African Agriculture at a Crossroads: Can Farmers' Socioeconomic Indicators give us Direction?

By

Professor Samuel Arkoh Donkoh
BA (Hons) Economics, Dip. Ed. (Cape Coast, Ghana), MPhil Economics (Cape Coast, Ghana) PhD (Reading, UK)

Department of Economics, School of Applied Economics and Management Sciences, University for Development Studies, Tamale, Ghana

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Inaugural Lecture Delivered under the Chairmanship of

Professor Gabriel Ayum Teye
Vice-Chancellor, UDS

Venue: Multipurpose Auditorium
Central Administration, Tamale Campus
University for Development Studies

Friday, July 15, 2022

PROFESSOR SAMUEL ARKOH DONKOH

BA (Hons) Economics, Dip. Ed. (Cape Coast, Ghana),
MPhil Economics (Cape Coast, Ghana) PhD (Reading, UK)

Professor of Agricultural Economics

Profile

PROFESSOR SAMUEL ARKOH DONKOH (PhD)

Professor Samuel Arkoh Donkoh was born on 26th November, 1965 at Srafa Aboano in the Ekumfi District of the Central Region of Ghana. He started his formal education in the Methodist Primary School, Srafa Kokodo, and continued to Urban Council Primary School at Odumkyere Damang and Kade Experimental Primary School, Okumaning, both in the Eastern Region of Ghana. He then continued to Abeadze Dominase Local Authority Middle School where he sat for the Common Entrance Examination in Form Two (2) in 1979.

He passed the Common Entrance Examination (CEE) and gained admission to Tarkwa Secondary School in that same year (1979). He wrote the General Certificate Examinations (GCE) (Ordinary Level) in 1984 and continued to Winneba Secondary School, where he sat for the General Certificate Examinations (GCE) (Advanced level) in 1986.

In the 1988/89 Academic year, Professor Donkoh gained Admission to the University of Cape Coast and graduated in 1992 with BA (Hons) Economics and Diploma in Education. After his National Service, Professor Donkoh went back to the University of Cape Coast in the 1994/95 Academic year and obtained an MPhil in Economics in the 1997/98 Academic year. In 2003/04 academic year, Professor Donkoh gained admission to the University of Reading, UK, where he had his PhD in Agricultural and Food Economics in 2007.

Professor Donkoh's professional life started in 1993 as a teacher (Principal Superintendent) with the Ghana Education Service (GES) at the Holy Child School in Cape Coast, after his National Service.

Professor Donkoh joined the University for Development Studies as a Senior Research Assistant in the, then Department of Agricultural Economics and Extension in 1998. Nearly a year after, when his MPhil certificate was ready, he was promoted to the rank of a lecturer. In 2012 and 2017, Professor Donkoh

was promoted to the ranks of Senior Lecturer and Associate Professor of Agricultural Economics respectively. He became a professor in Agricultural Economics in 2021. Professor Donkoh is also a fellow of the Institute of Chartered Economists, Ghana (ICEG).

Courses Taught

Since joining UDS, Professor Donkoh has taught a number of courses at both undergraduate and postgraduate levels for regular and sandwich programmes.

The undergraduate courses include the following: Principles of Microeconomics; Principles of Macroeconomics; Econometrics; Agricultural Policy & Development; Elements of Development Economics and Planning; Growth and Development; Introductory Statistics; Proposal Writing & Social Science Research Methods; Research Methods; Quantitative Research Methods; Rural Sociology.

The postgraduate courses also include: Business Economics; Microeconomics; Econometrics; Agricultural & Economic Development and Policy; Policy Framework of Agricultural Extension; Rural Sociology and Agricultural Extension; Research Methods II; Advanced Microeconomics; Advanced Macroeconomics; Project Development & Management

Thesis supervision and Publications

Professor Donkoh has supervised to completion, 43 undergraduate dissertations and 47 postgraduate theses comprising 10 PhDs and 37 MSc/MPhil. Thesis supervision in progress are PhD (6) and MPhil (2). Professor Donkoh has 95 scientific publications, including four (4) textbooks and four (4) book chapters. He also has to his credit, 30 conference proceedings and ten (10) technical reports.

Short courses

Over the years the short courses Professor Donkoh has attended include the following: **Quality Assurance, Higher Education Learner-Centred Teaching and Research Workshop For 21st Century Higher Education Personnel**, organised by UDS from 10th to 14th February, 2020 in Tamale-Ghana; **Enterprise Risk Management** also organised by the Internal Audit

Agency/UDS from September 16 to 20, 2019 in Tamale, Ghana; **Innovative Methods and Metrics for Agriculture and Nutrition Actions**, organised by UDS-University of Reading IMMANA PROJECT on 29th March, 2019 in Tamale, Ghana; **Providing input into Country Strategy of the AfDB, Private Sector Development, Industrialization, Trade and Regional Integration organised by the Northern Development Authority/AfDB** in March 2019, Tamale- Ghana; **Strengthening Higher Agricultural Education for Agri-Food System Transformation in Africa, organised by the World Bank/ GoG on**, July 19, 2018/**in** Accra- Ghana; **Academic Writing** organized by WAC-SRT, June 18-2018/ Accra-Ghana; **Social corporate responsibility**, organised by IIRaCS-UDS, May 3, 2018/Tamale- Ghana; **Proposal writing for grants, organised by** Noguchi Research Institute/UDS April, 26, 2018/Tamale-Ghana; **Focus on Urban Agriculture**, organised by Urban Food Plus, June 21 to 23rd 2017, Göttingen-Germany;. **Building Capacity for African Agricultural Transformation Champions for Change Leaders,** organised by FtF/USAID/AFRICALEAD from January 9 to 13, 2017, Tamale, Ghana; **Focus on Urban Agriculture,** organised by Urban Food Plus, from October 4 to 9, 2015; Bochum-Germany; **Climate change Downscaling and Applications/Crop modelling under the SATREPS Programme** , organised by CECAR Africa, from July 13 to 18, 2015/Accra-Ghana; **Enhancing Resilience to Climate and Ecosystem Changes in Semi-Arid Africa: An Integrated Approach** , also organised by CECAR-AFRICA PROJECT, from August 5 to 7, 2013/ Accra-Ghana; **Human Development II** organised by UDS, from July 16 to 18, 2013 Tamale, Ghana; **Human Development I** also organised by UDS, from October, 1 to 5 2012, Tamale-Ghana; D**evelopment, Improving the Efficiency of Small and Medium Scale Enterprises (SMEs) in Ghana with focus on Agribusiness,** organised by the National Agribusiness Development Programme (NADEP) Module, from August 4 to 7, 2008 Kumasi-Ghana; **Summer School on Theory and Practice of efficiency and productivity measures: Parametric approach** organised by Mansholt Graduate School, Wageningen University, from July 3 to 7, 2006, Wageningen-Netherlands; **Agricultural Research Techniques for Scientists (Social Sciences)], organised by** NARP/CSIR, on October 30 1998, Accra -Ghana

Grants and Research Projects

In terms of Grants and projects, Professor Donkoh was a member of the thesis supervision team in: Grant for "Social differentiation in West African food systems across the rural-urban continuum",; A Volkswagen sifting pre-proposal award 2019 €10,000.00 in 2019; UrbanFood^{Plus} Funded by Federal Ministry for Economic Co-operation and Development (BMBF) (US$) 725,400.00 from 2013 to 2018; WIENCO Grant For Research into new and promising possibilities for Agricultural development in Ghana Gh₵ 150,0000.00; International Food Policy Research (IFPRI) Ghana Strategy Support Programme (GSSP) (US$) 95,000.00; and USAID/Agriculture Policy Support Project: Categorical grant/commissioned research GH₵ 51, 590,00.00.

Administrative Positions

Since his appointment in the University for Development Studies, Professor Donkoh has occupied the following administrative positions: Acting Head of Department, Agricultural and Resource Economics, Faculty of Agribusiness & Communication Sciences (September, 2010-August-2012); Head of Department, Agricultural and Resource Economics, Faculty of Agribusiness & Communication Sciences (2012-July 2017); Faculty Quality Assurance Officer, Faculty of Agribusiness & Communication Sciences (November 2015-July 2018); Vice Dean/ Dean, Faculty of Agribusiness and Communication Sciences (January 2017-August 2018).; Dean, Faculty of Agribusiness and Applied Economics (September, 2018-September 2020); and now Dean, School of Applied Economics & Management Sciences (October 2020 to date).

Service on Boards, Committees and Outreach Programmes

Professor Donkoh has served and still serves on a number of boards, committees and outreach programmes. Currently he is Chairman of the UDS Basic School Management Committee (Tamale, since June 2022), (Nyankapala, since 2016). He is also the Chairman of the, Interim Management Committee (IMC) UDS Guesthouse (May, 2018 to date). Professor Donkoh is also a Professorial Member (Humanities) of the Senior Members' Appointment and Promotions Board (September, 2021 to date) and a member of the Graduate Board. He is also an Adjunct researcher of the Kazuhiko Takeuchi Centre for Sustainability and Resilience, UDS.

Other committees that Professor Donkoh has been member of are, Research and Conferences Committee (September 2013-2017); Finance Committee (December, 2010-2015) and Intellectual Property Policy Development Committee (October, 2019);

Professor Donkoh has also been a Coordinator for the Technical Committee on "Strengthening Higher Agricultural Education for Agri-Food Transformation in Africa (SHAEA)" (November, 2018); Agricultural Technology Transfer (ATT) Exceptional Students' Scholarship, IFDC/UDS, Tamale (July 2017- Dec. 2018); and UN Human Security Project in Northern Ghana (2009). Professor Donkoh has also served on a number of ad-hoc committees in the university.

National Assignments

In terms of national assignments, Professor Donkoh was Panel Member, Assessing Government's Flagship Programmes-the Journey so far. 4th National Policy Summit on Government of Ghana (GoG) Flagship Programme. September 24-25, 2018, UDS International Conference Centre, Tamale, Ghana. He was also a Discussant, Launch of the UNDP Northern Ghana Human Development Report. 17th August, 2018, UDS International Conference Centre, Tamale, Ghana. Professor Donkoh was also UDS representative on a World Food Programme (WFP) in 2012 P4P Annual Consultative Workshop. February 21-22, 2013, Anita Hotel, Ejisu, Kumasi; and a Member of the Scientific Committee of UN Human Security Conference. May 2013, Accra, Ghana.

International Assignments

Professor Donkoh was Chairman of the International Committee on Accreditation of Masters in Agribusiness, October 1-3, 2018. University of Science and Technology (NUST), Namibia.

He was also a member of: UDS Delegation to the SHAEA Proposal Development Event, The Ruforum Biennial Conference, 21 October 2018, Nairobi, Kenya; UDS Delegation to the 4th ESDA Consortium Meeting and an Open International Symposium on "Dialogue with African Universities on Capacity Building for Africa's Sustainable Development", 29th October to 1st November, 2018, United Nations University Headquarters, Tokyo, Japan; UDS Delegation to the Urban Food Plus Summer School "Focus on Urban

Agriculture", June 21-23, 2017, Georg-August Universitat Göttingen, Germany; and UDS Delegation to the Urban Food Plus Summer School "Focus on Urban Agriculture", October 4-9, 2015, Institute of Development Research Policy of Rur-Universitat Bochum (RUB), Germany

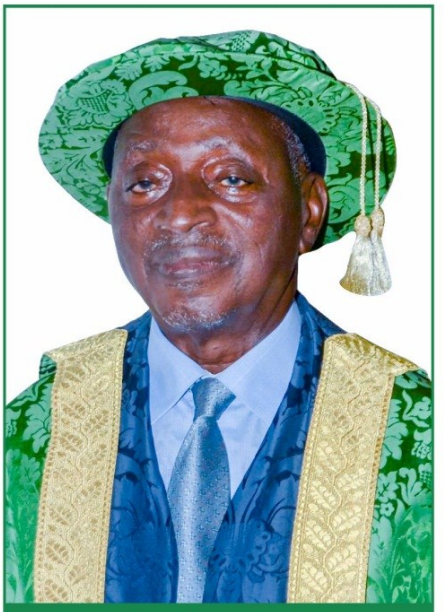
Membership of Learned Professional Societies

Professor Donkoh is a member of a number of learned professional societies including the following: Institute of Chartered Economists-Ghana (2017-date); Ghana Association of Agricultural Economists (2017-date); Ghana Science Association (2015-date); Ghana Association of Horticulturists (2012-date); African Association of Agricultural Economists (2011-date); and University Teachers' Association of Ghana (1999-date)

Honours and Awards

Between 1995 and 1998, Professor Donkoh received a Ghana Government Scholarship Award for his MPhil programme at University of Cape Coast. Then in 2003-2007, he received the Ghana Education Trust Fund (GETFUND) Scholarship for PhD in the University of Reading, UK. While at Reading University, Professor Donkoh received the Sue Morgan Award for Best African Student in 2005. In the 2017/2018 Academic year, Professor Donkoh was given the Vice-Chancellor's Award, Best Staff (Senior Member category, Teaching), Nyankpala Campus., UDS.

