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KUMASI

THE EFFECT OF DIGITALIZATION ON SUSTAINABLE DEVELOPMENT: THE MEDIATING ROLE OF OPEN INNOVATION IN THE AGRI-FOOD INDUSTRY FOCUSING ON THE FOOD PROCESSING SECTOR IN GHANA.

BY:

TABE SHADRACK Ayuk

(B.A Law, MBA Logistics & Supply Chain Management)

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DECLARATION

I, the undersigned, declare that this thesis is the result of my original work toward the Master of Science in Logistics and Supply Chain Management and that to the best of my knowledge, it contains no materials previously published by another person nor material that has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

TABE SHADRACK Ayuk (PG8287621) ……. …….

(Student Name & ID) **Signature** **Date**

Certified By:

Dr. Mrs. Matilda Owusu-Bio ……. …….

(Supervisor) **Signature** **Date**

Certified By:

Prof. David Asamoah ……. …….

(HOD-SCIS) **Signature** **Date**

DEDICATION

I dedicate this thesis to the Glory of the Almighty God through whose undeserved kindness I have been able to complete this work.

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ABSTRACT

Sustainability has become so impeccable in today's business that it is a fundamental requirement for all firms' operations which necessitated the adoption of digitalization for the singular aim of achieving it. This study has become timely since the world bank required all African companies to be digitalized by 2030 as well as the advancement in its literacy skills advocacy on digitization to minimize post-harvest food waste, boost good dieting, and improve business networking opportunities. Lack of awareness of the importance of digitization in African Agro-processing firms impedes sustainability. Though there has been a very strong commitment to transform the economy by promoting equitable and sustainable development using digitalization agriculture and food processing, these efforts to industrialize the sector and make it attractive globally, the productivity rate is still very low as indicated by the World Food Programme. Despite this, scanty empirical studies have investigated the rate of digitization implementation and its impact on sustainability. As a result of that, this study sought to answer the research question 'under what condition does digitalization drive sustainability?' By way of objectives, the study sought to determine the relationship between digitization and sustainability, the relationship between open innovation and sustainability, and the mediating role of open innovation in the relationship between digitization and sustainability. From the dynamic capability theory perspective and Theory of Acceptance and Use of Technology perspective, a cross-sectional design and modified questionnaires from the literature were used to collect data from 170 CEOs/top managers of food processing firms in Ghana (Accra and Kumasi). It is a firm-level analysis. Data was analyzed with Mplus version 7.5, the Statistical Package for Social Sciences (SPSS), and the Hayes PROCESS Model. The results show that there was a significant relation between digitalization and sustainable development and an indirect effect of open innovation by driving digitalization to sustainable development. The study encouraged collaborative partnership in adopting digitalization through open innovation to drive sustainable development while recommending that policymakers employ holistic stakeholder engagement to promote digitalization in the sector. This study serves as a platform for future research to leverage their investigations on integrating the value chain of the Agri-food industry.

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LIST OF ABBREVIATIONS

ADB	African Development Bank
AGI	Association of Ghana Industries
AU	African Union
AVE	Average Variance Extracted
CA	Cronbach's Alpha
CFA	Confirmatory Factor Analysis
CR	Composite Reliability
D4Ag	Digitalization for Agriculture
DE4A	Digital Economy for Africa
DigitLit	Digital Literacy
EFA	Exploratory Factor Analysis
GDP	Gross Domestic Product
GSS	Ghana Statistical services
Infras	Digital Infrastructure
IoT	Internet of Things
ICT	Information and Communication Technologies
KNUST	Kwame Nkrumah university of Science and Technology
MDGs	Millenium development Goals
OI	Open Innovation
PBV	Practiced Based View
PLAT	Platform
SCM	Supply Chain Management
SD	Sustainable development
SDGs	Sustainable Development Goals
SMEs	Small and Medium Sized Enterprises
SPSS	Statistical Package for Social Sciences
SuSAtt	Sustainable Attitude
SuSkno	Sustainable Knowledge
SuSBeh	Sustainable Behavior
UTAUT	Unified theory of Acceptance and Use of Technology
WWF	World Food Programme
1D1F	One District One Factory

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Sustainable development has been adopted globally as a modern times concept by statesmen to trigger operational performance and growth in communities and businesses (Saxena et al., 2021), which has led to the adoption of the United Nations Sustainable Development Goals (SDGs) that sparked a new horizon in the socio-economic and environmental revolution of business processes (Polishchuk et al., 2022). According to Jovanović et al. (2018), "Sustainable development (SD) is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Though there are several explanations for this concept, its main purpose is to channel the course of economic growth without ecological depletion (Banerjee, 2003). Research has shown that a holistic and collaborative implementation of the socio-economic and environmental features can trigger businesses and government actions to achieve sustainable development over time (Jovanović et al., 2018). The importance of sustainable development cannot be over-emphasized to abate poverty and trigger performance in the food processing sector in Ghana. Although global warming, land degradation, post-harvest food waste, and other problems affecting sustainable development can be overcome by an appropriate implementation using advanced technologies (Bag et al., 2021).

Emerging digital technologies have been confirmed as a key factor influencing all aspects of lives and businesses leading to sustainable development. For example, it has been posited that technology has been evolving at a faster rate and has a very high investment quotient; organizations must consistently hinge on this medium to sustain competition and growth of their businesses (Bahn et al., 2021). Empirical studies reveal an impressive entwined relationship between digitalization and economic development (Imran et al., 2022).

Digitalization "refers to the socio-technical application of digital technologies or innovations" (Bahn et al., 2021). It is causing exponential agricultural value chain growth (Sozaeva et al., 2021). To productively operate at optimum and achieve sustainable innovation in the food processing value chain, firms have to embrace and implement emerging digital infrastructure that ensures accurate, consistent, and secure data that contributes to informed decisions and tracked business processes (Nhamo, 2022). As one of the countries championing the digitalization agenda in Africa, Ghana has experienced massive usage of the digital space, especially in agriculture through the Internet of Things (IoT), remote sensing, Artificial

Intelligence, Information and Communication Technologies (ICT), and other advanced technologies to improve telecommunication, operational performance, profitability, competitive edge by developing the capabilities and meet growing consumer demand (Ampah et al., 2021, Carmela Annosi et al., 2020). The global environment is presently experiencing the fifth wave of technological evolution wherein there exists very rigorous competition and innovative implementation of digital technologies which provides ground-breaking operational performance and achieves desired goals (I-scoop, 2016).

Although Nhamo (2022) indicated that we are currently experiencing stage three of the digital landscape, this study leverages it to investigate innovative ways digitalization is applied to achieve sustainable innovation (Polishchuk et al., 2022) in the food processing sector by evaluating the measurable effects of innovative usage of digital devices that achieve sustainable development in the food processing sector in Ghana (Annosi et al., 2020). As a result of the rapid population surge, firms must employ creativity and novelty to scale up food production to meet growing requests from customers who desire sustained product availability, and value for money (Ben Ayed et al., 2022).

1.2 Problem Statement

Digitalization is crucial for modern businesses to achieve innovative breakthroughs and sustain development in the Agri-food industry. This is done by sustaining agile productivity, and livelihood sustainability, improving comprehensive radical operational performance, and enabling seamless material, financial, and information flow across the value chain (Ben Ayed et al., 2022, Schelenz and Schopp, 2018). Various studies advocated efficient deployment of digitalization resulting in effective management of resource allocation and commitment to sustainability (Bökle et al., 2022).

The World Bank laid down initiatives to ensure that all African citizens, businesses, and governments are digitally equipped with appropriate “digital infrastructure, digital platform, digital financial services, digital entrepreneurship, and digital skills” by 2030. This initiative is geared to revolutionize public institutions and businesses (Tsan et al., 2019b), is also predicted that the global digital economy will hit 25% in ten years and a tenfold rise in the supply of new digital equipment across African region (Clemente Miranda et al., 2019). The African Union in partnership with the World Bank is preparing a digital platform for governments and Agri-food firms in Africa to be better equipped with digital literacy skills in addition to a robust digital infrastructure to minimize post-harvest food waste, boost good dieting, and improve business networking opportunities. This will prepare the platform for Africa's agricultural revolution in

the coming decades which has great potential to be fueled by Digitalization for Agriculture (D4Ag) (Tsan et al., 2019a). According to Clemente Miranda et al. (2019), the government indicated a very strong commitment to transform the economy to promote equitable and sustainable development by employing the Digital Economy for Africa (DE4A) with the cornerstones of "digital infrastructure, digital platform, digital financial services, and digital entrepreneurship". This commitment has been supported by the African Union and World Bank in their digitalization drive by positioning Ghana as one of the six African countries whose government has prepared an enabling foundation for quick D4Ag build-up (Tsan et al., 2019a). D4Ag is actively promoted by the government through smart farming initiatives to maintain agriculture which was approximately 19.25% of Ghana's GDP (GSS, 2019). Since the introduction of digitalization, businesses in Ghana have undergone rapid transmutation by redesigning their pattern of skill development, commercialization, operations management, and practices to meet new lifestyles (Clemente Miranda et al., 2019). Leveraging this opportunity, the government attempted to establish schemes that support D4Ag by launching several projects, including "Planting for Food and Jobs, an e-registration platform for farmers, and an electronic, agricultural input distribution system with barcodes". The profound influence of digitalization on key business operations transcends merely improving productivity and effectiveness. According to Porter and Heppelmann (2014), this trend provides innovative framework for sustainable development. However, despite the undeniable impact of digitalization, their implementation and dissemination seem to encounter several obstacles (Van Knippenberg et al., 2015). This necessitates an in-depth investigation of the possible effects that this transition can exert on the agri-food industry especially the food processing sector.

The study seeks to address a myriad of problems hovering around the food processing sector in Ghana which has a related negative impact on firms in this sector. Earlier studies highlighted that the activities from cultivation to food processing and finally commercialization together make up the Agri-food industry (Velde and Kretz, 2020). This industry is presently experiencing a range of problems ranging from lack of sufficient food availability from the farm gate, inadequate traceability in the supply chain, poor road network, food insecurity, low quality and safety concerns with regards to sustainability, the exacerbated impact of the coronavirus pandemic, inflation and the too much reliance on importation of food items afflicted by the Russian-Ukraine war led to huge gaps between demand and supply due to population surge (Ben Ayed et al., 2022). Another study indicated that the inability of the food

processing firms to thrive in the industry and achieve sustainable growth is due to the lack of digital entrepreneurship, very high rate of farm gate food losses, transportation issues, and insufficient capital requirements to increase their operational capabilities (Sutton and Kapenty, 2016).

The lack of relevant skills to use and employ emerging technologies to ensure quality and sustainable produce across the chains is a very big challenge to achieving the digitalization agenda. Since agriculture is considered a major drive to Ghana's economic growth, it is, therefore, important to promote the sector to achieve ripple effects through digitalization (Ampah et al., 2021). Notwithstanding the efforts to industrialize the sector and make it attractive globally, the productivity rate is still very low as indicated by WFP (Gustavsson et al., 2011).

The food processing sector is considered to have been the most significant segment of the Agri-food industry (Quartey and Darkwah, 2015). The problem is further compounded by the fact that local activities in this sector are flooded by very small-scale business owners particularly the female workforce who are largely unskilled in producing high-value products and some of the businesses are sole/family owned which employ traditional tools and also lack adequate knowledge in food processing (Owoo and Lambon-Quayefio, 2017). Also, firms within this segment continue to lag in terms of employing emerging technologies in their operations and making tangible contributions to the value chain. These firms have limited accessibility to both markets and financial services, primarily due to their small size and underdeveloped operational processes. Consequently, they frequently operate below their full capacity and rely on inefficient technologies (Ampah et al., 2021). This makes it difficult for the government to achieve the "Planting for Food and Jobs," "an e-registration platform for farmers", "an electronic, agricultural input distribution system with barcodes" and "One District One Factory (1D1F)" initiatives have failed to meet its objectives (Ali et al., 2021). There are still numerous problems highlighted such as acquiring farmlands, access to financial credits to support smart food processing (Agyapong, 2020), lack of seamless flow of information sharing between stakeholders with the use of emerging digital technologies, poor digital infrastructures, digital platforms plagued with cyber criminality, a remarkable shift in taste of fast food without corresponding demand to meet supply (Agyapong, 2021, Andam and Silver, 2016). In addition to the above, some recurrent issues regarding inadequate practices leveraging advanced technologies were raised within the Agri-food companies to sustain innovation (Annosi et al., 2020).

If these challenges are not sorted out, it will retard the digitalization drive to achieve sustainable development.

The earlier report holds that though it's yet premature to appraise the effect of digitalization, there exist enormous worries that warrant a critical assessment of awareness concerning innovative sustainable development in Agri-food value-added activities (SNV, 2020), particularly the food processing sector (Baurina et al., 2022). Considering the recent trend of very high food prices and inflation, it becomes difficult to invest in emerging technologies and achieve sustainability (Calderon et al., 2022); causing a relative drop in the percentage of logistics drivers (Emmanuel et al., 2022).

It was revealed in a previous study that since many findings have been made concerning the implementation of digitalization, scanty scholarly works have investigated the effect of digitalization drive to sustainable development (Bag et al., 2021) in the study context. This study makes a valuable contribution to the existing body of literature on the nexus of digitalization and sustainable development by providing the following insights: This study aims to examine the empirical association between digitization and sustainable development by utilizing digital literacy, digital infrastructure, and digital platform as a metric for measuring digitalization. It is worth noting that alternative dimensions have been employed in previous research (Annosi et al., 2020). Furthermore, this study examines the nexus at the firm level. However, other studies have undertaken similar analyses at different levels, such as country and regional (Jovanović et al., 2018). Our research holds significant importance as it examines the correlation between digitalization and sustainable development, hence influencing the actions of many stakeholders such as managers, professionals, and policymakers in response to these imperatives. This study postulates that OI indirectly affects the digitalization drive for sustainable development. OI has been underexplored in most food processing firms when employing digitalization. OI should be deployed differently by different firms because diverse factors affect its success thereby promoting the concept of a circular economy by focusing on efficient value creation through the "used' repaired, and reused" philosophy with less effect on the triple bottom line dimensions (Eunice Oppon et al., 2021).

The researcher believes these contributions and the outcome of this study will not only add value to existing knowledge in this area but also trigger a positive impact on practitioners' knowledge and application. Though some relative studies have been carried out on digitalization in agriculture in Ghana, very scanty quantitative studies have been conducted, but the impact of digitalization on sustainable development in the food processing sector in

Ghana is yet to be sufficiently researched thereby creating methodological, geographical, and empirical gaps.

Earlier studies suggested that since the concept and practice of digitalization are undoubtedly still developing (Bienhaus and Haddud, 2018, Garay-Rondero et al., 2020, Lorentz et al., 2021), Schallmo and Rusnjak (2021) indicated that it poses difficulty to measure its rate of implementation since there is constant improvement of technology with associated high expenses (Ionescu-Feleagă et al., 2023). Nevertheless, other studies suggested a critical evaluation of the developmental progress of the level of digitalization that particular members of a distribution network have implemented before determining their benefits (Schallmo and Rusnjak, 2021). For this reason, it is important to measure the impact that digitalization has on sustainable development over time, though different metrics have been developed to measure aspects related to sustainable development (Ionescu-Feleagă et al., 2023). Considering the importance of digitalization, we pursue to examine its measurable effects on sustainable development and the mediating role of open innovation in the food processing sector in Ghana.

1.3 Research objectives:

The main objective is to investigate the measurable effects of digitalization mediated by open innovation driving the food processing sector in Ghana to sustainable development.

The specific objectives are as follows:

1. To examine the impact of digitalization on sustainable development;
2. To evaluate the relationship between digital skills and sustainable development;
3. To examine the role played by digital platforms and digital infrastructure driving sustainable development;
4. To determine the mediating role of open innovation on the effect between digitalization and sustainable development in the food processing sector in Ghana.

1.4 Research Questions:

The research questions in achieving the objectives of the study are:

1. What is the impact of digitalization on sustainable development?
2. What is the relationship between digital skills and sustainable development?
3. What is the role played by digital platforms and digital infrastructure in driving sustainable development?
4. Does open innovation play a mediating role between digitalization and sustainable development in the food processing sector in Ghana?

