OPEN ACCESS Int. J. Agr. Ext. 10 (02) 2022. 361-376 DOI: 10.33687/ijae.010.02.4187

Check for updates

Available Online at EScience Press Journals

International Journal of Agricultural Extension

ISSN: 2311-6110 (Online), 2311-8547 (Print)

http://www.esciencepress.net/IJAE

BUILDING CLIMATE RESILIENCE THROUGH THE ADOPTION OF CONSERVATION AGRICULTURE IN GHANA: THE FAO'S SHARP+ APPROACH

[a]Padlass P. Edeafour, [b]Aad Kessler, [c]Suzanne Philips, [d]Enoch K. Tham-Agyekum

[a] *Soil Research Institute, Council for Scientific and Industrial Research, Kwadaso-Kumasi, Ghana.*

[b] *Department of Environmental Sciences, Soil Physics and Land Management Chair Group, Wageningen University and Research, Netherlands.*

[c] *Plant Production and Protection, Food and Agriculture Organisation, Rome, Italy.*

[d] *Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.*

ARTICLE INFO

Article History

Received: March 06, 2022

Revised: June 18, 2022

Accepted: June 30, 2022

Keywords

Adoption

Climate Change

Conservation Agriculture

Farm system

FAO'S Sharp+

Motivation

Resilience

ABSTRACT

Building farm system resilience through the adoption of conservation agriculture (CA) is seen as a panacea to tackle the problem of climate change, environmental degradation and population growth because family farmers, whose livelihoods depend largely on rainfed agriculture, are constantly living in near crisis conditions. The FAO's SHARP+; the 'Self and Holistic Assessment of climate Resilience of farmers and Pastoralists' tool, was used to assess the resilience of farmers who were trained in conservation agriculture, as part of a food and nutrition security enhancement project. Results showed that trained farmers were generally more resilient in comparison to their untrained counterparts. Full-scale adoption of the CA technique was however found to be lacking, primarily due to the absence of intrinsic motivation on the part of the farmers. A strong and positive correlation was found to exist between intrinsic motivation and adoption, whilst adoption itself had the same relationship with resilience. The study recommends a stimulation of farmers' intrinsic motivation to foster better uptake of conservation agriculture, which will in turn strengthen their farm system resilience.

Corresponding Author: Padlass P. Edeafour

Email: pe.patrick@csir.org.gh

INTRODUCTION

Family farmers hold unique potential to become key agents of development strategies. Family farming is the predominant form of food and agricultural production in both developed and developing countries, producing over 80 percent of the world's food in value terms (FAO, 2014; Graziano, 2014). However, the interaction between climate change trends and social conflict on one hand and smallholder agriculture on the other is constantly threatening the livelihoods of these food producers (Douxchamps *et al.*, 2017). This is especially so in sub-Saharan Africa as large numbers of people whose livelihoods depend on rain-fed agriculture are most vulnerable to, and at risk from climate impacts (Dixon *et al.*, 2001; Choptiany, Colozza*, et al.*, 2016). Dixon and Stringer again reiterate that these groups of farmers are in most cases poor and often lack the robust systems and resources needed to cope.

Climate change and variability have thus increasingly become concerns in the context of development due to their potentially far-reaching impacts on human development (Choptiany, Phillips*, et al.*, 2016; Molina-

Murillo *et al.*, 2017). This is a result of rising greenhouse gas emissions, leading to loss of freshwater resources, erosion of topsoil, and general degradation of ecosystem services that are further undermining the ability of humans to meet their nutritional needs (Cabell and Oelofse, 2012). Again, the effects of climate change in sub-Saharan Africa and Ghana have been reported by Kuuzegh (2007) as well as Adjei-Nsiah (2012). They conclude that a 40-year climate data (1960 – 2000) showed a positive and visible rise in temperature with an accompanying decline in rainfall across all agro-ecological zones. These climate trends have impacted the patterns of agricultural production, especially in the Forest – Savanna agroecological transition zones. It is further thought that land degradation, increasing mismatch between water demand and supply and as a result, decreasing agricultural productivity, as well as subsequent changes in livelihoods, is expected to be rampant in rural areas of West Africa (Kuuzegh, 2007; Adjei-Nsiah, 2012; Callo-Concha and Ewert, 2014).

In recent times, the concept of resilience has also emerged as the flagship objective for policies and programmes aimed at development worldwide (ODI, 2015a; Douxchamps *et al.*, 2017). According to Cabell and Oelofse (2012), the primary purpose of assessing resilience is to identify vulnerabilities in social-ecological systems so that action can be taken to create a more sustainable future for people and their environment. Although, there has been a lot of ambiguity as to the exact definition of resilience (ODI, 2015a); Douxchamps *et al.* (2017) with insights from the IPCC (2012) working definition; describe it in the context of climate change as the 'ability of a system and its components parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner'. Strengthening agro-ecosystem resilience has been identified as a key and cost-effective development objective to tackle climate change challenges (Choptiany, Phillips*, et al.*, 2016) to promote food security, and alleviate poverty as well as to sustainability manage and conserve natural resources (Cabell and Oelofse, 2012).

According to a report by the Israel's Trade and Economic mission to Ghana (2020), agriculture contributes 19.7% of Ghana's current GDP, accounts for over 30% of export earnings and serves as a major source of inputs to our manufacturing industry. In 2019, 33.5% of labour force in Ghana was absorbed by the agricultural sector. Agriculture is the second largest employer in the economy but the smallest sector in comparison to services and industry. The agriculture sector grew from 2.9% in 2016 to 6.1% in 2017, recorded a growth of 4.8 in 2018 and grew at 6.9% in 2019. The agriculture value added that is the net output of the sector from 2018 is 11.98 billion USD. As so, agriculture is viewed by many as a key factor in Ghana's economic growth and development process (Akowuah, 2010; Akudugu *et al.*, 2012). In light of climate change as well as growing concerns regarding the unsustainability of conventional agricultural practices; especially the deep tilling of soils which are threatening the sustainability of this (agriculture) enterprise, the FAO, among others, began to promote a package of soil conserving practices under the banner of 'conservation agriculture' (Cabell and Oelofse, 2012).

Conservation agriculture (CA), a (supposedly) sustainable agricultural alternative, has again been promoted across Africa and for that matter within Ghana since the early 1990s (Akowuah, 2010; Ekboir *et al.*, 2002; Boahen *et al.*, 2007; FAO, 2008; Mlenga and Maseko, 2015) by researchers and (non)governmental organisations. The technique is based on three main principles, namely: minimal soil disturbance, permanent soil cover (through mulching and cover crops); and thirdly, the use of appropriate crop rotations and/ or associations (FAO, 2006; Akowuah, 2010).

Its adoption and continued use have however suffered major setbacks (Ekboir *et al.*, 2002) due to a host of factors. In 2014; as part of a food security project by the NGO; World Vision International, the Ghana office, undertook to train some farmers from the then Brong Ahafo region, (now renamed the Bono region) in conservation agriculture at the Howard G. Buffet Centre for no-till agriculture, located in the Ashanti region of the same country. The centre is a non-governmental research station for the promotion of CA as well as other soil and water conservation practices. The beneficiary farmers were then provided with inputs and further extension services for the duration of the project.

