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Impact of ICT Adoption and Governance Interaction on Food Security in West Africa

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Abstract: The impact of the interaction of governance and information and communication technolo-
gies (ICT) adoption on food security in West Africa is investigated in this study. The study engaged
the system generalised method of moments (GMM) approach on a panel data of 15 West African
countries. The data used for the study are obtained from the world development indicators (WDI)
and world governance indicators (WGI), for the period 2005 to 2018. The findings show that good
governance (government effectiveness and efficient anti-corruption control) can boost food security
by between 12% and 20%. Furthermore, the findings show that a 1% rise in ICT adoption may
boost food security by 12% to 15%. In explaining the level of food security, the relationship between
governance and ICT adoption is positive and significant. This implies that ICT and governance
(government effectiveness) interaction may have about 15% positive influence on food security, while
ICT and control of corruption interaction may positively influence the level of food security by 8%.
The study concludes by recommending that to enhance food security in West Africa, effectiveness in
governance and ICT adoption are crucial.

Keywords: access to ICT tools; food and nutrition security; sustainable development; institu-
tional quality

1. Introduction

One of the visions of global economies is to ensure food security, in order to achieve
the United Nations (UN) 2030 sustainable development goals (SDGs), especially SDG-2
(to reduce extreme hunger by half and achieve food security) [1]. As population increases,
so does the demand for food, thereby posing a threat to food security [2,3]. By 2050,
the global population is expected to reach 9 billion, leading to an increased level of food
demand and worsened the state of food insecurity, especially in Africa, which has low
marginal labour productivity in the agricultural sector [2,4].

To feed about 9 billion people by 2050, agricultural production and its marginal labour
productivity needs to be increased by 70% [2]. This is crucial due to the increasing rate
of food insecurity. According to FAO [2], 9.2% of the world's population (more than
700 million people) was exposed to insecurity in 2018. Food insecurity affects people at
all stages in life, with maternal malnutrition, low birth weight, and infant stunting all

increasing the likelihood of being overweight later in life. Therefore, raising agricultural productivity through ICT innovation and sustainable governance are necessary to cushion the negative impact of food insecurity [2].

The agricultural sector has a crucial role in the production of food and the growth of the general economy. It has been argued that growth from the agricultural sector is more efficient in reducing poverty and food insecurity than growth from other sectors of the economy [3]. This is because, agricultural sector provides employment and livelihood for more than 50% of the people, especially, in developing countries [2]. However, despite strategic efforts to alleviate food insecurity and hunger, there continued to be food insecurity in many developing regions, like West Africa. Over the sub-region, countries have suffered political challenges that have affected nearly all its growth and development sectors, resulted from weak governance and inefficient ICT infrastructure to stimulate production [5,6].

In West African sub-region, government at all levels, have designed strategies to ensure food security. Some of these policies are: the promotion of large investments in agricultural infrastructural facilities, extension services and increasing households purchasing power [7]. All these are efforts to control quality, promote local content, massive production and exportation, and encourage local farmers. However, the impact of these policies has remained inconclusive, primarily owing to the continuous challenges of weak governance and low ICT infrastructure, among others things [7,8]. Flowing from above argument, this study contributes to extant studies by examining the impact of: (a) governance on food security, (b) ICT adoption on food security, and (c) ICT adoption and governance interaction on food security, using the system GMM, which, to the best of the authors' knowledge, before now, has not been considered in the extant literature. This study is divided into five sections. The review of the literature follows this introductory section, followed by the methodology, the results and discussion are presented in Section 4, and the study concludes with Section 5.

2. Review of Literature

2.1. Governance, Institutional Framework, and Food Security Nexus

Globally, there have been a number of institutions in the area of food governance and food security achievement. The number and variety of international organisations with a mandate to work on food security has steadily increased [9–12]. One explanation for this growth is that the global governance of food security is unique in that it is highly diverse, with a wide variety of factors that can impact food security outcomes (for example, bad weather, a regional conflict, biotechnology, biofuel, and so on) [13]. Shaw [13] noted that the establishment of the Food and Agricultural Organisation (FAO) can be considered the origin of the contemporary global governance of food security.

For food security, there has been an increase in global governance activity. One of the millennium development goals, for example, was to reduce the number of hungry people around the world (MDG) [14,15] and is still pertinent in the sustainable development goals (SDG). The global food crisis of 2007–2008 prompted reforms in global food security governance, including the restructuring of established global structures and the establishment of new ones to address the future drivers of food insecurity, such as climate change [16,17].