Professor Donkoh is also a Founder and Head Pastor of Christ Universal Church (CUC), a small but vibrant church in Tamale.



Prof. Wayo Seini
CHAIRMAN, UDS COUNCIL

Prof. Gabriel A. Teye
VICE-CHANCELLOR

Prof. Felix K. Abagale
PRO-VICE-CHANCELLOR

Mr. Nurudeen I. Abubakar
REGISTRAR

Programme

Topic	:	**African Agriculture at a Crossroads: Can Farmers' Socioeconomic Indicators give us Direction?**
Venue	:	Multipurpose Auditorium, Central Administration, Tamale Campus
Chairman	:	Vice-Chancellor, **Professor Gabriel A. Teye**
2:00 pm	:	Guests Seated
2:15 pm	:	Vice-Chancellor Procession (Audience stand) - Prayers (Christian and Moslem) - Introduction of Chairman by Mr. Nurudeen Issah Abubakari, Registrar - Welcome Address/Introduction of Speaker by Vice-Chancellor - Lecture on the Topic by Prof. Samuel A. Donkoh - Chairman Closing Remarks - Vote of Thanks by Mrs. Juliana Abila Buame - Announcements - Recession (Audience stand)

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Dedication

This Inaugural Lecture is dedicated to my late father,
Albert Kingsley Donkoh

1.0 Introduction

Professor Chairman and Vice Chancellor
Pro-Vice Chancellor
Registrar
Other Principal Officers
Deans and Directors
Heads of Department
Members of Academic Board
Members of Convocation
Colleagues
Distinguished invited guests
Members of GAAE
Students and Alumni
Family and Friends
The Press
Ladies and Gentlemen

I deem it a great privilege to give the 12th Inaugural lecture in our great University since its establishment in 1992. Indeed, this lecture is the first in our new School of Applied Economics and Management Sciences (SAEMS). It is my hope that the lecture would serve as a motivation for the relatively young generation of the University, especially those in SAEMS.

The topic for the lecture today is **AFRICAN AGRICULTURE AT A CROSSROADS: CAN FARMERS' SOCIOECONOMIC INDICATORS GIVE US DIRECTION? A**nd I must state, this topic is very dear to my heart. The ultimate aim of all our endeavours as a people, is to attain a unique and holistic development not only for ourselves, but also for future generations.

According to the UN (2015) report, the world population is projected to reach 8.5 billion by 2030 and 9.7 billion by 2050. Given that natural resources are generally scarce and are getting depleted, the Montpellier Panel (2013) observed that growing population pressure will mean increases in food prices, especially in developing countries, including Sub-Sahara Africa (SSA). SSA is

faced with multiple challenges, including rapid population growth, rampant urbanisation, climate change, and chronic food insecurity.

Agriculture is the engine of growth for a number of both developed and developing countries (Tiffin & Irz, 2006). In SSA it is estimated that close to 60% of the population relies on agriculture. Thus, improvement in agricultural productivity could lead to a reduction in rural poverty and food insecurity. It is against this background that agriculture has become a priority in the development agenda, with the Maputo and Malabo Declarations, as well as the 2030 Agenda for Sustainable Development.

The Maputo Declaration in 2003 saw the adoption of the African Union's Comprehensive Africa Agriculture Development Programme (CAADP) to improve food security and nutrition, and increase incomes in Africa's agriculture-based economies. Consequently, African countries were to increase their annual national budgetary allocations for agriculture to at least 10% to ensure a growth of the agricultural output of at least 6% annually.

In the 2014 Malabo Declaration, African Heads of State and Government made a commitment to ending hunger by 2025 by doubling productivity, halving post-harvest losses, and significantly improving nutrition, among others. The 2030 Agenda seeks to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture. This implies doubling the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous people, family farmers, pastoralists and fisherfolks, as well as ensure sustainable food production systems.

Professor Chairman, Ladies and Gentlemen, the role of agricultural technology adoption in economic development cannot be over-emphasised. De Janvry and Sadoulet (2003) identify two ways by which agricultural technology adoption can reduce poverty: First, adopting farmers have the chance of increasing their welfare through increased production as well as revenue and second, growth in agriculture through technology adoption and diffusion implies that the price of food can fall, employment can rise, and there would be greater linkages between agriculture and the other sectors of the economy, leading to economic development.

However, according to Hall and Khan (2003), the contribution of new technology to economic growth can only be realized when and if the new technology is widely diffused or adopted. Diffusion itself, Hall and Khan (2003) argue, results from a series of individual decisions to adopt the new technology, decisions which are often the result of a comparison of the uncertain benefits of the innovation with the uncertain costs of adopting it.
In recent history, the two Green Revolutions of the 1960s (in Asia) and 2000s (in SSA) have been responsible for global increases in food supply, especially cereals like rice, wheat and maize.

Professor Chairman, Ladies and Gentlemen, my PhD thesis was on the topic Technology Adoption and Efficiency in Ghanaian Agriculture. I used the Ghana Living Standards Survey (GLSS Round IV) data of the Ghana Statistical Service.

I decided to work on the adoption effects of these modern technologies on farmers' technical efficiency and poverty levels. It was in the course of my PhD journey that I got introduced to the concept of Green Revolution; that even though Africa, and for that matter, Ghana, missed out of the first Green Revolution, there were traces of the adoption of the Green Revolution technologies such as improved seeds, inorganic fertilisers, insecticides, irrigation and tractor services. Since then, my research focus has been on analysing the extent to which farmers' socioeconomic indicators influence agricultural technology adoption, efficiency and welfare.

In this lecture, however, my emphasis will be on the determinants of agricultural technology adoption.

The outline of the lecture is as follows:

1. Introduction
2. The Concepts of Technology, Adoption and Diffusion
3. The Concept of Green Revolution (GR)
4. Motivation for the lecture
5. Cultural breakdown
6. The Crossroads
7. Appropriate technology

8. Some Research findings
9. Conclusions and Recommendations
10. Acknowledgements

Professor Chairman, I must acknowledge that the review of literature on the concepts of Technology, Adoption, Diffusion and the Green Revolution is largely extracted from my earlier studies (Donkoh, et al., 2009; 2011).

2.0 The Concepts of Technology, Adoption and Diffusion

Technology may be described as the current state of our knowledge of how to combine resources to produce desired products, to solve problems, to fulfil needs, or satisfy wants. Technology in this sense includes technical methods, skills, processes, techniques, tools and raw materials.
Sometimes technology is defined in terms of an innovation that is perceived as new and helps us to increase output.

Adoption simply means the extent of use of this new technology or innovation. Feder, Just and Zilberman (1985, p.256) emphasised that adoption takes place only 'in a long run equilibrium when the farmer has full information about the technology and its potential.' Normally, if a technology or innovation is made use of by an individual or a household at a point in time, it is termed adoption but if the use of the technology spreads among a community, region or even a nation it is termed diffusion. In this light diffusion can be interpreted as aggregate adoption (Feder et al. 1985).

Adoption/diffusion studies cut across several disciplines, each discipline explaining the terms from their own view point. For instance, whereas economists explain adoption (and for that matter diffusion) in terms of profitability, sociologists define it in terms of the nature of communication channels and differences in social position. Geographers explain it in terms of information flow and spatial attributes while anthropologists define it in terms of the compatibility of the innovation with the norms and values of society (Boahene, 1995).

2.1 The S-Shaped Curve

Studies of adoption and diffusion behaviours were undertaken initially by rural sociologists (Feder et al., 1985). These studies provided the basis for economic studies. Such sociological studies included Ryan and Gross, (1943) and Rogers, (1962). Rogers (1962) conducted studies on the diffusion of hybrid corn in Iowa, United States, and compared diffusion rates of different counties. Like his counterparts, he found that in most countries, diffusion was an S-shaped function of time. This was interpreted to mean that when a technology is first released, only a few agents adopt it. Then, for some reasons yet to be discussed, more agents adopt it increasing the rate of adoption. As time goes on, the number of potential adopters decreases, causing the rate of adoption to decrease. At this point, there is no increase in adoption. In most cases, the ceiling is reached before all the agents would have adopted it. For those who choose not to adopt, there may be several reasons; they may not find the technology to be profitable, nor feasible or they might have found what they perceive to be more efficient than the technology in question. Thus, the rate of technology adoption in the community or nation (rate of diffusion) initially increases and finally decreases, the curve looking like an S. The main driving force underlying the spread of innovation was argued to be the role of communication.

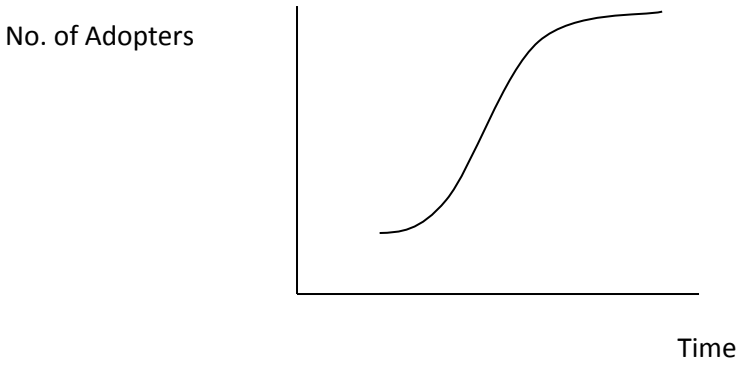


Figure 1: The S-Shaped Curve

2.2 The Epidemic Approach-Mansfield (1961)

Mansfield (1961) likens the diffusion of technology to the spread of a disease. Just as a disease may be contracted by one person and later spread to others through contacts, so is the rate of adoption of a new technology in a given community. According to Mansfield (1961) when an innovation is released and information and experience accumulate, it becomes less risky to begin using an innovation. However, competitive pressures may prevail and bandwagon effects occur. In a situation where the profitability of the innovation is difficult to assess, then the mere fact that a large number of competitors have adopted the innovation may prompt a firm to perceive it to be profitable and also adopt it.

The important thing to note about Mansfield's model is that the rate of diffusion of the technology is determined by variables such as expected profitability of the innovation, the size of the investment required and the rate of growth of the industry's sales. He asserts '… the probability that a firm will introduce a new technique is an increasing function of the proportion of firms already using it and the profitability of doing so but a decreasing function of the size of the investment required' (Mansfield, 1961, p.762-763). The specific factors that affect the adoption of technology, he argues, are firm size, market concentration, R&D expenditures, educational level of decision makers and access to information. Access to information is the key factor. However, the model is based on the assumptions that these innovation-specific variables remain constant during the diffusion process. In this case, one limitation with the model is the fact that these variables hardly remain unchanged over time

Hypotheses Underlying Technology Adoption and Diffusion- Foltz (2003)

Foltz (2003) summarises the factors explaining the rate of adoption/diffusion of a new technology under four hypotheses, namely resource scarcity, capital constraint, learning costs and risk aversion. These are discussed as follows.

2.3 Resource Scarcity

The resource scarcity hypothesis suggests that new technologies will diffuse depending on the relative prices of resources in the area. In this case those who have the greatest constraint of the natural resource will have a greater demand and therefore high price for the new technology. For instance, farmers who think that the fertility of their plots is poor, would have great demand for

fertilizer and consequently demand more of it as opposed to those who are satisfied with the fertility of their plots.

2.4 Capital Constraint

The capital constraint hypothesis implies that new technologies would spread faster among farmers with better access to capital to pay for the new technology than farmers with little or no access.

2.5 Learning Costs

The learning-cost-hypothesis suggests that technologies will spread fastest in areas where information about the innovation is readily available and most easily evaluated by potential adopters. This means that farmers who have access to extension services, have better education (to be able to read and understand information about the technology), farmers who have the opportunity to attend useful workshops and take part in on-farm experimentation stand a better chance to adopt the technology than the less privileged ones.

2.6 Risk Aversion

Risk aversion implies that farmers will not like to invest in unknown technologies because of uncertainties with respect to yield and for that matter income. Similarly, if a technology is expensive, it becomes riskier in the sense that farmers are not sure if they would be able to recoup the money invested into the technology. In this case the chances of adoption/diffusion would be slim. But if a new technology is risk-reducing in the sense that farmers are familiar with it or it is relatively cheap, then farmers would readily adopt it other things being equal. Of course, there is the individualistic component of risk aversion that also affects the adoption/diffusion of a technology: some people are generally optimistic in life while others are pessimistic. Generally, the former are early adopters while the latter are late adopters

3.0 The Green Revolution

There are broadly two meanings of the Green Revolution (Brook, 2005). The first and narrower one is the development of High Yielding Varieties (HYVs) of rice, wheat and maize using plant improvement technologies. The second

refers 'to a broad transformation of agricultural sectors in developing countries, to a reduction in food shortages and under nourishment, and to the elimination of agriculture as a bottleneck to overall development' (Griffin, 1979, p. 2).