Since adoption is not a dichotomous decision; characterized by a ''yes'' or ''no'' (de Graaff *et al.*, 2008; Kessler, 2006) a couple of questions therefore arise. Key amongst them include: are the farmers practising this CA technique adapting it correctly to their farm system; and on which scale or intensity (Kessler, 2006) and with regards to resilience in times of climate variability; is it

 DOI: 10.33687/ijae.010.02.4187

increasing their buffer capacity, self-organization and capacity for learning (Speranza *et al.*, 2014). Also; is there an opportunity to upscale these techniques to improve the resilience of farmers and their farm systems to evidential climate variability?

This research, sets out to assess the adoption rates of farmers who participated in the training and how this has impacted the resilience of their farm systems and households and compares these indices with farmers from the same communities who did not. The results of this study could provide scientific inputs for policies and upscale of CA-based interventions and advocacy, especially in the forest-savanna transitional zones of Ghana.

MATERIALS AND METHODS

The study was conducted in the Kintampo South District of the Bono region (Figure 1), Ghana. It lies within longitudes 1º20' West and 2º10' West and latitude 8º15' North and 7º45' North (Ghana Statistical Servcies, 2014). The district covers a total land area of 1,513.34 km^2, comprising about 122 communities, some of which can be described as hamlets and villages due to their low populations. The communities where the research was carried out include Amoma, Anyima, Jema, Krabonso, Abudwom and Ampoma. The physiographic characterization of the district is made of flat bedded rock which is extremely plain with rolling and undulating land surface, having an elevation between 60-150m above sea level (Ghana Statistical Servcies, 2014). Soil types here range from sandy loam to clay loam. The district also experiences wet semi-equatorial and tropical continental climates. Like other parts of Ghana, two seasons are experienced in the district, wet and dry. Annual mean rainfall is between 1400-1800mm. The mean monthly temperature ranges between 24ºC in August and 30ºC in March. The district has a population of about 93,000 people, with about 90% of households engaged in Agriculture, mostly undertaken at a subsistence level. Major crops cultivated include; yam, cassava, cereals, groundnut, watermelon, cashew, mango, tobacco and vegetables. Livestock also includes cattle, sheep, goats, pigs and poultry (MoFA, 2010).

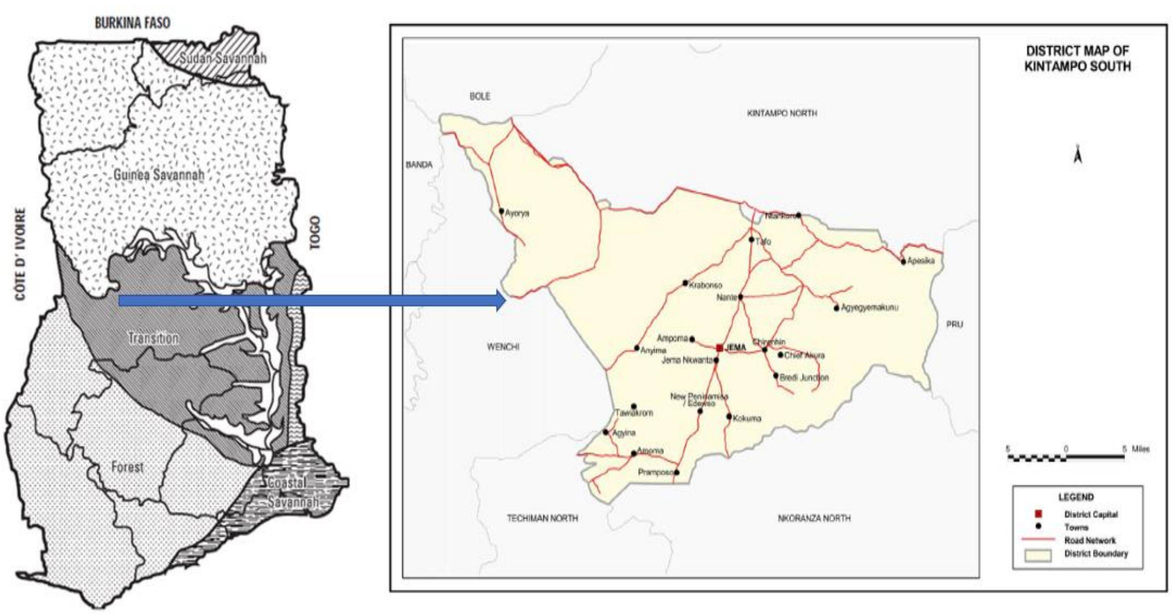

Figure 1. Agroecological zones map of Ghana (left), Kintampo South District Map (right) (Adapted from Ghana Statistical Servcies (2014).

The proneness and vulnerability of the region to impacts of climate change are highlighted by Adjei-Nsiah (2012), who state that; in the transitional agro-ecological zone, climate change effects may be more pronounced due to the faster depletion of the forest vegetation and the ever-expanding savannah horizon. There are annual bushfires, difficulty in producing valuable cash crops such as cocoa and other staples as well as a decline in soil fertility with corresponding high use of chemical fertilizers. Since a majority of this rural population is engaged in agriculture, stresses arising from the aforementioned make them vulnerable to lower yields and consequently, poverty and food insecurity.

FAO's Sharp+

The resilience concept used here is based on 13 resilience indicators proposed by Cabell and Oelofse, 2012 and adapted by the FAO to create its' "SHARP" tool, i.e. the "Self and Holistic Assessment of climate Resilience of farmers and Pastoralists" tool. The updated version of the SHARP; SHARP+, which will be used in this research; provides a participatory survey-based instrument for farmers (and pastoralists) to assess their resilience.

Aiming to fill the gap in current resilience assessments, which is primarily seen to be based mostly on experts' objective appraisal (ODI, 2015b), the SHARP assessment has been structured to combine quantitative information on respondents' resources, practices and knowledge, with their qualitative perceptions of the adequacy and importance of a particular aspect of their farm system (Choptiany, Colozza, *et al.*, 2016). The set of modules (each of which is made of questions) in SHARP+ has been designed to explore the major areas of agricultural livelihoods through agronomic, environmental, social, governance and economic aspects of climate resilience. The updated SHARP+ has 40 modules from an initial 54 in the SHARP. Out of the forty 40 modules, 20 are mandatory to be answered to get a holistic representation of the resilience of that particular farm system. In all, a total of 32 modules were used in this research. None of the mandatory themes was omitted. The 8 were dropped because they had not enough relevance in the context of this research.

The combination of the 13 resilience indicators (Cabell and Oelofse, 2012) and the 40 modules across the 5 segments ensures a holistic overview of the farm (pastoral)-scale climate resilience. The first part of each SHARP+ question explores farming resources/practices/knowledge. The second part explores participants' perceptions of the adequacy of the aspect of the farm/pastoral system whilst the last section probes the relative importance of that same aspect as perceived by the farmers (pastoralists), using five-level Likert scales. The overall relative resilience score for each aspect of the farm (or pastoral) system is realised by summing the scores obtained by normalising (out of 10) the responses given to the three scoring components.