1.5 Significance of the study:

The government of Ghana has invested enormously to address the intricate difficulties traditional farming, food availability, food safety, and post-harvest losses the Agri-food value chain is facing by implementing agricultural projects like "Planting for Food and Jobs," "an e-registration platform for farmers," and "an electronic, agricultural input distribution system with barcodes" (Banson, 2016). This study seeks to investigate the measure of innovation and sustainable development in the agricultural food processing sector through digitalization. However, it can build on the gabs with empirical support from (Annosi et al., 2020, Carmela Annosi et al., 2020, Raut et al., 2022, Sakhno et al., 2020) who have made valuable contributions to related hitches in the food processing sector. Digitalization offers innovative break-through as one of the vibrant triggers for global sustainable development, especially in the agricultural sector that helps to alleviate food scarcity and ensure safety through the production, storage, and transportation of farm and processed produce to the final consumers (Sakhno et al., 2020). The results and recommendations of this study are relevant for sustainable innovation in the Agri-food industry.

This study is designed to add value to existing research in the agricultural value chain by unraveling how digitalization drives innovative sustainable development in the food processing sector and its resulting implications in Ghana.

Since most players in this sector are yet to be advanced and are characterized by SMEs with very low investment capacity (Ampah et al., 2021). The government is interested in the outcome of this study to promote the economic and social development of the sector. Again, to develop a robust policy framework to support investment growth, improve digital skills, and enable infrastructural design (Annosi et al., 2020).

In addition, the entire stakeholders in the sector are encouraged to develop an interest in sustainable development in line with the United Nations Development Sustainable Goals (UN-SDGs).

1.6 Summary of methodology:

This study aims to achieve its objectives through the use of a survey design to obtain large data to gain a deeper understanding of the current innovative sustainability of the food processing sector in the Agri-food value chain in Ghana and generate unbiased findings that will represent the sample population. This led to a quantitative approach by employing questionnaires designed to collect data. Both descriptive and inferential statistical models are used to analyze

data collected through SPSS version 25, the hypothesis is tested, and the relationship between variables is operationalized to predict their outcome to ensure validity and reliability (Saunders et al., 2016). The population of this study consists of managers or heads of food processing organizations who are actively using various digitalization devices for their operations. Leaders in their various firms are carefully chosen because of their understanding of the operational performance of the business and their capacity to make decisions. The study adopted both primary and secondary data collection methods to answer the research questions.

1.7 Scope of the study

This study is designed to assess the effects of digitalization on sustainable development, mediated by open innovation in the Agri-food value chain in Ghana. Participants will be carefully chosen from key operators specifically in the food processing sector to represent the Agri-food value chain in Accra, Ghana. Theoretically, the study emphasizes digitalization, sustainable development, and innovation in the food processing sector in Accra-Ghana.

1.8 Limitation of the study:

The main objective is to investigate the measurable effects of digitalization on sustainable development mediated by open innovation in the Agri-food processing sector in Ghana. Some of the limitations experienced so far have been:

Accessing relevant literature related to the study variables. According to the relevant literature, this study has not been sufficiently investigated in context.

Data collection was a major challenge the researcher encountered. Some food processing firms especially the foreign-owned fast-food restaurants were unwilling to participate in the data collection for reasons best known to them, other local ones detected my accent and were scared that not being a Ghanaian might be a scam and gave repeated appointments.

Again, meeting up with the supervisor's milestone has been very challenging. The researcher's laptop crashed just when chapter one of the study was about to be completed. Since then, it has been very challenging to work effectively during vacation without a laptop.

Further, the temporary demonstration by the University Teacher's Association during the second semester of year one also affected this study because of the inability to get access to a desktop from the University library until it was uplifted. Again, challenges using Endnote software for referencing from the University library since it was not installed on it and students are not allowed to install any software on the desktop.

1.9 Organization of the study:

This study will be organized into five chapters.

Chapter one consists of the background, problem statement, objectives of the study, research questions, significance of the study, limitations of the study, scope of the study, and organization of the study.

Chapter two consists of the literature review based on the constructs of the study and other related concepts in line with the specific objectives of the study.

Chapter three consists of the methodology of the study. That is the survey research design and the different strategies that will be employed in conducting the research.

Chapter four will consist of analyzing data from the field using SPSS version 25, a presentation, and a discussion of findings.

Chapter five will consist summary of research findings, conclusions, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents reviews of related literature in two sections. The first section reviews literature related to the concepts of sustainable development as a dependent variable and digitalization as an independent variable, it explores a different facet of the variables and their relevance to the food processing sector in Ghana. Open Innovation is also reviewed as a mediating variable indirectly linking both the independent and dependent variables. The second section reviews the theoretical foundation of the study, empirical studies, and hypothesis development under investigation. All the relevant literature reviewed is subject to achieving the study objective.

2.2 Sustainable Development Concept:

The negative impact of societal actions on the surroundings is something that humanity is still struggling to grasp being unconscious of what those activities have on one another. People are facing both environmental harm and societal issues as a result of their failure to identify and comprehend the connections between them, their beliefs, and their surroundings. Authoritative sources reported that the earth's natural resources are currently being used at a fast pace causing the misuse of resources not to be sustainable (Fergus and Rowney, 2005). For instance, an estimated 25% of global mammalian species are in danger of being extinct at the expense of the earth's ecosystem, as well as rapidly eradicating the traditional vernaculars. Meaning, we are not cognizant of the logical repercussions of our acts (Fergus and Rowney, 2005).

The most renowned Brundtland Commission provided a universal definition stating that "Sustainable development (SD) is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Jovanović et al., 2018). The idea of sustainable development has recently gained popularity in an attempt to address ecological threats brought about by growth in the economy. Sustainable development has many diverse perceptions, though the main objective is to drive the process of economic expansion without causing environmental damage in society (Banerjee, 2003). It is arguably not certain whether economic growth, biodiversity, or both is being sustained. However, several researchers contend that the synchronization between economic growth and the ecosystem is only metaphorical to ignore real ecological threats (Banerjee, 2003). Humanity's activities have had a negative impact putting the safety of the planet and succeeding generations in jeopardy. This has led to the recommendation of some interventions to maintain the standard of logical

and judicious use of all resources to reduce the ecological impact (Larbie, 2019). A brief history will give a broader understanding of this concept and its relevance to this study.

2.2.1 Brief History of Sustainable Development:

Safeguarding global “peace, freedom, development and environment” has been a source of contention over decades from practitioners, the "Brundtland Commission" sought ways to reconcile growth and the ecosystem to make the above-mentioned concerns sustainable which resulted in the adoption of sustainable development at the 2002 South Africa international conference (Robert et al., 2005). This notion is now core to many global public and private establishments to ensure valuable continuity (Robert et al., 2005). According to Tuazon et al., (2013), the necessity of conserving resources was known as early in the 1800s, the basis of the ideas of sustainable development can be traced to the first international initiatives geared towards balancing economic growth with ecological concerns, which were initially launched through the UN Conference on the Human Environment in 1972 (UN, 1972), giving rise to the Stockholm Declaration and the United Nations Environment Program (Strezov et al., 2017). The first attempt to predict the effects of economic development on resource depletion, soil, and water quality was mentioned (Meadows et al. 1972), and it is now recognized as one of the essential criteria for sustainable development. In 1980, the International Union for Conservation of Nature and Natural Resources coined the phrase "sustainable development." One of the report's key recommendations was that while pursuing growth at the expense of the environment, people must comply with the fact that resources are limited and so must not be depleted for future needs (Strezov et al., 2017).

Though protecting the ecosystem was considered important, farm productivity was equally a source of concern (Larbie, 2019) for development. All of these efforts were geared to combat the myriad of socio-economic and environmental issues to safeguard the human race and planet from extinction (Ranchber, 2018).

2.2.2 Significance of Sustainable Development:

Extant literature suggested that stakeholders in the development sectors may adopt the most reliable strategies by operationalizing and taking more concrete actions to integrate the triple-bottom-line components by assisting societies in tackling the problems and enhancing both humanity and its ecological welfare (Banson et al., 2015). In reality, the socio-economic and environmental indicators are used to measure if a country or business is performing well to achieve the necessary development, and changes are all parts of the complete developmental

approach (Soubbotina and Sheram, 2000). These indicators can be viewed from both qualitative and quantitative perspectives to make them sustainable (Halisçelik and Soytas, 2019). Qualitatively, countries and practitioners take pride in investing and improving the holistic lives or social conditions of people over time using the "Human Development Index" as a barometer to measure meaningful economic and social lives (Halisçelik and Soytas, 2019). The other perspective is the quantitative approach by measuring the economic growth of a country using the Gross Domestic Product (GDP) or Index (Halisçelik and Soytas, 2019). According to the Human Development Report 1996, "human development is the end—economic growth a means". The most widely acceptable approach to sustainable development is the resolution of the Brundtland Commission to reconcile the "environment and development" as a starting point to understand the meaning and importance of the concept of sustainable development (Robert et al., 2005). Thus, due to its usage and reference, sustainable development has been globally defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Larbie, 2019). This implies that the development of humanity is not solely achieved on its own but on the foundation of the ecosystem indicating a positive association between development and the environment regarding future generations (Robert et al., 2005). Therefore, adopting the concept of sustainable development is a very important process to integrate with innovation as a means to creatively achieve growth, operational performance, competitive edge, and meeting stakeholders' expectations (Ashford and Hall, 2011). From the definition, it is important to note "what is to be sustained" for its worth and "who is to be sustained" with emphasis on growth in "people, economy and society" (Robert et al., 2005).

Whichever method is used, the main motives for both public and private institutions are geared toward achieving sustainable development.

2.2.3 Sustainable Development Goals:

Apart from the standard definition of sustainable development by the Brundtland Commission as earlier stated, it is also perceived by the attributes it aims to evaluate and accomplish within a certain time frame; more importantly is "what is to be sustained, what is to be developed and for how long" (Robert et al., 2005). Sustainable development has many other diverse perceptions and raised serious debates among stakeholders until it almost lost its meaning and is considered paradoxical (Robert et al., 2005). Even though the main objective of sustainability is to drive the process of economic expansion without causing environmental damage in society, it is arguably not certain whether it's economic growth or biodiversity, or whether the

two are being sustained. However, several researchers contend that the synchronization between economic growth and the ecosystem is only metaphorical to ignore the real ecological threats (Banerjee, 2003). Even though sustainable development has been adopted as a concept by modern economies and businesses to trigger operational performance and growth (Saxena et al., 2021), it is very challenging for countries and businesses to achieve the complexity of their qualitative and quantitative targets (Halisçelik and Soytas, 2019) due to the inability to implement digitalization appropriately (Bag et al., 2021). For example, the concept of sustainability gained popularity recently only in an attempt to address ecological threats brought on by a conscious attempt to improve development in the economy, though it has been established that out of the diverse meanings, it refers to a process of economic expansion without harming the environment (Banerjee, 2003). Another complexity is that not every economic development is translated to national achievement except the well-being of communities and people have even allocation of wealth (Halisçelik and Soytas, 2019).

These debates led members of the United Nations to narrow the complexities and adopt specific goals doped UN Millennium Development Goals (MDGs) which targeted “peace and prosperity for the people and planet” and further integrating development practitioners to achieve a “global partnership” by 2015; which was broadened to the UN Sustainable Development Goals (SDGs) to be achieved by 2030 (Griggs, 2013) charging each nation to effectively participate to achieve these goals in their respective countries (Bag et al., 2021). The UN identified sustainable development as one of its key global objectives emanating from the MDGs in 2015, with anticipated completion by 2030 (Imran et al., 2022). SDGs 9 (industry, innovation, and infrastructure) and 12 (Responsible consumption and production) will guide this study.

2.2.4 Dimensions of Sustainable Development:

According to the UN (1992) report, the United Nations Conference on Environment and Development in Rio de Janeiro (1992), also known as Agenda 21, made a clarion call to develop "systems for monitoring and evaluating progress towards achieving sustainable development by adopting indicators that measure changes across economic, social, and environmental dimensions," (Strezov et al., 2017). Nevertheless, the author stressed that other concerned stakeholders are at odds about which barometer is the most reliable. More dimensions than the triple bottom line indicators of sustainable development were thoroughly reviewed and compared with that posited by Wilson et al. (2007), they concluded that there is

a “lack of a clear direction at the global level on how to approach sustainable development” (Strezov et al., 2017). This position was confirmed by the interest of experts and incorporating their perceptions appeared to be very crucial; though still asserted that there is currently a majority of publications that cover the planet, people, and profit topics (Pawłowski, 2008). Again, a recent study argued that, though not very much deviated from the previous position the significance of achieving a balance between economic growth and environmental conservation is emphasized in sustainability, in addition to the importance of economic growth (Cao et al., 2019). Studies confirmed the views by Pawlowski (2008) that other elements are implicated in sustainability and a number of scholars have attempted with varying degrees of complexity to get to a consensus of interpretation of these concepts.

These intricacies led to the adoption of sustainable innovation which is frequently used to explain the interaction between the socio-economic and environmental sustainability components (Nuertey, 2015). McKenzie (2004) claims that the first model, often known as the “three-nested-dependencies”, consists of three overlapping circles that explain the premise that the people and profit components are reliant upon the productivity of the planet. Therefore, the level of economic progress is determined by the quality of living (Willard, 2010). For instance, a company might anticipate higher performance and improved profitability if it implements decent personal financial rewards and job satisfaction for its employees (Nuertey, 2015b). However, the school of thought of this paradigm expressed worry that depression's effects on the well-being of individuals were more profound at the time than they might have been. This suggests that a firm's ability to succeed economically is crucial to its development (Nuertey, 2015b). The integration of economic, environmental, and social variables is depicted in the second model, known as the overlapping or triple bottom line model. Should one of the elements is not strong enough, then the ecosystem in its entirety cannot be sustained (Nuertey, 2015 p.33). This idea is conceptualized by Carter and Rogers (2008) to create a strategy that predicts a win-win scenario while balancing limitless expectations and a controlled resource base. One may therefore infer from the overlapping model that some of the activities conducted on every component aren't always optimum or operate beyond the purview of realizing a minimum sustainable level (Nuertey, 2015b). It has however been concluded, that the majority of studies believed that development should be balanced in terms of its effects on the triple bottom line of sustainable development dimensions (Cao et al., 2019).

2.2.5 Economic Dimension:

The concept of sustainability gained popularity recently only in an attempt to firmly regulate threats to nature conservation as a result of pursuing expansion in the economy, though it is established that out of the diverse meanings of sustainability, it refers to a process of economic expansion without destroying the environment (Banerjee, 2003). This dimension is measured by the pursuit of revenue generation that results from the efficient mobilization of wealth (Tahon et al., 2017). It refers to the value chain's members' total revenues, in addition to the financial gains made by firms and nations; everything to do with the efficient utilization of resources, seamless productive operational performance, adoption of suitable digitalization and industry attractiveness, as well as its commitments to social development (Nuertey, 2015b). The author further explains that, when it comes to this dimension, sustainable development refers to ensuring future prosperity. But Harris (2000) made it much clearer that, a good operational strategy must have the ability to manufacture products and services uninterruptedly, sustain an acceptable level of public and liability outside the firm, and prevent excessive discrepancies that could cause impairment to the manufacturing line. It is acknowledged by earlier studies that, sustaining this dimension takes into consideration all operations that aim to increase revenue, enhance competition for the future, generate employment, boost sales, lower costs, and perform each activity concurrently (Ho and Choi, 2012).

2.2.6 Social Dimension:

Belief systems, cultural environment, spiritual practices, social interactions, and welfare issues are only a few of the many elements that make up the environment in question. Since all ecologic activities are implicated by the socio-cultural paradigms that are employed in a given community, even human relationships with nature have a social component (Pawłowski, 2008). Earlier studies established that relevant aspects like alleviating poverty, support programs, and the promotion of healthy and safe societies are included in the concept of social sustainability (Torjman, 2000). Mahler (2007) supported the views of Torjman (2000) and maintained that a firm's operations process and adoption of a suitable corporate social responsibility are all meant to boost this sustainability dimension. Although some findings buttress previous works that implement and sustain appropriate organizational cultures that are relevant to enhance the social responsibility of stakeholders within and without the firm (Nuertey, 2015b). It has been debated that this element ought to be viewed as not a one-time event for achieving an effective and sustained welfare program for the community and employees, even though the other two

elements are extensively acknowledged by practitioners when working on a project in the construction industry (Nasirzadeh et al., 2020).

