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## Article

# Working towards Sustainable Innovation for Green Waste Benefits: The Role of Awareness of Consequences in the Adoption of Shaded Cocoa Agroforestry in Ghana

Fred A. Yamoah <sup>1,\*</sup> , James S. Kaba <sup>2</sup> , David Botchie <sup>3</sup> and Joseph Amankwah-Amoah <sup>4</sup><sup>1</sup> Department of Management, Birkbeck-University of London, London WC1E 7HX, UK<sup>2</sup> Department of Agroforestry, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; seutra@yahoo.com<sup>3</sup> Business School, Brunel University London, London UB8 3PH, UK; David.Botchie@brunel.ac.uk<sup>4</sup> Kent Business School, University of Kent, Medway ME4 4TE, UK; j.amankwah-amoah@kent.ac.uk

\* Correspondence: f.yamoah@bbk.ac.uk

**Abstract:** Drawing on the awareness of consequence literature, this paper unpacks how the awareness of the consequences of full-sun cocoa production can encourage farmers to adopt shaded cocoa agroforestry that preserves the land and favours better cocoa farm waste management. Using Ghana as a case study, the paper provides distinctive insights on how shaded cocoa agroforestry systems provide sustainable yields in the medium- to long-term, relative to unshaded systems. We also find that cocoa farmers' awareness of consequences about the effects of undertaking unshaded cocoa production could make individual farmers exhibit pro-environmental behaviour, leading to the adoption of cocoa agroforestry systems that help preserve soil fertility and improve waste management. We recommend that the utilization of awareness of consequence protocols, coupled with the efficient diffusion of information on the benefits of agroforestry in terms of waste management and environmental improvements to the cocoa farmers, could increase the adoption of shaded cocoa production regimes in Ghana.

**Keywords:** shaded and unshaded agroforestry; waste management benefits; awareness of consequence; cocoa farmers; cocoa extension policy



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## 1. Introduction

Sustainable innovations remain a pivotal competitive weapon in today's fast-changing global environment as the needs of consumers for environmentally sustainable products and services increases [1,2]. In parallel, sustainable environmental innovations have also risen to the forefront of public policy agenda around the globe, forcing producers and manufacturers to embrace new sustainability practices [3]. Indeed, the environmental and economic benefits of agroforestry systems, including the use of nutrients from green agroforestry waste, cannot be overemphasised, however, their adoption by farmers has been dismal over the years [4–8]. Because cocoa is an understory plant in its natural habitat, it is very sensitive to extreme environmental conditions, such as light and temperature (above 30 °C), which reduce the photosynthetic mechanism of the leaves and damage the flowers, affecting the physiology and long-term sustainable yield [9]. Against this backdrop, this study seeks to understand the role of consequence awareness in the cocoa agroforestry system adoption in the context of Ghana's cocoa industry. It also examines farmer attributes that influence the adoption of shaded cocoa systems. Although the cocoa industry earns Ghana around 2 billion Ghanaian Cedi (about 340 million USD) per year and is the source of livelihood for 6.3 million Ghanaians, it is experiencing serious ecological challenges that require urgent effort on the part of all relevant stakeholders to minimise negative effects on production and livelihoods [10].

Unfortunately, many cocoa farmers in cocoa growing areas of the world including Ghana are moving towards an unshaded cocoa system (full sun) [11]. It is estimated that cocoa planted under tree shade covers only 25% of the 1.6 million hectares under cocoa cultivation in Ghana [12–14]. This has implications for cocoa as it is vulnerable to climate variability and no shade means a higher impact of temperature and light on cocoa plants. Farmers' decision to adopt an unshaded cocoa system is influenced by many factors, including economic considerations [11,15]. Indeed, farmers are adopting unshaded planting over shaded as a result of the short-term higher production yields [11,15,16]. However, there is evidence to confirm that the yield of unshaded cocoa systems does decline drastically over the medium to long term [16]. This situation presents a critical challenge not only to the survival of the cocoa industry but also has a negative effect on farmer livelihoods and community progress [17,18] as the full-sun system deprives farmers of the green agroforestry waste which is critical in maintaining soil fertility. This precarious situation required an immediate novel approach to refocus the minds of cocoa farmers on the huge benefits of a shaded agroforestry system and the urgent need for agronomic behaviour change to secure their livelihoods and save the entire industry.

Although previous studies have contributed enormously to the understanding of farmers' attitudes toward planting trees in their cocoa farms [13,19], the yield profitability of shaded and unshaded cocoa systems [15], and partnership to reduce deforestation [20], cocoa agroforestry adoption rate among cocoa farmers in Ghana continues to decline [16,21]. It is interesting to find that most of the approaches towards encouraging farmers to adopt shaded cocoa agroforestry systems have been cocoa extension services led and implemented in a top-down fashion [8,19,22]. We argue for a redirection of the approach of these extension services to the promotion of shaded cocoa agroforestry, through the consideration of evidence-based consequence awareness as a theoretical lens. As a concept, awareness of consequence is understood as an individuals' belief about the adverse consequences of environmental problems [23].