World Vision's "SATISFY" Project

The "Systems Approach to Improve and Sustain Food Security" (SATISFY) project was a five-year food security program implemented by the World Vision International (WVI), Ghana office. According to World Vision international (2016), its' overall objective was the improvement of the food security status of men and women in poor rural communities of the Kintampo South and Atebubu-Amantin districts of Ghana. Over twelve thousand farmers were reached with training in improved animal and crop production, business skills as well as other income-generating activities. Again, about 86% and 58% of crop farmers and livestock producers respectively adopted the improved practices in which they got the training (World Vision international, 2016).

As part of the project; selected farmers from the Kintampo south district, staff of Ministry of Food and Agriculture, including extension officers, as well as World vision staff were trained at the Howard G. Buffet Foundation Centre for No-Till Agriculture (HGBF|CNTA) on CA practices. The world vision contacts on the ground in the communities' nominated farmers for the SATISFY project. About half of the trained farmers interviewed were at the Centre for no-till, as first-hand trainees. The others were trained by their colleagues through farmer-to-farmer extensions and farmer field schools.

Data Collection and Analysis

In total 52 farmers, 31 males and 21 females, were interviewed face-to-face. The farmers were stratified into trained and untrained categories across all the communities. A list of trained and untrained farmers was obtained and the simple random sampling technique was then used to select the same number of trained as well as untrained farmers in each community, to give the sample a balance and give every respondent and independent chance of being selected. Each sub-group had 26 farmers. Even though the SHARP was supposed to be a tablet-based application, the paper-based questionnaire version of the new SHARP, the SHARP+ was administered to the farmers instead. This was so because the new update was not yet ready in the digital version. According to Kessler *et al.* (2015), progressiveness and intrinsic motivation of the farmer are perhaps the most important determinants of adoption and investment in SWC. To this end, an inquiry about the farmers' progressiveness, enthusiasm and sense of stewardship in safeguarding his/her farmland and the environment were investigated. The farmers' vision, willingness to experiment with new agricultural practices and sense of responsibility are also assessed. The questions used to assess this segment drew inspiration from a previous work undertaken in Burundi by Kessler *et al.* (2015) in the ''Plan integre du paysan'' or PIP case study. IM was scored on a scale of 0 – 30. The SHARP+ and IM interview took approximately an hour and a half per farmer. Aside from the interviews; field assessments were undertaken to determine their CA adoption level or scale. The criteria used included scoring each of the three CA components between 0 – 30, as in the case of IM, depending on the percentage of adoption and how well they adapted the technique to their farm. The total adoption score was a sum of all three CA indices. Since the android-based version of the SHARP+ was still not available at the time of data analysis; a partially completed web-based version made available by the FAO, Rome was used for the initial scoring. The scores that were not readily available were computed manually using the new SHARP+ rubric. Further analysis of relative resilience scores, as well as intrinsic motivation and CA adoption levels, were undertaken in excel. These are represented in radar and pie charts as well as in tables. SPSS is subsequently used for independent t-test comparisons to test the significance of the differences between relative resilience scores, IM and adoption levels for trained and untrained farmers. Pearson correlations are also run to investigate the interrelations between all the three indices above.

RESULTS AND DISCUSSION

Resilience: Trained Vs Untrained Farmers

The results show that trained farmers (TF) were significantly more resilient than their untrained colleagues in all the agronomic resilience modules except in two areas; "pest management" and "utilization of new breeds and adapted varieties" (Figure 2). With regards to "pest management practices", the difference is non-significant ($p = 0.17$) whilst in the "utilization of new breeds and adapted varieties", untrained farmers (UF) surprisingly actually performed significantly better than TF. All the farmers managed just about moderate resilience in all the agronomic aspects although as seen, UF lagged behind their trained counterparts in most of the areas (Figure 2). These areas include; household, agricultural production, crop and animal production activities as well as the integration and use of trees on the farm.

Other areas where the trained do significantly better are, intercropping and access to information on weather and climate change adaptation practices. The likely reasons for these differences are explored further.

Significant Differences: Household (Labour and children's access to education, $p = 0.01^*$): CA has been known to reduce field labour requirements by up to 45% over the first two years through improved weed control (Howard G. Buffett Foundation Centre for No-Till Agriculture (HGBF | CNTA), 2017) and general ease of farming. Reduction in labour costs and increased disposable income for families also create greater access to children's education beyond primary school (Howard G. Buffett Foundation Centre for No-Till Agriculture (HGBF | CNTA), 2017).

Agricultural production activities ($p = 0.01$), crop production activities ($p = 0.00$) and intercropping ($p = 0.00$). According to the FAO (2008), CA practices and principles and practices have been acclaimed to enhance sustainable agricultural production intensification. As permanent soil cover and appropriate rotations were key tenets of the CA training programme; practising farmers were likely to perform better in all these three areas. Trees (integration and use of trees on the farm, $p = 0.01^*$): CA principles discourage the practice of slash and burn which could be damaging to trees on the farm. It also advocates for more inclusion of trees on the farm.

Access to weather and climate change adaptation practices ($p = 0.00^*$): Here, it can be explained that the farmers who were trained got access to and were preview to an abundance of knowledge on climate change and coping strategies.

The utilization of new breeds and adapted varieties ($p = 0.00^*$): This deviation may be explained by the fact that trained farmers got seeds and other planting materials for new crop varieties as part of the SATISIFY project package. These inputs may not have been very adapted yet to local conditions. Their untrained colleagues, having no such access, probably stuck to their old and adapted planting materials, hence their performance.

Non-Significant Differences: Pest management practises (p = 0.17): Pest management practices were to some extent considered in the training, and indeed CA has been known to improve the management of pests (and weeds) (Howard G. Buffett Foundation Centre for No-Till Agriculture (HGBF | CNTA), 2017), but probably over a longer time duration. Perhaps, the non-significance should not come as a surprise as this was just the transition phase, as Knowler and Bradshaw (2007) make us understand; that, there is usually a loss of pest and disease maintenance previously catered for by conventional tillage. This usually calls for moderate use of chemical inputs as part of an integrated pest management system to ensure a healthy biotic community. Animal Production Practices (p = 0.14): Animal production practices were not part of the training, so the non-significance (p = 0.14) of the difference does not come as a surprise.

Environmental Resilience (P = 0.03*)

About environmental resilience; trained farmers obtain significantly better resilience scores than the untrained (Figure 2). It was only in the area of water access that the difference in scores was non-significant. As in the case of agronomic resilience above, both sub-groups manage more or less moderate resilience scores in all theme categories here except in the ‘’water quality’’. Here, unsurprisingly trained farmers obtain high scores, with their untrained counterparts still in the moderate resilience range (Figure 2).