However, for the new varieties to produce the desired 'high yielding' results, there must be irrigation, mechanisation, chemical fertilisers and pesticides. Unlike in Asia and Latin America, the revolution did not yield the desired impacts in SSA. The reasons mainly relate to policy, research, infrastructure and ecological problems.

Professor Chairman, as we know, there has been a re-introduction of the Green Revolution, courtesy former UN Secretary General, our own, the late Kofi Annan through AGRA. In 2006, two of the world's largest foundations, the Bill and Melinda Gates Foundation and the Rockefeller Foundation, joined forces to launch the Alliance for a Green Revolution in Africa. Since the re-introduction, AGRA has spent about 553 million dollars as at 2021. Following this, both local and foreign scientists have developed a lot of improved seed varieties for most of our food and cash crops.

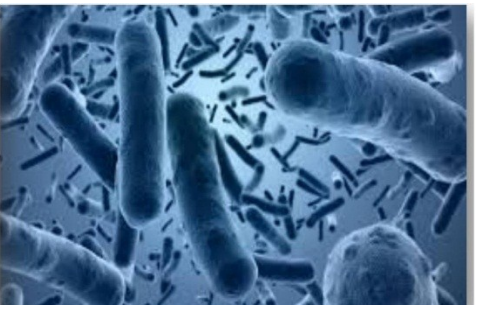
On the positive front the revolution has led to a remarkable increase in world output resulting in relatively lower prices, higher employment and incomes. On the negative front, the revolution has widened the gap between the rich and the poor because complementary inputs associated with the revolution were in favour of the rich. Also, the revolution encouraged excessive mechanization and use of chemicals and thus resulting in rural unemployment and the destruction of the environment respectively (Evenson and Gollin 2000; Low, 1994).

3.1 Harmful Effects of Using Chemical Fertilizers and Pesticides

The World Health Organization (WHO) estimates that acute pesticide poisoning (APP) affects three million people and accounts for 20,000 unintentional deaths per year, with 99 percent of these fatalities believed to be in developing countries (Dabady and Tulk, 2015).

Studies done in the Netherlands (Bouwknegt et al., 2012); UK (Fahrion et al., 2014); India (Sudershan et al., 2014); China (Sang et al., 2014) and the USA (Tam et al., 2014) have found that vegetables (and fruits) consumption is responsible for about 7-46% of foodborne diseases. Pesticide poisoning is responsible for contaminating the breast milk of women farmers and killing 150,000 people in developing countries alone (Ntow, 2008; Vidogbena et al., 2015). Pesticides residues lead to both acute (e.g., general headache and skin itches or rashes) and chronic (e.g., cancer, respiratory disorders, etc.) health repercussions on consumers (Baig et al., 2009; Chen et al., 2011). In acute situations, the effects of pesticide poisoning may spread more quickly in high temperature regions like SSA, as the human body reacts faster to poisons in hot weathers (Boland et al., 2004).

Residues on vegetables are usually not seen but impacts on human health are remarkable. Aliyu (2014) emphasized that pesticides do not just induce diseases but untimely death if diseases are out of control. For instance, human exposure to pesticides may result in liver, kidney and cardiac cell damages, disturbed hormonal balance, nephro and hepatotoxicity (Mattah et al., 2015). Mrema et al. (2017) reported that pesticide exposure to females causes reduced fertility, prolonged pregnancy and menstrual cycle disturbances.



The negative environmental impacts such as soil degradation and the depletion of the ozone layer are also a big challenge.

Some years back in the Eastern Region, Professor Chairman, immediately farmers cleared their field and burnt them, the next rains would lead to sprouting of cocoyam. It is believed that our inorganic fertilizers and pesticides have killed all these seeds and many other local seeds.

4.0 Motivation for the lecture

Professor Chairman, apart from the above-mentioned challenges, the strongest motivation for this lecture comes from two questions that the external examiner for my PhD thesis posed at the day of my viva. My examiner's first question at the viva was, please tell me what are the modern and conventional technologies you refer to in your thesis?

I answered that in all there were fifteen technologies or techniques that the farmers in my sample adopted. The modern techniques were improved seeds, inorganic fertilizers, insecticides, tractor services and irrigation among others. The traditional techniques were local seeds, organic fertilizers etc. His response was, oh so what we refer to as conventional inputs here are what you refer to as modern technologies in your home country? I answered in the affirmative.
His second question got me thinking seriously. Organic farming is their modern method of farming while the use of chemicals is their traditional farming which they were gradually moving away from.

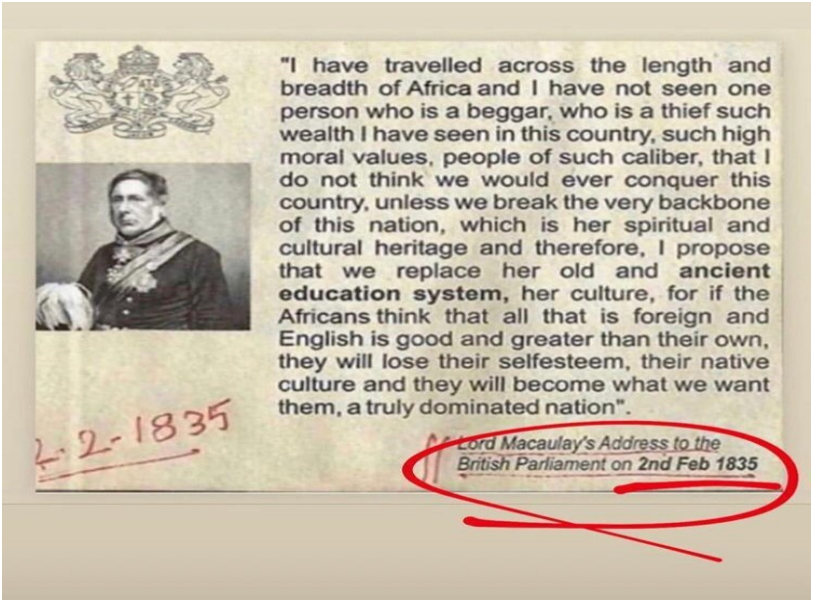
Professor Chairman, as we know, as a result of the relatively high cost of organic farming, their organic products are far more expensive than their conventional products. I grew up in my hometown (Ekumfi Srafa). During my childhood days we never used any form of fertilisers. We practised the bush fallowing method of farming where we would leave a cultivated land for a year or two to fallow before coming back to it. I never knew what NPK fertilisers were until after several years when, I came to Tamale. Agricultural produce was healthier and the environment was friendlier. Unfortunately, in those days we considered ourselves as underdeveloped because we were not using modern inputs. Now that we consider ourselves modern because we are using modern inputs, we have all the attendant health and environmental challenges.

Professor Chairman, the simple question I wish to ask is, the so-called developed countries took a particular path of agricultural development, and now they realise that the path is not good and they are coming back to where they began, why do we also want to repeat the mistakes they have made only to come back to our starting point later?

4.1 Cultural Breakdown-The root cause of the problem of adoption of inappropriate technology

Professor Chairman, before I talk about the crossroads and the alternative route, I would want to note that the root cause of the adoption of inappropriate technology is general cultural breakdown which dates back to the colonial era. I bumped into the WhatsApp image below in which Lord Macaulay presents his discovery of Africa in 1835 to the British Parliament. Macauley presents Africa on a high moral pedestal principally considering the strong moral fibre (customs, mores and social values) of the African people. Clearly, he noted the only way to conquer the continent and its people was to undermine the culture of the African; the very essence of her being.

Professor Chairman, my Introduction to Sociology Course taught me that culture has two main components; the tangible components and the intangible components. Examples of the tangible components are the foods we eat, the dresses we wear and the houses we build. The intangible components are our languages, values, proverbs, folklores etc. I learnt that the intangibles give birth to the tangibles. So, for instance, the values you uphold would determine the type of dress you wear and the type of food you eat. This is what our colonial masters knew and worked at replacing our intangible components of culture with theirs so that the tangible components would be a matter of time. We force our children to speak English in School and not their local languages, the next thing is that they want fried rice and chicken, not 'banku' with okro stew. When they have mastered the English Language, they would compose foreign songs like Raps and Reggae and dress accordingly to sing them the way the original people sang it. Professor Chairman, the menace is also in the church, where we prefer to preach in English even where the congregation understand the local language. And the preacher must be in suit and tie, not in cloth. Until we go back to embracing (the good components of) our culture, we are a lost continent.



Professor Chairman, Ladies and Gentlemen, again my introductory course in Education taught me that before the white man came to Africa, Africans had and still have our own form of education, called Traditional African Education. This is holistic and does not take place in a classroom setting. For example, the girl child who assists her mother to cook, after a few years, masters cooking through constant practices. The same applies to the boy child who follows the father to the farm or to the sea for fishing. As he watches and assists the father in his profession, with time he also becomes a master. Formal education has meant that these children spend most of the time in school, then in the end most of them are not only jobless, they are alienated from the jobs of their parents as well as the moral values that go with them.

Professor Chairman, Ladies and Gentlemen, I beg to say that in terms of employment it looks like formal education ends up 'Pasteurizing' most of our students to the extent that after school, they are not able to function, in terms of securing a job to contribute to development.

5.0 The Crossroads

5.1 Conventional Agricultural Intensification (CAI) Versus Sustainable Agricultural Intensification (SAI)

Professor Chairman, Africa is indeed at a crossroads! Do we continue with the path of the so-called modernisation of agriculture or we go by an improved traditional way? In other words, do we go by the route of conventional agricultural intensification or sustainable intensification?

Conventional Intensification of agriculture (The Green Revolution) uses external inputs such as agrochemicals. This comes with environmental costs/damages.

Sustainable Intensification of agriculture refers to the production strategies that simultaneously boost agricultural productivity and minimize environmental impact (Levidow et al., 2014).

5.2 Pillars of Sustainable Agricultural Intensification

There are three (3) pillars of Sustainable Agricultural Intensification (SAI), namely; Ecological Intensification, Genetic Intensification and Socioeconomic Intensification.

5.3 Ecological Intensification

Ecological Intensification involves using ecological processes more intensively in a sustainable manner. The aim is to use land, water, biodiversity and nutrients more ecologically efficiently and in ways that minimise negative environmental impacts (Godfray and Garnett 2014).

This has been defined within the framework of organic agriculture as "maximization of primary production per unit area without compromising the ability of the system to sustain its productive capacity" (FAO, 2019). It is a nature-based substitute for high-input agriculture (Kleijn et al., 2019). Therefore, ecological intensification complements or replaces external inputs in order to sustain agricultural production with minimal adverse effects on the environment (Bommarco, 2013).

Ecological Intensification assumes that the management of biodiversity either complements artificial inputs and increases agricultural productivity or replaces artificial inputs which leads to minimal environmental costs without negative impact on productivity of crops (Bommarco, 2013).

Thus, Ecological Intensification balances adequate food production, environmental preservation, consumer satisfaction, and income generation for farmers. The advantages about ecological intensification are that there is availability of resources (such as Natural environment (biodiversity); Cow dung for manure; Refuse dump for composting; Cattle and donkeys for ploughing; Local seeds; streams for dugouts) and above all farmers are much more familiar with it.

5.4 Genetic Intensification

Genetic Intensification includes 'conventional plant breeding,' 'biotechnology,' and 'livestock breeding' which incorporates elements of both breeding technologies. Genetic modification is a technique for changing the characteristics of crops and animals to suit a particular requirement such as high yield, pest and disease resistance, and drought tolerance, among others. Genetic modification (biotechnology) could produce crops with in-built resistance to pests and diseases and give higher yields. It could produce entirely new plants specifically for producing food, medicines, industrial chemicals and fuel (Worou et al., 2019).

Another way of agricultural intensification to meet the food demands of the ever-growing human population is through genetic means. With this, advances in plant and animal breeding and crop technology such as biotechnology are used to offer a large range of alternatives using agricultural land for production of crops, animals and fish. This has resulted in genetically modified (GM) crops/foods.

5.5 Socioeconomic Intensification

Socio-economic Intensification involves a greater intensity, variety and range of involvement of farmers in social and economic processes and institutions on the farm, in the community and across regions and nations.

Adoption of new practices and technologies by farmers will only happen and persist if an appropriate enabling environment is supported that favours not only agricultural intensification but also its sustainability.

Methods in Ecological and Genetic Intensification can help farmers to produce more with less, but an enabling environment is required to allow innovation for Sustainable Intensification to be adopted (Agriculture for Impact, 2013)
Socio-Economic Intensification involves supportive enabling environments, and building the social and human capital of smallholder farmers.

A supportive enabling environment combines macro-economic policies that favour markets and trade, the provision of inputs, related physical infrastructure (such as roads and irrigation) and social infrastructure (such as education and research) (Cary Institute of Ecosystem Studies, 2015) together with institutions (The Economics of Ecosystems and Biodiversity, 2015).