2.2.7 Environmental Dimension:

There was a major shift in how policymakers and practitioners perceived the environment and growth in the 80s. Both notions are not seen as being incompatible since it is widely understood that sustainable development and a thriving economy depend more on the environmental dimension. Additionally, economic analysts are starting to understand that economic development that depletes the rich earth's resources frequently fails (Pezzey, 1992). This dimension entails decision-making and actions in ways that safeguard the environment, with a focus on conserving the nature of the environment's capacity to support humanity. This position was affirmed by an earlier study which suggested that if relevant growth initiatives fail to sufficiently consider the importance of forests, soils, grasslands, and sustainability, and to effectively communicate how policy decisions affect freshwater, coastal areas, and fisheries may harm the resource base that underpins tomorrow's development (Pezzey p.iii). Firms must consider their long-term effects on the planet in addition to relative profits in the short run to be environmentally sustainable (Miemczyk et. al. 2012). Nonetheless, is therefore important to keep up the elements and activities that over time improve the environment's richness. According to Kaufmann and Carter (2010), environmental sustainability focuses on the importance of "atmosphere, water, food, soil, minerals, materials, and energy resources" without which neither manufacturing process could subsist nor could people survive (Nuertey, 2015 p.33). This position has been supported in the light of urban development by examining the evidence demonstrating how gas, liquid, and disposal challenges vary based on the median earnings of urban centers and how wealthy urban areas make a substantial contribution to pollution and generate waste that has been accumulated, for whom the impacts lie quite extensively and significantly likely to influence tomorrow's generations (The Environmental Dimensions of Sustainable Development for Cities).

2.3 The Mediating Role of Open Innovation:

The term "digitalization" refers to the implementation of a strategic plan by employing advanced technology, which opens up new avenues for a company's sustainable performance. It has been confirmed in literature to be the practice of web-based operation by an organization. It was postulated that whatever shipping technique is adopted that improves the customer base and makes use of competencies that can be exploited to provide a smarter customer experience

and a continuous competitive advantage is a way of value creation for the business (Arnold et al., 2016). Invariably, adopting open innovation in a business model is emerging with creative and improved approaches to satisfying customers' needs while simultaneously reaping more profits for the company. These developments may cause businesses to work collaboratively in innovative ways with their stakeholders (Arnold et al., 2016). In contemporary debate, innovation is often seen as a pivotal factor in effectively tackling and resolving issues related to society and the environment (Du et al., 2022).

The definition of the concept of open innovation was initially posited "as a paradigm that assumes firms can and should use external and internal ideas as well as paths to market if they aim to advance their technology" (Chesbrough, 2003), was expanded to include diverse strategies to disseminate the transfer of skills and competences across the limits of companies (Chesbrough and Bogers, 2014). Open innovation is believed to offer the best technique to support the operations of businesses for the appropriate development and usage of skills and competencies (Mubarak and Petraite, 2020). According to Trap (2014, p.1), "open innovation as a model enables businesses to build a structured innovation ecosystem that uses networks of external partners and focuses on developing core internal competencies." That is, it can be seen as a transfer of skills between companies which enables a company to survive in business and acquire new competencies (Lichtenthaler and Lichtenthaler, 2009). Earlier studies indicated that open innovation has been explored in several scholarly works (Feng et al., 2020, Franke and Piller, 2004, Sawhney and Prandelli, 2001, West and Gallagher, 2006). However, the advent of digitalization has brought more attention to open innovation. Instead of closed innovation, it creates value for enterprises through open collaboration, cooperation, and competition (Chesbrough, 2020, Trott and Hartmann, 2009). Although open innovation is being appraised to trigger performance between digitalization and sustainable development, it has not been exploited as a mediator in research (Pundziene et al., 2022) in this context.

While the application of digital technologies emphasizes how effectively digitized data is being streamlined and offers optimal operational performance for the firm, open innovation offers novelty in achieving long-term results (Fortunato et al., 2017). Thus, the core components of an open innovation strategy encompass both from within and outward-in techniques for innovation (Natalicchio et al., 2014), employing various processes aligned alongside the company's operational structure to expedite innovative thinking within and enhance the company's competitive edge (Chesbrough and Bogers, 2014). The key concept of open innovation is to assist in making creativity accessible from stakeholders outside the business to

support the seamless transfer of skills both within and outside of the company (Simeone et al., 2020).

According to Pundziene et al. (2022), in-bound and out-bound (Chesbrough and Bogers, 2014) as well as coupled (Enkel et al., 2009) are seen as types of open innovation.

The concept of an in-bound open innovation approach can be described as a strategic approach aimed at augmenting the company's current skill base by incorporating necessary expertise obtained from external sources (Pundziene et al., 2022), this position was challenged by arguing that developing skills within an organization mostly due to disruptive effects caused by advancements in technology and the dynamic nature of the business environment (Chesbrough and Bogers, 2014). Hence, it has been proposed that companies should consider using an inbound open innovation approach, wherein they actively seek to acquire expertise from sources outside the organization's limits (Ardito et al., 2020). Earlier findings associated the outbound innovation approach with businesses that aim to capitalize on outward stakeholders' application of the company's in-house expertise. This approach serves to supplement the company's operational growth (Elia et al., 2020). Coupled open innovation technic comprises a reciprocal flow of expertise that combines both in-bound and out-bound approaches through ongoing engagement. The process of open innovation, which encompasses knowledge management, has experienced a growing trend of being dispersed beyond the limits of the organization. However, the fundamental objective of open innovation remains consistent: to expedite creativity and enhance the competitive edge of the business (Garavelli et al., 2013). The traditional school of thought in business study holds that a company creates value along its production system and co-creation emanates from the perspective of the customer as a distinctive value only when innovation is consciously deployed across the value chain (Chen, 2020). Extant literature suggests that when firms implement resource integration in their business practices, they indirectly incorporate some aspects of open innovation (Aquilani et al., 2020). The concept of open innovation assumes that a business always possesses the capital requirements to achieve innovation. Therefore, collaborating with members both within and without the industry is a source of improving the value chain and winning competitive advantage (Aquilani et al., 2020). It has been reported that innovation negates the effect of social and environmentally sustainable dimensions (Bocken et al., 2014, p.44).

In the recent competitive environment, in which the boundaries between industries have become unclear and the business paradigm is changing rapidly, the capability of a single firm alone is not sufficient to follow the social changes caused by digitalization (Kapoor and

Agarwal, 2017). As a result, most scholarly works revealed that digitalization has a significant effect on sustainable development mediated by open innovation.

2.4 Digitalization Concept:

Information and Communication Technology (ICT), and other emergent technologies with their complementary elements such as the computer, hardware, software, and the internet constitute digital technology. Its main aim is to synchronize the processing of stored data and retrieval of information for consumption or effective decision-making (Nhamo, 2022). The timely and efficient distribution of goods and services across the Agri-food value chain can be made possible by the strategic and effective use of digital technology in conjunction with a reform-oriented mindset, the requisite core competencies, organizational frameworks, infrastructure, appropriate business systems, as well as legislative and regulatory settings (ADB, 2021).

The paradigm shifts of the technological advancement that took place in the last three decades served as a springboard for modern businesses today to leverage. This is heavily reliant on proficiency in technology which is increasingly important to bring about a significant transformation in the economy and society (Schwab, 2016). Digitalization is currently an emerging global concept in every walk of life that is creating value for customers and facilitating value co-creation with a tremendous impact on agricultural growth by increasing agricultural productivity and profitability (Sozaeva et al., 2021). Conferring to Parviainen, et al. (2017) "digitalization" is defined as "the action or process of digitizing; the conversion of analog data (especially in later converting photos, video, and text) into digital form." (Sausen, 2020 p.4). For simple understanding, digitalization is the incorporation of innovative emerging technologies into routine activities across the workplace, corporate, and other societal areas with much emphasis on the specific impact of digitization on a firm's value chain (Sausen, 2020). Better still, a company's capability to leverage its advanced technologies for operational performance (Lee et al., 2019).

It is argued that digitalization has a substantial influence on operations that are very critical to the business which extends further than just boosting productivity and resourcefulness. It establishes new foundations for societal and economic sustainability (Porter and Heppelmann, 2014). In other to ensure innovative growth in the firm's capacity, job satisfaction, optimum use of strategic resources, and competitive advantage, vigorous approaches must be adopted through the implementation of emerging digital agriculture that will go beyond just traditional

food availability to sustain development across the Agri-food value chain (Kuzmich, 2021). The implementation of Industry 4.0 is motivating businesses to redesign their strategic capabilities as a result of the use of the "Internet of Things (IoT), information and communication technologies (ICT), and other digital technologies" to enhance food cultivation, minimize post-harvest waste, streamline food processing improve information sharing across the value chain and become more competitive (Annosi et al., 2020). More to the above benefits, firms will enjoy enhanced creativity and good working conditions for their workers who are responsible for meeting customer's expectations, and processing data and information for them to win a competitive edge in the industry (Nöhammer and Stichlberger, 2019). These firms also need to improve their current resources and cultivate ways to transform existing know-how into professionalism. Although the influence of Industry 4.0 is indisputable, several reasons seem to be impeding their adoption and proliferation (Van Knippenberg et al., 2015). This is because it is important for identifying and resolving challenges and working to improve people's lives. It is now extremely important for firms to monitor both the broad and local trends of emerging digital technologies. Transitioning beyond classical to digital business models to increase economic viability represents a remarkable change in contemporary investments. One of the main drivers of today's development is digitalization (Jovanović et al., 2018). Although studies have suggested that there is a sporadic improvement in technologies, couple with the fact that it entails very huge capital, firms must always rely on it to sustain their strategic position in the industry, diversify and strengthen their system of operational (Bahn et al., 2021).

Digital innovation has been anticipated to make a substantial contribution to the Agri-food industry's ability to address some current issues, including capacity utilization and meeting growing food anticipated demand without interruption (Annosi et al., 2020). Notwithstanding the exorbitant expenses of deploying digitalization, it is, therefore, necessary to examine how advancements affect sustainability (Jovanović et al., 2018).

The initial age of machines saw an enormous advancement including the invention of the steam rail steal during the 18th centennial by continuously improving and leveraging new technologies on the previous ones (Schwab, 2016). The subsequent era sparked the discovery of electrical energy and large-scale manufacturing; the industrialization in the early 1900s experienced the introduction of electronics connected to the World Wide Web (WWW) also referred to as the technological age. Industry 4.0 is currently being driven by "artificial intelligence, machine learning, and the Internet of things," leveraging on the preceding technological age (Jovanović et al., 2018 p.907). Previous studies postulated and provided a

vivid explanation of “Schumpeter's waves of innovation” by arguing that the pattern of emerging technological advancement is unequally swift (Levi Jakšić et al., 2018a). The global environment is presently experiencing the fifth trend of technological evolution wherein there exists very rigorous competition and innovative implementation of digital technologies with an emphasis on telecommunication which provides ground-breaking operational performance and achieving desired goals (I-scoop, 2016).

2.4.1 Digitalization Transformation Period:

Digitalization has been described as one of the key factors orchestrating the holistic development of sustainable innovation. It has been found that promoting employment, bridging wealth inequality, fostering social inclusion, and easing the seamless flow of products and services both upstream and downstream of the supply chain among others have been identified as some of the features of digital innovations to advance the African Union’s Agenda 2063 and the Sustainable Development Goals (AU, 2020).

The trend of the digital transformation era is categorized into different periods ranging from Digitization, Digitalization, and Digital transformation (Jovanović et al., 2018). The notion of "digitization" and "digitalization" has become very controversial as the debate on digital transformation persists. In a real sense, these three words have different meanings, or at the very least, we might interpret them differently depending on which authority we follow (Bloomberg, 2018).

Other schools of thought have linked these three categories with emerging information and communication technologies that are necessary to re-engineer the operational performance of firms (Gobble, 2018; Verhoef et al., 2019).

Switching from classical to emerging technology is one of the most unprecedented transitions for modern businesses to leverage these three phases as illustrated in the “fifth wave of innovation” to trigger an increase in market attractiveness (Jovanović et al., 2018 p.908).

The first phase is digitization, which refers to transcribing from manual using physical representation into an encrypted computerized version in the form of bytes for easy storage, processing, and dissemination by the computer when needed (Bloomberg, 2018; Jovanović et al., 2018).

The second phase is digitalization, which refers to the use of emerging digital technologies to alter the system of operations to make them more efficient and valuable to generate income,

and enhance company and value-producing potentials (Rachinger et al., 2019; Verhoef et al., 2019). In a variety of literary works, the concepts of "digitalization" and "digitization" are tightly connected frequently used, and considered synonymous. We describe digitalization as the remodeling of several spheres of human activity around digital communication and media infrastructures (Bloomberg, 2018). Another school of thought focused on the definition of digitalization of links between people online. Though the modern world is becoming more digitized as communication shifts from analog platforms. For example, from postal mail service, and manual phone calls to email and chats via social media. Again, another study defines "digitalization refers to the application of computer media to transform a business strategy and exploit new cash and real worth opportunities." (Gartner, 2020). However, it seems Garner is divided on his early definition of digitalization based on social connection, other sources indicated that suggested another definition for digitalization to mean “the process of transforming business operations through the use of digital technologies and information” (Muro, 2023).

Digital transformation is quite different from digitalization and refers to the application of digital technologies to all functional areas of the organization (Jovanović et al., 2018); though other studies reported that it incorporates the other two notions (Verhoef et al., 2019; Vial, 2019). Digital transformation entails a system-wide implementation across the board that may require much development on digitalization (Bloomberg, 2018).

Concluding from the above trends of digital transformation, it is suggested that “we digitize information, we digitalize processes, and roles that make up the operations of the business, and we digitally transform the business and its strategy.” (Bloomberg, 2018).

2.4.2 Digital Divide and Readiness:

The disparity between those with and without steady online connection including digital gadgets and individuals who have intermittent or no connectivity at all is known as the "digital divide." (ADB, 2021). Another research suggested that the digital divide is extending to the availability of computer equipment, programs, and cellular phones (Van Dijk, 2017). Earlier scholars simplified it as a separation between literateness and abilities (Radovanović et al., 2015; van Dijk, 2005; Warschauer, 2002)). Though the digital divide has been a debatable topic among researchers, these complications can be characterized by two key factors: access to a fast internet connection and trusted technological gadgets (Nhamo, 2022). However, another study emphasizes physical accessibility and digital literacy skills (Van Dijk, 2017). Other studies discovered that at the peripheries, there was a weak association between remoteness

and higher bandwidth illustrating the difficulties faced by rural communities (Lai and Widmar, 2021). Policymakers have critical roles to play in providing robust digital infrastructure and being resourceful enough to improve the digital readiness of their people at different socioeconomic levels. Identifying best practices for readiness training and mentorship, the government can also offer training materials and curricula because of the importance of cyberspace to bridge the gap of sustaining growth individually and collectively (Radovanović et al., 2020).

The degree to which a firm or government is prepared to make a conscious shift to improve business operations through the availability of emerging technologies is known as "digital readiness." Reengineering high-tech goes beyond a huge deployment of capital in Information and Communication Technologies but also involves “culture, procedure, and technology” (Ogbevoen, 2023).

2.4.3 The Landscape:

Studies report that there exist three progressive segments of the digital landscape (Nhamo, 2022). The respective deployment of these progressive segments to enhance sustainable innovation in the Agri-food in Ghana is discussed below with an illustrative diagram.

2.4.3.1 Stage One:

Segment one of the digitization landscape includes “mobile phone networks, satellite imagery, the internet, and Geographic Information Systems (GIS)” (Nhamo, 2022). Technological innovations as such have stood the test of time for a while, giving consumers access to fundamental knowledge, data dissemination, and search functions. These innovations have already achieved prominence in the business world and have completely been incorporated into modern business and individual lives. To some extent, the creation and broad commercial use of these innovations have opened the foundations for the growth of digital technologies in the following two stages (ADB, 2021).