We adopt the awareness of consequences theory for this study because it enables us to demonstrate how extension services could be leveraged to encourage environmentally friendly behaviour in cocoa growing communities in Ghana [24]. In the context of this research, it is an approach that also provides evidence of the system's merits, such as shade coverage and a cheaper source of green agroforestry waste, and the demerits of the prevalent unsustainable full-sun cocoa production. Indeed, there is evidence supporting the position that there is a relationship between awareness of consequences, the assumption of responsibility, and pro-environmental behaviour [24].

The determinants of intentions to perform pro-environmental behaviours include awareness of consequences, which refers to an individuals' beliefs about the adverse consequences of environmental problems [23,25]. Hansla et al. [23] posited that people become engaged in environmental issues and perform pro-environmental behaviour to the extent that the environmental problems have threatening and harmful consequences for egoistic, social-altruistic, or biospheric objects that they value (e.g., individual health, humankind, or animals and plants, respectively).

The study makes a theoretical contribution to the consequence awareness scholarship through the revealing insight that consequence awareness plays a positive role in cocoa farmers' decision to adopt a shaded agroforestry system. Further, the study contributes empirically by highlighting the critical role of farmers' educational level, years of cocoa production experience, and knowledge on shaded trees cocoa intercropping as a source of shade and cheaper green nutrients from agroforestry waste in the adoption of cocoa agroforestry systems.

The rest of this paper is presented as follows: Part 1 of Section 2 covers a critical review of the consequence awareness literature that set the background for the knowledge gap and salient research questions. This section also highlights the myriads of contexts within which the consequence of awareness concept has been applied, key findings, and any notable trends. Part 2 of Section 2 also presents a critical review of the state of affairs of the cocoa

production system in Ghana. Section 3 then covers the methodology employed in the study. Section 4 presents the results and discussion on the role that consequence awareness plays in cocoa agroforestry adoption. Finally, Section 5 presents conclusions and implications of the findings in terms of pro-environmental behaviour among cocoa farmers, sustainable cocoa production, cocoa farmer livelihoods, and cocoa extension services methods.

## 2. Cocoa Agroforestry System Adoption and Awareness of Consequence Approach

Awareness of the consequence concept is connected with Stern's [25] value belief norm theory of pro-environmental behaviour. It is viewed as one of the predictors of intention to undertake a pro-environmental behaviour [23]. The underlying tenet of awareness of consequence is that it activates a sense of responsibility in a person in order for them to perform pro-environmental behaviour. Historically, cocoa was grown under forest systems and this dates back to the early (19th century) is the case of Ghana. The cocoa farmers practiced shifting cultivation forest clearing systems; where production was mainly accompanied by the clearing of virgin forest and the planting of cocoa seedlings [12,26,27]. During the forest clearing, farmers either deliberately left on the farm some timber/legume trees or planted important food crops (cocoyam, plantain, banana etc.) to provide shade to the cocoa plant [28]. The waste from this biomass also served as an important source of green nutrients after decomposition. However, with limited forest available for clearing due to rapid deforestation (2% per annum) and population growth (10–20% per annum), there has been a shift from shaded to unshaded (full sun) systems accompanied by little or no fallows [12,14,16,17,29,30]. Thus, farmers deprive their plants of shaded coverage and nutrients from the agroforestry waste.

The adoption of an unshaded (full sun) cocoa system to meet the increasing demand for cocoa beans [13,31] has led to the negative environmental consequences of deforestation, carbon loss, higher temperatures, depleted soil nutrient level, high inorganic fertilizer use, and the loss of aboveground and belowground biodiversity [16,32]. Despite interventions by the government and other stakeholders, shaded cocoa systems in Ghana still cover only 25% of the 1.6 million hectares under cocoa cultivation [13]. This trend highlights the urgent need to scrutinize why farmers have not adopted the environmental innovations introduced, especially when Ghana's agricultural policies and practices (the National Agroforestry Policy) have the overall objectives of promoting agroforestry practices that exploit beneficial waste management for sustainable land-use [33].

The extant literature has employed awareness of consequence in different contexts. Hörisch et al. [34] used awareness of consequence in the context of corporate sustainability development. The authors employed awareness of consequence to investigate how to foster corporate action for sustainable development. Papagiannakis et al. [35] further argue that the feedback companies receive, as a result of their awareness of consequence, on their actions could influence their corporate social responsibility policies. It determines the extent and pace to which organisations develop with corporate sustainability [34]. Other studies have applied awareness of consequence from the perspective of behavioural change. The awareness of consequence approach to behavioural change has proven effective in the research context of disaster consequences [36] and environmentally friendly behaviour [24] that promotes behaviour change for either the adoption of sustainable innovation or avoidance of deleterious actions. Additionally, Hansla et al. [23] posited that:

“People become engaged in environmental issues and perform pro-environmental behaviour to the extent that the environmental problems have threatening and harmful consequences for egoistic, social-altruistic, or biospheric objects that they value (e.g., ones' own health, humankind, or animals and plants, respectively).”