Without secure rights to land farmers will not invest in improvements to their farms. Farmer associations, including cooperatives, out grower and contract farmer groups, are essential if smallholders are to exert their bargaining power
Increasing productivity on current land will also require significant investments in agricultural research and extension, in the road infrastructure that links farmers to markets and in the development of better rural services, including access to education and health care.

Insurance, a tool to manage price and production risk, can encourage farmers to adopt production systems that are potentially more resilient, productive and more profitable, but involve greater financial risk. Agricultural finance is the provision of services that are dedicated to supporting both on- and off-farm agricultural related activities, but it must become accessible and affordable to smallholders.

Social capital is the value that can be created through social networking and trust within and between people and organisations, an important element for creating sustainable livelihoods and economic development (Godfray and Garnett, 2014).

Social capital may be the most important resource available to poor communities burdened with low incomes, poor education and few assets (Juma, Tabo, Wilson and Conway, 2013). Cooperatives, value chains and institutions create the infrastructure for relationships to be developed, forming the basis for building social capital and contributing to socio-economic intensification.

6.0 Appropriate Technology Adoption

Professor Chairman, sustainable intensification implies appropriate technology adoption. Appropriate technology is technology that is conducive to the social, environmental and economic conditions of the geographical area in which it is adopted.

According to Zelenika and Pearce (2011) the term Appropriate technology was coined by E.F Schumacher in the 1970s. The initial term was "intermediate technology" conceptualised in his influential book "Small is Beautiful: Economics as if people Mattered (Schumacher, 1973).

In fact, Appropriate technology is considered to be an ideological movement that prescribes technologies and projects to have the following qualities:

- Small-scale
- Labour intensive
- Energy efficient
- Environmentally sound
- People centred
- Locally controlled
- Culturally sensitive
- Demand driven-meet identified need
- Involving interactive collaboration where both parties grow and develop from the experience.
- Economical / Affordable

According to Evans & Adler (1979), appropriate technologies are "more productive than the often labour-intensive, inefficient traditional technologies,

but less costly and more manageable than the large scale, labour saving but capital-intensive technologies of the industrialized society.

Schumacher (1973) stressed that Appropriate technology is meant to address four major problems that GDP-growth does not cover, namely: extreme poverty, starvation, unemployment, and urban migration.

Appropriate technology is an alternative to technology transfer from developed to developing countries. While the latter often involves one party telling the other what to do and what they need, the former places both parties on an equal level.

Some Reasons for Appropriate technology adoption

- Abundant natural resources
- Abundant labour resources Farm sizes are small
- Low level of formal education
- Farming is in the hands of those who cherish their culture
- Unpredictability of the external world (e.g., fertiliser scarcity due to the Rusia, Ukraine War).

Professor Chairman, talking about appropriate technology for marketing and packaging, Food fraud is another serious menace, the world over, and particularly Africa.

"Food Fraud: a collective term encompassing the deliberate and intentional substitution, addition, tampering or misrepresentation of food, food ingredients or food packaging, labelling, product information or false or misleading statements made about a product for economic gain that could impact consumer health" (Spink, & Moyer (2011).

Food fraud undermines product authenticity, namely: its origin, quality (Protected designation of Origin, Protected Geographic Indication) and biological characteristics (species, varieties, races).

Examples of Food Fraud in Ghana

- Harvesting fruits and vegetables a short time after spraying.
- Forcing fruit to ripen fast.
- Millipede in 'Zomi' (red oil).
- Black polyethene sack mixed with 'kokonte'.
- Wrong packaging of food.

Professor Chairman, again, I bumped into the image below from First Ghana News about the packaging of 'banku'. Our grandparents used leaves, which I believe are healthier than the polythene sacks we are using now in the name of modernisation.

The white transparent polythene bag was originally NOT produced to carry hot foods because it contains two deadly chemicals called bisphenol A and phthalates which cause brain and liver damage. These two chemicals when exposed to high temperatures react by injecting themselves into the heated environment. So when you wrap hot banku into banku rubber, these deadly chemicals immediately begin to inject themselves into the banku. The banku then becomes poisonous before you eat it.

FIRSTGHANANEWS.COM
Dying to survive! The daily poison we eat from rubber food wrappers - First Ghana News

7.0 Some Research findings on the effects of socioeconomic indicators on technology adoption

Professor Chairman, Ladies and Gentlemen, my argument is that in every nation, it is the nature of the farmers' socioeconomic indicators that determine whether that nation should adopt conventional or sustainable intensification.

For instance, conventional intensification requires relatively large farm size, heavy agricultural equipment, a huge capital outlay, high formal education and a good extension service delivery. Unfortunately, in SSA, the opposite is the case, hence our inability as a continent to catch up with the rest of the world in the so-called agricultural modernisation drive. For instance, in Ghana, the agriculture situation prior to the inception of the Planting for Food and Jobs programme in 2017 as given by the Minister of Agriculture on MoFA website is as follows:

- Only 11% of food crop farmers were using improved seeds
- About 15% farmers were using fertilizers
- Fertilizer application rates was 8kg/Ha
- Extension-Farmer Ratio was 1:1,900
- Total number of Extension Agents in 2016 was 1,560
- Yields of most staple crop varieties (maize, rice & root tubers) were between 40%-45% of potential yields.
- Vegetable exports to the EU were banned.
- Rising devastating effects of the Fall Army Worm (FAW) on crops especially maize.
- All 68 mechanization centres were down and providing no service to farmers

Professor Chairman, it is quite worrying, that with all the interventions in the agricultural sector since independence, the aforementioned was the situation with the sector at 2017. The Minster did indicate some significant improvements in the statistics just after two years as below: Fertiliser use increased from 14kg/Ha to 20kg/Ha. Quantity of improved seeds in Mt increased from 4,400 to 18,333. Beneficiaries of PFJ increased from 202,000 to 1,183,000. Yield of Maize increased by 50%. Yield of Rice increased by 51%. Soybean increased by 76%, but how sustainable are these?

The problem with modern seeds is that they are hybrid and require the farmer to buy new seeds every farming season. Not many small-scale farmers are able to buy the seeds as well as the complementary inputs. So even though they may be willing to adopt, they may not have effective demand for the seeds. As indicated earlier, one of the problems associated with the first GR is the fact

that it led to the widening of the gap between the rich and the poor (Donkoh et al., 2011).
Another problem with hybrid seeds is the perception that they may replace the local seeds in the long run. It is believed that hybrid seeds can cross the local seeds to produce new hybrids to replace the local seeds.

The complementary technologies of improved seeds are chemical fertilisers, insecticides, tractor services and irrigation are not only expensive, some of them are difficult to administer by farmers who have very little or no formal education. Also, we have very little or no control over some of the inputs such as inorganic fertilisers, insecticide, irrigation and tractor services (e.g., fertiliser supply and the Russian, Ukraine war).

Professor Chairman, In the figure below, PPF_1 represents a production frontier of traditional farming (i.e., non-Green Revolution technology adoption). Utility (represented by the indifference curve, is maximised at E_1 where the slope of PPF_1 and indifference curve I_1 are the same. With the adoption of Green Revolution technology, we assume a neutral outward shift of the PPF_1 where a new equilibrium is established at E_2. At this new equilibrium, output and welfare are higher. Also, households can enjoy more leisure because of the presence of markets.

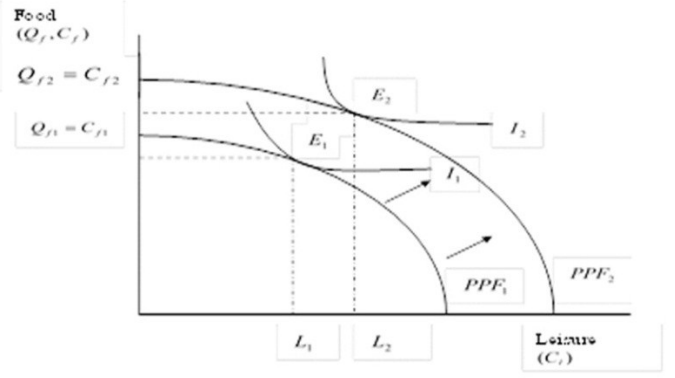


Figure 2: Effect of Technology on Output and welfare

I have always asked myself the question, if technology adoption leads to increased output and welfare why is it that all our farmers don't adopt the technologies? They don't adopt the technologies because of their socioeconomic challenges.

At this stage, Professor Chairman, Ladies and Gentlemen, I wish to take you through some of my research findings about the extent to which the socioeconomic characteristics of our farmers influence their adoption of agricultural technologies. In general, my argument is that these indicators cannot support conventional intensification but can support the adoption of appropriate technologies.

7.1 Formal Education

Formal education is helpful in technology adoption because it aids the farmer to be able to understand the application of the technology). Professor Chairman, in my studies, formal education largely showed positive influence on adoption (e.g., [(Boateng et al., 2022); Marfo et al., 2021); (Adzawla et al., 2020) (Donkoh 2019); Donkoh et al., 2019); Abdul-Hanan et al., 2014); Donkoh et al., 2009). Meanwhile, farmers' educational level exhibited **inconclusive** adoption effects in the following: Lamptey et al. (2022); Azumah et al. (2020); Azumah et al. (2017; and Donkoh et al. (2016). Only in Adzawla et al. (2016), did we find a negative adoption effect on Bambara groundnut production. In that study, we found that educated respondents had greater likelihoods of exiting Bambara groundnut production for higher paying off-farm jobs.

Majority of our farmers have little or no formal education. Researchers keep recommending that governments should step up formal education if they want farmers to adopt new agricultural technologies. The irony we have is that when the youth are educated, they evade farming and migrate to the urban centres for unavailable jobs. Those who stay behind are those who in one way or the other could not access formal education. They are the ones who take over from their ageing parents, and so the problem persists.

In principle free SHS is good because it would help to educate our future farmers, but we cannot be sure of getting them into farming. Farming is perceived to be for the poor and those who live in the rural areas are

considered as "villagers". Unfortunately, these perceptions are also held by some politicians who are not even afraid to voice them out. As a continent, until we change our perception concerning farming, we will not go far with our agricultural development agenda. Also, we need to step up efforts aimed at encouraging the educated youth to stay in agriculture.

In the absence of formal education for our farmers, the non-formal education programme was initiated. However, it appears to be dying in most communities. This also needs to be revamped.

7.2 Farm size/Commercialisation:

The probability of adopting modern agricultural technology is high for large farm ownership. The reason is that when the farm size is large the farmer can allocate some percentage of the plot to cultivating the modern variety with which he/she is not so much familiar. Large farm size also implies that the farmer is wealthy and so he/she can afford the cost of improved seed variety and that of the complementary input [(Ansah et al., 2020); (Azumah et al., 2020); (Azumah et al., 2017)].

However, land holdings are generally small in Africa. In fact, about 80% of the farmers have 2 hectares or less of farm holdings. Amid uncertainties surrounding an improved variety, adoption of such technology would be far-fetched [(Donkoh et al., 2019); (Abdulai et al., 2018); (Awuni et al., 2018); (Zakaria et al., 2016); (Abdul-Hanan et al., 2014)).

Not only are farm holdings generally small in Africa, but some of them are also undulating, which does not support mechanisation. In Ghana most southern lands are undulating which makes ploughing and other mechanised activities on such lands difficult.

One of the reasons for small landholdings is the prevalence of customary and communal lands in our land tenure system that does not allow for individual entitlement to large tracts of farmland. Lack of or limited ownership to farmland does not also augur well for the adoption of soil and water conservation technologies because these are not only laborious and costly, but

they are permanent. The farmer would not like to invest permanently on a piece of land that does belong to him (Donkoh & Awuni (2011a)).

Another threat to landholding in Ghana, and Africa as a whole is land grabbing by foreign companies.

7.3 Extension Service Delivery

Extension staff offer direction to farmers on the adoption of agricultural technologies and so in most cases, the greater the number of extension visits a farmer receives during a farming season, the higher the probability of adopting that technology. Most of my studies [Boateng et al., 2022); (Marfo et al., 2021); (Azumah et al., 2020); (Donkoh, 2014, 2019); (Abdulai et al., 2018); Azumah et al., 2017); (Donkoh et al., 2016); Abdul-Hanan et al., 2014); (Donkoh & Awuni, 2011b); and (Donkoh & Awuni, 2011a)]. found positive effects of extension service delivery on adoption.

Over the years the extension staff to farmers ratio is very low. Not only is the ratio low, but the staff do not have adequate resources to carry out their mandate. They are thus, not motivated. However, my thinking also is that the educational level of the present extension staff (mostly certificate and diploma) is quite low for the kind of agriculture we are expecting from our farmers. It is not surprising that in some of our studies [(Lamptey et al., 2022); Ansah et al., 2020)], the extension staff variable is not significant or it is negative [(Azumah et al., 2020); (Donkoh et al., 2019); (Awuni et al., 2018); (Ansah et al., 2016)].