2.4.3.2 The internet:

The Internet comprises technological gadgets and network connection that spans the entire world. These gadgets transmit data and information within each other for effective decision-making that affects businesses or individual lives (ADB, 2021). The UN sustainable development goal guidelines declare “access to the Internet as a basic human right and fundamental for achieving the SDGs” (Radovanović et al., 2020). One of its objectives is to disseminate of share real-time information and network to exploit opportunities (Greenwood et al., 2016). Despite not technically being a new technology, the Internet is the key enabling

technology of the Digital Age. Although it gained remarkable and speedy global recognition in the 1990s after being deregulated and liberated by the government of the United States of America's tight control (Castells, 2014). The data input, storage, and dissemination of digital material in all versions are all made possible by the Internet. According to statistics, 95% of all information on the planet is in electronic versions, and the majority of it is available across computer networks like the Internet (Hilbert and López 2011). Though it's digital transmission has rapidly and profoundly transformed the network environment and also led to complexities in the global internet space (Castells, 2014). Users can access webpages and instant messaging services by linking a compatible digital gadget to the internet. People can connect to the internet via browsers, which also perform a web search to check relevant material or web pages (Nhamo, 2022). A recent survey reveals that only around 63% of people globally have internet access, which means advanced countries have a much larger percentage of internet consumers than emerging economies do. This indicates that just 63% of the population has a connection to the digital economy and can make use of online tools (Nhamo, 2022).

2.4.3.3 Mobile phones and Databases:

Thanks to mobile phones, their users can communicate with one another via short messaging services (SMS) and telephone conversations. Mobile phones are simple to use, offer extended battery lifespan, and are not very expensive for an average user (Nhamo, 2022). They can access the internet even if they continue to use pushbuttons rather than smartphones which is a more sophisticated mobile phone with extended features (ADB, 2021). The "smartphone" also called a cellphone or cellular phone is a new category of mobile phones that offers a range of interoperability such as teleconferencing, messages, managing personal data, and applications potential to facilitate business transactions and improve social networks (Nath and Mukherjee, 2015). Coupled with the growing migration to cell phones for daily online activity, the classical keypad mobile phone will eventually become outdated. Cell phones are innovative, handy, and mostly available (Budiu, 2015). The operating speed of today's cell phones is more than that of personal computers, enabling users to complete almost any task with ease (Kalia et al., 2022). According to consumers, cell phones (54.98%) have a much larger market share than desktops (42.54%) and tablets (2.47%) (Statcounter.com, 2022). In the same light, Broadbandsearch.net (2022) reported that 80% of cellphone owners engage in the internet community for surfing, and this number is considerably greater for some handles, such as Facebook at 95.1%, Twitter got 86%, and 60% for LinkedIn (Kalia et al., 2022). 72.9% was also reported to be attributable to mobile phone usage for global online marketing revenue (Statista.com, 2022a). It is clear

from the above statistics that cell phones are developing into multipurpose digital gadgets that allow owners to carry out a variety of tasks (Kalia et al., 2022).

It is a broad compilation of online documents that serve as a repository per classification for achieving, retrieval, and information dissemination when needed (ADB, 2021). It is very important to the business and government in terms of backup for a seamless flow of information and effective information sharing, it helps in the protection and retrieval of information when needed (Nhamo, 2022).

2.4.3.4 Stage Two:

"Social media, Applications, and Cloud computing" are all models for the second phase of emerging online technologies which is characterized by speedy virtual information and document sharing (Nhamo, 2022). Businesses operating virtually should become fascinated by the transformative innovation that the internet community represents though the concept behind phase two of emerging technologies is not novel (Kaplan and Haenlein, 2010).

2.4.3.5 Social Media, Applications, and Cloud Computing:

Social media serves as a means for bloggers on media channels to post, disseminate, and share ideas and knowledge via web-based networks. It is currently a critical and essential component of an innovative digital culture in recent times. DataReportal, (2022) reports that billions of online operators are very busy on the World Wide Web for various reasons. Electronic media can further help in many different ways to address issues of socio-economic and environmental concerns. For example, Firms can market their products and in addition, make use of online data for future purposes; on the other hand, consumers are now more able to critique ethical issues and the performance of firms (Nhamo, 2022).

Applications or simple Apps are operating systems that give operators the ability to undertake certain activities on the computer or mobile device (ADB, 2021). Apps meant for "desktops" and "laptops" are referred to as desktop apps, whilst those for mobile devices are known as "mobile Apps". Mobile apps, in particular, are useful across a wide range of subjects and give up-to-date information depending on the user's search (GCFGlobal, 2020). Apps can support business operations and desirable results in addition to making contributions to sustainable development.

Cloud computing is a program accessible through the World Wide Web and serves firms to gain server space and maintain accurate datasets. This digital system provides convenience and an opportunity to retrieve stored and disseminated information among stakeholders. It has been

reported that “cloud computing” is necessary for an inventive economic system because it enhances data performance (Nhamo, 2022).

2.4.3.6 Stage Three:

Level three advanced digital innovation targets to enhance cognitive beings using “artificial intelligence” (AI) and “robotics” for physical activities (ADB, 2021). “Artificial intelligence, machine learning, the internet of things, intelligent systems, blockchain, big data, predictive analytics, robotics, and unmanned vehicles” constitute elements of phase three of digital innovation (Nhamo, 2022). These technological innovations have shown the ability to substantially speed up activities to bring about timely solutions to business operations and social life. It is anticipated that they will soon achieve remarkable economic progress.

2.4.3.7 Artificial Intelligence (IA) and Big Data:

Artificial intelligence (AI), is an operating system that executes transactions with the use of technology to simulate people’s intelligent performance with little or no human interference. Scholars believe that AI triggers the development of robots (Hamet and Tremblay, 2017). Additionally, phase three emerging technologies developed more easily thanks to AI. For instance, statistical inputs that are captured through the Internet of Things are analyzed using AI (Nhamo, 2022).

Today, artificial intelligence (AI) is regarded as an area of technological engineering that employs innovative ideas and creative strategies to tackle difficult problems. Computers might someday be equally smart as people if innovations in technological velocity, performance, and systems coding are made in the future (Hamet and Tremblay, 2017).

Big data is referred to as “high-volume, high-velocity, and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision-making.” (Garner, 2023). For simple understanding, it addresses the quantum of datasets, the multiplicity of databases, and the speed at which data is generated, stored, and disseminated (Einav and Levin, 2014). Previous research introduces "the three 'V's" to differentiate Big Data from normal data (Eaton et al., 2012). Even though these new terms may be used for all sorts of data and do not specifically refer to the relative measurements of big data, their application has stirred up some debate. Policymakers may conduct more accurate analyses of citizen preferences thanks to big data (Pencheva et al., 2020).

2.4.3.8 Internet of Things (IoT) and Blockchain:

Although the Internet of Things is challenging to define because of its mutation since its invention, scholars have attempted to narrow a better notion to define it as an innovative computer system that is equipped with a distinctive identity with the capability to transmit very fast and timely information with little or no human effort globally (Kuzlu et al., 2021). "The edge, the platform, and the user" are three elements that constitute the Internet of Things (ADB, 2021). The "edge" is the point at which data is generated. The "platform", which is hosted by the cloud receives the data, and then computer programs are used to do data mining. Analyzed data are transferred from the Internet of Things platform to the user for information sharing or decision-making (Nhamo, 2022). In terms of device connectivity, the IoT idea has offered the world a greater degree of connectivity, reliability, affordability, adaptability, privacy, and universality. Nevertheless, because of their so many attack surfaces, lack of security standards and regulations, and newness, Internet of Things are susceptible to assaults (Kuzlu et al., 2021).

Several innovative "cryptocurrencies" emanated from blockchain technology. It represents a web of decentralized and dispersed "blocks" that are used for the storage of material with digitalized signals. Blockchain technology is characterized by decentralized, immutable, transparent, and auditable attributes that protect its databases for enhanced business negotiation. The applications of this technology are mostly employed in areas such as "risk management, healthcare facilities, and financial and social services" (Monrat et al., 2019). For enhanced understanding, blockchain technology is a database that stores, and maintains a historical database, and achieves the survival of business processes. Blocks are used to hold data from the register and are connected in a cryptographic pattern. Most precisely, blockchain technology has three key characteristics: distributed data storage, peer-to-peer networking, and decentralization. Let's examine each of these aspects separately (FreemanLaw, 2022).

The following key technologies identified throughout this study are in-exhaustive. This is because some of the identified digital technologies have either received attention from a single study, or their practical impact on innovative sustainability is not practically recognized. Steps will be taken to investigate their usage and contribute to the body of knowledge.

2.5 Food Processing Sector:

The Agri-food industry refers to a system of operations across the Agrarian value chain from cultivation at the farm gate to processing, and commercialization until it reaches the final customer (Ben Ayed et al., 2022). There exist approximately twenty-five thousand manufacturing companies that are licensed by the Registrar General, above 79% of these are micro-enterprises, and about 55% of them are based in Tema and other areas of the Greater Accra region. “Mining, light manufacturing, aluminum smelting, food processing, cement, and small commercial ship building” are some of the main segments in this industry (Alembummah, 2015 p.68). The food processing sector is anticipated to have a considerable impact on the country's economy, but on the contrary one sector that is currently facing enormous challenges to thrive most likely because it is primarily characterized by Small- and Medium-Size Enterprises (SMEs) (Ben Ayed et al., 2022). There are a variety of processing activities within the sector such as the handling and storage of a multiplicity of food, fruits, and beverages (Alembummah, 2015).

Table 2:1 Sub-group of Activities under the Food Processing Sector

No.	Activity
1	Processing and preserving of meat products
2	Manufacture of starch and starch products
3	Processing and preserving of fish, fish crustaceans, and mollusks
4	Processing and preserving fruits and vegetables
5	Manufacture of vegetable and animal oils and fats
6	Manufacture of dairy products
7	Manufacture of grain mill products
8	Manufacture of bakery products
9	Manufacture of cocoa, chocolate, and sugar confectionery
10	Manufacture of other food products
11	Distilling, rectifying, and blending spirits
12	Manufacture of malt liquors and malt
13	Manufacture of soft drinks; production of mineral waters and other bottled waters
14	Manufacture of sugar
15	Manufacture of macaroni, noodles, couscous, and similar farinaceous
16	Manufacture of prepared meals and dishes
17	Manufacture of prepared animal feeds
18	Manufacture of wines

Source: Ghana Statistical Service, 2011

Again, the African Union in partnership with the World Bank is preparing a digital platform for governments and Agri-food firms to be better equipped with literacy skills in addition to the digital infrastructure to increase food production, nutritional safety, boost good dieting, and business networking opportunities.

The very significant contribution of the food processing sector cannot be overemphasized, reasons the African Union in partnership with the World Bank is preparing a digital platform for governments and firms in the sector to be better equipped with digital literacy skills in addition to digital infrastructure that will increase food production, nutritional safety, boost good dieting, and business networking opportunities. This will prepare the platform for Africa's agricultural revolution in the coming decades which has a great deal of potential to be fueled by Digitalization for Agriculture (D4Ag) (Tsan et al., 2019a).

The government indicated a very strong commitment to transform the economy to promote equitable and sustainable development using DE4A with the cornerstones of digital infrastructure, digital platform, digital financial services, and digital entrepreneurship, (Clemente Miranda et al., 2019). D4Ag is actively promoted by the government through smart farming initiatives to maintain agriculture which was approximately 19.25% of Ghana's GDP (GSS, 2019). Leveraging on this opportunity, the government has attempted to establish schemes that support D4Ag by launching several projects, including "Planting for Food and Jobs, an e-registration platform for farmers, and an electronic, agricultural input distribution system with barcodes". This inventiveness triggered a floodgate of stakeholders to seize the opportunity and gain entry into the Agri-food value chain and made great benefits from these schemes (Tsan et al., 2019a). One of the unresolved concerns trending in the world today is achieving a consistent sustainable business model for firms in the Agri-food industry. For the industry to boost productivity and quality while reducing the overall environmental effect on the food supply, it is necessary to adopt and implement digitalization that will orchestrate food processing 4.0 (Els Van de Velde and Kretz, 2020).

2.5.1 Relevance of Digitalization to the Food Processing Sector:

The government indicated a very strong commitment to transform the economy to promote equitable and sustainable development using DE4A with the cornerstones of digital infrastructure, digital platforms, digital financial services, and digital entrepreneurship (Clemente Miranda et al., 2019). This commitment has been supported by the African Union and World Bank in their digitalization drive (Tsan et al., 2019b).

Digitalization offers innovative break-through to sustain development in the Agri-food industry by increasing operational performance, long-term profits, adaptability to global warming, sustained productivity, inclusion, and livelihoods sustainability for firms in this industry and other benefits across the value-chain (Bahn et al., 2021, Baumüller and Addom, 2020, Schelenz and Schopp, 2018). In addition, it offers a comprehensive radical change and brings timely

solutions to operational problems, facilitating an uninterrupted, agile, and ultimately financial performance to the value chain (Ben Ayed et al., 2022). Other studies added that, its efficient deployment results in sound judgments in resource allocation and commitment to sustainability concerns (Bökle et al., 2022, Tsan et al., 2019b). In addition, the World Bank laid down initiatives to ensure all African citizens, businesses, and governments are digitally equipped with "digital infrastructure, digital platform, digital financial services, digital entrepreneurship, and digital skills" by 2030 to revolutionize public institutions and business (Tsan et al., 2019b). And also, predicts that the global digital economy will hit 25% in ten years and a tenfold rise in the supply of new digital equipment across the African region (WorldBankGroup, 2019). Again, the African Union in partnership with the World Bank is preparing a digital platform for governments and Agri-food firms to be better equipped with literacy skills in addition to the digital infrastructure to increase food production, nutritional safety, boost good dieting, and business networking opportunities. This will prepare the platform for Africa's agricultural revolution in the coming decades which has a great deal of potential to be fueled by Digitalization for Agriculture (D4Ag) (Tsan et al., 2019a). The above-mentioned advanced technologies are relevant within food processing firms to enhance operational performance across the value chain and achieve customer satisfaction (Els Van de Velde and Kretz, 2020). One of the most striking features triggered by digitalization is the paradigm shift to robustness and resilience to create value for the firm and fruitful engagement with external stakeholders for value co-creation (Schlaepfer et al., 2017)

2.6 Theoretical review:

According to the literature, a theory is an abstract model that explains the relationships or absence between variables in the study, better explaining an occurrence, and also adds value to the body of scientific understanding in the scholarly community (Turner et al., 2018). The development of theory is to interpret the world around us to better "understand, explain, foresee, know, and act" in our surroundings or environment, theories are put into practice (Lynham, 2002a, p. 222). Some scholars also describe a theory in terms of how explanatory variables are related, one such option for developing theories is the perceptions of positivist and interpretive reasoning (Samuel, 2015).

The theoretical review for this study is based on the foundation of related previous research works that give an explanation of the operationalization of the research constructs and aid a proper investigation of the measurable impact of digitalization on sustainable innovation

mediated by open innovation in the Agri-food processing sector in Ghana by resolving the problem statement and answering the research questions.

2.6.1 Operationalization of Digitalization and Sustainability Development:

To enhance a broader understanding of the concepts within this research area, extant literature has made use of related constructs interchangeably. Therefore, this study adopted the notion of digital technology to mean digitalization (Gray and Rumpe, 2015); sustainable Development to mean "sustainability", "sustainability innovation", "sustainable innovation", green innovation", "eco-innovation", or environmental sustainability (Alkemade, 2019; Cillo et al., 2019;" Inigo and Albareda, 2016; Boons, Lüdeke-Freund, 2013. p.12); digitalization to mean sustainable innovation (Ghobakhloo et al., 2021); and "industry 4.0" to mean "Agri-food 4.0" (Lezoche; et al., 2020). Digitalization and digitization are employed interchangeably (Bloching et al., 2015).

Operationalizing the effect of digitalization on sustainable innovation has been a challenge for many scholars of which very few extant works of literature examined its quantification. This is probably because different factors account for which stage of the digitalization landscape is adopted. However it has been suggested that to quantify the level of digitalization, it is necessary to examine the network of stakeholders and the system of operations of a particular business segment about their possible long-term advantages (Becker et al., 2015; Schallmo and Rusnjak, 2015). Whereas others perceive it as some strategic attributes such as "leadership, products, operations, culture, people, governance and technology are assessed" to achieve (Azhari et al., 2014 p. 38); "Customer experience, product innovation, strategy, organization, process digitalization, collaboration, information technology, culture, and expertise and transformation management" (Berghaus et al., 2017 p.8).