People have a moral obligation to protect their environment when they become aware of the consequences and implications of destroying their environment [36,37]. Not only do pro-environmentalists consider environmentally related issues very important, they are also prepared to sacrifice their resources, including wages, to save the environment [36]. Han [38] also explained further that a person's awareness of possible damaging con-

sequences could be enhanced if they take responsibility to ensure pro-environmentally friendly actions. Earlier studies by Cordano et al. [39] and De Groot and Steg [37] also agreed with Han's assertion. They explain that the awareness of consequence activates an individual's readiness to prevent harmful outcomes. The theory further shows that socio-economic issues, including poverty and low social status, could inspire people to take decisions that could be inimical to a sustainable green environment [40,41]. For instance, the quest to gain employment could lead people to engage in illegal mining activities [42]. Thus, in view of the fact that farmers are fully aware of the benefits of cocoa agroforestry but do not generally adopt shaded cocoa production system brings to the fore the need to interrogate the traditional top-down approach to cocoa innovation dissemination to farmers. The extant literature confirms that the top-down innovation dissemination approach is the most common approach used to promote shaded cocoa agroforestry systems innovation to cocoa farmers [8,19,22]. Hence, there is ample ground to examine the cocoa extension services innovation–diffusion approach to promote shaded cocoa agroforestry by considering farmers' responses to the evidence-based awareness of consequence method. Furthermore, limited research exists on the awareness of consequence in the context of the cocoa agroforestry system.

The literature available mostly analyse the effects of shaded agroforestry practices [9,43–45] and unshaded agroforestry practices [46,47] on the environment separately. To our knowledge, innovation-induced agroforestry, including its waste management studies, are seldom researched in developing countries. Thus, this research examines one confirmatory and one exploratory research question as follows:

Confirmatory research question: Does the adoption of shaded cocoa agroforestry lead to sustainable yields in the medium to long term?

Exploratory research question: Does the awareness of the consequences of full-sun cocoa production lead to a change of intention towards the adoption of shaded cocoa agroforestry?

Addressing these questions contributes to the expansion of knowledge on cocoa agroforestry innovation and the awareness of consequence literature and also provides ample grounds and a rigorous basis upon which to seek innovation in the cocoa extension services' traditional approach to innovation transfer and diffusion.