In the food security governance issues, there are a number of categories [17,18]. There are international organisations that focus on broad area of food policies (relating to agriculture production). The FAO, International Institute of Tropical Agriculture (IIAT), the Consultative Group on International Agricultural Research (CGIAR), and the International Food Policy Research Institute are only a few of these organisations (IFPRI). There are other organisations working on areas relating to nutrition and public health policy-making activities relating nutrition and food assistance for food insecure and marginalised groups [2]. Other organisations channel their efforts on agriculture trade by harmonising cross-border trade policies, Intellectual property rights for seeds and plant genetic materials, as well

as technological trade barriers (these are World Trade Organisation—WTO, International Grains Council—IGC, United Nations Conference on Trade and Development—UNCTAD).

Institutional framework forms the basis for food governance–food security achievement. Institutions properly designed to take care of agriculture productivity are requirements for achieving food security [18]. Institutional capacities—defined as the range and depth of financial, human, and political capital, as well as specialised expertise and practices that an institution requires to carry out its mandate in order to achieve agriculture development (food security)—are important.

Hawkins [19] finds that globally, food insecurity has risen in countries with high level of corruption. Corruption hinders social and economic development, negatively affects international and regional development agencies' efforts to combat hunger and famine in a systematic way, and disrupts market operations [20]. According to Uchendu et al. [21], Smith et al. [22], Subramaniam et al. [23] and Ogunniyi et al. [24], corruption thrives in communities where there are flaws in governance or weak institutions. Ibidunni et al. [4] asserts that the four facets of governance, namely, anti-corruption, effective democratic accountability, political stability, and rule of law and order, play critical roles in ameliorating child malnutrition and stunted growth.

Both nutrition and food security are improved by government effectiveness, political stability, democratic transparency, and the rule of law and order [23,24]. Conflicts are emerging within countries as a result of poor governance and rampant corruption, posing the greatest threat to food security [25,26]. Internal conflict, which plays a significant role in undermining a country's food security, has once again been identified as a major cause of internal conflict [27,28]. Some scholars have studied the nexus between governance, institutions and food security and have found varied conclusions.

The study by Osabohien et al. [29] examined agricultural sector's performance, looking at the institutional framework vis a vis food security in Nigeria. The study reveals that with massive investment in agricultural production and increased credit facilities, food security will increase by 2%, reducing the rate of undernourished in Nigeria by 18%. As opined by Olofin et al. [7], many Nigerian farmers have been denied access to credit due to the weak institutional framework. In a similar way, Osabohien et al. [8] carried out a study on accountability in agricultural governance and food security in Nigeria, applying the autoregressive distribution lag (ARDL) and found that effectiveness in governance will enhance agricultural performance, which in the long-run, contributes to food security in Nigeria.

Asogwa et al. [30] studied an ICT-Based System for improved food security in Nigeria, and outlined a framework based on the development of a national ICT/Internet host that will house a comprehensive knowledge database of agricultural research results, best farming practices, technology, and farming opportunities that will be easily accessible by all stakeholders in an interactive and ubiquitous manner. The study came to the conclusion that not enough has been done to embrace ICT resources as a necessary base for improved agriculture.

Similarly, Anser et al. [31] looked at how institutions and political risk impact on food security in 128 countries across Africa, Asia, Europe, Latin America, and the Caribbean, using system-GMM. Internal and external conflicts, socioeconomic conditions, corruption, military involvement in politics, religious tensions, ethnic tensions, and low bureaucracy efficiency exacerbate food security in developed and developing countries, while government stability, law and order, democratic accountability, and investment profile have a positive and significant impact on food supply.

2.2. ICT Adoption, Innovation, and Food Security

There are studies that generally assert that ICT adoption will drive Africa's transformation leading to food security [30]. ICT deployment cum innovation activities could help achieve food security [1,30]. ICTs and innovation in agriculture (e-agriculture) help to ensure food security in three broad categories; through production, postharvest storage,

and the supply value chain [1]. It should be noted that while production is an essential factor in ensuring food security, other factors such as access to food and utilisation are also important Anser et al. [32].

ICTs are critical in providing farmers with valuable information, such as weather forecasts and crop prices, as well as in educating them about modern farming techniques, to ensure food security [1]. The study by Jere et al. [33] carried out in the KwaZulu-Natal Province of South Africa, the effect of ICT adoption on food security was assessed in the iLembe district. The study applied the structural equation model (SEM) on data of 517 smallholder farmers and found that ICT adoption positively and significantly impact food security. Anser et al. [1] studied the connections between social inclusion, innovation, and food security in 15 West African countries, using the system-GMM, found that innovation is one of the drivers of food security in Africa.