In the light of these limitations, some civil society organisations have employed extension staff that advise their farmers. In some studies, the extension staff from the NGOs do better than those from MoFA.

7.4 Agricultural Credit

Agricultural credit facilitates adoption of modern/improved technologies. This is confirmed by some of my studies [(Boateng et al., 2022); (Marfo et al., 2021); (Azumah et al., 2020); (Appiah-Twumasi et al., 2020) (Donkoh, 2019); (Donkoh et al., 2016); (Donkoh et al., 2009)]. With credit, the farmer can buy more technologies and inputs to expand his/her farming business for greater returns, other things being equal. Professor Chairman, there are times the other

things are not equal. For instance, in periods of drought or flood, or when there is bushfire, the farmer may not be able to get enough proceeds to feed on, let alone pay his/her loan. Agriculture is a risky business. This explains why most financial institutions are not willing to give loans to farmers.

Furthermore, as a result of the low educational backgrounds of our farmers, they simply do not feel comfortable going to the banks for loans, especially considering the documentation that bank loans require. Thus, the farmers prefer to go to traditional money lenders whose interest rates are even higher than that of the banks. Lack of collateral securities on the part of our farmers has also meant that they are not able to secure bank loans. It is against this backdrop that some financial institutions have adopted the group loans where the group tends to be the collateral. The issue of dishonesty is also a hindrance to effective adoption of modern/improved technologies. Agricultural loans used to be on cash basis, but misapplication was common and so lenders resorted to inputs in kind. Unfortunately, with this also there are instances where inputs meant for some cash crops (e.g., cotton) are diverted to the food crops, resulting in negative or inconclusive impacts of access to credit on adoption [(Donkoh et al. (2019); (Adzawla et al., 2016); (Abdul-Hanan et al., 2014)); (Lamptey et al., 2022); (Ansah et al., 2020); (Azumah et al., 2020); Awuni et al., 2018); (Azumah et al., 2017); (Zakaria et al., 2016)).

7.5 FBO Membership

Professor Chairman, farmer-based organizations (FBOs) have become ubiquitous in the farming systems of most African countries, and for good reasons too. FBOs provide the platform for farmers' collective actions to solve some of their problems instead of always relying on government and external sources. They contribute to the agricultural development efforts of Ghana and enhance the adoption of technologies through several means. For example, FBOs help in the education of members on modern agricultural practices and provision of other vital information to farmers; facilitate the provision of agricultural inputs and machinery to members; and as indicated earlier in the discussion on access to agricultural credit, FBOs help in obtaining production and consumption credit from financial institutions for their members as well as mobilize funds for production and marketing of agricultural produce. Together, these show the near indispensability of FBOs in driving adoption of

sustainable agricultural intensification technologies. It is therefore not surprising to find from my studies [(Boateng et al., 2022); (Lamptey et al., 2022); (Marfo et al., 2021); (Azumah et al., 2020); (Donkoh, 2019); (Donkoh et al., 2019; 2014); (Abdulai et al., 2018); (Donkoh et al., 2016); (Zakaria et al., 2016); (Abdul-Hanan et al., 2014)] that farmers who join FBOs reported positive adoption effects However, a few [(Awuni et al., 2018); (Adzawla et al., 2016); and Donkoh, 2020)] also reported inconclusive effects

7.6 Sex/Gender

Sex is an important determinant of agricultural technology adoption. In most of the studies [(Azumah et al., 2020); (Marfo et al., 2021), (Azumah et al., 2020); (Donkoh, 2020; (Donkoh et al., 2019); Awuni et al., 2018)] there is a positive correlation between sex and adoption. The implication of a positive outcome for the sex variable is that, male farmers have higher probability of adoption than their female counterparts. This is not surprising, given that men generally have more access to production resources than females and are responsible for taking major farm decisions. However, in Azumah (2020), female farmers had higher probability of adopting coping and adaptation strategies than male farmers. The reason was that they were harder-hit by climate change and needed to adopt the strategies as a coping and adaptation mechanism. The sex variable was not significant in Donkoh et al. (2016) and Donkoh et al. (2009).

Professor Chairman, as we know, sex as a variable, is a very topical issue. Even though, the emphasis of this lecture is on adoption, permit me to show that two of my early studies on the determinants of poverty and educational expenditure using GLSS DATA-IV revealed that female headed households in Ghana are richer and have higher probability of spending more on formal education than their male headed counterparts.

> **DONKOH, S. A.** (2010). THE DETERMINANTS OF POVERTY IN GHANA. *DEVELOPMENT SPECTRUM*. *2*(1), 128-148.

Halving the proportion of poor and hungry people by the year 2015 is the first of the eight Millennium Development Goals that the world has targeted. This shows how important the goal is. If this target is to be met it is important that we know the determinants of poverty and therefore, the probability of a household becoming poor, among others, for a more precise policy

formulation. This study estimates a probit model to find out the Probability of becoming poor using the Ghana Living Standards Survey (GLSS-V) data. Factors that reduce the probability of a household becoming poor are education, ownership of durable assets and international remittances. Others are: a household head being a female or young; a household living in an urban centre as opposed to a rural area; or in a forest as opposed to a coastal zone. Factors that increase the probability of becoming poor are a high number of dependents and remoteness from the national capital. Policy formulation should focus on: increasing access and quality of education; rural development; and decentralization as well as ensuring a regional balance in the distribution of the 'national cake.'

Table 1: Maximum likelihood estimation results of the determinants of poverty in Ghana

Variable	Parameter	Marginal Effect	Standard Error
Constant	γ_0	-1.19***	0.14
Sex of HH head	γ_1	-0.22**	0.06
Age of HH head	γ_2	0.001**	0.00
Edu. Of HH Head	γ_3	-0.02**	0.01
No of Dependants	γ_4	0.23***	0.02
Durable assets	γ_5	-0.69***	0.07
Bus ownership	γ_6	-0.15**	0.06
International Remittance	γ_7	-0.64**	0.20
Locality	γ_8	0.33***	0.07
Coastal	γ_9	0.36***	0.08
Savannah	γ_{10}	0.10	0.10
Region	γ_{11}	0.21***	0.01
	Chi Square	1416.52	

***Significant at 1% **significant at 5% Note: Dependent variable: Poverty status:1 if welfare>maximum poverty line; 0 if welfare <maximum poverty line. No. of observation=3941. Degrees of freedom=11. Log likelihood function and restricted log likelihood are -1456.79 and -2165.05 respectively. Marginal effects are computed at the means of the independent variables.

DONKOH, **S. A**., & AMIKUZUNO, J. A. (2011). THE DETERMINANTS OF HOUSEHOLD EDUCATION EXPENDITURE IN GHANA. *EDUCATION RESEARCH AND REVIEW (ERR), 6*(8), 570-579.

A logit model was estimated to investigate the socio-economic determinants of a household's probability of spending on education. The data used was the 2006/2007 Ghana Living Standards Survey Round Five (GLSS-V). We found that high education expenditure does not necessarily mean high probability of spending on education. Two categories of households with high probability of education expenditure were identified. The first category consists of households whose heads have formal education, households who own land, vehicles, and other durable assets, as well as households living in the forest belt. The second category includes: female-headed households; households with greater number of children of school going age; rural households; and households living farther away from the nation's capital. Households in the second category are those that must be targeted for urgent support. Governments support in the form of capitation grant, free feeding and free supply of uniforms and stationery are in the right direction, but this must be stepped up in a sustainable manner.

Table 2: Maximum likelihood estimation results of the determinants of education expenditure in Ghana

Variable	Parameter	Marginal Effect	Standard Error
Constant	γ_0	-5.19***	0.38
Sex of HH head	γ_1	-0.12***	0.02
Age of HH head	γ_2	-0.36***	0.00
Age of HH head sqd	γ_3	0.88***	0.07
Edu. Of HH Head	γ_4	0.05***	0.01
Bus ownership	γ_5	0.09***	0.02
Land ownership	γ_6	0.01	0.01
Durable assets	γ_7	0.01***	0.00
No. of children	γ_8	0.23***	0.04

No. of male youth	γ_9	0.25***	0.03
No. of female youth	γ_{10}	0.29***	0.03
Locality	γ_{11}	-0.05**	0.02
Coastal	γ_{12}	0.07***	0.03
Savannah	γ_{13}	0.09***	0.02
Region	γ_{14}	0.01**	0.01
Log likelihood function		88.42	

***Significant at 1% **significant at 5% Note: Dependent variable: Education Expenditure: 1. if household made any expenditure on education in 2007: 0 if otherwise. No. of observation=3941. Degrees of freedom=14. Log likelihood function and restricted log likelihood are -2241.2 and -2682.9 respectively. Marginal effects are computed at the means of the independent variables.

Professor Chairman, Ladies and Gentlemen, another important study worth-showing is how our people perceive development and the indicators of a good development project.

> DONYONG, K. K., **DONKOH**, **S. A**., & ALHASSAN, H. (2012). PERCEPTIONS OF DEVELOPMENT IN THE NORTHERN REGION OF GHANA. *JOURNAL OF RESEARCH IN ECONOMICS AND INTERNATIONAL FINANCE*, *6*, 169-178.

This study sought to investigate beneficiaries' views about development and the qualities of a good development project, among others. The study was carried out in Tamale, Savelugu and Kpalsogu/Dundo in the Northern Region of Ghana. The stratified and simple random sampling techniques were used to select the communities and 240 respondents respectively. Data collection techniques consisted of focus group discussions, individual face-to-face questionnaire administration and observations.

7.7 Development Indicators

To probe respondents' views about development indicators, they were made to rank some pre-determined development indicators (in Table 3) by assigning 1 to the most important; 2 to the second most important, 3 to the third most important, in that order. The most important indicator, in the opinion of the respondents, was Good health (3.0), followed by Peace (3.3), High formal

education (3.4), Enough food (4.1), High income (5.1) and Religion (5.9). Tamale being a conflict-prone area, it is not surprising that respondents ranked peace as the number two indicator of development. The overall Kendall's Coefficient of Concordance was 0.81, which means that there was agreement among 81% of the respondents in the ranking.

Table 3: Respondents' ranking of Development indicators

Development indicators	Study Area (Mean Ranks)			
	Tamale	Savelugu	Kpalsogu/Dundo	Pooled
High formal education	3.4	3.3	3.4	3.4
Good health	2.7	3.2	3.1	3.0
Enough food	4.1	4.7	3.4	4.1
Peace	3.4	3.6	2.9	3.3
High income	5.8	5.4	4.2	5.1
Enough clothing	7.7	7.3	8.2	7.7
Enough entertainment-playing draught, going to night clubs, etc	10.4	9.0	11.8	10.4
Satisfying the Supreme Being, the gods and the ancestors	12.5	10.3	12.5	11.8
Satisfying politicians	13.1	12.2	11.5	12.2
Satisfying the chiefs and elders	10.3	10.2	10.8	10.4
Satisfying God/Allah	4.9	5.6	7.1	5.9
Many wives/husbands and children/siblings	11.9	11.7	12.1	11.9
Many houses	8.8	9.5	8.0	8.8
Many cars	10.1	11.8	10.0	10.6
Many gadgets (sounds system, T.V, sewing machine, etc	11.2	12.1	11.0	11.4

7.8 Qualities of Development Projects/programmes

Development projects must meet some qualities, if they are to serve the purposes for which they are provided. Respondents were asked to rank some pre-determined qualities (listed in Table 4) by assigning 1 to the most important; 2 to the second most important, 3 to the third most important, in

that order, like they did with the development indicators. The six most important qualities, in the opinion of respondents were Conformity to culture (4.4), Usefulness (4.6), Credible source (4.6), Conformity to religious belief system (5.2), Use of local resources (5.9) and Legality (5.9). It was quite surprising that beneficiaries' involvement in planning and implementation did not come as an important quality.

Table 4: Respondents' view on the Qualities of Development Projects

Qualities	Tamale	Savelugu	Kpalsogu/Dundo	Pooled
Credible donor/individual/organization	6.3	2.2	5.3	4.6
Conformity to culture	5.7	3.7	3.7	4.4
Conformity to religious belief system	6.0	4.2	5.6	5.2
Use of local resources	7.0	5.7	5.1	5.9
Involvement of beneficiaries in planning and implementation	5.9	5.3	9.8	7.0
Legality	5.7	7.1	4.9	5.9
Suitability	6.8	8.2	5.6	6.9
Usefulness	4.4	6.3	3.0	4.6
Sustainability	5.9	8.2	7.1	7.1
Environmental friendliness	6.6	7.2	9.0	7.6
Affordability, if for sale	8.4	9.1	9.9	9.1
Non-excludability	9.4	10.8	8.9	9.7

*Respondents were asked to assig 1 to the most important; 2 to the second most important, 3 to the third most important, in that order.

