed proportionally across the four communities in relation to the total number of farmer-households in each community. The number of farmer-households selected in Nakori, Kpongu, Sing and Guli were 95, 49, 31 and 25, respectively. The population and the number of households in all four communities informed this distribution. Simple random sampling was applied for sampling households and farmers (respondents) from each household (male and female farmers). Interview schedules were administered to farmers in local language (Waali/Dagaare) by trained research assistants due to the high level of illiteracy in the study area.

[1] Ghana Statistical Service (2014)

[2] Sponsored by the Research for Resilience Program (R2R2)

[3] Sponsored by Endogenous Development Service (EDS), a research and consultancy firm

[4] This represents about 30% of farmer households in all four selected communities

About two-third (64%) of farmers who participated in the household survey were males while the remaining one-third were females. Also, a majority (86%) of respondent farmers were married. Four out of every 10 farmers who participated in the study were at least 40 years old. The study benefited from the lived experiences of farmers. A majority (64%) of the respondents did not have formal education while 36% had basic education. The survey enabled collection of socio-demographic data on farmers and local knowledge systems of cropping and adaptation. The data was analysed using SPSS.

1.4 Results

1.4.1 Adaptation Strategies of Farmers in Crop Farming

The results of the study revealed that crop farmers in the Wa Municipality over the past two decades have employed diverse strategies to adapt to environmental change in crop production. These strategies broadly include (i) local knowledge systems of crop diversification and (ii) local knowledge systems in soil and water conservation for crop production.

1.4.2 Crop Diversification Strategies for Climate Change Adaptation

Crop diversification was identified as the main strategy for adapting crop farming to environmental change, especially, climate variability. These diversification strategies include the adoption and cultivation of early maturing new crop varieties and sustaining the cultivation of drought resilient indigenous crop varieties. The results from all study communities reveal that the duration of rainfall has reduced. Thus, the rainy season, which used to last for seven months (April to October) four decades ago now last four months (June – September), sometimes even shorter. Farmers have therefore altered their local production systems by resorting to the adoption and cultivation of new crop varieties that have the ability to mature within three (3) months. Major among them are *kamabile* (a 70-day maize variety), *Genbile* (a three-month groundnut variety) and *Omongdoo* (a new bean variety). The Earth Priest of *Kpongu* in an in-depth interview stated how local knowledge in crop production has been altered to adapt to environmental change as follows:

> The duration of rainfall for the past decade has reduced drastically. Three decades ago, rains lasted from April to early November…but these days, rains start sometime in May and stop in early September. So, if you cultivate our traditional maize, guinea corn and

> millet, which needs about 4-5 months to mature, you will reap nothing…very few households still cultivate the traditional crops varieties. We now cultivate new and early maturing crop varieties which mature in two to three-months, especially maize [white maize] and guinea corn. Such changes in our choice of crop varieties is helping us adapt to reduced length of the raining season. At least some harvest for consumption is guaranteed.

Furthermore, FGD discussants in *Kpongu* revealed their exposure to risk and how they are adapting in the following statement:

> The rains no long support the cultivation of traditional crops, which were bequeathed to us by our forefathers…we have resorted to the cultivation of new crop varieties, which have the ability to mature within two (2) to three (3) months. These crops include new crop varieties of beans, maize and yam.

FGD discussants in *Nakori* also affirmed the cultivation of early maturing new crops, especially, maize, beans and vegetables due to variability in rainfall. A discussant stated as follows:

> We have all stopped cultivating the old crops (meaning indigenous crop varieties) that have a long maturity duration… we now depend on new and shorter maturity duration crops which the Agriculture Extension Agents (AEAs) and other organizations to supply to us for production. Those ones mature early, before the rains stop completely.

In *Kpongu*, a key informant (the Earth Priest) showed how farmers are using various methods to adapt to environmental change in their communities. He stated as follows: "It is drought that is affecting our production. So, we grow different varieties of crops against crop failures. We all use improved variety of crops, referring to early maturing crop varieties".