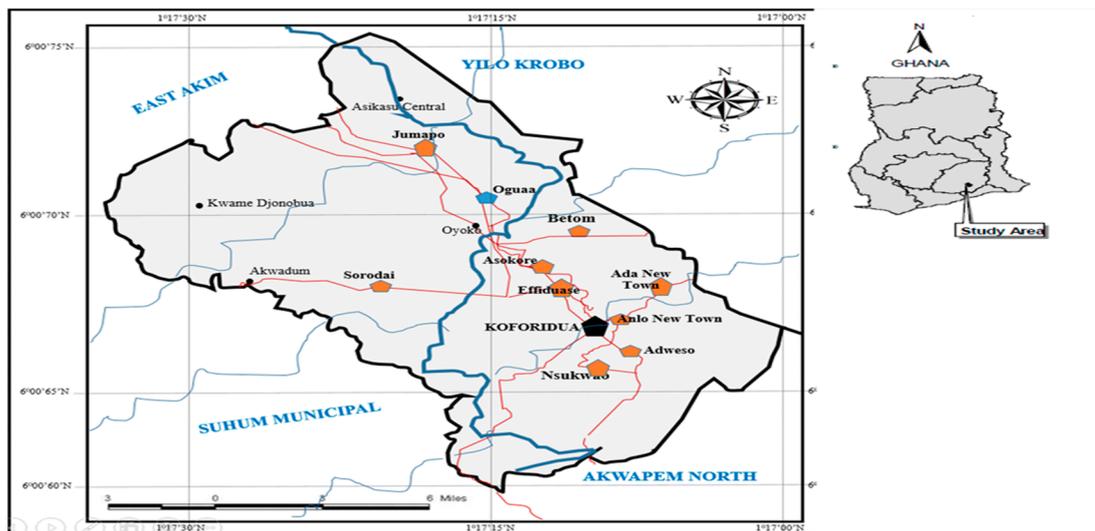
### 3. Methodology

#### 3.1. Study Context

The traditional cocoa production system was characterised by high rainforest and moist semi-deciduous forest. Current production has however been constrained by rapid deforestation, at the rate of 2% per year, giving rise to a shift from the traditional shaded cocoa agroforestry to a full-sun (unshaded) system [13,16,28–30]. This shift is due to the widespread perception of a negative relationship between shade cover and cocoa yield [8,11,32]. There has been devastating consequences of vegetation (forest) clearance on soil ecosystems which in turn affected cocoa productivity. For instance, the exposure of the soil to higher temperatures has depleted the soil nutrient level which is needed for the growth and development of the cocoa plant [43,48,49]. In addition, besides cocoa being an understory plant, the importance of the traditional cocoa production system relates to the fact that young cocoa trees (0–3 years) require shade levels of about 70 % and mature and old cocoa trees (4 years and beyond) need about 30–40% shade for efficient growth [50]. The departure from the cocoa agroforestry system has contributed to the limited new forest for cocoa cultivation. Consequently, major cocoa growing regions of Ghana have become unsuitable for cocoa cultivation, whilst current growing regions require the heavy application of inorganic fertilizers to produce optimum results.

The study area chosen for this systematic study was the New Juabeng Municipality which is located in the eastern region of Ghana, at longitudes 1030' west and 0030' east and latitudes 60 and 70 north (Figure 1). The Municipality covers approximately 159 square kilometres with a population of 183,727, representing 6.9% of the Eastern region's total population [51].

Though the area is classified as semi-deciduous forest, the progressively intense land-use pressure has reduced the original pristine forest vegetation to isolated patches of forest formations [52]. The vegetation is currently characterized by tall trees with evergreen undergrowth and rich in economic trees including *Chlorohorae excelsa*, *Ceiba pentandra*, *Antaris Africana*, and *Triplochinton scleroxylon*. The Municipality has a bi-modal rainy season, ranging between 1200–1700 mm per annum. The dry season is experienced between November to February. Temperatures generally range from 20–32 °C [51].



**Figure 1.** Map of New Juaben Municipality showing the location of the selected communities (indicated by the circles).

The major soils of the area are Nankese-Koforidua/Nta-Ofin, Adawso-Bawjiasi association, and Fete-Bediesi Complex associations, and these soils are considered suitable for trees and arable crop production [51,53]. Even though the Municipality is one of the earlier important frontiers of cocoa production in Ghana, some areas have experienced significant decline in cocoa production due to progressively intense land-use pressure [52,54]. Currently, it has a medium productivity rating for cocoa under medium agriculture input [54]. The communities we selected for this study (Figure 1) are considered the prime places for cocoa production in the Municipality [52,53].

According to the Ghana Statistical Service [51] report, Asokore, Effiduase, and Oyoko are the second, third, and fourth most populated communities in the Municipality, with populations of 15,787, 13,113s and 8650 respectively, whilst Jumapo is ranked sixth (5403) and Akwadum eighth (2850). These selected communities are located where the forest vegetation has high tree densities and supports high levels of sustainable cocoa production (Table 1).

**Table 1.** Communities of high levels of sustainable cocoa production found in the study area (New Juaben Municipality in Ghana) with suitable soils and high tree densities (adopted from Pabi [52]).

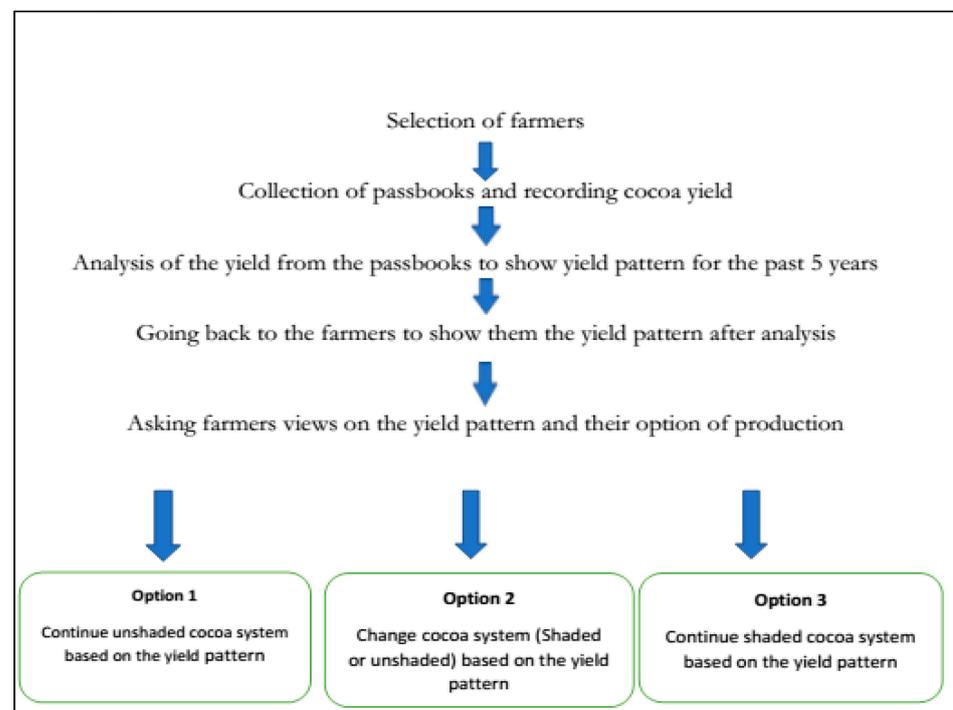
- Sushen
- Jumapo
- Oyoko
- Akwadum
- Koforidua
- Nkurakan