Professor Chairman, Ladies and Gentlemen, having talked about the negative effects of chemical use, it is also important that I show you the results of three studies: one on how our farmers use insecticides on their farms, another on the factors influencing the adoption of organic vegetable farming and its effect on technical efficiency and the last on consumers' willingness to buy organic vegetables in Tamale Metropolis.

DONKOH, **S. A**., OWUSU SARPONG, E., & NYARKO, G. (2016). INSECTICIDE APPLICATION IN VEGETABLE PRODUCTION AND THE RISK OF FOOD POISONING IN NKORANZA MUNICIPALITY, GHANA. *GHANA JOURNAL OF HORTICULTURE, 12*(1), 50-63.

The application of insecticides in vegetable production has become an issue of global concern following reports of food poisoning in some countries, including Ghana. The main objective of the study was to determine incidence of insecticide related food poisoning in vegetable production in the Nkoranza Municipality in the Brong Ahafo Region. The study involved a total of 120 respondents, consisting of 40 each of producers, consumers and food vendors/vegetable traders. The most common chemicals used in controlling insects in the study area were Confidor 2500SL [Imidacloprid (2500g soluble liquid)], Karate 2.5 [Lambda-cyhalothrin (25g emulsifiable concentrate)], Karate 5.0 [Lambda-cyhalothrin (50g emulsifiable concentrate)], Rambo 2.5EC [Deltamethrin (25g emulsifiable concentrate)] and Pawa [Lamda-cyhalothrin]. The period for the last spraying before harvesting the vegetables for the majority of the farmers was 30 minutes to 4 hours. Salt solution and water were the main solutions used in treating vegetables. However, only 7.5% of the consumers reported of illness after eating the vegetables. This was confirmed by the health officials. Recommendations by vegetable farmers included: education (43.6%); use of organic insecticide (30.8%); follow instructions (20.5%); and education and follow instructions (5.2%). While the consumers suggested Treatment (54.4%); Education (34.6%); and buying from a hygienic source (9.8%). Given the level of insecticide misapplication in the study area, it is important that education on pesticide usage and regular monitoring is conducted to ensure conformance to recommended application regimes.

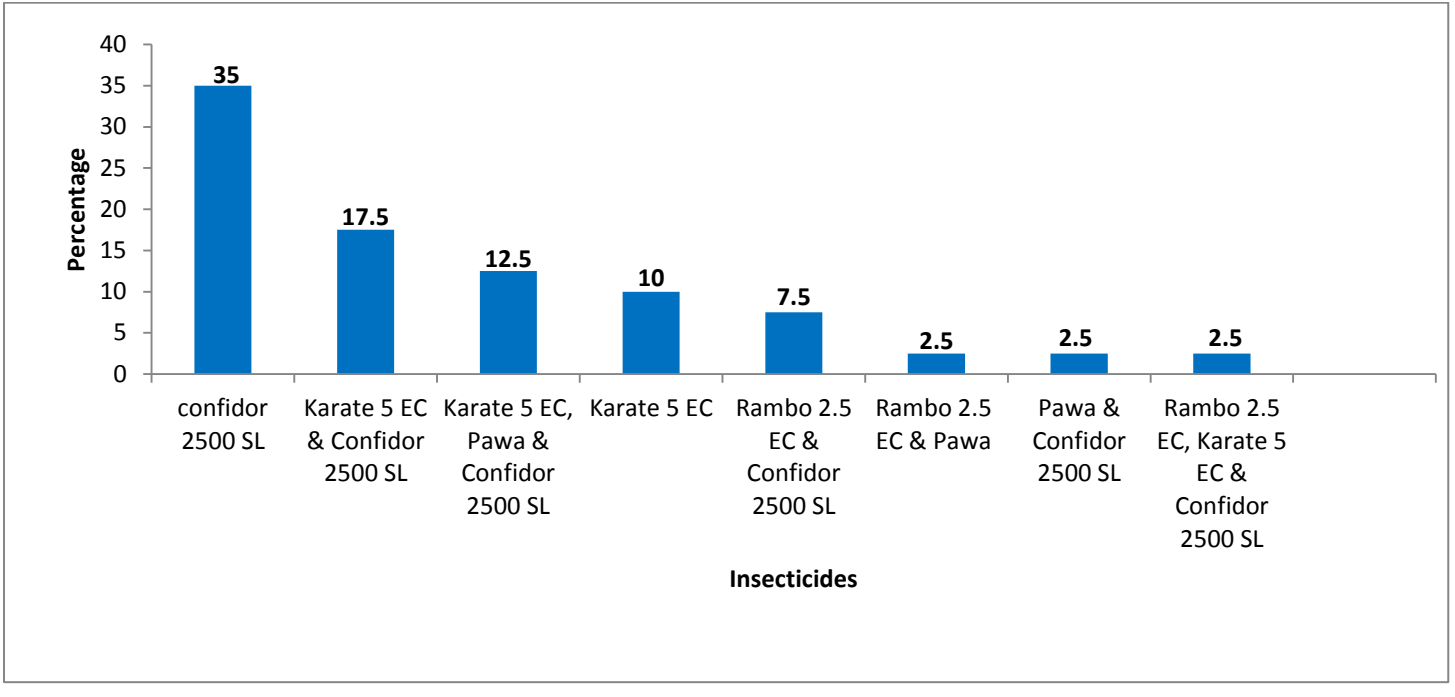


Figure 3: Categories of insectides applied on vegetable in Nkoranza Municipality

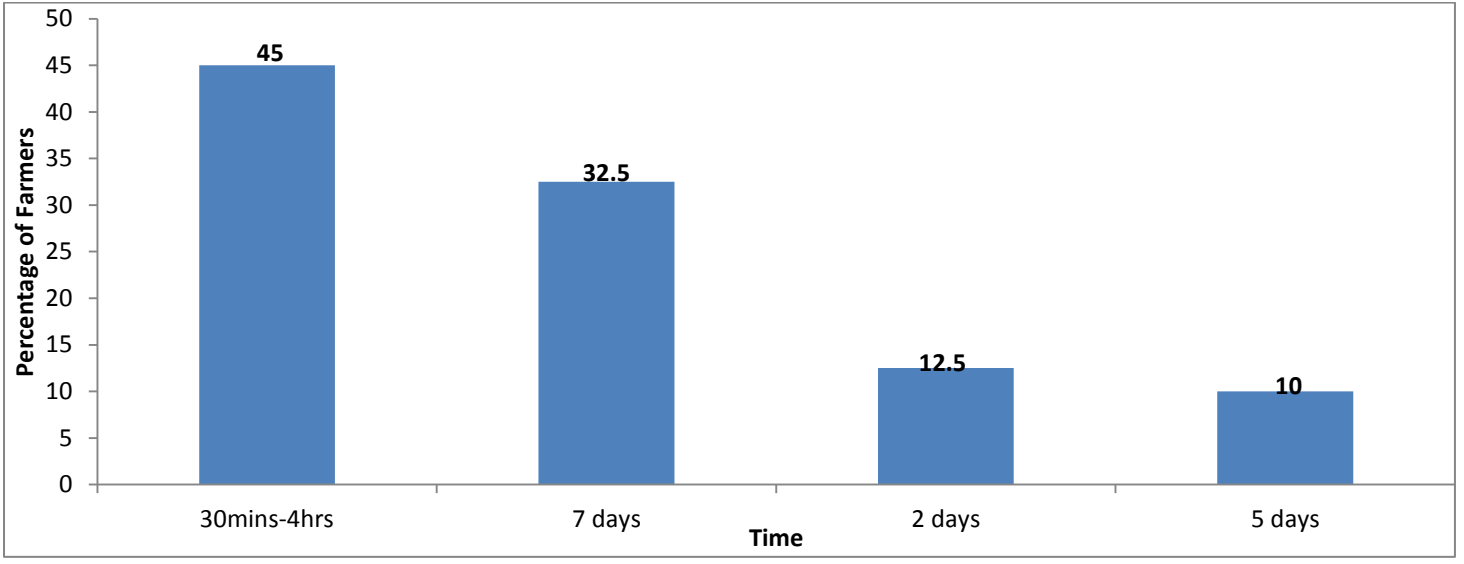


Figure 4: Time of last spraying of vegetables in Nkoranza Municipality

BOATENG, V.F., **DONKOH, S.A**. & ADZAWLA, W. (2022) ORGANIC AND CONVENTIONAL VEGETABLE PRODUCTION IN NORTHERN GHANA: FARMERS' DECISION MAKING AND TECHNICAL EFFICIENCY. ORG. AGR. 12, 47–61 (2022). HTTPS://DOI.ORG/10.1007/S13165-021-00379-7

This research estimates the farmers' decision-making into organic or conventional vegetable production and their technical efficiency. A total of 200 each of organic and conventional vegetable producers were selected through multistage sampling technique, and the data was collected through semi-structured questionnaires. A stochastic frontier model (SFM) with sample selection was employed to correct for selectivity bias in estimating the effect of organic vegetable farming on vegetable output and technical efficiency.

The results show that farmers:

- Formal education; Ability and ownership of resources to farm throughout the year (ARCAY); Ability to make own inputs (AMOI); Membership in a farmer-based organisation (FBO); Access to extension services; Access to external credit support (AECS) significantly explained the probability of engaging in organic vegetable production.

The mean technical efficiency scores for organic and conventional vegetable producers were 34.2 % and 30.7% respectively. Organic vegetable farming had a positive significant effect on the technical efficiency of vegetable farmers. The study concluded that organic farming is an important source of insurance for farmers to increase vegetable production and reduce inefficiencies. However, institutional factors such as extension delivery, group formation, and credit provision should be enhanced to promote organic agriculture among vegetable farmers in the region.

CONSUMERS' WILLINGNESS TO PAY FOR SAFER VEGETABLES IN TAMALE, GHANA MENSAH TAWIAH COBBINAH, **SAMUEL ARKOH DONKOH** AND ISAAC GERSHON KODWO ANSAH AFRICAN JOURNAL OF SCIENCE, TECHNOLOGY, INNOVATION AND DEVELOPMENT, 2018
HTTPS://DOI.ORG/10.1080/20421338.2018.1519062

Consumers' concerns over misuse of agrochemicals and untreated wastewater for irrigation in vegetable production are increasing demand for safer vegetables in urban cities. Providing safer vegetables requires production methods that minimize or eliminate the associated risks. Nevertheless, these practices involve extra cost, which requires that consumers, at least, bear part

of the cost. The main objective of this paper is to examine factors influencing consumers' willingness to pay price premiums for safer vegetables. We sampled a cross-section of 331 consumers in Tamale, and elicited their willingness to pay premium prices for safer vegetables. The results show that consumers are willing to pay average premiums of GH¢8.01 (US$1.90), GH¢3.27 (US$0.78) and GH¢2.89 (US$0.69) for standard quantities of safer cabbage, safer 'ayoyo' and safer okra, respectively. These premium prices are equivalent to 128.6%, 197.3% and 189.0% of the current average market prices of same quantities of the conventional vegetables. Typically, consumers willing to pay premium prices are those with income generating employment, have trust in traders and care about the use of untreated wastewater for irrigation. These findings mean that consumers are generally willing to bear extra cost to secure consumption of safer vegetables, and avoid health-related risks associated with unsafe, conventional vegetables. Policymakers and development partners could also assist vegetable farmers in the provision of adequate, constant flow of treated water and good knowledge in the use of agrochemicals to reduce health risks.

Professor Chairman, the next study is a unique study on adoption because it goes beyond adoption of improved varieties of rice to consider their dis-adoption also. We found interesting results.

> LAMPTEY, C.Y., SULEMANA, N., **DONKOH, S.A**., ZAKARIA, A. AZUMAH, S.B. (2022) THE EFFECT OF ADOPTION OF IMPROVED VARIETIES ON RICE PRODUCTIVITY IN THE NORTHERN REGION OF GHANA. REVIEW OF AGRICULTURAL AND APPLIED ECONOMICS. ADVANCE ONLINE PUBLICATION. DOI: 10.15414/RAAE.2022.25.01.42-54

Using primary data collected from 404 farmers, the study examines the adoption levels of the main rice varieties among farmers and investigates the reasons for their adoption and dis-adoption in the Northern Region. The empirical results revealed that rice varieties namely, Agra, Sakai, Jasmine 85, and Afife were the most adopted in the study area. Also, the study finds that GR-18, Nerica, Digang, Tox, Mandee, and Faro-15 were the most dis-adopted rice varieties.

The main reasons for which farmers adopted the improved rice varieties were:

- Availability of a ready market for the produce;
- Crop resistance to pests and diseases;
- Consumer higher demand for rice;
- Advice by extension staff to cultivate; and
- Encouragement from researchers to adopt.

The reasons for the dis-adoption of improved rice varieties in the study area were:

- High input requirements;
- Lack of ready market for the varieties; and
- Unfavourable climatic conditions.