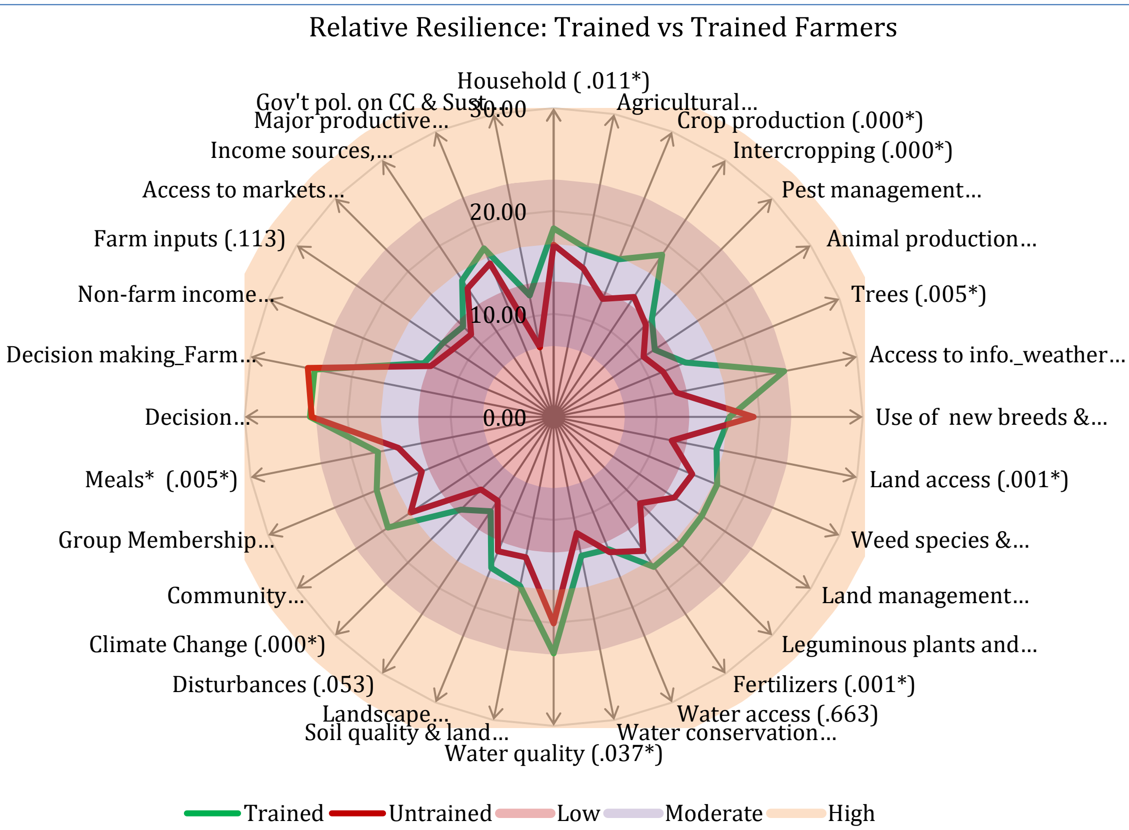

Figure 2. Overall resilience for Untrained vs Trained farmers with respective p – values.

Agronomic Resilience (p = 0.05)

Significant Differences: Land access (p = 0.00*): According to data from the Howard G. Buffett Foundation Centre for No-Till Agriculture (HGBF | CNTA) (2017), CA sustains arable land because CA farmers productively farm on the same land year after year, whereas slash and burn farmers' land become unproductive after an average of two years. The difference here could also be because farmers with more land are wealthier and may probably afford to spend time getting trained or are more used to training. CA could be responsible for this but other factors may also be at play. Weed species and management (p = 0.00*): From earlier discussions, there is proof that CA leads to improved management of weeds (and pests) which reduces input costs, herbicides usage and manual labour. Land management practices (p = 0.00*), Soil quality and land degradation (p = 0.00*): Generally, CA principles are known to make agriculture more sustainable and provide improved ecosystem services (FAO, 2008; Akowuah, 2010; Mlenga and Maseko, 2015; Friedrich *et al.*, 2013). In terms of land management, CA sustains arable land, maintaining soil structure and productivity (Knowler and Bradshaw, 2007), thereby preventing land degradation (Mlenga and Maseko, 2015), as well as a host of other benefits including erosion prevention. Improved land management eventually increases the productivity of agriculture and the income of farming communities (Miheretu and Yimer, 2017) thereby contributing to poverty reduction as well as rural environmental protection and economic development.

Fertilizers (p = 0.00*), Leguminous plants and trees (p = 0.00*): The importance of the inculcation of legumes as part of rotations/ associations as well as cover crops in the CA cannot be overemphasized. Legumes add nutrients and organic matter to the soil. CA systems also favour beneficial biological activity in the soil to contribute to soil organic matter and various grades of humus as well as contribute to capturing, retention, chelation and slow release of plant nutrients. To add to this, trained farmers got knowledge on the appropriate use of organic and inorganic fertilizer use (Dhaliwal *et al.*, 2019).

Water conservation practices and techniques (p = 0.00*), Water quality (p = 0.04*): Conservation agriculture practices have been known to ensure that water enters the soil so that plants never, or for the shortest time possible, suffer water stress. CA also allows residual water to pass down to groundwater and stream flow, not over the surface as runoff (Wang *et al.*, 2011). Again, at the training centre, techniques and practices aimed at water conservation on the farm are taught to farmers as part of the CA package. Trained farmers are thus better equipped with the knowledge to know and prevent water pollution sources on their farms; e.g., the prevention of water contamination arising from proper handling of pesticides and fertilizers.

Landscape characteristics (p = 0.01*): The reason here is hard to explain at first glance but a more careful look could reveal that; in general, the improved ecosystem services and habitat-friendly environment brought about by CA creates a conducive atmosphere in the landscape (e.g. for beneficial insects, natural predators, trees etc.). Such conditions benefit the farm environment and household eventually.

Non-Significant Differences: Water Access (p = 0.66): As would be expected, access to water for domestic and on-farm use was no different between the two sub-groups, probably because both sub-groups lived in the same communities hence their water sources are the same and were less dependent on a farmer's practicing CA or otherwise.

Social Resilience (P = 0.54)

The resilience of both sub-groups in terms of social interactions ranges from low, to moderate, to high (Figure 2). Concerning the disturbances module, untrained farmers score low, whilst the trained ones manage a moderate score. It must also be said here that, this was also borderline moderate, meaning there is not much of a difference between these two sub-groups here (p = 0.05). In terms of decision-making, both at the household and farm level, all the farmers score high on resilience. In the other areas of social resilience such as; community cooperation, group membership, as well as the access to and consumption of (nutritious) meals, both trained and untrained farmers, perform moderately. Together with climate change, there exists a significant difference in resilience scores between both groups for all three themes. The same cannot be said for the other socially related resilience assessment modules (Figure 2).

Significant Differences: Climate change (Perception of CC and coping strategies, p = 0.00*): CA has been reported to help farmers fight the negative impacts of CC through the improvement of farm system resilience (FAO, 2008b; Mlenga and Maseko, 2015). It may be assumed here that the trained farmers probably got well informed about CC issues and that help them to outperform their untrained colleagues in this aspect.

Community Cooperation (p=0.00*): The bringing together of farmers in the community to embark on the project could have influenced the significant variations here between the two sub-groups. For instance, not all the interviewed trained farmers were at the HGBF|CNTA, the ones that participated in the initial training were as part of the project model tasked to engage in farmer-to-farmer extension (FFE). According to Ruben and Vaessen (2000), farmer to farmer exchange programmes has been known to offer the most incentives for the uptake of SWC practices. Perhaps the interactions through the FFE and collaborations spurred trust and cooperation amongst participating farmers and their colleagues in the community. This was an opportunity the untrained farmers never got.

Group membership (p = 0.00*): This module is similar to the case of ''trust and cooperation'' above. It could be assumed that because the trained farmers belonged to the project group and network, they were better placed to do well in group membership. But generally, the results showed that the trained farmers belonged to more groups and were very participative in group connectedness and networks. This could probably account for why they got the opportunity to be selected for the project in the first place, and not their untrained colleagues. This is so, even though both sub-groups lived in the same or similar communities.