The agricultural sector is an important source of employment for about 26.1% of the population in the Municipality, with the majority (87.6%) of households engaged in crop farming. Even though the majority of the farmers operate on small scale (less than five hectares), the area contributes significantly to the production of industrial crops such as

cocoa, cola nut, and oil palm in Ghana [53]. The average yield of cocoa in the study area is about 345.26 kg/ha and currently accounts for about 19% of the total cocoa production in Ghana [48,53].

### 3.2. Research Design

We designed and followed a systematic approach in the selection of the cocoa farmers and the data collection processes for both the survey and interviews components of the study. These stepwise activities are summarised and presented in Figure 2. After selecting the farmers, we collected farmers' passbooks (a book in which farmers keep records of the quantity of cocoa beans sold within the cropping season/year) to record their yield data for the past five years. There are nine cocoa growing communities in the Municipality, but the farmers were selected from five communities (Figure 1) for this study. Farmers were selected based on the presence of a variable number of shade trees on their cocoa farms. Besides, the age of cocoa farms was between 5 and 21 years, which is within the economically favourable age of cocoa trees [15].



**Figure 2.** Awareness of consequence procedure adopted during the data collection process.

Phase one of the study involved the analysis of the five-year cocoa yield data gleams from the passbooks of selected farmers, in order to compare the yield pattern between the two groups of farmers practicing the shaded cocoa system and the full-sun system (unshaded). After analysing the yield pattern, researchers went back to the farmers and presented the results to them. The results of the sharing session were the first stage of the second phase of the study to elicit farmers' reactions to the yield patterns of the shaded versus unshaded cocoa production practices.

For the qualitative phase 2, a total of 91 in-depth interviews were conducted, which comprised of 52 male and 39 female cocoa farmers. The age of the farmers was from 31 to above 60 years. Prior to the selection of our respondents, we consulted cocoa extension officers from the Cocoa Research Institute of Ghana (CRIG) and the Ministry of Food and Agriculture (MoFA) to create a list of cocoa farmers that served as the sample population. The sample communities were selected (purposively) based on their intensity of cocoa farming, especially their history of practicing a shaded cocoa agroforestry system and the

age of their cocoa farms; which fell within the economically favourable age of cocoa trees (between 5 and 21 years). The cocoa farms were small to medium (1 to 25 acres) in size.

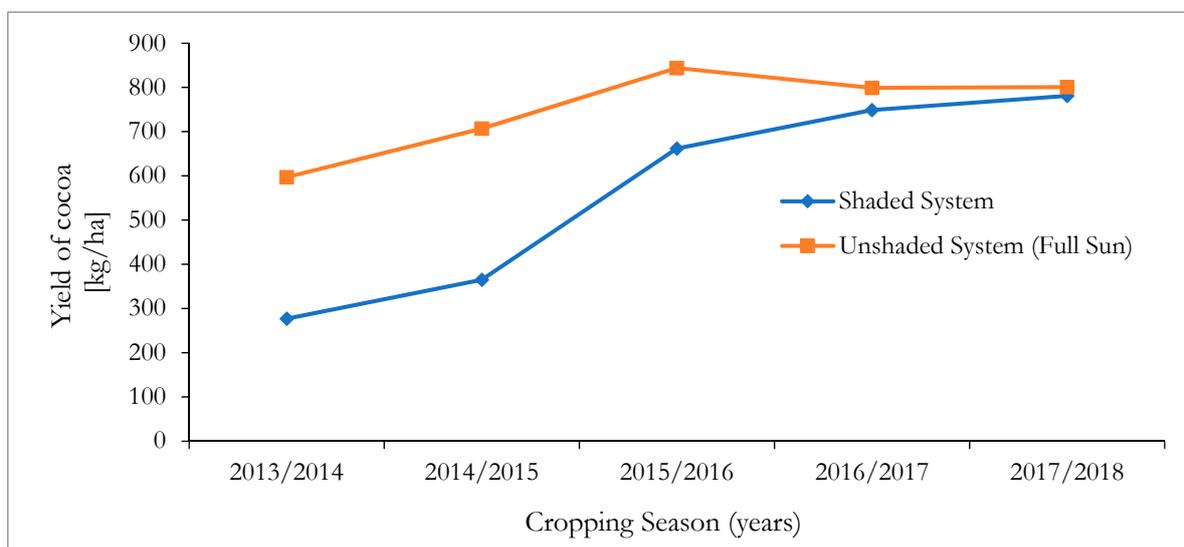
The interviews featured two key questions presented to the two groups of farmers as to whether they will consider changing to a shaded system (unshaded practitioners) or continue using a shaded system (shaded practitioners) on basis of the yields patterns revealed from analysing the data from their passbooks (see Figure 2). The interviews lasted between 45 and 60 min per farmer and were recorded, transcribed verbatim, and coded based on dominant themes. Verbatim quotations were included as part of the content analysis, since these quotations are the most suitable means to tell how respondents articulated meanings and experiences in their own words.