The findings of the study give direction as to the angle from which the adoption of improved rice varieties can be stepped up while dis-adoption is reduced. Research scientists should research into rice varieties that are more suitable for the soil and climatic conditions of the study area and continue to sensitize and motivate the farmers to adopt them, while government should step up its support for the research scientists as well as the extension officers to deliver on their mandate.

Professor Chairman, the next study is also unique in the sense that it tries to summarize the socioeconomic determinants of agricultural project participation such as the Planting for food and jobs (PFJ) into two, namely; human and institutional capabilities in line with Amartya Sen's capability theory.

> ANSAH, I. G. K., LAMBONGANG, M., & DONKOH, S. A. (2020). GHANA'S PLANTING FOR FOOD AND JOBS PROGRAMME: A LOOK AT THE ROLE OF CAPABILITY IN FARMERS' PARTICIPATION. JOURNAL OF HUMAN DEVELOPMENT AND CAPABILITIES, 21(2), 161-182. DOI:10.1080/19452829.2020.1745162

An objective interpersonal comparison of wellbeing requires that people's capabilities are considered. This paper operationalises Sen's capability concept

in maize-based farming systems and assesses how it influences farmers' participation in the Planting for Food and Jobs programme in the Bunkpurugu-Yunyoo District of the Northern Region, Ghana. We used data from 315 households collected through multi-stage sampling procedure. Capability was quantified using factor analysis, while its determinants were identified through multiple linear regression analysis. Afterwards, an instrumental variable probit model was used to examine the effect of capability on programme participation. We identified two attributes of capability, which were labelled as human capability and institutional capability. These capability attributes are significantly enhanced by availability of markets and good roads. Our results provide evidence that the two attributes of capability influence farmers' participation in the Planting for Food and Jobs programme. The findings indicate that, for effective participation in agricultural interventions, farmers' capabilities need to be enhanced. This could be achieved through the provision of, and/or improvement in infrastructure, including roads and markets in remote production centres.

Table 5: Determinants of capability dimensions in maize-based farming system

Variable	Institutional Capability		Human Capability	
	Coefficient	Std Error	Coefficient	Std Error
Age	0.004	0.003		
Sex	0.309**	0.131		
Time taken from household to farm	-0.002*	0.001		
Access to credit	0.499	0.313	-0.275	0.313
Time taken to nearest access road	-0.005***	0.002		
Non-farm income	0.143*	0.087	-0.115	0.089
Availability of input market	0.621***	0.088	0.105	0.118
Availability of output market			-0.002*	0.002
Total land size			0.018	0.010
Farmer's experience			-0.008	0.004
Price received for maize in previous season			0.273***	0.103
Type of road			0.250***	0.097
Ethnicity			0.178	0.137
Model diagnostics				

R-squared	0.23	0.11
F-statistic	11.97	3.73
P-value	0.00	0.001
Number of observations	302	302

Notes: ***, ** and * denote 1%, 5% and 10% significant levels respectively

Professor Chairman, the next study is on value chain participation and its effects on credit access, loan repayment and farmers' income in northern Ghana. One of the interesting findings is the fact that actors of the agricultural value chain, including farmers prefer to borrow from informal sources to formal sources. The actors reiterate a lot of the findings in the literature with respect to their challenges.

AGRICULTURAL VALUE CHAIN PARTICIPATION AND ITS EFFECTS ON CREDIT ACCESS, LOAN REPAYMENT AND FARMERS' INCOME IN NORTHERN GHANA

Linking farmers to agricultural value chains is considered a strategic way to improve their credit access as such interventions tend to minimize the costs and risks associated with agricultural lending. Using primary data drawn from 500 farmers in northern Ghana, this study examined the role of agricultural value chain (AVC) in farmers' credit access. A multivariate probit model that corrects for sample selection bias was used to address a possible endogeneity of AVC participation and farmers' credit access due to unobserved heterogeneity. A propensity score matching was used to estimate the effect of AVC participation on credit access. The results revealed a direct effect of AVC participation on farmer access to credit. Also, participants of AVC vertical linkages (AVC-VL) are more likely to access informal credit while participants of AVC horizontal linkages (AVC-HL) are more likely to access formal credit. As expected, farmers who participated in AVC had higher odds of accessing credit than non-AVC participants. We therefore suggest that farmers are sensitized and supported to participate in value chains to enhance greater access to credit for agricultural purposes.

With regards to the other determinants of formal credit access, the study revealed age of farmer, resident status and number of crops cultivated to have

a negative effect on the probability of formal credit access. At the same time, confidence to approach a bank, access to a bank account, extension contact and guarantor were found to influence formal credit access positively. On the other hand, the study found number of crops cultivated, engagement in irrigation farming and access to a bank account to have a negative correlation with informal credit access while resident status of farmer and networking had a positive significant influence on informal credit access.

Table 6: Frequency/percentage distribution of the types of credit obtained by farmers from the different financial institutions

	Type of credit			
	Cash credit	Input credit	Mechanization credit	All
Sources	Freq. (%)	Freq. (%)	Freq. (%)	Freq.
Formal (n = 93)				
Commercial banks	45 (100.0)	0 (0.0)	0 (0.0)	45
Rural & community banks	10 (27.8)	26 (72.2)	0 (0.0)	36
Microfinance institutions	8 (66.7)	4 (33.33)	0 (0.0)	12
AVC (n = 165)				
Input suppliers	0 (0.0)	21 (91.3)	2 (8.7)	23
Aggregators	1 (14.3)	5 (71.4)	1 (14.3)	7
Colleague farmers	2 (100.0)	0 (0.0)	0 (0.0)	2
Nucleus farmers	0 (0.0)	11 (26.2)	31 (73.8)	42
Marketers/traders	2 (7.7)	24 (92.3)	0 (0.0)	26
Commercial agribusiness	3 (7.0)	25 (58.1)	15 (34.9)	43
NGOs	5 (22.7)	9 (40.9)	8 (36.4)	22
Informal (n =129)				
Friends	75 (92.6)	4 (4.9)	2 (2.5)	81
Relatives	37 (80.4)	9 (19.6)	0 (0.0)	46
Moneylenders	2 (100.0)	0 (0.0)	0 (0.0)	2

Source: Estimations from Author's Data, 2017

Table 7: Mean analysis of farmers' constraints to AVC participation, access to credit and loan repayment

Constraints		Gender	Location		
AVC participation Constraints	All farmers	Male (Female)	Northern	Upper East	Upper West
Smaller landholding	2.24	2.22 (2.25)	2.25	2.22	2.22
Limited access to extension services	2.27	2.26 (2.29)	2.36	1.85	2.00
Limited access to production technology	2.30	2.2 (2.34)	2.33	1.67	2.19
Limited access to inputs	2.57	2.42 (2.6) [c]	2.55	2.15	2.42
Lack of encouragement from stakeholders	2.73	2.71 (2.76)	2.77	2.41	2.70
Poor road network	3.49	3.78 (3.53) [c]	3.70	3.22	4.15
Lack of irrigation facilities	3.70	3.43 (3.63)	3.58	2.89	3.41
Access to Credit Constraints					
Lack of Financial Institutions	1.82	1.77 (1.85)	1.73	1.96	2.13
High transaction cost	3.16	3.09 (3.21)	3.14	3.12	3.39
Lack of confidence to approach financial institutions	2.87	2.84 (2.93)	2.88	2.78	2.94
Fear of default and being chased to repay	2.90	2.92 (2.86)	2.86	3.11	2.79
Lack of off-farm activities to regular income	2.98	2.89 (3.11)	2.93	3.14	3.00
Fear of losing collateral used to secure loan	3.22	3.22 (3.22)	3.15	3.37	3.34
Proof address and identification	3.39	3.40 (3.35)	3.4	3.40	3.28
Lack of access to guaranteed market	3.54	3.23 (3.42)	3.32	3.51	3.19
Lack of Collateral	3.58	3.52 (3.69)	3.55	3.67	3.63
Loan Repayment Constraints					
Low incomes	3.94	3.92 (3.96)	3.87	4.11	4.04
Unforeseen circumstances	2.71	2.71 (2.72)	2.65	2.95	2.69
Late acquisition of inputs	3.29	3.35 (3.18)	3.28	3.33	3.25

Lack of guaranteed market	3.34	3.29 (3.42)	2.82	2.30	3.41
High interest on loans	3.77	3.80 (3.73)	3.72	3.90	3.89
Fire outbreaks	3.82	3.82 (3.82)	3.80	3.92	3.78
Low productivity	4.14	4.16 (4.11)	4.12	4.12	4.28
Unfavourable weather	4.14	4.22 (4.02)	4.11	4.21	4.22
High post-harvest losses	4.15	4.18 (4.09)	4.10	4.20	4.3

1 = Strongly disagree; 2 = Disagree, 3 =Neutral 4= Agree 5= Strongly agree

8.0 Summary, Conclusions and Recommendations

The following observations are made from the empirical papers presented:

- Feminisation of poverty is not supported by the GLSS data.
- Female-headed households also have higher probability of spending on education than their male-headed counterparts.
- Rural households and households farther from the capital town have higher probability of becoming poor than urban households and households close to the Greater Accra Region.
- Adoption of multiple technologies have greater impacts on output than the adoption of a single technology.
- In general, adoption of local technologies is higher than that of the exotic technologies.
- Professor Chairman, I need to mention that, largely there is a simultaneous relationship between adoption and most of the policy variables. We could not show this in the report, and needless to say, using a wrong model will lead to wrong results and therefore inappropriate policy recommendation.

African Agriculture is at a crossroads in the sense that farmers are confronted with adopting either conventional intensification or sustainable intensification (adoption of appropriate technologies). My theoretical and empirical arguments in this lecture indicate that farmers' socioeconomic indicators cannot support the former, hence the relatively slow pace of the continent's agricultural development over the years. Our physical and social environments as a people is key in the development and adoption of appropriate technology Even with sustainable intensification, more needs to be done by way of socioeconomic intensification to attain the desired goals. Investments in the human and other resources across the agricultural value chain must be stepped

up significantly and the appropriate policies and programmes implemented. This would take commitment on the part of all stakeholders including governments and civil society organisations as well as the farmers themselves. Professor Chairman, may I also propose the following:

The adoption of one of our local languages as our official language and encourage the use of our local languages in our schools? Our counterparts in Eastern, Northern and Southern African are doing better at this.

Part-time formal schooling as an alternative to the full time where children who show early signs of interests in some occupations (e.g., farming, fishing, artisanry, mechanics) are allowed to be on the jobs while going to school. They may take a longer time to complete school, but not only would they have ready jobs, they would be better at them than those who do full time schooling before coming to the trade.

Lastly, as a continent, we must make every effort to GROW what we EAT, EAT what we GROW and TRADE among ourselves!

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References

Abdallah, A. H., Michael, A., & Samuel, A. D. (2014). Smallholder adoption of soil and water conservation techniques in Ghana. *African Journal of Agricultural Research*, *9*(5), 539-546.

Abdulai, S., Zakariah, A., & Donkoh, S. A. (2018). Adoption of rice cultivation technologies and its effect on technical efficiency in Sagnarigu District of Ghana. *Cogent Food & Agriculture*, *4*(1), 1424296.

Adzawla, W., Donkoh, S. A., Nyarko, G., OReilly, P. J., Olayide, O. E., Mayes, S., ... & Azman, H. R. (2016). Adoption of Bambara groundnut production and its effects on farmers welfare in Northern Ghana. *African Journal of Agricultural Research*, *11*(7), 583-594.

Agriculture for Impact (2013). Sustainable Intensification: A New Paradigm for African Agriculture, A Montpellier Panel Report, London.

Agriculture for Impacts: Growing opportunities for African development https://ag4impact.org/

Agriculture Sector in Ghana Review (2020) Agriculture-Sector-Review.pdf (itrade.gov.il)

Aliyu, A. (2014). Organophosphate and Pyrethroid Insecticide Residue Levels in Water Bodies in Cotton Growing Areas in Savelugu-Nanton District, Northern Region, Ghana (Master's Thesis, Kwame Nkrumah University of Science and Technology).

Ansah, I. G. K., Lambongang, M., & **Donkoh, S. A**. (2020). Ghana's Planting for Food and Jobs programme: A look at the role of capability in farmers' participation. *Journal of Human Development and Capabilities, 21*(2), 161-182. doi:10.1080/19452829.2020.1745162

Ansah, I. G. K., Tetteh, B. K. D., & **Donkoh, S. A.** (2017). Determinants and income effect of yam postharvest loss management: evidence from the Zabzugu District of Northern Ghana. *Food Security, 9*(3), 611-620. doi:10.1007/s12571-017-0675-1

Ansah, I. G. K., Toatoba, J., & **Donkoh, S. A**. (1). The Effect of Credit Constraints on Crop Yield: Evidence from Soybean Farmers in Northern Region of Ghana. *Ghana Journal of Science, Technology and Development*, *4*(1), 51 - 67. doi.org/10.47881/78.