Meals (Food security and nutrition, p = 0.01*): CA practice has been reported to improve yield within the first two years of crop production (Howard G. Buffett Foundation Centre for No-Till Agriculture (HGBF | CNTA), 2017). According to data from the centre for no-till agriculture, this helps practising families to achieve food and nutrition security as they get increased disposable incomes (by up to 25% in the first 2 years) through the higher yields. Another reason could also be that; because trained farmers are probably better connected, have more land/ wealth which could translate into more food sources and variety.

Non-Significant Differences: Disturbances (P=0.053): This module is based on the thinking that resilience is maintained when systems from time-to-time probe at the boundaries of their sustenance and still manage to survive while learning to adapt. Thus, to strengthen the resilience of an individual or system, past exposure to shocks and stresses is very essential (Carpenter *et al.*, 2001; Dixon *et al.*, 2001; Choptiany, Colozza, *et al.*, 2016). A 'p' score of .053 makes it difficult or vague to ascribe reasons, but probably due to the training, TFs were more exposed to coping strategies to help them move through the phases of disturbances better than their colleagues. That said, it is also worth mentioning that both groups of farmers have low scores in this department (Figure 2).

Decision making: Household (p = 0.87) and Farm management (p = 0.47): Both sub-groups of farmers do score high on resilience in terms of participative decision making and task division. This is because most of the farmers had partners or lived as couples and per the nature of the social setting in the locality (Ghana), couples mostly made decisions or shared tasks together. To add to this, most of the respondents had spouses and family living together; this meant that they took decisions and performed tasks together as a household. For those that had no partners in their farming ventures, the farms belonged to them so decisions about the farm were made by them, in most instances, alone. CA training or not had nothing to do with this.

Economic Resilience (P = 0.44)

The resilience of economic aspects between the two groups is hard to differentiate. Apart from the area of ''access to markets'', where a significant difference (p = 0.02) is seen, all remaining four areas show non-significant (Figure 2; see Appendix) variations. For the levels of resilience, it can be said from Figure 2; that both TF and UF average just moderate resilience, although in practice the scores range from low to high moderate.

Significant Difference: Access to markets (p = 0.02*): One key attribute of a resilient farm system should be the reasonable profitability of the venture (Cabell and Oelofse, 2012). The SATISFY project had a marketing component as part of the package. It included finding available markets for the produce of the participating farmers. As to how well that went, it is unknown as farmers gave varying degrees of its' (marketing) shortfalls in practice. But at least there was an attempt to help them in this regard. Also, as has been stated before, the training may have left them well-informed and networked farmers with potential buyers.

Non-Significant Differences: Major productive assets (MPA; p = 0.06): As has already been stated CA increases disposable income within the first two years, but to deliver full benefits, one needs at least 20 years (Friedrich *et al.*, 2013). Thus, to fully gain the economic impacts of this system, more time is needed. It can safely be said that trained farmers are starting to gain in terms of productive assets (p = 0.06).

Non-farm income generating activities (IGAs, p= 0.50)

Income sources, expenditures and savings (p = 0.29): Although CA is reported to foster innovation and entrepreneurship as marketable cover crops and the use of time saved through reduced labour creates new income, it is yet to reflect here. The same reasons as given in the ''major productive assets'' module could be ascribed here. Farm inputs (p = 0.11): The non-significance in the resilience variation here is a bit surprising as trained farmers were supposedly given inputs as part of the project. One would have assumed that they would do significantly better in this category. A close look however may reveal that probably that was the case, but after the expiration of the project in the early part of 2017, the input (incentive) supply ceased and then things went to back normalcy again. This aspect has nothing to do with CA training by the way, but about the project package.

Resilience of Governance Aspects (P = 0.00*)

Government policies and programmes on Climate Change and sustainable agriculture: This is the only module in the Governance segment of the SHARP+ resilience assessment. The results (Figure 2) show that trained farmers obtain borderline moderate scores, whilst their untrained colleagues manage a paltry low. This could be explained by the fact that the farmers were generally unaware of the policy environment they operated in and are also not exposed to programmes and projects related to climate change and sustainable agricultural practices. Trained farmers edge out their untrained colleagues here probably because they participated in the SATISFY project; which this research in particular assesses.

Overall Resilience -Trained Vs Untrained Farmers

When all the resilience aspects are put together and comparisons drawn from the results for both subgroups of farmers; one could see that all manage just about moderate resilience in all segments. The only deviation from these findings; is in the aspect of governance, where untrained score low and trained, still in the moderate region (Figure 2). In terms of variations in the scores; it can be seen that the differences are significant in the environmental, governance and to lesser (borderline) extent, agronomic (p = 0.05) sections (Figure 2, appendix 1). The differences in the remaining aspects; economic and social, are non-significant.

As already stated, CA takes at least twenty years to produce full benefits (Friedrich and Kassam, 2009). CA technology is also deemed simple for those who have an innovative spirit and who engage in a lifelong process of learning, whereas it may be too complex for those who give up when the first problems appear and for those accustomed to conventional agriculture (Friedrich *et al.*, 2013; Akowuah, 2010). Perhaps it is too early to expect very significant differences between the groups, as the training was very short; as technically it has been only three years since the farmers in question were exposed to these interventions. That said Friedrich *et al.* (2013) conclude however that; even if farmers would revert to conventional tillage farming after the intervention, they would not have lost, but gained some new insights. Perhaps that is why there are significant differences between the agronomic, environmental as well as governance aspects and not the economic or social. In fact, with social interactions, however, it can be said that both groups of farmers all live in the same communities and have similar social networks and probably this aspect has little to do with the CA intervention.

In practice also, the SHARP+ outputs are to serve as a guide rather than results being taken as absolute values (FAO, 2015; Choptiany, Phillips, *et al.*, 2016). In this respect, the scores help to identify the vulnerabilities of farmers (and pastoralists) to assist project implementers (extensionists) and policymakers identify which areas to focus their immediate intervention on and which aspects could wait in terms of creating a more sustainable future for them and the environment (Cabell and Oelofse, 2012). The moderate resilience scores in this survey are also not so dissimilar to what was realized in the work by Molina-Murillo *et al.* (2017), with agroecological farmers in Costa Rica, albeit in quite different contexts. That said, it is a general belief that these (average) scores are not the best; ergo, they should be enhanced if the farmers' livelihood is to be improved and sustained. In practice again also, the SHARP tool is fairly new; as such, it is now being applied gradually in terms of research outside the remits of the FAO. Perhaps, it is in comparison to other data from the FAO in the region that real meaningful conclusions can be drawn as to how the farmers in this study fared in relation to their counterparts across the sub-region, who may also be involved in other equally beneficial soil and water conservation interventions.

Adoption Rates of Conservation Agriculture – TF Vs UF

Adoption levels for both sub-groups were about average (Figure 3). Unsurprisingly, trained farmers had better adoption rates in all three indices. There were indeed significant differences in adoption for the indicators; no-tillage (p = .017) and crop rotation (p = .021), but not in the use of 'soil cover'' (Figure 3; Table 1).