#### 4. Results and Discussion

##### 4.1. Yield Pattern of the Different Cocoa Systems (Shaded vs. Unshaded)

Based on the different cocoa systems being practiced, we selected a total of 91 farmers to assess how the awareness of consequence influenced their adoption of a shaded cocoa agroforestry system. Out of the 91 farmers, 48 farmers (53%) practiced shaded cocoa agroforestry, with 12–18 shade trees present in every hectare of land. However, 43 farmers (47%) had no shade trees on their farm (they practiced an unshaded system). The average farm size for the shaded system was 8.5 hectares compared to 5.4 hectares for the unshaded system.

Generally, the average yield for five cropping seasons was higher in the unshaded system (751 kg/ha) than the shaded system (564 kg/ha). However, the general pattern within the five cropping seasons showed a steady increase in the quantity of cocoa yield in the shaded farms whereas the unshaded system showed a gradual decline in yield after the third (2015/2016) cropping season (Figure 3).



**Figure 3.** Cocoa yield from shaded and unshaded (full sun) systems over five years of cropping seasons.

The studied rise in outputs of the former is further explained by the fact that cocoa is highly sensitive to changes of environmental conditions and requires shade for efficient physiological functioning [49,55]. Intercropping shade trees with cocoa is a common practice among farmers; as it ameliorates the negative impact of environmental stress. Asare and David [50], recommended that young cocoa trees (0–3 years) should receive shade levels of about 70%, while older cocoa trees (4 years and beyond) need about 30–40% shade after establishment. Consequently, in Ghana, about 41% to 58% of cocoa farms are intercropped with either legume or timber shade trees [56].

It is important to emphasise that cocoa is an understory plant in its natural habitat, established in a shaded/agroforestry system. This shaded system provides an organic source of nutrients and organic matter to the cocoa plant through litter fall or prunings [4,8]. In addition, cocoa trees show a more superficial root system compared with most shade trees, thus, shaded cocoa agroforestry systems have shown to provide the “safety net” potential to retrieve nutrients that are moving down the soil profile outside the effective root zone of cocoa [8,28,32]. This promotes greater long-term production of cocoa plants with low levels of fertilization, especially, where regular application of fertilizers cannot be guaranteed [11,16]. There are also reports of lower incidents related to pests and diseases in shaded cocoa systems [28]. These characteristics make a shaded cocoa system more efficient and guarantee long-term sustainable cocoa yields in comparison to the unshaded system.

#### 4.2. Pre-Awareness Perception of Farmers

Our initial assessment of the types of cocoa production systems practiced in the selected communities revealed that farmers have different reasons for either adopting shaded or unshaded cocoa systems. For instance, farmers who practiced shaded cocoa systems mentioned an improved climate and healthier cocoa pods due to agroforestry waste’s rich nutrients as some of their reasons. For example, a farmer in the Jumapo community, justifying his adoption of a shaded system, said:

“The climate within my farm is usually better with the shade trees and we rest under the shade trees after farm work or when we want to crack the cocoa pods after harvest”. The waste also enriches the soil when it breaks down.

Most farmers had considerable understanding on the soil fertility role of the shade trees on their farms, and this served as a motivation for their integration with the cocoa trees. In the Effiduase community, where the majority of the farmers had no access to inorganic fertilizers, a farmer mentioned that:

“When I do not apply Asasewura inorganic fertilizer my yield is still okay, even though it is usually not much like when I use the recommended fertilizer. I believe the shade trees contribute to the cocoa yield without the fertilizer”.

However, the majority of the farmers who practiced a no-shading (full sun) system (47%) attributed the removal of the shade trees to the higher yield that they harvested, in comparison to the shaded system. In the Akwadum community, where most farmers had no shade trees, a farmer explained:

“My cocoa yield is higher for the past three years after I removed the shade trees and I noticed lower incidence of pest and diseases”.