Ansah, I. G., Lambongang, M., & **Donkoh, S. A.** (2020). Ghana's planting for food and jobs programme: A look at the role of capability in farmers' participation. *Journal of Human Development and Capabilities*, *21*(2), 161-182.

Awuni, J. A., Azumah, S. B., & **Donkoh, S. A.** (2018). Drivers of adoption intensity of improved agricultural technologies among rice farmers: evidence from northern Ghana. *Review of Agricultural and Applied Economics (RAAE)*, *21*(1340-2018-5180), 48-57.

Azumah, S. B., Adzawla, W., **Donkoh, S. A.,** & Anani, P. Y. (2021). Effects of climate adaptation on households' livelihood vulnerability in South Tongu and Zabzugu districts of Ghana. *Climate and Development*, *13*(3), 256-267.

Azumah, S. B., **Donkoh, S. A.**, & Ansah, I. G. K. (2017). Contract farming and the adoption of climate change coping and adaptation strategies in the northern region of Ghana. *Environment, Development and Sustainability, 19*(6), 2275-2295. doi:10.1007/s10668-016-9854-z

Azumah, S. B., **Donkoh, S. A.,** & Ansah, I. G. K. (2017). Contract farming and the adoption of climate change coping and adaptation strategies in the northern region of Ghana. *Environment, Development and Sustainability*, *19*(6), 2275-2295.

Azumah, S. B., **Donkoh, S. A.,** & Awuni, J. A. (2018). The perceived effectiveness of agricultural technology transfer methods: Evidence from rice farmers in Northern Ghana Cogent Food & Agriculture, 4(1), doi:10.1080/23311932.2018.1503798

Azumah, S. B., **Donkoh, S. A.,** & Awuni, J. A. (2018). The perceived effectiveness of agricultural technology transfer methods: Evidence from rice farmers in Northern Ghana. *Cogent Food & Agriculture*, *4*(1), 1503798.

Azumah, S. B., **Donkoh**, **S.A**, & Ehiakpor, D. (2016). Examining the determinants and effects of contract Farming on Farm Income in the Northern Region of Ghana. *Ghana Journal of Science, Technology and Development, 4*(1), 1-10.

Azumah, S. B., Mahama, A., & **Donkoh, S. A.** (2020). Modelling the determinants of adoption of multiple climate change coping and adaptation strategies. A micro analysis of smallholder farmers in northern Ghana. *Review of Agricultural and Applied Economics (RAAE)*, *23*(1340-2021-003), 30-37.

Boahene, K. (1998). Innovation Adoption as a Socio-Economic Process: The Case of the Ghanaian Cocoa Industry. Amsterdam: Thesis Publishers.

Boateng, V. F., **Donkoh, S. A.,** & Adzawla, W. (2022). Organic and conventional vegetable production in northern Ghana: farmers' decision making and technical efficiency. *Organic Agriculture*, *12*(1), 47-61.

Boateng, V.F., **Donkoh, S.A.** & Adzawla, W. (2022) Organic and conventional vegetable production in northern Ghana: farmers' decision making and technical efficiency. Org. Agr. 12, 47–61 (2022). https://doi.org/10.1007/s13165-021-00379-7

Bommarco, R. (2013). Ecological intensification: harnessing ecosystem services for food security. Trends in Ecology and Evolution, Elsevier 28 (2013): 230-238.

Borlaug, N. (1972) (Ed.). *The Green Revolution*, Mexico, CIMMYT.

Cary Institute of Ecosystem Studies. 2015., Definition of Ecology. [24 June 2015]

Cleaver, H. (1972). The contradictions of the Green Revolution (GR). *Monthly Review*, 24, 2.

Clute, R.E. (1982). The role of agriculture in African development. *African Studies Review,* 25, 4, 1-20.

Donkoh, S. (2020). Rice commercialisation and improved agricultural technology adoption in Northern Ghana: Endogenous switching Poisson approach. *Alanya Akademik Bakış*, *4*(1), 105-121.

Donkoh, S. A. (2010). The determinants of poverty in Ghana. *Development Spectrum*. *2*(1), 128-148.

Donkoh, S. A. (2019). Agricultural input credit and the adoption of sustainable agricultural practices (saps) in selected sub-Saharan Africa (SSA) countries: An endogenous Poisson regression approach. *UDS International Journal of Development*, *6*(3), 97-115.

Donkoh, **S. A.** (2019). Rice commercialisation and improved agricultural technology adoption in **n**orthern Ghana: endogenous switching poisson approach. *Alanya Akademik Bakış, 4*(1), 105-121.

Donkoh, **S. A**., & Amikuzuno, J. A. (2011). The determinants of household education expenditure **in** Ghana. *Education Research and Review (ERR), 6*(8), 570-579.

Donkoh, S. A., & Awuni, J. A. (2011). Adoption of farm management practices in lowland rice production in Northern Ghana. *Journal of Agriculture and Biological Sciences*, 2(6), 183 – 192.

Donkoh, S. A., Azumah, S. B., & Awuni, J. A. (2019). Adoption of improved agricultural technologies among rice farmers in Ghana: A multivariate probit approach. *Ghana Journal of Development Studies*, *16*(1), 46-67.

Donkoh, **S. A.**, Eliasu, A., Setsoafia, E. D., & Ansah, I. G. K. (2016). Participation and output effect of a Block Farm Credit Programme in selected districts of Northern Ghana. *Agricultural Finance Review, 76*(3), 348-361. doi:10.1108/AFR-01-2016-0005

Donkoh, S. A., Kudadze, S., Adzawla, W., & Ansah, I. G. K. (2016). Adoption of dry season vegetable farming and its effects on income at Golinga and Botanga irrigation sites, Northern Ghana. *Ghana Journal of Science, Technology and Development*, *4*(1), 29-41.

Donkoh, S.A., Tiffin, J., & Srinivasan, C. (2011). Who adopts green revolution (GR) technology in Ghana? *International Journal of AgriScience, 1*(1), 32-44.

Donkoh, S. A., Tiffin, R., & Srinivasan, C. (2009). Adoption of green revolution services and poverty reduction in Ghana. *Ghana Journal of Development Studies*, *6*(1), 64-92.

Donkoh, S.A., Owusu Sarpong, E. and Nyarko G. (2016) Insecticide Application in Vegetable Production and the Risk of Food Poisoning in Nkoranza municipality, Ghana Noranda Journal of Horticulture Vol. 12 (1) pp.50-63

Donkoh, S. A., & Awuni, J. A. (2011). Farmers' perceptions and adoption of improved farming techniques in low-land rice production in northern Ghana.

Donyong, K. K., **Donkoh, S. A.,** & Alhassan, H. (2012). Perceptions of Development in the Northern Region of Ghana. *Journal of Research in Economics and International Finance (JREIF),* 1(6), 169-178.

Drechsel, P. & Keraita, B. (Eds.). (2014). Irrigated urban vegetable production in Ghana: characteristics, benefits and risk mitigation, 2nd ed. Colombo, Sri Lanka: International Water Management Institute (IWMI). 247.

Evenson, R.E (2001). IARC 'Germplasm' Effects on NARS Breeding Programmes. In R. Evenson & D. Gollin (Eds.), *Crop Variety Improvement and Its Effect on Productivity: The Impact of International Agricultural Research*. Wallingford, UK: CAB International.

Evenson, R.E., Gollin, D. (2000). The Green Revolution: an end of century Perspective. [Online] Available from : http://w.w.w.williams.edu/economics/wp/gollin%20The%20green%20revolution. [Accessed 24 June 2006].

Foltz, J.D. (2003). The economics of water-conserving technology adoption in Tunisia: an empirical estimation of farmer technology choice. *Economic Development and Cultural Change,* 51, 2 (January), 359-73.

Food and Agricultural Organization (FAO) (2009). Glossary on Organic Agriculture. FAO, Rome, Italy.

Foster, J., Greer, J. & Thorbecke, E. (1984). A class of decomposable poverty Measures. *Econometrica,* 52, 4, 761-765.

Glaeser, B. (1987). Agriculture between the Green Revolution and Eco-Development: Which Way to go? In B. Glaeser, (Ed.), The *Green Revolution Revisited: Critiques and Alternatives.* London: Allen and Unwin, 1-9.

Godfray, H.C.J. (2010). Food security: the challenge of feeding 9 billion people. Science 327: 812-818.

Gollin, D., Morris, M. & Byerlee, D. (2005). Technology adoption in intensive post-Green Revolution systems. *American Journal of Agricultural Economics,* 87, 5, 1310-1316.

Griliches, Z. (1957). Hybrid corn: an exploration in the economics of technical change. *Econometrica,* 25, 4, 501-522.

Hall, B.H. & Khan, B. (2003). *Adoption of New Technology. UC Berkeley working papers,* E03-330. Department of Economics, University of Berkeley, Berkeley.

Hazell, P.B.R. & Ramasamy, C. (Eds.), (1991). *The Green Revolution Re-considered.* London: The John Hopkins University Press, 1-9.

Johnson, M., Hazell, P. & Gulati, A. (2003). The role of intermediate factor markets in Asia's Green Revolution: lessons for Africa? *American Journal of Agricultural Economics,* 85, 5, 1211-1216.

Johnston, J. & Dinardo, J. (1997). *Econometric Methods.* U.S.A: McGraw-Hill Companies Inc.

Kleijn, D., Bommarco, R., Fijen, T. P., Garibaldi, L. A., Potts, S. G., & Van Der Putten, W. H. (2019). Ecological intensification: bridging the gap between science and practice. *Trends in ecology & evolution*, *34*(2), 154-166.

Lamptey, C. Y., Sulemana, N., Donkoh, S. A., Zakaria, A., & Azumah, S. B. (2022). The effect of adoption of improved varieties on rice productivity in the Northern Region of Ghana. *Review of Agricultural and Applied Economics.* 25(1), 42-54.

Levidow, L., Pimbert, M. and Vanloqueren, G. (2014). Agro-ecological research: conforming with transforming the dominant agro-food regime? Agro-ecology and Sustainable Food Systems 38 (10): 1127-1155.

Low A. (1994). Placing Improved Agricultural Technology in the Hands of Resource Poor Farmers. In Maddock, N. & Wilson, F.A. (Eds.), *Project Design for Agricultural Development. Aldershot: Avebury*,38-58.

Marfo, E., Danso-Abbeam, G., Donkoh, S. A., Dikro, M. A., Ehiakpor, D. S., & Ofori, D. (2021). The complementarity and substitutability of sustainable agricultural practices among maize farm households under AFRINT regions in Ghana: Do the socioeconomic determinants confirm these? *Cogent Food & Agriculture*, *7*(1), 1969736.

Morris, L.M., Tripp, R. & Dankyi, A.A. (1999). Adoption and impacts of improved maize production technology: a case of the Ghana grains development project. México D.F.: IMWIC. CCMYT *Economic Programme Paper 99-01.*

Nyanteng, V.K & Dapaah, S.K. (1993). Agricultural Development Policies and Options. In V.K. Nyanteng (Ed.), *Policies and Options for Ghanaian Economic Development.* Ghana: ISSER, University of Ghana, Legon, 145-160.

Nyanteng, V.K & Seini, A.W. (2000). Agricultural Policy and the Impact on Growth and Productivity. In E. Aryeetey, M. Nissanke & J. Harrigan *(Eds.*), *Economic Reforms in Ghana: The Miracle and the Mirage.* U.S.A.: James Currey Ltd, 267-283.

Omojokun, J. (2013) Regulation and Enforcement of Legislation on Food safety in Nigeria, In Mycotoxin and Food safety in Nigeria https://www.intechopen.com/books/mycotoxin-nd-food-safety-in-developing-countries/.

Rogers, E.M (1962). *Diffusion of Innovation*. New York: Free Press.

Ryan, B., & Gross, N. (1943). The diffusion of hybrid seed corn in two Iowa communities. *Rural Sociology*, 8, 15-24. Schultz, T.W., (1964). *Transforming Traditional Agriculture*. New Heaven-CT: Yale University).

Schultz, T.P (1981). *Economics of Population*. Reading- MA: Addison-Wesley.

Spink, J. & Moyer, DC (2011) Journal of Food Science, 76(9), 157-163)

The Economics of Ecosystems and Biodiversity n.d., Ecosystem Services. [24 June 2015]

Tiffin, R. & Irz, X. (2006). Is agriculture the engine of growth? Agricultural Economics, 35, 1, 79-89.

Todaro M.P& Smith, S.C (2003). *Economic Development* London: Pearson, Addison Wesley.

World Development Indicators (2021) Ghana National Sectoral GDP Contribution from 1960-2021 - Bureau of Market and Social Research (marketresearch.com.gh)

Zakaria, A., Ansah, I. K., Abdulai, S., & Donkoh, S. A. (2016). The determinants and effects of JICA rice technology adoption in the Sagnarigu District of the Northern Region, Ghana. *UDS International Journal of Development*, *3*(1), 1-12.