Intrinsic Motivation – TF vs UF

About 19% of the UF had very high motivation, compared to 8% of the TF (Figure 4). On high motivation, however, they are almost equal at 27% and 23% respectively between the UF and TF. As much as half (50%) of the surveyed TF had regular motivation compared to about 39% for UF. The same trend is exhibited in ''low motivation'' where TF scores 19% with UF at 12%. No TF had very low motivation, compared to an almost 4% for UF. Notwithstanding the differences in Intrinsic motivation in the charts between untrained and trained farmers, the t-test results showed that the differences were non-significant (p = .405; Table 1). These results suggest that the training did not have any effect on farmers' intrinsic motivation to adopt conservation agriculture. It can also be concluded from the results that both sub-groups of farmers had just about moderate intrinsic motivation.

Table 1. T-test results for CA adoption levels and IM - TF vs UF.

IM/ Adoption Indicator	Adoption / IM Scores (30)		p-value
	Trained	Untrained	
No-tillage	17.69	14.42	0.02*
Soil Cover	14.62	12.50	0.06
Crop rotations/ associations	18.85	15.38	0.02*
Intrinsic Motivation	17.31	16.15	0.41

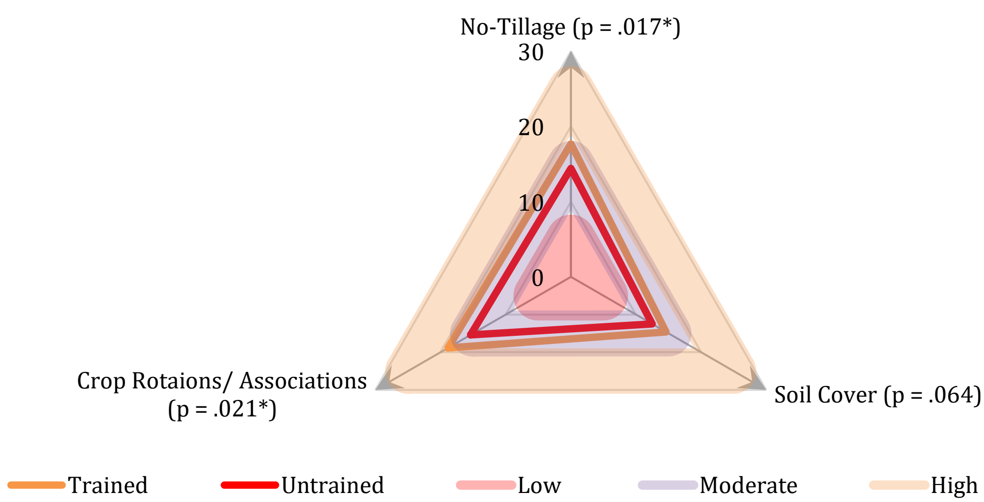

Figure 3. CA adoption levels for TF vs UF (Scale 1 – 3 0).

Again, the SATISY project had ended about half a year before this study. As a result, it is assumed that incentives that were driving the project would have been withdrawn, these would lead to the participating farmers not being intrinsically motivated (Table 1), enough to continue the use of the CA technology as described in the earlier sections. This is especially so if the project did not aim at stimulating intrinsic motivation through changing farmers 'attitudes but rather chose to do so through the use of incentives, leading to extrinsic motivation. Withdrawal of these incentives would lead to discontinued use of the CA practices (Kessler, 2006; de Graaff *et al.*, 2008). The implication is that the use of these incentives can

 DOI: 10.33687/ijae.010.02.4187

sometimes turn out to be bad initiative because farmers are likely to try out or continue innovation on the farm if it turns out to be profitable (Morris *et al.*, 2010).

Being profitable here does not refer to the profitability of the innovation itself only but, as Kessler (2006) put it, the combination of activities that accompany the introduction of the intervention. In other words, it is alright to use incentives to have farmers take part, but these should be not linked to the use of the practice, as that distorts farmers' perceptions of what the benefits are of that specific technology. In other words, the incentives which are used so that farmers adopt for the sake of adopting are negative, farmers should only be facilitated in understanding whether a given practice works for them specifically in their context. Furthermore, adoption requires a favorable mental attitude and is influenced by farmers' feelings and aspirations. Without IM, some farmers would never adopt and replicate SWC interventions; even if it's profitable. Projects that aim at fostering SWC must therefore seek to whip up farmers' intrinsic motivation by working to change farmers' attitudes towards progressiveness and a sense of stewardship (Kessler, 2006).

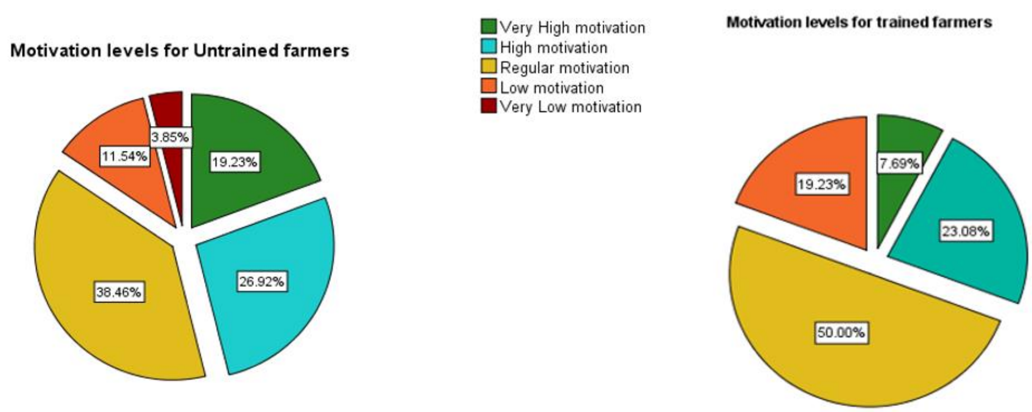

Figure 4. Intrinsic Motivation levels for UF (left) and TF (right) in Percentages.

Correlations Between Intrinsic Motivation, CA Adoption and Resilience

Indeed, the argument expounded in the previous sections is further strengthened by the fact that among all the surveyed farmers, intrinsic motivation had a very strong correlation (0.45**; Table 2) with the farmers' adoption levels of conservation agriculture. Conservation agriculture is a sustainable agricultural alternative which holds tremendous potential for all sizes of farms and agro-ecological systems (FAO, 2006; Akowuah, 2010). Fostering its adoption is therefore critical to mitigating and making communities more resilient to the negative impacts of climate change, population growth as well as land degradation, while at the same time achieving food security through sustainable farming (Mlenga and Maseko, 2015). Stimulating intrinsic motivation is therefore imperative if projects are to ensure that farmers adopt and sustain CA interventions to derive the full benefits associated with it. With insights from here and the sections before, it can be concluded that the decision to train farmers in conservation agriculture itself was a brilliant initiative as it may have contributed to strengthening resilience for certain aspects of the farmers' livelihood and the environment.

What was lacking was perhaps the concerted effort to motivate farmers with positive stimuli to start experimenting, for as Kessler (2006), noted; these actions when undertaken earlier in projects or programmes are essential in motivating stakeholders in environmentally related interventions. Farmers therefore should be able to compare the different practices, what they do with a potential new practice, and assess whether it is suitable for them in terms of labour, margins, yields, environmental and health costs. In this sense, intrinsic motivation will quickly grow when one successfully discovers something by experimenting rather than being forced. In the case of SWC practices that work, this will eventually lead to sustained adoption.