The results from the survey corroborate results from FGDs and KIIs. From the survey, majority (73%) of farmers have adopted the cultivation of early maturing new crop varieties as an adaptation strategy to rainfall variability (Fig. 3).

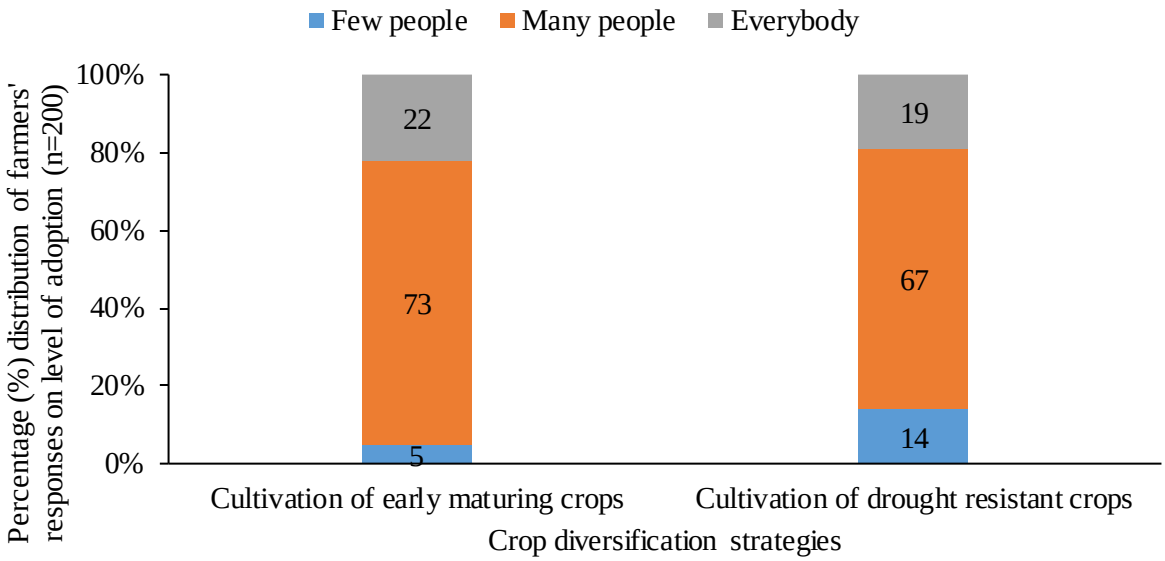

Figure 3: Level of adoption of crop diversification strategies

Another crop diversification strategy is the cultivation of drought resistant crops**.** It was reported in FGD sessions that; the rainy season has not only reduced in length but that it's also characterized by intermittent droughts. In Kpongu, FGD discussants lamented that environmental stressors were major impact factors in food crop farming:

> For the past ten years, droughts, floods and rainstorms have become perennial events…this year's drought (that is 2016) is the severest of all. It started raining in April and so we planted cops by end of May…. thereafter, there was a prolonged drought. Our groundnuts, beans and maize we planted wilted because of the drought. Even yam, the most drought resilient crop could not survive the drought. The only way out was to replant if the rains resume.

To adapt, some farmers have sustained the cultivation of drought resistant indigenous crop varieties such as *Kazie* (millet variety), and *Ponaa* and *Larboko* (yam varieties) as part of an inherited tradition and local knowledge passed down from generation to generation. From the survey, majority (67%) of farmers and their households have sustained cropping of drought resistant indigenous crop varieties for adapting to climate change and climate variability (Fig.1). Further analysis of the survey results shows that majority of farmers (50% to 82%) have adopted early maturing crops and drought resistant crops for adapting crop farming to climate change regardless of age, gender and educational levels of respondents.

1.4.3 Soil and Water Conservation for Climate Change Adaptation

The results further showed that a range of soil and water conservation measures are employed by farmers to adapt cropping to the adverse effects of declining soil fertility, high temperature, high sunshine and drought on food crop production. They include the use of agro-chemical fertilizers, manure and compost and ridging.