Scanning through related review, it was realized that many scholars indicated that, the concept of "Digitization" and "Digitalization" is used by stakeholders interchangeably, although there exist significant variances in the meaning (Saarikko et al., 2020). While "Digitization" denotes the conversion of manual data into digital data mining algorithms (Rachinger et al., 2018); "Digitalization" on the contrary does not just depend on software Apps, but also deals further with the deployment of Information and Communications Technology (ICT) with an emphasis of telecommunication to develop business processes, diversify revenue sources and investment opportunities in business space (Parida et al., 2019); with the main aim is to synchronize the processing of data, storage, analysis, and retrieval of information for consumption or effective decision making (Nhamo, 2022). "Digitization" refers to transcribing from a manual using

physical representation into an encrypted computerized version in the form of bytes for easy storage, processing, and dissemination by the computer when needed (Bloomberg, 2018; Jovanović et al., 2018). “Digitalization” has also been affirmed with the precision that the notion of "digitization" and "digitalization" has become very controversial as the debate on digital transformation persists. In a real sense, these concepts have different meanings, or at the very least, we might interpret them differently depending on which authority we follow (Bloomberg, 2018). "Digitalization" is defined as the course of activities in “digitizing” analog data into byte formats such as photographs, videos, and text messaging (Sausen, 2020). For simple understanding, digitalization is the incorporation of innovative emerging technologies into routine activities across the workplace, the business, and other societal areas with much emphasis on the causing specific impact on a firm’s value chain (Sausen, 2020; Westerman et al., 2011). Better still, a company’s capability to leverage advanced technologies for operational performance (Lee et al., 2019).

“Being digital is not just introducing mobile apps for customers. It is taking advantage of the opportunity to redefine a business — and possibly even an industry. “(Ross, 2017)

It is argued that digitalization has a substantial influence on operations that are very critical to the business which extends further than just boosting productivity and resourcefulness. It establishes new foundations for societal and economic sustainability (Porter and Heppelmann, 2014). Another school of thought has linked these concepts with emerging information and communication technologies that are necessary to re-engineer the operational and financial performance of firms (Gobble, 2018; Verhoef et al., 2019). Switching from classical to emerging technology is one of the most unprecedented transitions for modern businesses to thrive as illustrated in the “fifth wave of innovation” to trigger an increase in market attractiveness (Jovanović et al., 2018 p.908). As part of benefiting from the opportunities presented by digitization, firms must also restructure their system of operations and respond to changing market research demands to conquer prevailing challenges and maintain their competitiveness (Tahiri, 2022). Extant literature suggested that the dichotomy between the traditional and virtual worlds is progressively overlapping, therefore there is an absolute need for industry players to be digitally literate to efficiently benefit from advanced technologies (Linz et al., 2017). It is possible to be accomplished, for instance, when practitioners incorporate the available advanced technologies like IoT, big data, blockchain, and ancillary services into their routine operating systems (Kagermann et al., 2013) and create value through data mining to become more attractive in the industry (Porter and Heppelmann, 2015).

Given that open innovation is primarily driven by "digitalization" and should be able to be deployed taking into consideration the sustainable dimensions. Businesses with a significant degree of "digitalization" implementation portray more innovativeness than others (Bruckner, 2018).

It is becoming more and more necessary for firms to create innovations that integrate social, environmental, and economic targets if they want to conform to the notion of long-term sustainability and thrive in the industry (Cillo et al., 2019). "Sustainable innovation" refers to "the development of new products, processes, services, and technologies that contribute to the development and well-being of human needs and institutions while respecting natural resources and regeneration capacities" (Tello & Yoon, 2008, p. 165). In the same vein, another author defines the concept as "innovations in which the renewal or improvement of products, services, technological or organizational processes not only delivers an improved economic performance but also an enhanced environmental and social performance, both in the short and long term has generated positive social and environmental impacts" (Bos-Brouwers 2010, p. 422).

Extant literature posited that practitioners are more and more restructuring them by considering adopting notions like stakeholders' freedom and waste disposal into their sustainability innovation system (Pastré and Vigier, 2003). These actions led to the growth of stakeholder engagement due to the adoption of measurable indicators for sustainability innovation and in turn enhanced value co-creation (Cillo et al., 2019). Other studies supported this position and highlighted that firms should not only focus on winning competition but also engage in the welfare of the community and become eco-friendly (Carayannis et al., 2017). It has been suggested that scholars and industry players are currently focusing on and adopting sustainability targets in their business processes because of the inherent advantages (Bates et al., 2008).

There has been a debate among scholars that, "sustainable innovation" can be better understood from 3 diverse points of view "internal managerial, external relational, and performance evaluation". Empirical studies revealed a very strong association between "sustainability" and "innovation" (McWilliams and Siegel, 2001); in addition to financial performance (Waddock, 2010). For these reasons, most firms that have been examined shifted their "innovation" practices from research and development to different operations across their value chain that will be responsive to the growing consumer expectations (Peterson et al., 2013).

With regards to “the external-relational”, point of view, previous research indicated that the current “innovation” practice relied on between the “internal and external” surroundings (Rauter et al., 2013); in addition, firms whose emphasis is placed only on “value addition” find it difficult to thrive (Forstater et al., 2010).

With regards to “performance evaluation”, stakeholders are delighted to patronize products from firms who practically engage in “sustainability”. This has been a source of motivation for studies to be carried out in this area (Cillo et al., 2019). According to Cohen, Smith, and Mitchell (2008) Cohen, Smith, “sustainable innovation” is among the foremost efforts to go further than classical “financial performance” measurement while examining the entrepreneurship concept, therefore resulting in a multi-dimensional construct that takes into consideration the triple bottom line factors as proposed by. Another practical case is the financial framework that was advanced by Liu and De Giovanni (2019) describing that the deployment of digitalization by firms can restructure novelty (Ghobakhloo et al., 2021). Recently, Rauter et al. (2018) proposed a framework for measuring technological change and sustainable development by stating that there is a relationship between the two variables since “economic and sustainable innovation” targets can be achieved through an emerging technological model (Cillo et al., 2019 p. 1019).

2.6.2 Underpinning theories

The theories underpinning this study will give better explanations and understanding to ensure the successful implementation of innovative digitalization for sustainable development by food processing firms in Ghana. Earlier studies of population theory postulated by Thomas Malthus posited that geometric population growth as against arithmetic food cultivation can lead to food shortage and human catastrophe, but was criticized by Ester Buserup and other modern critics by adopting innovative technologies to improve food production, processing, and commercialization across the Agri-food value chain (Kuzmich, 2021).

2.6.3 Practice-Based View (PBV)

The perception under this approach was postulated by (Bromiley and Rau, 2016) in an attempt to conceptualize Resource-Based View articles that according to the authors were no longer relevant in all supply chain management (SCM) studies since not all SCM research is motivated to achieve financial growth and profitability (Alexy et al., 2018). According to Bomiley and Rau (2016), PBV was advocated as a preferable alternative for business management

academicians to underpin a theoretical framework whereby the variables represent the standard practices for a sustainability innovation of advanced technologies (Weng, 2022). With this approach, the response variable in PBV is technically used and analyzed at the midpoint as well as the concluding outcomes and is also very significant (Bag et al., 2021). The PBV presumed that businesses exhibit a high variance in growth within an industry; also, not every company implements every technique that may be helpful in the industry. As a consequence, using this practice may help to understand variation in a company and not necessarily industry growth. The outcome of every activity may differ all over the company due to the influence of portable skills and other moderators that may be introduced on business operations. PBV can also solve a variety of RBV-related issues. (Bag et al., 2021).

This study will propose a theoretical framework by adopting the PBV to illustrate how different organizations can improve their productivity by using a variety of different methods to improve upon adopting digitalization for sustainable development moderated by open innovation in the food processing sector.

2.6.4 Dynamic Capability Theory

Operations management literature has made numerous uses of dynamic capacity theory, particularly for the decision-making process across a variety of corporate contexts (Barreto, 2010). According to Teece (2007), DCT " can be used firstly, to anticipate and mould opportunities and threats, secondly, grab opportunities, and thirdly, to sustain competitiveness through improving, integrating, defending, and, fourthly, when required, reconfiguring the tangible assets of the firm".

This study proposes that the appropriate deployment of digital infrastructure, coupled with a digital platform and suitable literacy skills mediated by open innovation will achieve sustainable development through digitalization in a changing environment.

2.6.5 The Unified Theory of Acceptance and Use of Technology (UTAUT)

In the past couple of years, several conceptual representations have been suggested and employed to investigate IS/IT acceptance and usage. In an attempt to improve upon the initial UTAUT framework to drive theory forward and determine where prospective studies in this area should be focused, critical evaluation and refinement of the original Unified Theory of Acceptance and Use of Technology (UTAUT) were conducted. The Unified Theory of Acceptance and Use of Technology (UTAUT) originates from the Technology Acceptance Model, which is a widely recognized and extensively applied conceptual structure for

investigating the adoption of technology. The UTAUT framework combines two significant determinants of implementation intention: performance expectancy, which refers to an individual's perception of the extent to which using a system will contribute to improved work performance, and effort expectancy, which pertains to the perceived simplicity to effectively operate digitalization drive to sustainable development (Venkatesh et al., 2003).

2.6.6 The Digital Twin

The Digital Twin Theory refers to system applications that configure actual statistical inputs to computational models. The configuration between emerging technology and these system Applications can improve the outcome of telecommunication and decision-making (Deuter and Pethig, 2019). Other schools of thought view the concept as actual statistical inputs converted into bytes; giving a detailed structural and practical explanation of goods and services; a simulation model of a tangible or abstract item; and also ensuring a model for potential goods and services through digitalization (Deuter and Pethig, 2019). It has been postulated that academicians have usually been quite confident when using the sustainable development model to examine the impact of digitalization on its dimensions, (Beier et al., 2020). Even though the high-tech drive for digitalization would not essentially optimize ecological sustainability, the interrelationship and efficiency in the value chain processes through digitalization indirectly result in reducing pollution and enhancing eco-efficiency (Nascimento et al., 2019; Stock et al., 2018). The school of thought that supports emerging technologies also considers that currently, digitalization stimulates social sustainability by enhancing customer experience, employment opportunities, and working conditions (Kadir & Broberg, 2020).

2.7 Empirical review:

This part of the study reviews related literature to the variables to be examined. The gaps and key findings identified from empirical studies will aid this study in establishing multi-dimensional relationships by developing theories that will predict and test the outcome variables.

By implication, the mediating role of open innovation plays a very significant part in explaining the process through which the application of digitalization can achieve sustainable development in the food processing firms in Ghana. Most researchers have discussed the merits of the open innovation model, and although its relevant practices on innovation capability are a result of knowledge development and information dissemination, it has not been adequately examined (Yan et al., 2014).

Table 2:2 A selected empirical review of the determinant variables from the literature

Author(s) (Year)	Digitalization construct	Objectives	Contingency variable	Theoretical Perspective/ key argument	Methodology and Context	Key findings
(Charatsari et al., 2022)	Technological innovation	To theoretically analyze and discuss their major features, describe how they relate to the agrifood systems' resilience through innovation channels.	Agrifood system resilience2	N/A	The study made use of a systematic literature review and criteria-based selection to answer the research questions.	Encouraging this kind of technological advancement is difficult since the intended audience for micro-innovations is economically unfavorable, and policymakers are still trying to find suitable approaches to screen for and disseminate appropriate technology.
(Bag et al., 2021)	Industry 4.0	To investigate the magnitude of the impact of digitalization implementation on the industrial capacity of circular economy and their impact on sustainability in the context of an online shipment.	Industry 4.0 Delivery System	Practice-based view and Dynamic capability view	A survey was conducted using the convenience sampling method to collect virtual data from 500 sampled CIPS companies in South Africa.	It was found that the rate of implementation of digitalization and circular economy is important; rendering circular economy to strong influence on sustainability.

Note: Independent=[1], Dependent=[2], Mix=[3], Moderator=[4], Mediator=[5]

Author(s) (Year)	Digitalization construct	Objectives	Contingency variable	Theoretical Perspective/ key argument	Methodology and Context	Key findings
Sharma et al. 2016)	Digital literacy	Assesses the effect that digital literacy has on knowledge societies' ability to grow sustainably	Knowledge societies[4]	Grounded theory	The study assessed the ICT guidelines, Software, and its impact in five advanced countries dedicated to information society and characterized by extensive use of communications technology, by employing a multi-dimensional assessment from previous research.	The provision of ICT infrastructure via public-private partnerships resulted in the growth of digital skills, consequently improving the information society and leading to sustainable development.
(Gui and Argentin, 2011)	Digital skills	To assess college students who are already surrounded by emerging technologies and have acquired digital literacy, by analyzing the diversity in their digital competence.	Digital literacy[1,2]	N/A	A virtual eLearning assessment was conducted addressing the "theoretical, operational and evaluation skills" in a survey data collection from 980 students in Italy using a random sample through regression analysis.	It was found that scholars made more progress in operational skills compared to other parameters and performed poorly in evaluative skills.

Note: Independent=[1], Dependent=[2], Mix=[3], Moderator=[4], Mediator=[5]

Author(s) (Year)	Digitalization construct	Objectives	Contingency variable	Theoretical Perspective/ key argument	Methodology and Context	Key findings
(Ng, 2012)	Digital Natives	This article analyses how a community of Australian college students pursuing Introduction to eLearning acquire knowledge using new technology.	Digital skills[2]	N/A	This article analyses how the sampled population composed of a community of Australian college students acquired knowledge using new technology. The computer skills and ease of learning new technologies were examined to determine the digital skills.	The results suggest that students could readily leverage new technology to generate valuable products. But, they ought to understand formative assessment and be given the chance to utilize them. Self-perception measurements showed that digital natives may learn digital literacy.
(Fan and Wang, 2022)	Digital literacy	To ascertain the consistency of the items used to measure digital skills and the statistical inference and prediction of the students' digital skills.	Digital skills[2]	Exploratory factor analysis (EFA) and model-data fit	A survey was conducted with a two-sampled population of 222 and 231 college students through randomization in a Chinese university. An exploratory factor analysis was employed to evaluate the internal consistency of the initial group and model fitting for the latter to confirm the suitability of the survey instrument.	The questions evaluating digital literacy were developed following the "Code for the Construction of Digital Campuses in Colleges and Universities (for Trial Implementation) (2021)" which demonstrated that the survey instrument was significantly valid and reliable. This gives an interesting perspective on how surveys should be examined and administered to their implementation, population, and context.

Note: Independent=[1], Dependent=[2], Mix=[3], Moderator=[4], Mediator=[5]

Author(s) (Year)	Digitalization construct	Objectives	Contingency variable	Theoretical Perspective/ key argument	Methodology and Context	Key findings
(Ren et al., 2023)	Digital infrastructure	To probe into the general effect of China's rural digitization strategy on agrarian greenhouse gases and the environment, as well as its conductive mechanism and policy implications by blending new digital infrastructure and development into agricultural sustainability.	Agricultural Eco-Efficiency[2], Mechanism[4]	N/A	SBM-DEA model, entropy weighting method, and mixed regression were adopted to analyze the data from 30 provinces of China from 2011 to 2020.	The outcome of the research confirms that digital infrastructure strongly affects agrarian environmental sustainability.
(Yan et al., 2014)	Open innovation strategies	To hypothesize and examine the corresponding effects of several open innovation approaches on the inventiveness of new products.	Internal research and development (R&D) [4]		The hypotheses were tested using SEM constructed questionnaire to collect data from 272 projects in the U.S.	The outcome of the study revealed that it collaborative relationship with non-members of the distribution network is more was more sustainable to work with than collaborative members.

Note: Independent=[1], Dependent=[2], Mix=[3], Moderator=[4], Mediator=[5]

Author(s) (Year)	Open Innovation Construct	Objectives	Contingency variable	Theoretical Perspective/ key argument	Methodology and Context	Key findings
(Rosa et al., 2020)	Open innovation	To examine the challenges of investigating innovation and Open Innovation dimensions.	Open innovation measures	N/A	An exploratory systematic review was conducted proceeded by data collected from managers of 77 small tech firms at key Brazilian industrial and technical hubs.	The suggested indices were found to be solidly important for the measurement of open innovation.
(Oke et al., 2013)	Innovation chain		Product innovation strategy[5], strategic SC partners[2]	resource dependence theory, social capital theory, and the knowledge-based view	A cross-sectional virtual investigation was conducted to collect data from 207 Australian manufacturing companies.	It was revealed that implementing innovation on the core distribution network members has a significant influence on innovative production practices. Again, innovative practices strengthen the association between core distribution network members.
(Al-Belushi et al., 2018)	Open innovation	To examine the growth of an organization in Oman's marine biotech companies.	Open innovation metrics	N/A	OI features were determined through a systematic literature review and a survey design to solicit data from 22 marine biotech companies in Oman ranked based on their open innovation score	Omani marine bio-industry companies may improve their open innovation capabilities by engaging increasingly extensively with public agencies as well as academic institutions to boost the standard of their open innovation operations in a quantifiable manner.