#### Consequences of Unshaded Cocoa Agroforestry Regimes on the Environment

Our field data shows that unshaded cocoa agroforestry regimes increase yield in the short to medium term, however, this could have environmental stress implications in the long term. Among the environmental stresses, high temperature and low rainfall and drought are reported as the most critical factors influencing cocoa growth, productivity, and yields, thus, contributing to a decrease in global cocoa production of up to 15% [57–60]. The mechanism of damages caused by environmental stress are varied: for instance, nitrate reductase is an important enzyme that catalyses nitrate to nitrite, regulates nitrogen assimilation, and promotes general growth and productivity in cocoa plants, however, because it is sensitive to water stress, its activity is affected by drought [61,62]. In addition, there is evidence of a reduction in the plant height, leaf area, and stem diameter of cocoa plants due to drought conditions [59,63].

Several authors [58,61,63] have also mentioned lower photosynthesis, respiration, and stomatal conductance as the effect of drought on some important physiological characteristics of cocoa plants. A lower photosynthetic rate is reflected in the lower growth and yield of the cocoa and, according to Zakariyya and Indradewa [63], this is caused by the following consecutive steps: (a) the qualitative and quantitative degradation of

photosynthesizing pigments, especially chlorophyll; (b) the reduction of CO<sub>2</sub> uptake due to stomatal closure; and (c) low levels of water compound because water in the soil and plant is limited.

Unlike matured cocoa trees which are able to withstand this environmental stress for a short period, young cocoa plants are more susceptible when exposed to these stresses, with records of significant reductions in leaf area, shoot and root dry weight, plant height, and stem girth [58,59,64]. Carr and Lockwood [65] also found visible symptoms of drought stress to include premature leaf fall, yellowing of basal leaves, wilting, small leaves, slow trunk growth, and even seedling death.

In addition, because cocoa is considered a tropical crop, it needs a warm and humid climate, with mean temperatures of 18–32 °C [50]. Temperatures below 10 °C can damage sprouting seedlings, cause the inhibition of the photosynthesis rate, reduce the net CO<sub>2</sub> assimilation rate and stomata resistance to water vapour, and reduce yields by approximately 50% [66,67]. Likewise, long periods of high temperatures above 30 °C increase the rates of soil evaporation, affecting the physiology of the cocoa tree and reducing bean size [68,69].

Moreover, cocoa trees are known to be associated with a low light saturation point (LSP) of 400  $\mu\text{E m}^{-2} \text{s}^{-1}$  and a low maximum photosynthetic rate of 7  $\text{mg dm}^{-1} \text{h}^{-1}$ . The photosynthetic rate of cocoa declines if it is exposed to light intensities beyond 60% of full sunlight (1800  $\mu\text{mol m}^{-2} \text{s}^{-1}$ ), with prolonged exposure resulting in damage to the photosynthetic mechanism of the leaves. Low light intensities (less than 1800  $\text{h year}^{-1}$ ), however, suppress cocoa flower production and subsequently pod yield [70–72]. Generally, climate change models predict reduced rainfall, increased light intensity, and higher temperatures. These changes will have significant limitations to cocoa production in the near future, with some areas of West Africa already being affected according to Läderach et al. [17] and Hutchins et al. [73]. These studies contend that longer periods of drought and higher temperatures are causing fluctuations in cocoa productivity and death, hence, recommend that farmers develop resilient shade-grown cocoa systems, as it is believed that shade trees play a key role in regulating light intensity, humidity, and temperature, and provide green waste for soil nutrient improvement [28,66,74].

#### 4.3. Post Awareness Perception of Farmers

Cocoa yield data for the five cropping seasons was taken from the farmers' passbooks beginning from the 2013/2014 to the 2017/2018 cropping season. The yield data was analysed to establish the trend in the past five years (Figure 3).

The analysed data was shown to all of the 91 farmers. The 53% of the farmers who practiced the shaded system still wanted to continue maintaining shade trees on their farms. A farmer, who after seeing the pattern of the yield data in Figure 3, put it this way:

“I do not apply any Asasewura inorganic fertilizer, but it looks like there is not much difference between my yield and those without shade trees”.

To answer the research question: does awareness of consequence influence farmers' adoption of shaded agroforestry systems? we went back to the farmers (43%) who practiced a no-shading system and presented the analysed yield patterns in Figure 3 to them. After seeing the yield pattern, we asked them if they will continue their practice of no-shading or if will they intercrop shade trees with their cocoa. In total, 37 out of 43 farmers (86%) changed their mind and were willing to start intercropping shade trees. In the Akwadum community, a farmer who had earlier removed all shade trees on his cocoa farm made the following observation:

“I have never been shown any data to prove that my yield can be good with shade trees. So I removed the shade trees to plant more cocoa trees to enable me to get more yield, but if your result is true then I will try to have more of the shade trees on my farm”.