First, the application of little quantities of agro-chemicals especially, fertilizer was high among farmers. These include the application of fertilizer, weedicides and pesticides. From the survey, 65% of farmers reported the use of agro-chemicals in farming (Figure 4). Due to continuous tilling of land, many farm lands have lost their nutrient, and thus unable to support the cultivation of cereals, root tubers and vegetables. To address this, farmers have found fertilizer to be very useful in improving soil nutrient and increasing crop yields, especially, early maturing crop varieties. They have found the use of weedicides, insecticides and pesticides very useful in controlling weeds, insects and pest, respectively. Although farmers affirmed the effectiveness of agro-chemicals in increasing yields, they lamented that they are expensive and out of reach for many of them. In an FGD session, male farmers at *Kpongu* narrated how they are adapting to poor soil fertility:

> Before you can get good yield from your farm these days, you have to apply chemical fertilizer on the farm. In this community, almost every household buys fertilizer. The land has lost its fertility… it is no more fertile as it used to be…now if you don't have money to buy fertilizer to apply on your crops, then forget of good yields. You will either harvest nothing or some little yield. Therefore, what we do these days is to sell livestock and use the returns to purchase fertilizer for supporting crop production.

Secondly, majority of farmers (51%) also apply organic manure and compost in cropping as a means to adapting cropping to climate change (Figure 4). Due to the high cost of agro-chemicals, some farmers resort to the use of animal droppings (cattle, sheep and goats) and household waste as an alternative means to improve soil fertility for crop production. Some farmers also make compost from residues of leguminous crops.

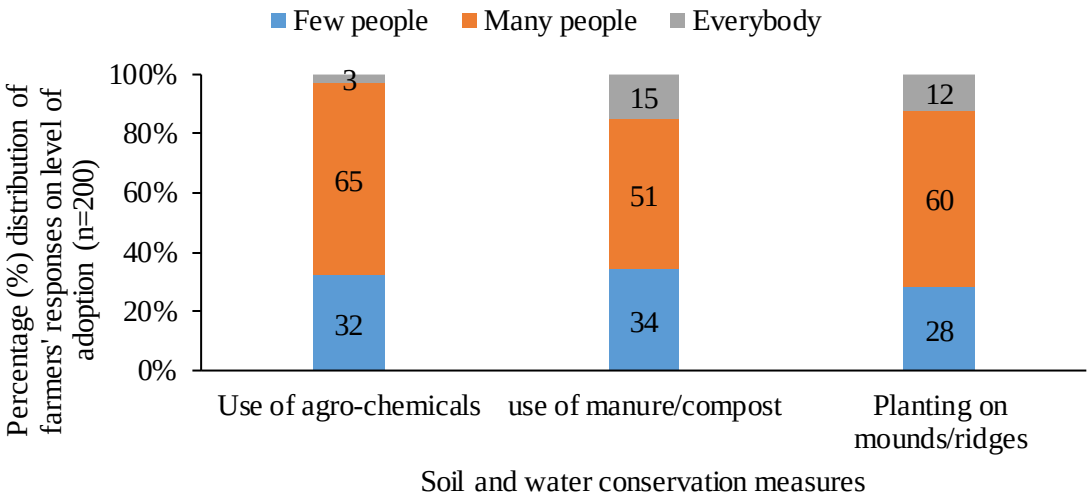

Figure 4: Level of adoption of soil and water conservation measures

From the focus group discussions, most male discussants reported that, manure and compost are their means of soil conservation for sustaining crop production. It was also revealed that, with the exception of leguminous crops, all other crops needed organic manure or fertilizer in order to secure a good yield. The youth of *Kpongu* highlight this issue in an FGD session:

> The land and soils have lost its fertility these days. However, with fertilizer you can secure a good harvest…because we don't have money to buy enough chemical fertilizer, we usually complement that with compost and manure from household refuse and leguminous crops. The local manure prepared using cow dung is the best for the soil…. we also prepare compost-using leguminous crop residues.