Note: Independent=[1], Dependent=[2], Mix=[3], Moderator=[4], Mediator=[5]

Author(s) (Year)	Sustainable Development Construct	Objectives	Contingency variable	Theoretical Perspective/ key argument	Methodology and Context	Key findings
(Sakhno et al., 2020)	Digitalization	To determine systematic and empirical underpinnings to enhance Ukraine's institutional and economic regulation to sustain Agri-food cultivation to improve competition through digitalization.	Sustainable development[2]	N/A	A systematic qualitative literature review was conducted to improve the degree of digitalization for sustainable development in Ukraine.	The study encountered challenges in ensuring social sustainability but noticed that digital platforms could guarantee sustainability in the agricultural industry.
(Gupta and Rhyner, 2022)	Digitalization	This study provides an assessment of a new guideline for the practical evaluation of the effect of digitalization on the SDGs.	Sustainable development2	N/A	A systematic qualitative literature review was conducted to improve digitalization for sustainable development	Considering the outstanding opportunities that digitalization presents for advancing SDGs, the Digitalization Assessment Framework serves as a fresh analytical tool to investigate the function of the Digitalization intervention by promoting additional evaluations, assisting in dealing with uncertainties, and facilitating context-inclusive systemic measures.

Note: Independent=[1], Dependent=[2], Mix=[3], Moderator=[4], Media

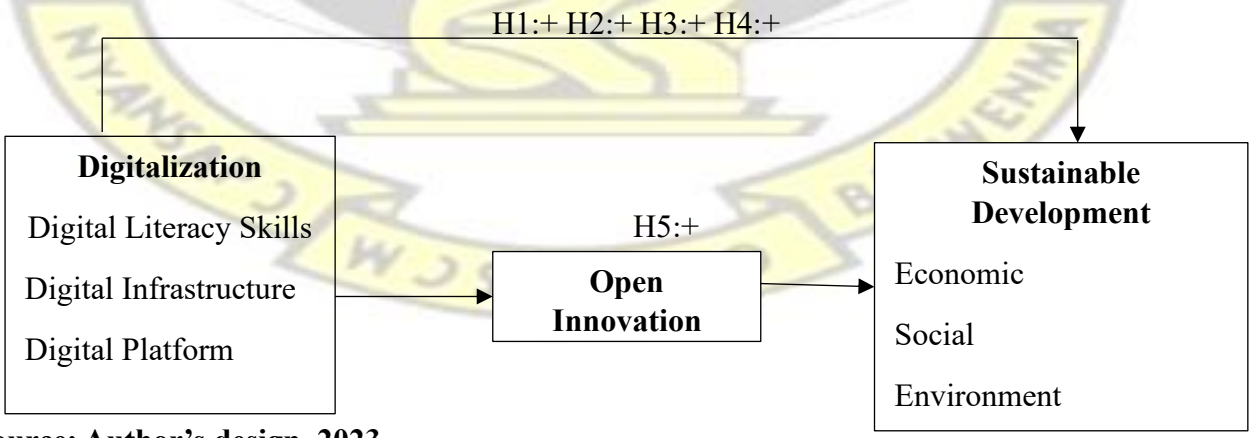
2.8 Conceptual Framework and Hypothesis Development:

A conceptual framework is designed to aid the understanding of the hypothesized development that will contribute to the scholarly community.

A hypothesis is a statement of assumptions to predict the outcome of a study. An effective research hypothesis is testable to conclude a prediction, the investigation must be limited to the operationalization of the constructs that will ease data collection, analysis, and interpretation (Walliman, 2010). It has been posited that several years ago have seen the ecosystem disorientated thereby affecting classical food cultivation (McIntrye et al., 2009; Schut et al., 2014) resulting in the distortion of the Agri-food value chain's ability to achieve sustainability (Klerkx and Leeuwis, 2009; Leeuwis, 2010; Swanson and Rajalahti, 2010). Reasons among others the significance of innovative digitalization in solving global socio-economic and environmental problems, especially in modern businesses have triggered much attention among scholars (Annosi et al., 2020). Even though there is a myriad of literature that has demonstrated an enormous benefits and difficulties that the impact of digitalization has on sustainable innovation, this researcher came across very few studies examining their relationships.

The following arguments and their divergent perspectives concerning the relationship between digitalization and sustainable development are supported by evidence-based related studies developed by the theorists cited above.

Figure 2:1 Conceptual Framework



Source: Author's design, 2023.

2.8.1 The Relationship between Digitalization and Sustainable Development.

According to many scholarly works consulted, digitalization has been perceived to be a major trigger for sustainability (Gupta and Rhyner, 2022). The constructs under investigation have also been perceived as having a significant impact on sustainability innovation within financial operations through the "FinTech" concept (Sahabuddin et al., 2019). According to the literature, "innovation" makes a fundamental contribution to many firms' sustainability in their financial operations (Rizvi and Ashad, 2017 Sahabuddin et al., 2019) such as the effective adoption of advanced technologies with an uninterrupted cyberspace streamlines operations and leads to financial performance (Leong et al., 2017), facilitating financial transaction across the globe (Amalia, 2016; Fan,2018) and much other novelty in performing financial operations across many segments in society to enhance opportunities for businesses and achieving sustainable development (Sahabuddin et al., 2019).

While "digitalization" simply denotes the process of digitizing specific information to enhance output, "innovation" signifies generating creativity in ensuring durability (Sahabuddin et al., 2019). With sectors such as food processing, where information as well as smart virtual interaction play a crucial part in a company's capacity to accomplish essential everyday operations, technological innovations bring new obstacles and present a wealth of potential to humanity. The adoption of technological innovations by food processing professionals is essential for effectively addressing emergencies and improving the sustainable transformation of the value chain operations (Kao et al., 2012). Nevertheless, the process of digitization is often complex and challenging. Although its adoption could appear suitable for sustainable development, it is important to note that the real-life results may not align with initial expectations (Appio et al., 2021, Correani et al., 2020). It has been indicated that there currently exists both a conventional and an online shop, as well as conventional ways to settle bills and electronic settlement options and other forms of e-transactions. Additionally, there is a distinction between actual life and digital actuality. The concept of digital transformation has fostered sustainable development, increased degree of efficacy, enhanced accountability, and extended solutions beyond the inconceivable (Bhutani and Paliwal, 2015). Instead of focusing on processes, it is more appropriate to consider the various emerging technologies that contribute to value creation. Every element of these technologies is distinct element for developing digital economy and potential reservoirs of future worth (Bhutani and Paliwal, 2015).

That is why it has been suggested that the concept of open innovation is gaining traction to be a transformative model that shifts beyond conventional techniques to stretched innovation approaches where key players collaborate to jointly innovate shared benefits (Chesbrough, 2017). This 5th wave of the Schumpeterian innovation cycle has experienced a massive use of ICT with the introduction of innovative mass media, breaking boundaries of globalization through the World Wide Web to achieve value for money (Sharma et al., 2016); consequently leading to the declaration of the cyberspace as a fundamental right for all (Mossberger et al., 2012). Based on the above assertion, a strong relationship between the increasing use of digitalization and sustainable development has been confirmed (Solomon and van Klyton, 2020).

H1: There exists a significant relationship between digitalization and sustainable development.

2.8.2 The relationship between Digital literacy and Sustainable development

The contemporary world has experienced an enormous paradigm shift with the use of telecommunication for sustaining development (Radovanović et al., 2020). A study conducted in China reveals that sustained development corresponds with ensuring the existence of a stable trajectory of sustainable growth (Luo et al., 2023).

A comprehensive report defined digital literacy as the capacity to utilize digital communication technologies and/or networks to access, manage, integrate, evaluate, and generate data (Panel, 2002). This skill is essential for people to effectively participate in a society driven by knowledge. Another study put forth a comparable meaning, suggesting that digital literacy consists of the acquiring of technical knowledge and skills necessary for comprehensively applying information and communication technologies (Tornero, 2004). Furthermore, it includes the development of fundamental pragmatic and cognitive abilities that enable people to fully realize their potential within the context of the digital age. Digital literacy constitutes the technological skills employed in ICT to access, coordinate, synchronization, appraise, and generate information (Sharma et al., 2016); while Haythornthwaite (2007) emphasized attributes such as virtual search skills, managing information, generating information, effective communication and eloquence in using innovative devices (Radovanović et al., 2020). It was confirmed in earlier studies that digital literacy is having accessibility to extensive practice and capabilities that can be applied to technological devices. It is the ability to make and share meaning in different modes and formats; to create, collaborate and communicate effectively

and to understand how and when digital technologies can best be used to support these processes" (Son, 2017 p.78).

The definition of digital literacy has experienced different perspectives in the past years, striving to embrace the rapidly changing evolution of emerging technologies, its adaptability, and its role in reducing the universal digitization gap. The application of digital literacy encounters several obstacles at each stage including the exclusion of a significant number of people with no education of digital user experiences in indigenous tongues, material that is appropriate for context-specific digital literacy learning, and the integration of graphic designs (Radovanović et al., 2020).

In today's technologically focused world, the development of the digital economy and the prevalence of the "Internet of Things" have made computer skills and competencies very useful resources for sustaining people's ambitions on a global scale, especially in their local vernacular (Radovanović et al., 2020). Notwithstanding a systemically established technological disparity in most parts of Africa especially some sampled populations of this study, and conversely, the growing prevalence of the internet in an era of high-tech culture, the need to skillfully harness acquired data for improvement is still an essential engine for economic growth (Sharma et al., 2016). It has been postulated that the panacea for addressing this disparity remains in developing digital skills to incorporate vulnerable groups. Closing this disparity will increase the effective use of emerging digital technologies economic performance of businesses (Sharma et al., 2016).

Digital divides and digital literacy are closely related concepts. Without the first, the second will continue to be widening. From the standpoint of regulators, eLearning enables humanity's citizens to benefit from its innovative wealth and would supposedly result in much more sustainable economic growth. (Sharma et al., 2016, Son et al., 2017).

A study in China confirms that Digitization plays a crucial role in facilitating a prosperous economy through three key transformations: enhancing value, improving productivity, and increasing energy. It illustrates the mechanisms through which digitalization contributes to effective economic development (Luo et al., 2023). Recently, the growing use of information technology like cloud computing, big data, and the Internet of Things is contributing toward a development that has an additional effect on enhancing the efficiency of all factors and fostering economic development (Sarangi and Pradhan, 2020). The use of digitization has the potential to facilitate the transition and transformation of old infrastructure into digital

infrastructure, hence enabling the digital transitioning of classical businesses and enhancing the overall efficiency of many sectors (Gao et al., 2022).

Technological innovation has emerged as a catalyst for the development of a new economic system, facilitating the swift growth of online businesses and fostering the emergence of various innovative businesses. Consequently, this transformative process has led to a shift in existing workforce models and has amplified the sales potential of current businesses. The ease of data interchange and the widespread use of internet-based services have facilitated the movement of labor resources across different locations and businesses, hence enhancing the adaptability of economic growth (Mugge et al., 2020). It is argued that firms ought to carefully select as well as integrate themselves with closing the digital divide that is strongly related to their core operations and ethical values. This strategy is seen as being crucial in ensuring the fact initiative is fully embraced and effectively implemented by all relevant parties interested (Bhutani and Paliwal, 2015). Digital literacy is a crucial component of our many projects, as it empowers the workforce to actively participate in sustainable community service endeavors (Duarte et al., 2018).

H2: There exists a strong positive relationship between Digital literacy and Sustainable development.

2.8.3 The relationship between Digital Platforms and Sustainable development

Several businesses are promoting the integration of ecological initiatives within their operations, including the adoption of greener technologies and the incorporation of renewable or recycled materials, intending to improve sustainability within their distribution networks (Dong et al., 2019). A shift of businesses has increasingly focused on sustainable development and digitalization as key areas of growth. The establishment of a virtual network platform has the potential to offer businesses a holistic perspective on several aspects such as designing products, manufacturing processes, managing the logistics network, client satisfaction, and financial performance. This, in turn, facilitates the development of a sustainable business model (Li et al., 2020).

Digital platforms are resilient and versatile innovations that have made their way within the telecommunications technology space into information systems literature (De Reuver et al., 2018). Digital platforms play a very crucial role in the advancement of a company's innovation and online capabilities (Wang et al., 2022a). They facilitate the integration of various sources by offering multiple technological features and serving as a means to sustain interaction

between stakeholders (Ahmed et al., 2022). Cenamor et al. (2019) claim that digital platform capacities encompass two key components: digital platform integration capabilities and digital platform reconfiguration capacities. Digital platform integration capacities encompass the capacity to communicate distinct information both inside and across organizations, hence facilitating enhanced interaction and collaboration both inside and outside these organizations. Businesses possessing the ability to integrate digital platforms have demonstrated a significant success rate in establishing innovative interactions with their clients (Khan and Tao, 2022). These businesses are adept at leveraging outside data and expertise, in addition to perceiving and recognizing possibilities for innovative growth (Zhou et al., 2019). Moreover, they excel at orchestrating resources from within as well as outside to capitalize on sustainable innovation prospects, thereby gaining an advantage over their rivals (Helfat and Raubitschek, 2018, Inigo et al., 2020, Jin et al., 2022, Liu et al., 2022). Digital platform reconfiguration capability is a method to reorganize system resources through segmental frameworks and standard interfaces in process and application development (Cenamor et al., 2019, Liu et al., 2022).

Recent findings claimed that developing operating systems centered around digital platforms may effectively balance economic and environmental goals, hence boosting sustainable development (Reuter, 2022). It is nevertheless important to note that relying solely on digital platforms is insufficient for attaining an edge over our competitors. The full benefits of digital platforms are only achievable once they are integrated into the resources and competencies of a business (Wang et al., 2022a).

The latest research revealed that small-scale farmers can get better deals when they use digital platforms in agri-food supply chains (Srai et al., 2022). The advancement of "digital platforms" or the internet portal to boost global commercialization and enhance socio-economic welfare is one of its proven benefits for the sustainability of businesses (Eaton, 2012; George et al., 2021; Pouri & Hilty, 2018). One glaring example as posited by scholars indicated that the internet portal involves crowed-base capitalism (Cusumano et al., 2019; Pouri & Hilty, 2018; Sutherland & Jarrahi, 2018) which offers people and firms who would not have had this occasion before the advent of advanced technologies to do business and socialize (Acquier et al., 2019; Elia et al., 2020). The collection and dissemination of vital details about the various state of affairs, stakeholders, and characterizes the complexities of social challenges businesses need to solve with the help of digitalization through the Internet portal (George et al., 2021). Another example is when the online agent portals integrate stakeholders within the value chains who were not connected online and provide them with the chance to exchange knowledge and

resources to address the growing issue of food waste (Ciulliet al., 2020). Since the firm's philosophy triggers the implementation of the new media, it will easily be possible for social inclusion of employees and hence achieving sustainable development through digitalization (Eaton, 2012).

Nevertheless, the mentioned advantages of online media must not be seen as solely an integral characteristic, in reality, scholars investigated that the use or misuse of the internet portal frequently causes or creates challenges to sustainable growth (Gupta and Rhyner, 2022). Despite previous studies emphasizing the significance of digital skill development (Kim et al., 2016, Papa et al., 2021), organizations are unable to successfully transform skills into a sustained competitive advantage if they lack a comprehensive understanding and utilization of that knowledge (Wang et al., 2023).

H3: There exists a strong positive relationship between Digital Platforms and Sustainable Development.