According to the study by Asogwa et al. [30], a well-informed farmer has a higher chance of becoming a good farmer, because of the availability of information to cultivate, when and where to sell goods, and when and how to receive loan and credits. For example, television can be used to educate farmers on best agriculture practices, because it allows farmers to visualise demonstrations by experts in the field; as a result, the farmer gains a deeper understanding and is better prepared. In Kerala, India, it has been demonstrated that using mobile phones while at sea allows fishermen to respond quickly to market demand and avoid waste due to overfishing [34]. Sugar cane farmers in Kenya who received personalised SMS urging them to complete certain tasks on their fields and increased their yields by 11.5% on average, according to research [35].

ICTs can help increase food security by increasing supply chain productivity. ICTs will increase information flow between farmers, food producers, traders, and consumers which will lessen the food wastage and increase reliability of food in the supply chain. The use of radio-frequency identification (RFID) tags allows inventories to be tracked from farm to store to sale outlets [34]. The RFID helps to provide information on perishable products and the details of each product's origin that can be used to curtail food spoilage. Individual monitoring of farm animals is increasingly being implemented in the European Union to protect consumers. After 31 December 2009, all animals born are given an RFID tag that will monitor their location throughout their lives [34].

Another broad area of ICTs and innovation ensures food security is in the marketing and sales of farm products, where farmers have easy access to market. Farmers can get market price information, inputs information and where they can sell their produce at better prices. Svensson and Yanagizaw [36] found that farmers in Uganda who received price information via radio increased their crop revenues by up to 55%. According to Aker [37], the introduction of mobile phones among grain traders in Niger enables them to search for price information over a larger area and sell grains in more markets. Grain price dispersion was reduced by 10% to 16% as traders' ability to buy and sell through markets, making food more accessible to consumers.

3. Methodology

3.1. The Empirical Model

To achieve the objective of this study, a panel dataset comprising of 15 West African countries was engaged to explore how ICT adoption and governance interact to impact on food security status. The econometric models (in double-log form) which are estimated are shown in Equations (1) and (2), drawing insight from the empirical study by Anser et al. [1].

$$lY_{it} = \varphi_0 + \varphi_1 lICT_{it} + \varphi_2 lGE_{it} + \varphi_3 lCC + \varphi_4 l(ICT_{it} * GE_{it}) + \varphi_5 l(ICT_{it} * CC_{it}) + e_{it} \tag{1}$$

where, Y represents food security (the outcome indicator); ICT means information and communication technology, GE represents government effectiveness, CC means control of corruption, $ICT_{it} * GE$ captures ICT adoption and governance interaction, $ICT * CC$ means ICT adoption and control of corruption interaction. In this study, government effectiveness

and corruption control are used as governance indicators. The natural logarithms of the variables in the model minimise the incidence of heteroscedasticity. Equation (1) is analysed with the use of fixed effect and the pooled ordinary least Squares (POLS) regression.

The method GMM approach in line with Arellano and Bond [38] and Windmeijer [39] is used to control for unobserved heterogeneity and possible issues of endogeneity, as shown in Equation (2).

$$lY_{it} = \varphi_0 + \omega lY_{it-1} + \varphi_1 lICT_{it} + \varphi_2 lGE_{it} + \varphi_3 lCC + \varphi_4 l(ICT_{it} * GE_{it}) + \varphi_5 l(ICT_{it} * CC_{it}) + u_{it} \qquad (2)$$

From the above model, Y_{it-1} represents the first-lag of food security and ω captures its coefficient. In the same way, φ_1, φ_2, φ_3, φ_4 and φ_5 represent the coefficients of the independent variables. The model as presented in Equation (2) is estimated with the use of the system GMM. From the model, u captures the stochastic term, which represents other independent variables not included in the model. Additionally, it represents entities and time, respectively. Time means the years (2005–2018), while entities represent the 15 West African countries engaged in the study.

3.2. Data and Summary Statistics of Variables

As previously mentioned, to achieve the objective of the study, a panel datum of 15 West African countries that are members of the economic community of West African states (ECOWAS) was employed. The data were soured from the world development indicators (WDI) and world governance indicators (WGI) of the World Bank.