Another female farmer from the Oyoko community, who practiced a no shade system, stated that:

“If I can still get such good yield from my farm with the shade trees, it may be better leaving the shade trees on my farm”.

However, six farmers, representing 14% of the total [43], who practiced no-shading, maintained that they were still going to remove the shade trees because the yield pattern in Figure 3 showed a better yield without shade. Other reasons were the higher incidence of pests and disease they recorded on their cocoa farms due to the presence of the shade trees.

Two farmers, one from the Oyoko community and the other from Asokore, justified that:

Farmer 1 (Oyoko community): “My farm activities like weeding, spraying, fertilizer application is usually difficult to undertake when shade trees are present”.

Farmer 2 (Asokore community): “I am able to plant more cocoa trees without the shade trees, and as you have shown me the result in the figure my yield looks better than those with shade trees”.

Generally, out of the 43 farmers who initially practiced no-shading, 37 farmers (86%) changed their mind and indicated that they would integrate shade trees with their cocoa after seeing the analysed yield pattern of the shaded versus unshaded cocoa systems, whilst 6 farmers’ views remained unchanged and they indicated a preference to continue with an unshaded (full sun) system.

## 5. Policy Implications

We argue that the awareness of the consequences of non-shaded cocoa production and the adoption of shaded cocoa agroforestry for a sustainable yield in the medium to long term has implications for policy formulation, particularly for cocoa extension policies. There is the need to review the top-down cocoa extension approach, where farmers in most cases do not appreciate why they are encouraged to adopt a new policy. The findings of this study have shown that when farmers are confronted with the consequences of their unsustainable activities, behaviour change is likely engendered towards pro-environmental production systems such as shaded cocoa agroforestry, especially when farmers become aware of the direct effects of this system on waste management and their economic status and livelihoods. Mission-oriented policies, focused on strengthening agriculture extension institutions to partner cocoa farmers to generate demonstration materials which show the consequences of their actions, will facilitate the diffusion of agroforestry related information and innovations for shaded cocoa production relative to unshaded conditions. Understanding the consequences of unshaded cocoa production will enable farmers to appreciate how to increase their cocoa yield within a shaded agroforestry environment.

We argue that in the short to medium term, good agricultural practices coupled with efficient uses of land—focused on pro-environmental activities such as green waste management—must be the main focus for achieving these mission-oriented policies. Furthermore, successive governments in Ghana must discriminate between the paid producer prices for cocoa beans from shaded and unshaded cocoa farms, in order to encourage farmers to focus on sustainable yields to avoid nurturing short-term profit maximisation motives. As demonstrated in the discussion section, farmers focus on increasing cocoa output through unshaded cocoa farming to maximise short-term profits. The role of governments and public institutional support has been found to be a critical motivator towards the undertaking of sustainable activities, as is evident in the case of food-related rural farmers in Denmark, where institutional policies that reward environmental conservation have proven effective [75].

In the long term, there is the need to embark on an ecologically intensive cocoa agroforestry system in which farmers will be equipped and educated to increase cocoa cultivation under shaded agroforestry regimes for all the agronomic and green waste benefits. This policy must be complemented with an extensive public awareness campaign on the importance and sustainable use of agrobiodiversity resources within cocoa growing communities to encourage ecological integrity in the cocoa production landscape.

## 6. Summary and Conclusions

In summary, the results confirm the strand of literature that suggests that a shaded cocoa system provides a consistent and sustainable cocoa yield in the medium to long term, compared with an unshaded system.

Secondly, the results further provide ample grounds to suggest that the awareness of consequence, understood as an individuals' beliefs about the adverse consequences of environmental problems [23], engenders the assumption of responsibility and pro-environmental behaviour [24], as exemplified by the stated intentions of the cocoa farmers in this study.

This study set out to investigate whether the awareness of the consequences of unsustainable unshaded cocoa production systems will lead to an intention to change and adopt shaded cocoa agroforestry. Addressing two research questions using the collection and analyses of the cocoa yield data from unshaded and shaded systems, we have established that a shaded cocoa system provides consistent and sustainable cocoa yields in the medium to long term compared with an unshaded system. In addition, through a qualitative investigation of the cocoa farmers' views post awareness of consequence, the study demonstrates that the majority of cocoa farmers' awareness of consequence about the adverse effects of the adoption of an unshaded/full-sun cocoa system could lead to individual farmers' assumption of responsibility and pro-environmental behaviour, leading to an increased adoption of Cocoa Agroforestry System for green nutrients from agroforestry waste and a steady yield. It can be inferred from the results that when cocoa farmers currently practising the full-sun system adopt the shaded agroforestry system they are likely to benefit from a more sustainable yield over a longer period and this will translate into steady income over a long period. The results have implications for agroforestry innovation adoption and cocoa extension approaches and policies to innovation diffusion.

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