2.8.4 The relationship between Digital infrastructure and Sustainable development

Some scholarly works suggested that financing digital "infrastructure" is a solid foundation for the long-term growth of high-tech enlightenment (Bauer, 2010; Pradhan et al., 2014). It is also noted that web-based diffusion media has enhanced the use of technological "infrastructure" and internet software by enhancing sustainability (Hilbert, 2011); thereby facilitating active telecommunication through cyberspace for operational performance (Dwivedi et al., 2011; Leiner & Stoll Kleemann, 2009). Digital "infrastructure" stimulates inclusive high-tech enlightenment (Sharma et al., 2016). Studies carried out in Italy confirm that the digital "infrastructure" has a great influence on the sustainability of the business environment by enhancing product exportation and market development (Remondino and Zanin, 2022). Considering the emergence of technological innovation, the research community has consistently emphasized the significant role played by internet connectivity and digitalization in facilitating exchanges across multiple tiers (Forman, 2005, Mack, 2014, Maiga et al., 2015, Vial, 2021). Moreover, research demonstrated that the key elements that enhance the development of technology also comprise factors outside the business like the environment, which hold significant influence (Kraus et al., 2019, Orlandi et al., 2021, Scott, 2007). Digital infrastructure can be made possible by several determinants, including ICTs, internet usage, and connection (Moore and Manring, 2009). High-speed internet is commonly acknowledged as a catalyst for improved efficiency, as it serves as a prerequisite for the advancement of

digitalization. According to Grimes et al. (2012), companies that have access to high-speed internet tend to be more driven to take advantage of online resources for conducting their business operations. Additionally, Mack (2014) suggests that these businesses are also more prone to engage in collaborative activities by establishing robust value chain relationships.

Nevertheless, it is commonly acknowledged that the apportionment of wireless internet infrastructures displays heterogeneity, resulting in varying speeds throughout different environments. This geographically specific technological gap provides opportunities to businesses that possess access to superior infrastructures (Mack, 2014). Many analyses indicate that businesses with higher levels of technological advancement tend to concentrate in an environment characterized by superior digital connectivity infrastructures (Grubesic and Murray, 2004, Whitacre et al., 2014). Digital infrastructures, such as high-speed internet access or optic fiber, play an essential function in promoting digitization, from within individual firms (Kraus et al., 2019) and between multiple businesses (Zoppelletto et al., 2020). It has again been argued that digital infrastructure is now recognized as an essential ingredient in supporting sustainable development during the period of digitization and also serves as a crucial determinant of performance. Nevertheless, the extensive interconnection of digital infrastructure and systems gives rise to environmental impacts, including high power usage and a notable impact on global warming (Liu and Song, 2020, Munoz and Naqvi, 2017). Nevertheless, different perspectives posit that the consumption of power by digital infrastructure has limits due to advancements in technology, upgrades in power systems, and enhancements in environmental sustainability (Chen et al., 2022, Fuchs et al., 2020). However, there is a limited amount of investigation that has thoroughly examined the impact of digital infrastructure on power usage and pollution levels concerning the actions of city dwellers and the distribution of resources. This is crucial for conducting a comprehensive evaluation and effectively addressing the adverse environmental effects associated with digital infrastructure (Tang and Yang, 2023). Tang and Yang (2023) again claimed that existing findings primarily examine the impact of digitalization on environmental sustainability, the majority of these studies paid attention to particular kinds of digital infrastructure. However, these investigations tend to overlook the comprehensive impact that the entire growth level of digital infrastructure on sustainability at the city level.

H4: There exists a positive relationship between Digital infrastructure and Sustainable Development.

2.8.5 Open innovation (OI) has an indirect relationship between Digitalization and Sustainable Development.

OI was defined in an earlier study as implementing strategic flows of skills and competencies to stimulate value creation and co-creation within the company and stakeholders of that company (Chesbrough and Crowther, 2006). For businesses to include the environment in their innovative techniques, businesses have recognized the necessity of using information, competencies, and technology from outside their firms for the growth of the company. This has resulted in the promotion of open innovation (Bigliardi and Filippelli, 2022). The contribution of OI cannot be overemphasized, reasons Pundziene et al. (2022) indicated various types of OI and their impact on the success of a business. Several studies have established the significance of inbound OI in enhancing a company's ability to sustain competition (Kim et al., 2016, Papa et al., 2021) in the digital space. However, it is imperative to also acknowledge the corresponding significance of out-bound OI (Cheah and Yuen-Ping, 2021) to harness a sustained skillset and competencies of a business (Papa et al., 2021, Rodríguez-Espíndola et al., 2022). OI has been confirmed to frequently promote creativity that generates value and has a great relationship in a broad spectrum of business operations. OI is considered to be a critical boost to innovation because it easily facilitates material, information, and financial flows between businesses (Chesbrough, 2003, Gassmann et al., 2010). It is also established that innovative sustainability and value co-creation can be achieved when organizations implement OI programs between all stakeholders, therefore paving the way for a sustainable community (Aquilani et al., 2020). An empirical study investigated emerging technologies and OI indicating that digitalization has caused business frontiers to become more open to accommodate effective communication with their stakeholders necessitating OI (Zahra and George, 2002). With the above assertion, the introduction of OI has been anticipated to generate substantial advantages for organizations (Chesbrough, 2003). Although open innovation offers opportunities for sustainable businesses, they have experienced challenges in efficiently carrying out OI measures (Huston and Sakkab, 2006, Sarker et al., 2012).

Previous empirical research indicated that most firms become unsuccessful and wind up when they fail to implement OI since innovation is a very important requisite for sustainable development. An interdisciplinary broad consensus indicated that information is a crucial driver of sustainability, the study conceptualizes that “ICT infrastructure, governance in terms of policy implementation, human capital development, and innovation” is a collection of

technological advantages that would encourage a culture of inclusion and economic expansion (Chong et al., 2016, Sharma et al., 2016).

Different findings claimed that the effective development of skills by businesses has been found to have a significant impact on their focus on sustainable development and social challenges (Chaudhary et al., 2022, Jum'a et al., 2022). Although it is undertheorized in the OI literature (Bullinger et al., 2012, Miller and French, 2016), the OI model can promote innovations in digitalizing the food processing sector. Therefore, it is evident there exists a distinct requirement for enhanced understanding regarding the impact of OI in value-creation within the space of the food processing sector (Haverfield et al., 2020). Given the trend of the current information society, it is frequently the case for businesses to seek simultaneously in-bound and out-bound open innovation, but studies argue that it is uncertain whether this will have embedded restrictive or collaborative consequences (Du et al., 2022, Wang et al., 2022b). Even though, argued that it would be beneficial for businesses to integrate both types or at least implement one more than the other, many scholarly investigations underscored the imperative necessity of incorporating both types of OI (Wang et al., 2023), positing that these distinct forms of OI may exhibit a mutually reinforcing relationship (Hwang et al., 2023, Shi et al., 2020, Wang et al., 2021). A framework was established to demonstrate the effects of in-bound and out-bound OI techniques upon the quality of healthcare and the financial viability of e-healthcare services. Following the principles based on values, the argument posits that non-financial worth should be prioritized over monetary worth in the context of e-health amenities (Pundziene et al., 2023).

Nevertheless, existing literature posited that most organizations can utilize their technological assets to facilitate open innovation (Brady and Targett, 1995, Duhan et al., 2001, Hidding, 2001). Existing scholarly research has indicated that to achieve the highest level of productivity, the adopted digitalization approach must be in alignment with the company's overall goal (Reich and Benbasat, 2000). That is why investigating how digitalization affects OI is necessary since it is crucial in supporting open innovation efforts (Cui et al., 2015). It has been posited that OI arguably can strengthen the relationship that exists between digitalization and sustainable development.

H5: The indirect relationship between digitalization and sustainable development through open innovation has a strong positive effect.

2.9 Conclusion:

The literature reviewed by the study indicated that the appropriate adoption of emerging technologies has ground-breaking socio-economic and environmental advantages for firms' value creation and co-creation with stakeholders across its value chain. The review of the literature was based on theoretical reviews and empirical arguments related to the variables under study to hypothesize how digitalization is strongly correlated to sustainable development moderated by open innovation.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this Chapter, the study demonstrated the fundamental approach and reasons adopted to carry out data collection that will provide a solution to the problem raised (Saunders et al., 2016). The research methodology is further developed by focusing more on the research design, population of the study, sample size and sampling technique, sources of data, data collection instruments used, method of data analysis, their validity and reliability tests, the perception of ethical consideration, and profiling of the unit of measurement.

3.2 Research design

Research design denotes the roadmap of the study. It enables the study to follow a certain pattern and achieve the ultimate goal of the research by explaining reasons for adopting the appropriate research paradigm, philosophies, approaches, and strategies specifying the right data collection techniques for providing unbiased answers to clear research questions by hypothesizing (Saunders et al., 2016). According to Cavana et al., (2022), some fundamental elements such as the "purpose of the study, the types of investigation, the extent of researcher interference, the study setting, the unit of analysis, and the time horizon of the study" have been suggested to create a better understanding of research designs and help to achieve unbiased answers to clear research questions (Nuertey, 2015 p.87; Samuel, 2015 p.57).

3.2.1 Research Philosophy

Research philosophy is a pattern of thinking or presumed method of discovering how knowledge is generated through data collection of the study under investigation (Saunders et al., 2019). The importance of presumptions in research cannot be over-emphasized, empirical study confirmed that in the course of conducting research, the researcher at some point may consider presuppositions (Burrell and Morgan, 2016). Some basic presuppositions such as when conducting most business research are those that consider the actual state of action in the course of the study (ontology), those that concern when generating knowledge (epistemology), and those that concern how the researcher might influence the study (axiology) (Saunders et al., 2019). These presumptions help in shaping a very good research philosophy (Crotty 1998) taking into consideration the entire facets of research design (Saunders et al., 2019). This study will adopt the "pluralist" approach which indicates that each of the presuppositions is very important and gives a different perception of the actual study (Morgan, 2006.)

3.2.2 Research approach

Different scholars have perceived research approaches differ according to the nature of their study (Nuertey, 2015a). The clarity of the theories postulated in the review of the literature above will have a significant effect in explaining the research design and the outcome of the study (Saunders et al., 2016). This study is however flexible enough to stay in the ambit of the research design to adopt parallel quantitative and qualitative methods of examining its constructs using deductive reasoning with the "positivist" school of thought where theories and hypotheses are advanced, design a research strategy to test them after data collection and draw a logical conclusion after analyzing the data (Saunders et al., 2016). The researcher will first engage in a quantitative method to examine the measurable impact of digitalization of sustainable innovation and later qualitative method to investigate personal experiences in the food processing sector in Ghana that will provide some in-depth knowledge stakeholders in the value chain appreciate the impact of digitalization on sustainable innovation.

Grounded theory is also justified to be adopted for this study as a strategy to better appreciate the significant relationship that exists between digital literacy and the economic dimension of sustainable development that will be based on the collection of some additional raw facts from the conduct of some stakeholder used to generalize conclusions and development of a theory (Sharma et al., 2016). Grounded theory is defined as a bottom-up reasoning approach to infer a conclusion from the collection of raw facts (Glaser, 1998). The grounded theory which could be for quantitative and mixed research methods is frequently used for a qualitative study to investigate specific experience(s) based on the collection of raw facts to generalize conclusions and development of a theory (Mediani, 2017).

3.2.3 Research purpose

According to Saunders et al. (2016), the "research question" posed serves as a guide on whether to employ "descriptive, explanatory, or exploratory" studies to solve the problem raised in the study. Exploratory research explores the depth of the study by investigating new outcomes necessary for solving the research problem. The main purpose of the descriptive study is to give the researcher a focus on how to go about collecting data beforehand; though scholars agree that both explanatory and exploratory studies constitute elements of descriptive studies. Explanatory research, on the other hand, looks at how the degree of relationship between the constructs will impact the outcome of the study that will respond to the research questions (Saunders et al., 2016).

The main objective of this study is to establish the indirect effect of open innovation on the measurable impact of digitalization on sustainable development in the Agri-food processing sector in Ghana. For this study to realize this purpose, it will adopt the "descriptive, explanatory, and exploratory" studies to provide a more succinct response to the research problem. Exploratory studies will be employed to get a deeper understanding of the current state of digital experience and sustainability issues of the food processing value chain. The study adopts a descriptive approach to examine the degree of adoption of digitalization and sustainability issues in the food processing value chain which will employ an explanatory approach to explain and predict the relationships between the constructs.

3.2.4 The type of investigation

Previous studies by Cavana et al. (2009) suggest that "clarification, correlation, and causal" approaches decide the type of investigation in research (Samuel, 2015). This research will employ all the approaches to justify how the investigation will be conducted. To deduce a better understanding of how stakeholders, appreciate sustainable innovation across the value chain, we will make use of the "clarification approach". Meanwhile, the "correlation and causal approaches" will aid the study in analyzing and discussing the association between the construct (Nuertey, 2015b).

3.2.5 The extent of researcher interference

We acknowledge the many challenges and complexities that exist during data collection in the field and declare limited interference only to the process of data collection within the scope of the study.

3.2.6 The unit of analysis

The earlier study acknowledged several units of analysis ranging from "individual, dyads, and organizations" used when carrying out research. Whichever is adopted depends on the degree of aggregating data when analyzing it (Cavana et al., 2009). This research will embark on data collection using firm-level investigation.

3.2.7 The study setting

The data collection exercise was conducted in a physical space where the system of operations contributes to improving the value chain (Nuertey, 2015; Samuel, 2015). The survey questionnaire was conducted in the workspace of the organization's physical address of the food processing firms in Accra and Kumasi.

3.2.8 The time horizon

The time horizon is very vital to be considered before embarking on research. But again, is dependent on the "research questions" to solve the research problem (Saunders et al., 2016). This study was conducted under the supervision of an academic institution that is limited to an academic calendar. Hence, constraint by time allows the researcher to adopt a "cross-sectional study" through a "survey strategy" (Easterby-Smith et al., 2008; Robson, 2002).

3.3 Research Strategy

A good research strategy depends on succinct research questions, the degree of understanding of the current state of the study, the duration of the period allocated for the study, and resource availability among others (Saunders et al., 2016). According to the deductive approach, descriptive and explorative research, this study will make use of the survey strategy to better provide unbiased answers to the research questions. The survey strategy will also be helpful to carry out quantitative data in a very large pool of respondents within ample time, facilitate analysis, and advance explanations of the pattern of certain associations between the study's constructs (Saunders et al., 2016).

3.4 The population of the study

In research, the population of a study refers to the totality of people or cases that are valid for scholarly investigation from where the data is taken (Larbie, 2019). The target population was carefully chosen based on the significance of the research questions and the context of the study, which was limited to different personnel versed with the operations of food processing companies in the manufacturing industry in selected cities of Accra and Kumasi. This will help ensure the reliability and validity of responses.

3.5 Sample Size and Sampling Technique

(Saunders et al., 2016) defined the size of a sample as the sub-group of a given population. All organizations of the food processing sector in Ghana were not able to be examined because of the available resources and time constraints or better still because the study is not a census and also due to the challenges of accessing reliable sources of business data (Boso et al., 2013). The researcher, therefore, adopted an appropriate sampling technique to select the required cases (sample) from the sample frame to gain sufficient knowledge of their attributes and be able to generalize the findings of the study (Nuertey, 2015b). Sampling saves time and resources, and the possibility of providing precise results is very high (Saunders et al., 2016). Judging from the submissions of the authoritative sources above, it was not feasible to investigate all the cases of the food processing value chain in Ghana given the resource

limitation. Therefore, the selection of the elements was carefully chosen and filtered from the list of manufacturing companies in the database of the Association of Ghana Industry (AGI) which measures the likelihood that they are representative of the general population of the food processing companies in Ghana. This organization is mandated to facilitate a conducive business atmosphere for manufacturing companies in Ghana.

Sampling refers to the technique employed in carefully choosing cases from the entire population to be examined and the process used in carrying out data is known as the sampling technique (Singh and Masuku, 2014). Recent research indicated that data obtained from a sample size as small as fifty may provide reliable and valid results. However, it is worth noting to achieve consistent Maximum Likelihood Estimation solutions, it is generally recommended to have a baseline sample size ranging from one hundred to one hundred and fifty cases (Hair Jr et al., 2020). This study comprises diverse stakeholders engaged in the manufacturing, processing, preservation, and commercialization of processed foods across its value chain. Since the subgroups of firms in this sector have a heterogeneous population, examining the degree of implementing digitalization for sustainable innovation is divided according to similar attributes (homogeneity) (Singh and Masuku, 2014).