Table 1 shows summary statistics of the variables engaged and their respective sources. Food security was captured using the food production index. Food production index covers food crops that are considered eatable and contain nutrients. Control of corruption (CC) and government effectiveness (GE) are two governance indicators obtained from the world governance indicators database (WGI). Control of corruption encapsulates people's expectations of how often public influence is used for private benefit [40]. The expectations of the quality of public services, the quality of the civil service and its independence from political constraints, the quality of policy development and implementation, and the legitimacy of the government's commitment to those policies are all factors that influence government effectiveness [40]. Table 1 summarises the variables used in the study.

Table 1. Summary of data sources and measurement of variables.

Variable	Identifier	Measurement	Source	Mean (SD)	Min (Max)
Food Security	FS	Food Production index	WDI	122.98 (21.98)	75.58 201.22
ICT Adoption	ICT	Mobile internet service (% of total population)	WDI	1.3707 (2.8007)	138.8100 2.0708
Government Effectiveness	GE	Estimate of standard normal distribution. Ranges from −2.5 (lowest) to 2.5 (highest).	WGI	−0.8065 (0.4526)	−1.7600 (0.35)
Control of Corruption	CC	Estimate of standard normal distribution. Ranges from −2.5 (lowest) to 2.5 (highest).	WGI	−0.6141 (0.5245)	−1.56 (0.950)
ICT-govt. effectiveness interaction	ICT*GE	The multiplication of ICT and governement effectiveness	X	-	-
ICT-control of corruption interaction	ICT*CC	The multiplication of ICT and control of corruption	X	-	-

Note: CPIA stands for country policy and institutional assessment. WDI stands for world development indicators and WGI stands for world governance indicators. X means computed by the authors. Source: Authors.

The summary statistics presented in Table 1 shows that the mean of food production in West African sub-region is about 122.98 metric tonnes, while about 1.4 billion of the total population has access to ICT (mobile internet service). For governance indicators, using

government effectiveness and control of corruption, the negative signs (for both variables), show that, in West African sub-region, there is a weak institutional framework. This suggests that policy development and execution are of poor quality, as is the government's dedication to such policies, which could have a detrimental impact on food systems.

4. Result and Discussion

4.1. Pooled Ordinary Least Squares Result

This study aims to examine how governance and ICT adoption interact to influence food security in West African sub-region. The econometric analysis starting by conducting the pooled ordinary least squares (POLS), presented in Table 2. The R-squared (0.59) shows that about 59% variation in the explanatory variables is explained in the model. ICT adoption is significant and positive across the POLS result, meaning that ICT adoption is significant and positive in explaining the level of food security. The implication of the result is that, increased level of ICT adoption is capable of increasing the level of food security by about 10%. On the hand, government effectiveness, though significant, but negative in explaining the level of food security. The implication of this is that weak governance in executing efficient mechanisms towards enhance food security may lower food security by 20%. On the contrary, control of corruption and interaction variables are not significant in POLS model.

Table 2. POLS result (Dependent variable: food security).

Variable	1	2	3	4	5	6
ICT	0.10044 * (0.000)	0.09314 * (0.000)	0.10460 * (0.000)	0.10305 * (0.000)	0.09752 * (0.000)	0.10021 * (0.000)
GE	−0.19548 * (0.007)				−0.20018 * (0.005)	−0.20990 * (0.005)
ICT-GE interaction		−0.01027 * (0.009)				
CC			−0.05444 (0.396)			
ICT-CC interaction				−0.00390 (0.316)		
Constant	2.597 * (0.000)	2.712 * (0.000)	2.8220 * (0.000)	2.8379 * (0.000)	2.6060 * (0.000)	2.2842 * (0.000)
R.sq	0.588	0.587	0.580	0.581	0.594	0.594
Groups/obs.	173/15	173/15	173/15	173/15	173/15	173/15
Wald chi2	179.43 (0.000)	181.52 (0.000)	166.40 (0.000)	169.47 (0.000)	179.67 (0.000)	164.68 (0.000)

Note: The *p*-values are in the parentis ( ), * means that the coefficient is significant at 1% level.

4.2. Fixed Effect Result

Due to perceived weakness of the POLS, the fixed effect was conducted to examine the effect of governance and ICT interaction on food security, in validation of the POLS result. The result obtained from the fixed effect analysis is presented in Table 3. The rule is that the fixed effect (FE) or random effect (RE) model should be estimated; the statistics from the Hausman (1978) test suggests using the fixed effects instead of the random effects model. The Hausman test result for the regression is $\chi^2 = 131.37$ ($p = 0.000$), that is, the assumption that a model using random effects is preferable is rejected.