Intrinsic Motivation and Resilience

Intrinsic motivation is positively correlated with all aspects of farm system resilience, including overall resilience for the surveyed farmers, except for the governance aspect (Table 2), where the correlation is negative. All the correlations are however non-significant. This again goes to support the earlier argument made, that; because high intrinsic is missing among most of the farmers, it is not having any influence on resilience yet. Furthermore, it can also be explained, with inference from the measurement of IM in the methodology part, that IM measurement in general, had to do with farmers' attitude towards progressiveness, sense of enthusiasm to experiment with new SWC techniques on the farm as well as his/ her inclination to safeguard the natural vegetation. To add to this, the IM assessment also looked amongst others, at the willingness of the farmer to invest in SWC activities, both now and in the future and not only on the practice of CA. This could perhaps be the reason IM is mostly positively correlated with resilience but non-significantly because a lot of factors seem to be at play here and not only how well they are motivated intrinsically to practice conservation agriculture.

Table 2. Pearson correlation of Intrinsic motivation, CA Adoption and Resilience.

Resilience Aspect/ IM	All farmers, n = 52	
	IM	Adoption
Agronomic	0.22	0.49**
Environmental	0.23	0.47**
Social	0.16	0.18
Economic	0.01	0.19
Governance	-0.03	0.35*
Overall Relative Resilience	0.11	0.45**
IM	1	0.45**

Adoption and Resilience

Perhaps, this is where the strongest of correlations exist. To start with, adoption is weakly and non-significantly correlated with social (0.18) and economic (0.19) resilience (Table 2). Governance and adoption have a moderately positive (0.35*) and significant correlation. Very strong correlations also exist between adoption and agronomic (0.49**), environmental (0.47**) as well as overall (0.45**) resilience for the combined group. The findings from the above correlations go to show that the more farmers adopted conservation agriculture, the more their climate resilience was strengthened. Experts and project implementers seeking to improve the farm system resilience of farmers should therefore aim at fostering the adoption of CA and in the wider sense other equally effective SWC technologies.

This is in concurrence with what other researchers like Nin *et al.* (2003); Akudugu *et al.* (2012) and Mlenga and Maseko (2015), have noted in the past. In essence, they all agree that the uptake of sustainable soil and water conservation practices on the farm, in this case, conservation agriculture, by farmers helps them build the resilience of their farm systems and households against climate change and its associated debilitating effects on environment and human livelihoods.

CONCLUSION

This study investigated the issues of intrinsic motivation, conservation agriculture adoption as well as farm system resilience for two groups of family farmers in the Kintampo South District of the forest-savanna transitional zones, Ghana. The groups are; farmers who received training in conservation agriculture and those who did not. The training, through a project, influenced them to practice the technique to some extent. The results from the FAO's resilience assessment tool, the SHARP+, evidenced that, farmers who took part in the training had significantly better resilience in terms, of environmental as well as governance aspects, and to a lesser extent agronomic practices, when compared to their neighbors who missed out. No such differences exist between them and their untrained colleagues in social and economic resilience. The full potential of the CA intervention is however not realized currently. Consequently, all the farmers average just about moderate resilience scores. This is because more waiting time is needed to reap the full benefits of conservation agriculture. Secondly, and more importantly; the trained farmers are not adapting and adopting the CA technology completely. Although a multitude of reasons could be responsible for the low uptake, the lack of intrinsic motivation has been shown here as the most important, as there was a very strong correlation between intrinsic motivation and adoption. High adopters of conservation agriculture in turn scored high on farm system resilience. It is thus proposed that efforts should be geared towards improving adoption by nurturing farmers' intrinsic motivation through more participative knowledge sharing and experimentation to enable them to benefit fully from CA to help strengthen their resilience. This is particularly important as farmers livelihood and survival, in these parts of the world, which is largely dependent on rain-fed agriculture, are constantly threatened by the adverse effects of climate variability, environmental degradation as well as population growth. Future research could look at the possibility of a time series resilience performance assessment of these farmers as well as the interrelations between resilience and gender differences.

REFERENCES

Adjei-Nsiah, S. 2012. Climate Change and Shift in Cropping System: From Cocoa to Maize Based Cropping System in Wenchi Area of Ghana. British Journal of Environment and Climate Change, 2: 137-52.

Akowuah, P. 2010. Farmers Experience and Practice of No-tillage System: Towards the Adoption of Conservation Agricultural Production in Atwima-Nwabiagya District of Ashanti Region, Ghana. Journal of Developments in Sustainable Agriculture, 5: 191-202.

Akudugu, M. A., E. Guo and S. K. Dadzie. 2012. Adoption of modern agricultural production technologies by farm households in Ghana: what factors influence their decisions?

Boahen, P., Addo D. B., Delali D. G., Asare B. E., B. Triomphe, S. Daamgard-Larsen and J. Ashburner. 2007. Conservation agriculture as practiced in Ghana. Conservation agriculture in Africa series, African Conservation Tillage Network, CIRAD and FAO, Nairobi-Kenya. Place Published.

Cabell, J. F. and M. Oelofse. 2012. An Indicator Framework for Assessing Agroecosystem Resilience. Ecology and Society, 17.

Callo-Concha, D. and F. Ewert. 2014. Using the Concepts of Resilience, Vulnerability and Adaptability for the Assessment and Analysis of Agricultural Systems. Change and Adaptation in Socio-Ecological Systems, 1.

Carpenter, S., B. Walker, J. M. Anderies and N. Abel. 2001. From Metaphor to Measurement: Resilience of What to What? Ecosystems, 4: 765-81.

Choptiany, J., D. Colozza, S. Philips and B. Graub. 2016. SHARP user manual. Food and Agriculture Organization of the United Nations. Place Published.

Choptiany, J. M. H., S. Phillips, B. E. Graeub, D. Colozza, W. Settle, B. Herren and C. Batello. 2016. SHARP: integrating a traditional survey with participatory self-evaluation and learning for climate change resilience assessment. Climate and Development, 9: 505-17.

de Graaff, J., A. Amsalu, F. Bodnár, A. Kessler, H. Posthumus and A. Tenge. 2008. Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. Applied Geography, 28: 271-80.

Dhaliwal, S. S., R. K. Naresh, A. Mandal, R. Singh and M. K. Dhaliwal. 2019. Dynamics and transformations of micronutrients in agricultural soils as influenced by organic matter build-up: A review. Environmental and Sustainability Indicators, 1-2: 100007.

Dixon, J. A., D. P. Gibbon and A. Gulliver. 2001. Farming systems and poverty: improving farmers' livelihoods in a changing world. Food & Agriculture Org.

Douxchamps, S., L. Debevec, M. Giordano and J. Barron. 2017. Monitoring and evaluation of climate resilience for agricultural development – A review of currently available tools. World Development Perspectives, 5: 10-23.

Ekboir, J., K. Boa and A. A. Dankyi. 2002. Impact of no-till technologies in Ghana.

FAO. 2006. Conservation Agriculture. http://www.fao.org/ag/ca, accessed January, 2018. Place Published.