Majority of farmers (60%) farmers also use mounds and ridging as a soil and water conservation measure in crop cultivation (Figure 4). According to farmers, ridges/mounds help conserve moisture for crop growth, especially, during dry spells. It was revealed that, root tubers and leguminous crops such as yam, groundnuts, bambara beans, sweet potatoes and cassava yield very well when planted on mounds/ridges because the soil is usually loose for easy development of the tubers and roots. In an interview with the Chief of *Kpongu*, he explained changes in planting method due to the high incidence of drought in recent times:

> Some 50 years ago, our fathers and grandfathers could just clear the land and plant on the bare land and yet they will harvest bountifully. The land was fertile and rainfall consistent and sufficient too. However, due to continuous farming, many lands and soils have lost

> their fertility. The situation is further exacerbated by erratic rainfall. These days, drought in the rainy season can last as long as three weeks, and anytime there is long period of drought, crops planted on the bare ground wither. However, if they are planted on mounds and ridges, they survive because some moisture is conserved to support crop growth. This is how important mounds and ridging are in our efforts at adaptation.

It was reported that, floods compared to those planted on the bear ground do not easily destroy crops planted on mounds/ridges. Accordingly, this practice was not common about 50 years ago. Its adoption among farmers is driven by the need to adapt crop farming to environmental change, particularly, poor soil fertility and climate change.

Further analysis of survey results show that majority of farmers have adopted the application of chemical fertilizer, organic manure and plant on mounds/ridges as soil conservation measures for adapting crop farming to environmental change regardless of age, gender and educational levels of respondents. For instance, between 54% and 75% of respondents of age categories[5] reported application of chemical fertilizer, with older respondents reporting more the practice in crop farming than younger age group. Similarly, between 68% and 75% of respondents reported the practice of chemical fertilizer application in cropping for adaptation considering educational level. More respondents with higher education (secondary and tertiary) have adopted the practice more than farmers without any form of formal education, although the latter are still in the majority. Similarly, between 51% and 75% of respondents practice planting on mounds and ridges across different age groups, with the older farmers reporting the practice more than younger farmers. The level of education did not have significant effect on adaptation of mounds and ridging for planting. The percentages range from 50% (farmers without formal education) to 64% farmers (with tertiary education).

[5] Age groups 20-29; 30-39;40-49 and 50+.

1.4.4 Discussion

The key observation is that farmers in the Wa Municipality have resorted to diversification in crop and soil and water conservation strategies for adapting crop farming to environmental change and stressors such as rainfall variability, drought and soil degradation.

In the area of crops, farmers have shifted away from the cultivation of only indigenous crop varieties that have long maturity duration. Instead, they have resorted to the cultivation of a mix of drought resilient indigenous crop varieties and new and early maturing crop varieties to adapt production to a drying trend in the climate. Hence, it's not a question of choice between the two streams of crop varieties. Rather, the evidence points to diversification of crop portfolios in which farmers maintain a fairly balanced mix of indigenous and new crop varieties for minimizing risks to environmental change in crop production. Thus, this contrast literature that reports widespread adoption of early maturing crops among farmers in Northern Ghana as a means to adapting to changing environmental conditions. For instance, Gyampoh & Asante (2011) reveal that farmers in Northern Ghana have responded to the impacts of reduced rainfall regime and increased temperature by adopting the cultivation of early maturing food crops, with limited interest for traditional crop varieties. They noted that, the "obaatanpa" variety of maize, "supieh" (white beans) and white guinea corn are the preferred choice for cultivation due to their short time maturity period. Similarly, Bawakyillenuo et al. (2014) reveals that, farmers in the Upper East Region have shifted from the cultivation of late maturing maize varieties to 3-month early maturing maize and white cowpea varieties in response to reduced rainfall duration.