The result obtained from the fixed effect analysis is somewhat similar that of POLS. From the result (presented in Table 3), ICT adoption is significant across models, showing that ICT significantly and positively influence food security. The implication is that increased access to ICT is capable of increasing the level of food security by about 10%. In addition, a fixed effect method of estimation based on Hausman results was used in this analysis. On the contrary, governance, using government effectives, though significant, negative related to food security. The same applies to governance–ICT interaction, which

is also negatively. The result implies that though, effectiveness in governance can help mitigate food insecurity, on the contrary, weak governance will also worsen the state of food insecurity. Furthermore, maintaining food security necessitates the control of corruption. However, the result implies that ineffectiveness of governance will worsen the state of food insecurity by 17% to 18%, respectively. To achieve food security in the countries, it is important to encourage the use of modern farm equipment such as tractors, harvesters, and other machinery rather than manual labour on farmland.

Table 3. Fixed effect result (Dependent variable: food security).

Variable	1	2	3	4	5	6
ICT	0.11457 * (0.000)	0.10723 * (0.000)	0.11759 * (0.000)	0.11465 * (0.000)	0.11361 * (0.000)	0.11200 * (0.000)
GE	−0.17102 ** (0.047)				−0.1873 ** (0.030)	−0.1937 ** (0.031)
ICT*GE		−0.0080** (0.049)				
CC			−0.0660 (0.345)			
ICT*CC				−0.00514 (0.233)		
Constant	2.3811 * (0.000)	2.4869 * (0.000)	2.496 * (0.000)	2.527 * (0.000)	2.350 * (0.000)	2.468 * (0.000)
R squared	0.5890	0.588	0.580	0.582	0.596	0.598
Groups/observation	15/173	15/173	15/173	15/173	15/173	15/173
F-stat	74.05 * (0.000)	73.99 * (0.000)	71.56 * (0.000)	72.01 * (0.000)	56.92 * (0.000)	54.77 * (0.000)

Note: The *p*-values are in the parentis ( ), * and ** means that the coefficient is significant at 1% and 5% respectively.

4.3. System Generalised Method of Moments Result

The generalised method of moments (GMM) is used to control for endogeneity problems. One of the issues may be that the disturbance autocorrelation in the time-series regression analysis may be present. Another concern may be the existence of possible endogeneity in the main regressors [38,39]. As a result, the study controls for this issue by employing the GMM method as specified in Equation (2), with the result provided in Table 4.

The precondition for system GMM is that the autocorrelation at the first-order autoregressive AR (1) process should be significant, and autocorrelation at the second-order autoregressive AR (2) should not necessarily be significant. The Sargan test is insignificant, which shows the instruments engaged are not correlated with the residuals, and, thus, are considered valid.

Due to the weakness of POLS and random effect, conclusions for this study are drawn from the system GMM results. Unlike the POLS and fixed effect result (presented in Tables 2 and 3), the result presented in Table 4 (the system GMM), across models, shows that the variables used in the study are statistically significant at the 1% level, and are positive in explaining the level of food security. According to the findings, an improvement in ICT has the potential of improving food security by 12% to 15%.

4.4. Discussion of Result

This section of the study presents the summary of the discussion based on results obtained from the models estimated. This discussion mainly focuses on the results obtained from the system GMM model. The result shows that ICT adoption and governances are drivers of food security. This means that increased technical advancement has the potential of increasing food security by at least 12%. This supports the study by Anser et al. [1], which found that innovation lowers production costs, food costs, and food insecurity. Similarly, governance indicators (control of corruption and government effectiveness) show that a

1% increase in effectiveness in governance may likely increase the level of food security by about 12% to 18%. In the same way, effective control of corruption may increase food security by 20%.

Table 4. System GMM result (Dependent variable: food security).