———. 2008. Report of the Conference Committee on Follow-up to the Independent External Evaluation of FAO (CoC-IEE), Immediate Plan of Action. FAO Conference, Thirty fifth special session, FAO Rome, 18-22 November 2008.

———. 2008b. Investing in Sustainable Agricultural Intensification: The Role of Conservation

Agriculture–A Framework for Action' FAO Rome, August 2008 (available at www.fao.org/ag/ca/). Place Published.

———. 2014. The State of Food and Agriculture. Innovation in family farming, Rome, FAO. Place Published.

———. 2015. Food and Agriculture Organization of the United Nations- Agriculture and Consumer Protection Department. What is Conservation Agriculture? http://www.fao.org/ag/ca/1a.html Place Published.

Friedrich, T., A. Kassam and S. Corsi. 2013. Conservation agriculture in Europe. CABI. Place Published. pp.127-79.

Ghana Statistical Servcies. 2014. 2010 Population and Housing Census. District Analytical Report, Kintampo South District. Ghana Housing and Population Census. Government of Ghana, Accra, Ghana. Place Published.

Graziano, S. J. 2014. The family farming revolution. Opinion Article. Available at: www.fao.org/about/who-we-are/director-gen/faodg-opinionarticles/.../c/212364/. Place Published.

Howard G. Buffett Foundation Centre for No-Till Agriculture (HGBF | CNTA). 2017. Conservation Agriculture Training Module 1, Amanchia-Ghana. Place Published.

IPCC. 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp. Place Published.

Israel's Trade and Economic mission to Ghana. 2020. Agriculture Sector in Ghana Review, Embassy of Israel, Mannet tower, Airport city, Accra, Ghana, https://itrade.gov.il/ghana/files/2020/05/Agriculture-Sector-Review.pdf Place Published.

Kessler, C. A. 2006. Decisive key-factors influencing farm households' soil and water conservation investments. Applied Geography, 26: 40-60.

Kessler, C. A., N. van Duivenbooden, F. Nsabimana and C. L. van Beek. 2015. Bringing ISFM to scale through an integrated farm planning approach: a case study from Burundi. Nutrient Cycling in Agroecosystems, 105: 249-61.

Knowler, D. and B. Bradshaw. 2007. Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food Policy, 32: 25-48.

Kuuzegh, R. 2007. Ghana's Experience at Integrating Climate Change adaptation into national planning: official communication to the UN on Adaptation workshop. Submission. http://www.un.org/esa/sustdev/natlinfo/nsds/ egm_Climate Change/ghana.pdf. Place Published.

Miheretu, B. A. and A. A. Yimer. 2017. Determinants of farmers' adoption of land management practices in Gelana sub-watershed of Northern highlands of Ethiopia. Ecological Processes, 6.

Mlenga, D. H. and S. Maseko. 2015. Factors influencing adoption of conservation agriculture: A case for increasing resilience to climate change and variability in Swaziland. Journal of Environment and Earth Science, 5: 16-25.

MoFA. 2010. Ministry of Food and Agriculture (2010). Agriculture in Ghana: Facts and figures." Government of Ghana. Publications, 1-41. Place Published.

Molina-Murillo, S. A., G. Barrientos, M. Bonilla, C. Garita, A. Jiménez, M. Madriz, J. Paniagua, J. C. Rodríguez, L. Rodríguez, J. Treviño and S. Valdés. 2017. ¿Son las fincas agroecológicas resilientes? Algunos resultados utilizando la herramienta SHARP-FAO en Costa Rica. Revista Ingeniería, 27: 25.

Morris, N. L., P. C. H. Miller, J.H.Orson and R. J. Froud-Williams. 2010. The adoption of non-inversion tillage systems in the United Kingdom and the agronomic impact on soil, crops and the environment—A review. Soil and Tillage Research, 108: 1-15.

Nin, A., C. Arndt and P. V. Preckel. 2003. Is agricultural productivity in developing countries really shrinking? New evidence using a modified nonparametric approach. Journal of Development Economics, 71: 395-415.

ODI. 2015a. A comparative overview of resilience measurement frameworks: analysing indicators and approaches. Schipper, E.L.F. & Langston, L.

Working paper 422. www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9754.pdf. Place Published.

———. 2015b. Understanding and measuring 'subjective' household resilience (Working Paper 423). Lindsey Jones, Thomas Tanner. Place Published.

Ruben, R. and J. Vaessen. 2000. Soil Conservation Practices and Farmers' Adoption Strategies in Costa Rica. Palgrave Macmillan UK. Place Published. pp.127-43.

Speranza, C. I., U. Wiesmann and S. Rist. 2014. An indicator framework for assessing livelihood resilience in the context of social–ecological dynamics. Global Environmental Change, 28: 109-19.

Wang, Y., C. Tu, L. Cheng, C. Li, L. F. Gentry, G. D. Hoyt, X. Zhang and S. Hu. 2011. Long-term impact of farming practices on soil organic carbon and nitrogen pools and microbial biomass and activity. Soil and Tillage Research, 117: 8-16.

World Vision international, W., Ghana,. 2016. Food Security Fact Sheet, 2016. Available at worldvision.org/ghana. Place Published.

Appendix

Overall resilience t-test results

Module Number	Modules	Resilience Scores /30 Trained	Untrained	p - value
Agronomic Resilience		16.61	13.79	0.05**
2	Household	18.32	16.73	0.01*
3	Agricultural Production Activities	16.63	14.71	0.01*
6	Crop production	16.57	12.42	0.00*
7	Intercropping	18.96	14.02	0.00*
9	Pest management practices	13.47	12.66	0.17
13	Animal production activities	11.78	10.50	0.14
22	Trees	13.85	11.48	0.01*
28	Access to info. on weather & CC adaptation practices	22.80	12.15	0.00*
16	Utilisation of new breeds and adapted varieties	17.08	19.40	0.00*
Environmental Resilience		16.87	14.16	0.03**
5	Land access	16.10	11.69	0.00*
8	Weed species and management	17.17	14.54	0.00*
10	Land management practices	17.29	14.10	0.00*
11	Leguminous plants and trees	17.44	11.87	0.00*
12	Fertilizers	17.50	15.64	0.00*
18	Water access	13.92	14.20	0.66***
19	Water conservation practices and techniques	13.75	11.49	0.00*
20	Water quality	22.96	20.04	0.04*
21	Soil quality and land degradation	16.71	13.89	
22	Landscape characteristics	15.85	14.13	0.00*
Social Resilience		18.05	16.21	0.54
26	Disturbances	11.01	9.78	0.05**
27	Climate change	12.70	9.97	0.00*
36	Community cooperation	19.35	16.70	0.00*
37	Group membership	18.59	13.85	0.00*
38	Meals	17.39	15.35	0.01*
39	Decision making – Household	23.66	23.50	0.87
40	Meals Decision making – Farm Management	23.67	24.34	0.47
Economic Resilience		14.55	13.45	0.43
4	Non – farm income generating activities	13.63	12.92	0.50
17	Farm inputs	12.93	11.81	0.11
31	Access to markets	12.46	11.35	0.02*

32	Income sources	15.98	15.03	0.29
33	Major productive assets	17.73	16.13	0.06***
Governance Resilience		12.03	6.91	0.00*
30	Government policies on CC & sustainable agriculture	12.03	6.91	0.00*