The findings further reveal that farmers have also resorted to Integrated Soil and Water Conservation (ISWC) for enhancing the adaptation of crop farming to environmental change. These measures include the application of chemical fertilizer, organic manure and compost and planting on mounds and ridges. Again, the evidence suggests that farmers have resorted to diversification of these strategies for sustaining production. Thus, it is not a question of choice between the three main strategies of soil conservation. Rather, one farmer may combine two or all three methods of soil and water conservation methods for supporting crop production in one season depending on his/her resourcefulness. The literature reveals that the kinds of fertilizers farmers use include NPK, SA, UREA and organic, and the application of these inputs improve crop yield (UNDP, 2011), although it also degrades the soils and environment if not well managed. In recent times, many farmers are oriented to applying fertilizer to improve crop

yield although they are unable to apply enough and or significant quantities due to the financial constraints. According to Bawakyillenuo et al. (2014) in their study in Wa East District, farmers are unable to acquire enough fertilizer for their farms due to financial constraint. Consequently, poor farmers also resort to the use of other methods such as compost and manure and ridging. Though inorganic fertilizer is less costly, it is difficult to produce enough quantities for application.

The results support the adapted SL framework (Figure1) proposed by Derbile (2010) that livelihood outcomes of smallholder farmers are an expression of the relationship between environmental change and local knowledge in crop farming. Local knowledge systems are expressed through carefully thought through diversification strategies in risk management that minimize exposure to environmental stressors on one hand and thus on the other hand, enhance adaptive capacity for enabling smallholder farmers irk a living within the context of a constrained environment.

Smallholder farmers maintain a diversified portfolio of risk management strategies in crop production, comprising both indigenous knowledge systems (knowledge from within) and new knowledge systems (external knowledge adapted to local applications) expressed through diversification in crop varieties and soil and water conservation methods. This is also reflective of the willingness of people to change and experiment with new resources and knowledge, and thus, reflective of the dynamic nature of local knowledge systems for meeting needs of local populations in a changing environment (Cohen & Levinthal, 1990; Derbile, 2010; Ajani, 2013). In this context, the key need for the local population is environmental sustainability for sustaining livelihoods from farming.

The environment is a life support system for humanity. It provides food, shelter, air and other forms of livelihoods. This underscores the need for environmental sustainability, a concept traceable to the publication of the Brundtland report – 'Our Common Future' in 1987, which emphasized sustainable development as one that meets both the needs of present and future generations through sound management of resources and abilities (Brundtland Commission, 1987). Although this perspective of sustainable development bears relevance to the subject of this paper, the concept of environmental sustainability as expressed by Morelli (2011), is more apt in this context. He describes environmental sustainability as a condition of balance and resilience through interconnectedness in human society that enables meeting its needs in a

manner consistent with maintaining biodiversity, its capacity and regenerative potential and services for supporting livelihoods. Thus, in the application of local knowledge systems in smallholder agriculture, the ultimate goal is to achieve environmental sustainability, through preservation and improvement of productive capacity (DFID, 1999), conservation, enhanced regenerative capacity and products and services that contribute to environmental sustainability (Morelli, 2011).

1.4.5 Conclusions and Policy Implications for Development Planning

The study explored the application and dynamics of local knowledge systems for adapting food crop farming to environmental change in the Wa Municipality. The paper concludes that farmers have resorted to integration of indigenous and new (external) knowledge systems for diversifying crop varieties and soil and water conservation strategies for adapting farming to environmental change, including climate change and soil degradation. While the paper supports evidence that farmers are adopting new knowledge systems, as in the adoption of new crop varieties and application of chemical fertilizer in smallholder production, the paper concludes that this is done in tandem with the application of indigenous knowledge systems of production, as in the production of drought resilient indigenous crop varieties and soil and water conservation methods.

The paper advocates that, Development Planning (DP) should build on the strengths of local knowledge systems, emphasizing an Endogenous Development (ED) approach and particularly, promoting pro-poor and green interventions for enhancing environmental sustainability of smallholder agriculture in the Wa Municipality and Ghana at large. The results have two main policy implications for development planning. First, policies and programmes that support farmers' adaptation efforts to environmental change should promote crop diversification. In this regard, the policy objective should be to promote access to seeds of early maturing crop varieties, promote conservation and or improvement of drought resilient indigenous crops. Secondly, the paper advocates the promotion of Integrated Soil and Water Conservation practices, particularly, green approaches, for enhancing inclusive adaptation capacities among smallholder farmers. Innovations in extension support as a cross-cutting intervention and through a community-based approach can enhance adaptive capacities of farmers and improve environmental and livelihood sustainability.

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