Variable	1	2	3	4	5	6
Food security (−1)	0.27062 * (0.003)	0.3050 * (0.000)	0.3288 * (0.000)	0.3638 * (0.000)	0.2558 * (0.008)	0.2547 * (0.008)
ICT Adoption	0.1358 * (0.000)	0.1553 * (0.000)	0.1257 * (0.000)	0.1311 * (0.000)	0.1427 * (0.000)	0.1548 * (0.000)
Governement effectiveness	0.1282 * (0.002)				0.1692 * (0.000)	0.1824 * (0.000)
ICT-Goverment effectivenss interaction		0.0154 * (0.000)				
Control of corruption			0.1972 * (0.000)			
ICT-control of corruption interaction				0.0181* (0.000)		
Constant	2.0853 * (0.000)	2.0766 * (0.000)	2.2181 * (0.000)	2.1630 * (0.000)	2.1309 * (0.000)	0.7137 * (0.002)
Groups/observation	15/159	15/159	15/159	15/159	15/159	14/151
Wald chi2	299.74 * (0.000)	282.71 (0.000)	285.32 (0.000)	259.76 (0.000)	313.21 * (0.000)	386.49 * (0.000)
AR (1)	−3.97 * (0.000)	−3.96 * (0.000)	−4.35 * (0.000)	−4.41 * (0.000)	−3.89 * (0.000)	−3.76 * (0.000)
AR (2)	1.63 (0.104)	1.53 (0.126)	1.14 (0.320)	1.28 (0.220)	1.71 (0.880)	1.44 (0.151)
Sargan Test	2.25 (0.325)	1.25 (0.534)	3.26 (0.196)	4.26 (0.119)	4.95 (0.176)	4.14 (0.247)

Note: The *p*-values are in the parentis ( ), * means that the coefficient is significant at 1% level. Source: Authors

Governance and ICT interact positively to influence food security. From the result (presented in Table 4), ICT adoption and control of corruption interact positively to increase the level of food security by about 15%, while ICT adoption and government effectiveness interact may increase the level of food security 18%. This implies that effectiveness in governance and the deployment of efficient mechanisms in controlling corruption and the interaction with ICT may improve the level of food security. With ICT adoption and good governance, agricultural performance will be improved. Similar to the findings obtained by Ibidunni et al. [4], one of the major drawback of the agricultural sector is low marginal productivity of labour. On the other hand, Osabohien et al. [29] findings that with good governance, agricultural sector performance will be improved, leading to a positive spill-over effect on food security. This finding is also in line with that of Uchendu and Abolarin [21], noting that with less corruption, agricultural efficiency will be enhanced.

5. Conclusions

This study contributes to the literature by exploring how governance and ICT interact to affect the level of food security in West Africa in order to achieve the United Nations sustainable goals (SDG) by 2030, primarily GDG-2, to "end extreme hunger and achieve food security". A panel of 15 West African countries that are members of the economic community of West African states was used (ECOWAS).

The system GMM is used to account for unobserved heterogeneity and possible endogeneity. The study used data from the World Bank's world development indicators (WDI) and world governance indicators (WGI) for the years 2005 to 2018. Despite the fact that the POLS and fixed effect regression were carried out, inferences were drawn from the system GMM result, due to the possibility of endogeneity and the perceived weakness of the POLS and fixed effect estimates.

The results of the system GMM show that governance (as measured by government effectiveness and corruption control) has a significant and positive impact on food security.

The result shows that government effectiveness, effective control of corruption may increase the level of food security by 12% and 20%, respectively. Similarly, ICT adoption is found to be positive and significant in explaining the level of food security. It implies that, a 1% increase in ICT adoption, may increase the level of food security by 12% to 15%.

The interaction between governance and ICT is positive and significant in explaining the level of food security. The result implies that ICT and governance (government effectiveness) interaction may have about 15% positive influence on food security, while ICT and control of corruption interaction may positively influence the level of food by 8%.

The study concludes that to feed the growing Africa's population, towards achieving SDG-2, given that the current means of food production and governance across African countries needs to be improved. In this wise, to enhance food production, institutional quality (governance) and ICT should be interacted to drive food security. To the government, effective mechanisms should be put in place to enhance institutional quality towards achieving sustainable governance. In the same way, to improve ICT adoption, the cost of a phone and internet subscription should be lowered. This can be done by partnering with the telecommunication industries to ensure that basic monthly data subscription is cost-effective. This is because access to ICT has the capacity of improving households' agricultural production and profitability, increase job opportunities, and encourage the adoption of healthier practices and more effective risk management techniques.

However, this study is not without limitations. Some of the study's limitations include: (i) the study used a panel data of 15 West African countries, but unable to account for the impact of governance and ICT interaction on food security at the country level; (ii) the study used mobile internet subscription (percentage of total population) to capture ICT adoption, which may not capture the exact proportion of ICT used for agricultural purposes; (iii) the study used food production to capture food security, which may not be sufficient enough to capture all the dimensions of food security (availability, accessibility, utilisation, and stability).

Given data availability, further research should focus on: (i) how government and ICT interact to affect food security in West Africa, at the country or household level; (ii) other aspects of food security should be considered in addition to production; (iii) other research should take into account other ICT indicators that accurately represent the percentage of internet services used for agricultural purposes.

References

1. Anser, M.K.; Godil, D.I.; Aderounmu, B.; Onabote, A.; Osabohien, R.; Ashraf, J.; Peng, M.Y.-P. Social Inclusion, Innovation and Food Security in West Africa. *Sustainability* **2021**, *13*, 2619. [CrossRef]
2. FAOSTAT. 2019. Available online: http://www.fao.org/faostat/en/#home (accessed on 15 March 2021).
3. Osabohien, R.; Olurinola, I.O.; Matthew, O.A.; Igharo, A.E. Enabling Environment and Agriculture in ECOWAS: Implications for Food Security. *WSEAS Trans. Environ. Dev.* **2021**, *17*, 38–46. [CrossRef]
4. Ibidunni, A.S.; Ufua, D.E.; Okorie, U.E.; Kehinde, B.E. Labour productivity in agricultural sector of Sub-Sahara Africa (2010–2017): A data envelopment and panel regression approach. *Afr. J. Econ. Manag. Stud.* **2019**, *11*, 207–232. [CrossRef]
5. Beecroft, I.; Osabuohien, E.; Efobi, U.; Olurinola, I.; Osabohien, R. Manufacturing export and ICT infrastructure in West Africa: Investigating the roles of economic and political institutions. *Inst. Econ.* **2019**, *12*, 1–36.
6. Ramphul, N.; Nowbutsing, K.B.; Chittoo, H.B. An Analysis of Government Policies in Ensuring Food Security in Small Island Economies: A Case Study of Mauritius. *IOSR J. Humanit. Soc. Sci.* **2016**, *21*, 43–59. [CrossRef]
7. Olofin, O.P.; Olufolahan, T.J.; Jooda, T.D. Food Security, Income Growth and Government Effectiveness in West African Countries. *Eur. Sci. J.* **2015**, *11*, 417–429.
8. Osabohien, R.; Adeleye, N.; De Alwis, T. Agro-financing and food production in Nigeria. *Heliyon* **2020**, *6*, 04001. [CrossRef] [PubMed]
9. Barling, D.; Duncan, J. The Dynamics of the Contemporary Governance of the World's Food Supply and the Challenges of Policy Redirection. *Food Secur.* **2015**, *7*, 415–424. [CrossRef]
10. Duncan, J. *Global Food Security Governance: Civil Society Engagement in the Reformed Committee on World Food Security*; Routledge: London, UK, 2015.
11. Margulis, M.E. Global Food Security Governance: The Committee for World Food Security, the Comprehensive Framework for Action and the G8/G20. In *The Challenge of Food Security*; Rosemary, R., Nicole, E., Eds.; Elgar Publishers: Cheltenham, UK, 2012; Volume 231254.
12. Margulis, M.E. The Regime Complex for Food Security: Implications for the Global Hunger Challenge. *Glob. Gov.* **2013**, *19*, 53–67. [CrossRef]
13. Shaw, D.J. *World Food Security: A History Since 1945*; Palgrave Macmillan: London, UK, 2007.
14. Fukuda-Parr, S.; Orr, A. The MDG Hunger Target and the Competing Frameworks of Food Security. *J. Hum. Dev. Capab.* **2014**, *15*, 147–160. [CrossRef]
15. Fukuda-Parr, S.; Hulme, D. International Norm Dynamics and the "End of Poverty": Understanding the Millennium Development Goals. *Glob. Gov.* **2011**, *17*, 17–36. [CrossRef]
16. Cohen, M.J.; Clapp, J. *The Global Food Crisis: Governance Challenges and Opportunities*; Centre for International Governance Innovation and Wilfrid Laurier University Press: Waterloo, ON, Canada, 2009.
17. FAO. *Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security*; FAO: Rome, Italy, 2004.
18. Margulis, M.E. The Global Governance of Food Security. In *Handbook of Inter-Organizational Relations*; Joachim, K., Rafael, B., Eds.; Palgrave MacMillan: London, UK, 2017; pp. 503–525.
19. Hawkins, D.G.; David, A.L.; Daniel, N.; Michael, J.T. *Delegation and Agency in International Organizations*; University Press: Cambridge, UK, 2006.
20. Helal, G.; Ahmadigheidari, D.; Kosoy, N.; Melgar Quiñonez, H. Exploring the Relationship between Corruption and Food Security Status on a Global Scale. *FASEB J.* **2016**, *30*, 1149.
21. Uchendu, F.N.; Abolarin, T.O. Corrupt practices negatively influenced food security and live expectancy in devel-oping countries. *Pan Afr. Med. J.* **2015**, *2015*, 20.
22. Smith, L.C.; Haddad, L. Reducing child under-nutrition: Past drivers and priorities for the post-MDG era. *World Dev.* **2015**, *68*, 180204. [CrossRef]
23. Subramaniam, Y.; Masron, T.A.; Subramaniam, T. Institutional quality and food security. *Singap. Econ. Rev.* **2020**, 1–29. [CrossRef]
24. Ogunniyi, A.I.; Mavrotas, G.; Olagunju, K.O.; Fadare, O.; Adedoyin, R. Governance quality, remittances and their implications for food and nutrition security in Sub-Saharan Africa. *World Dev.* **2020**, *127*, 104752. [CrossRef]
25. Anser, M.K.; Alharthi, M.; Aziz, B.; Wasim, S. Impact of urbanization, economic growth, and population size on residential carbon emissions in the SAARC countries. *Clean Technol. Environ. Policy* **2020**, *22*, 923–936. [CrossRef]
26. Hendrix, C.; Brinkman, H.-J. Food Insecurity and Conflict Dynamics: Causal Linkages and Complex Feedbacks. *Stab. Int. J. Secur. Dev.* **2013**, *2*, 26. [CrossRef]
27. Fox, J. The ethnic-religious nexus: The impact of religion on ethnic conflict. *Civ. Wars* **2000**, *3*, 1–22. [CrossRef]
28. George, J.; Adelaja, A.; Weatherspoon, D. Armed Conflicts and Food Insecurity: Evidence from Boko Haram's At-tacks. *Am. J. Agric. Econ.* **2020**, *102*, 114–131. [CrossRef]
29. Osabohien, R.; Osabuohien, E.; Ohalete, P. Agricultural sector performance, institutional framework and food se-curity in Nigeria. *Bio-Based Appl. Econ.* **2019**, *8*, 161–178.
30. Asogwa, S.C.; Ugwoke, F.N.; Ozioko, F.E. ICT-Based Framework for Improved Food Security in Nigeria. *West Afr. J. Ind. Acad. Res.* **2015**, *13*, 23–28.

31. Anser, M.K.; Yousaf, Z.; Khan, M.A.; Voo, X.H.; Nassani, A.A.; Alotaibi, S.M.; Abro, M.M.Q.; Zaman, K. The impacts of COVID-19 measures on global environment and fertility rate: Double coincidence. *Air Qual. Atmos. Health* **2020**, *13*, 1083–1092. [CrossRef] [PubMed]

32. Anser, M.K.; Yousaf, Z.; Nassani, A.A.; Alotaibi, S.M.; Kabbani, A.; Zaman, K. Dynamic linkages between poverty, inequality, crime, and social expenditures in a panel of 16 countries: Two-step GMM estimates. *J. Econ. Struct.* **2020**, *9*, 1–25. [CrossRef]

33. Jere, N.J.; Maharaj, M.S. Evaluating the influence of information and communications technology on food security. *SA J. Inf. Manag.* **2017**, *19*, 7. [CrossRef]

34. International Telecommunication Union–ITU. The Importance of ICT in Food Security. *Technology Watch Report.* 2009. Available online: http://www.itu.int/net/itunews/issues/2009/08/25.aspx (accessed on 24 February 2021).

35. Nakasone, E.; Torero, M. A text message away: ICTs as a tool to improve food security. *Agric. Econ.* **2016**, *47*, 49–59. [CrossRef]

36. Svensson, J.; Yanagizawa-Drott, D. Getting Prices Right: The Impact of the Market Information Service in Uganda. *J. Eur. Econ. Assoc.* **2009**, *7*, 435–445. [CrossRef]

37. Aker, J.C. Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger. *Am. Econ. J. Appl. Econ.* **2010**, *2*, 46–59. [CrossRef]

38. Arellano, M.; Bond, S. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Rev. Econ. Stud.* **1991**, *58*, 277–297. [CrossRef]

39. Windmeijer, F. A finite sample correction for the variance of linear efficient two-step GMM estimators. *J. Econom.* **2005**, *126*, 25–51. [CrossRef]

40. World Bank. *The World Bank Green Bond Impact Report*; World Bank: Washington, DC, USA, 2019.