Saunders et al. (2016) categorize sampling technique into "probability" which implies that each element from the sample frame is recognized and has the same opportunity to be selected, and "non-probability samples" which implies that each element from the sample frame is unknown and cannot be inferred statistically. The study made use of both stratified random sampling and cluster sampling techniques under probability sampling by selecting respondents from the entire sample frame of the food processing sector in Ghana which has been retrieved from the Association of Ghana Industries (AGI). Stratified random sampling was employed to categorize heterogeneous cases into homogenous "strata" for easy randomization of each category of element(s) depending on their similar features and which emerging technology is appropriate for sustainable innovation (Singh and Masuku, 2014). The selected category will ensure a proportionate representation of the sampled population (Saunders et al., 2016). The cluster sampling technique will aid this study in categorizing and appreciating both big and small food processing firms in Accra and randomizing them into strata using stratified random sampling for each as explained above. It is understood that most small food processors in Accra fall into a cluster of independent family members doing it for livelihood sustainability.

3.6 Sources of data

In research, researchers always make use of data initially collected for other studies (secondary data) or new data to serve current needs (primary data) to answer research questions (Saunders et al., 2016). This study will make use of primary sources of data because they are collectively important to answer our research questions or meet the objectives of the study. Multiple sources of secondary data aided this study in terms of enriching its empirical literature reviews; while administering questionnaires and interviews through the primary data sources to the respondents for data collection for analysis, interpretation, discussion, and providing valid answers to research questions.

3.7 Data Collection and Instrument

The use of a closed-end questionnaire was the main instrument to deduce primary data from the sampled elements from the population of food processing firms retrieved from the Association of Ghana Industries (AGI) through self-administered questionnaires and on-spot visits and phone calls was made to ascertain existing firms in the sector. The information provided aided the testing of hypotheses. The items on the questionnaire were categorized following the research questions that were answered using a 7-point Likert scale format.

3.7.1 Measurement of questionnaire

This study made use of a closed-end questionnaire as a data collection instrument to provide answers to research questions. Therefore, to ensure reliability and validity to obtain the anticipated outcome (Achampong, 2011), which aided the study in hypothesizing the variables. Questions were posed as simply as possible for the understanding of all research participants (Saunders et al., 2016) and where possible translated into Twi by a recruited research assistant. A 7-Likert scale format was employed to categorize according to A for questions on the impact of digitalization, B on innovation, and C on sustainable development in food processing companies in Ghana. Measuring the different sections from 1=strongly disagree to 7=strongly agree; 1=not like at all to 7=extremely likely; extremely dissatisfied to 7=extremely satisfied. The initial segment of the questionnaire examines the demographic characteristics of the respondents. The next segments captured the independent, dependent, and mediating variables which were adapted from previous literature as measurements for the questionnaire. The items of each construct are detailed on the questionnaire.

3.7.1.1 Independent variable: Digitalization

According to earlier studies, the concept and practice of digitalization are undoubtedly still developing (Bienhaus and Haddud, 2018, Garay-Rondero et al., 2020, Lorentz et al., 2021),

Schallmo and Rusnjack (2016) suggested that it poses difficulty to measure its rate of implementation by firms. This is because of the constant improvement of technology although with associated outrageous expenses (Ionescu-Feleagă et al., 2023). For this reason, it is important to measure the effect that digitalization has on sustainable development over time, though different indices have been developed to measure aspects related to sustainable development (Ionescu-Feleagă et al., 2023). Other studies suggested a critical evaluation of the developmental progress of the level of digitalization implementation that particular members of a distribution network have implemented before determining their benefits (Schallmo, Rusnjack, 2015). Previous literature has not provided sufficient data to examine the impact of digitalization on innovation for sustainable development in the food processing sector in Ghana, therefore, diverse sources will be solicited from the literature to measure digitalization. Based on prior research, digital skills (Fan and Wang, 2022, Son et al., 2017), digital infrastructure (Bag et al., 2021), and digital platforms (Hautala-Kankaanpää, 2022, Queiroz et al., 2020) are relevant and effective measurements for digitalization. As a result, this study borrowed from the collection of papers already in existence (Ma and Zhu, 2022, Xu et al., 2022) to develop a concise evaluation model from the viewpoints of both "digital infrastructure and digital technology application". To quantify "digital infrastructure", three metrics were used: "long-distance optical cable density, Internet penetration rate, and penetration rate of telephone". "Online mobile payment level and the digitization degree of digital finance" were two metrics of "digital technology application (Yang et al., 2022)This study adopted, digital infrastructure, and from literature to measure the degree of digitalization to evaluate the profile of firms in the food processing sector.

3.7.1.2 Dependent variable: Sustainable Development (SD)

Most reviewed literature confirms that sustainable development is composed of three different dimensions (Bag et al., 2021); the economic dimension seeks the sustain and reinforce the financial performance of the business, the social seeks to develop competencies and welfare of workers or humanity, and the environmental seeks to nature protection. They all have different targets which contribute to sustaining the business (Kirchherr et al., 2017). To design a survey tool that could measure SD, each of the items in the survey instrument as proposed by Michalos et al. (2012) was classified under the environmental, economic, and social dimensions (Gericke et al., 2019). It has been established that innovative sustainability and value co-creation can be achieved when organizations implement open innovation programs between stakeholders, therefore paving the way for a sustainable community (Aquilani et al., 2020).

3.7.1.3 Mediating Variable: Open Innovation

Previous years have experienced the interaction of social evolution and people's actions with the consequences of climate change and soil degradation to distort conventional agricultural practices and increase the challenges in agriculture (McIntyre, 2009, Schut et al., 2015). Agricultural stakeholders now have a greater need to adapt and react to various problems and objectives at once if the industry is to continue to thrive (Swanson and Rajalahti, 2010). Because of this, there is a greater need for extension organizations to use systemic methods that effectively connect them to larger dynamics and innovation support services (Klerkx et al., 2012, Leeuwis and Aarts, 2011). Open Innovation has been suggested as the current strategy for implementing innovation in business operations (Bogers et al., 2018); It is grounded in the notion that it is unattainable for one firm to innovate in isolation (Dahlander and Gann, 2010). The best innovation strategy (Von Hippel, 2006) requires collaborative partnerships with stakeholders in the industry to share resources and information from outside the company and stay ahead of the competition (Chesbrough, 2006, Laursen and Salter, 2006). Although it is evident that open innovation and collaborative partnerships between the academia and practitioners drive innovation in developed nations, it is not as obvious how similar practices provide value in developing nations. We understand the significance of providing support for creative efforts and environments (Osorno-Hinojosa et al., 2022). Based on the above foundation, OI is measured with items adapted from literature review as suggested by (Rosa et al., 2020, Al-Belushi et al., 2018).

Table 3:1 Summary of survey questionnaire measurement

Constructs	Indicators	No. of Items	Sources
Digitalization	Digital Literacy skills	24	(Nhamo, 2022), (Fan and Wang, 2022, Ng, 2012)
	Digital Infrastructure	6	(Ren et al., 2023, Yang et al., 2022)
	Digital platform	6	(Hautala-Kankaanpää, 2022, Queiroz et al., 2020, Saryatmo and Sukhotu, 2021)
Sustainable Development	Economic	37	(Gericke et al., 2019)
	Social		
	Environmental		
Open innovation	Open innovation	10	(Rosa et al., 2020)

Source: Author's design (2023)

3.7.2 Pre-test of Questionnaires

A pre-test was conducted to polish, and erode any ambiguity in responding and assess if research participants are familiar with the context and content of the questionnaire. In addition, to evaluate if the data to be collected will be valid, reliable, suitable, and cover all constructs to be examined, my supervisor reviewed the questionnaire and approved it before self-administering it to a few research participants closest to the researcher (Saunders et al., 2016). In conjunction with authoritative sources, the researcher adopted stratified and cluster sampling to select and conduct a pre-test of the questionnaires with minimal elements of the sample frame to verify its authenticity (Nuetey, 2015; Saunders et al., 2016).

3.8 Data Analysis Method

For any data to be informative for stakeholder consumption, content analysis is employed for analyzing quantitative data where systematically categorized statistical, mathematical, and other characteristics are processed and analyzed to better explain the associated variables to the audience (Saunders et al., 2016). After data collection, every questionnaire was adequately verified for possible discrepancies (illegibility, incompleteness, or missing). Where software is used for data collection, it is directly analyzed. But in cases where it is collected manually, it will be coded, entered into the system, and analyzed using Statistical Package for Social Science (SPSS) version 20 software to ensure reliability and validity tests. The descriptive analysis was performed to scrutinize the opinions of research participants on the variables under investigation using frequencies, percentages, mean, and standard deviation to explain the measures of the variables. Also, inferential statistics will be run to reveal relations between variables.

3.9 Validity and Reliability

Scholars have confirmed that validity and reliability are very important attributes in determining the value of data collected for research purposes (Saunders et al., 2016). While content validity measures the elements that represent the variable, criterion validity refers to how other variables can be predicted by a particular variable; and is usually performed using correlation and regression analysis (Alembummah, 2015). Validity is the rate at which accuracy is measured for the purpose it was intended for. Some scholars suggest that it is important to adopt both to sufficiently assess the accuracy of variables and their relationships. Earlier studies outlined that both are vital in assessing the value of the research questions (Alembummah, 2015; Hair et al., 2004). Reliability on the other hand measures the consistency of outcomes even when repeated (Saunders et al., 2016). Hair et al., (2014) indicated that the Cronbach

alpha is been adopted by many scholars for the measurement of how consistent relationships between variables are over time and that for internal consistency to be achieved, the Cronbach's alpha value should be more than 0.07.

These two measurement tools were considered from the beginning of this study to data analysis and hypothesizing to ensure the accuracy and consistency of the intended results (Samuel, 2015).

3.10 Ethical consideration

Ethical consideration is very important throughout every research process. It denotes accepting and developing generally acceptable principles that influence the conduct of a credible research study by respecting the integrity of all stakeholders of the study (Saunders et al., 2016).

The researcher has considered due diligence to ensure the credibility of this study by abiding by the ethical consideration research code of conduct outlined by the Kwame Nkrumah University of Science and Technology (KNUST) "Guide for the Preparation and Evaluation of Higher Degree Research Thesis" outlining the conduct of student research. The researcher solicited approval from the Association of Ghana Industry (AGI) to gain access to the sampled population and assure openness and treatment of confidentiality by declaring informed consent before data collection.

3.11 Profile of the Organization

The food processing sector is one of the sectors in the manufacturing industry in Ghana that makes an enormous contribution to the country's GDP but at the same time floods local SMEs with very minimal capital and degree of operations (Alembummah, 2015). The food processing sector is anticipated to have a considerable impact on the country's economy, but on the contrary one sector that is currently facing enormous challenges to thrive most likely because it is primarily characterized by SMEs (Ben Ayed et al., 2022). There are a variety of processing activities within the sector such as the manufacturing, processing, and preservation of a multiplicity of food, fruits, and beverages (Alembummah, 2015).

3.12 Conclusion

This chapter discusses the methodology of the study and makes use of the survey design to collect data from respondents in the food processing companies in Accra and Kumasi by adapting items from literature related to the study's constructs.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, AND DISCUSSION

4.1 Introduction

This chapter presents summaries of the data collected by the study carried out on the effect of digitalization on sustainable development: the mediating role of open innovation in the food processing sector in Ghana**.** Data summaries are subjected to analysis, interpretation, and blended to conclude and make appropriate recommendations in the subsequent chapter. The analysis was done with the aid of SPSS version twenty-five to present the findings using descriptive statistics such as frequencies, mean, and standard deviation in the form of tables, figures, percentages, and descriptive statements to draw inferences from them according to particular questions on the questionnaire as per the objectives and research questions. 165 responses were received. The research survey also adopted a multiple linear regression analysis to report how well digitalization can predict sustainable development in the food processing companies in Ghana.

The analysis was run under five different headings. That is, analyzing the demographic nature of the respondents, the perceptions of the three concepts that were used as the operational definition of digitalization (digital literacy, digital infrastructure, and digital platform) as provided by the following tables below and that of socio-economic and environmental characteristics to rate sustainable development in the food processing companies.

4.2 Response Rate Analysis

Response rate is just one significant indicator of how good the data sample of a community is. Still, it constitutes many common ways to measure the accuracy associated with an analysis (Montgomery et al., 2016). This study sought to investigate the measurable effects of digitalization mediated by OI to drive the food processing sector in Ghana to sustainable development. The selection of the elements was carefully chosen and filtered from the list of manufacturing companies in the database of the Association of Ghana Industry (AGI) which measures the likelihood that they are representative of the general population of the food processing companies in Ghana. Five hundred and eighty-one active manufacturing companies in Ghana are currently registered in the AGI's database, of which one hundred and seventy food and beverage companies in the Greater Accra and Ashanti regions were filtered from the database to be sampled.

The questionnaire was scrutinized by the research team to ensure ethical consideration. One hundred and ten were distributed in Accra and one hundred responses were retrieved; seventy were distributed in Kumasi and forty-four were retrieved. The responses were carefully verified for possible inconsistencies. The researcher found out that many were filled based on delegation of power, two were filled twice and care was taken to reject those with issues.

Response Rate (RR) $RR = \frac{\text{Number of Responses}}{\text{Number of } Survey\ Sent} \times 100$

$$\text{RR} = \frac{144}{170} \times 100 = 84.7\%$$

A response rate of 84.7% represents the proportion of the respondents who have completed the survey questionnaire, relative to 170 respondents who were targeted in the study. 84.7% is the ratio of individuals who responded to the research inquiry. A response rate of 84.7% is typically seen as advantageous in research due to its indication of substantial sample size and enhanced probability of obtaining data that accurately reflects the target population. An increased response rate enhances the generalizability of the results by mitigating the risk of non-response bias, which occurs when the characteristics of non-respondents differ substantially from those who did reply, distorting the findings.

Researchers frequently want to achieve high response rates to improve the reliability and validity of their findings. However, achieving a high response rate can be challenging, and factors such as follow-up reminders, and the nature of the research can impact participants' inclination to respond. It is imperative to acknowledge that although a high response rate is typically considered advantageous, the analysis and interpretation of study findings should not be exclusively predicated on the response rate. In addition to the aforementioned factors, it is imperative to take into account the representativeness of the sample, the suitability of the data collection methods, and potential sources of bias to derive significant findings from the study.

4.3 Demographic Characteristics of Respondents Company Profile

The demographics of respondents are very significant in this study determine the source of their responses and also, it can influence the choice of response needed to achieve the research questions.

Table 4:1 Frequency Distribution Table for Respondents

Variable		Frequency	Percent
Gender			
	Male	85	56.7
	Female	58	38.7
Age			
	< 20	5	3.3
	20-30	63	42.0
	31-40	52	34.7
	41-50	17	11.3
	51+	6	4.0
Education			
	No formal	1	.7
	Primary	2	1.3
	Vocational	9	6.0
	Secondary	46	30.7
	Tertiary	82	54.7
	Other	3	2.0
Ownership			
	Ghanaian	115	76.7
	Foreign	26	17.3
	State-run	2	1.3
Work Experience			
	0-10	127	84.7
	11-20	13	8.7
No. of Employees			
	<6	48	32.0
	6-29	39	26.0
	30-59	20	13.3
	60-99	10	6.7
	100+	26	17.3
Ann Revenue			
	<10.000	40	26.7
	10.000-50.000	48	32.0
	50.001-110.000	11	7.3
	100.001-150.000	14	9.3
	150.001-200.000	5	3.3
	200.001-500.000	9	6.0
	500.000-1.000.000	6	4.0
	>1.000.000	11	7.3
Company's operations			
	Processing & preservation of meat & fish products	11	7.3
	Processing beverages & vegetables (fruit juice)	9	6.0
	Processing starch/dairy/grain products	70	46.7
	Bakery & other food processing (restaurants)	7	4.7
	processing cash crops (chocolate, cashew…)	6	4.0

	processing of noodles & similar products	2	1.3
	Processing of malt, liquors & wines	2	1.3
	Processing of sugar	1	.7
	Processing of animal feed	30	20.0
Company Orientation			
	Locally street vented	16	10.7
	Solely Ghanaian	87	58.0
	Foreign Owned	25	16.7
	Joint venture ship	13	8.7
	Other	3	2.0
Legal form			
	Sole Proprietorship	80	53.3
	Limited Liability	27	18.0
	Partnership	21	14.0
	Public Limited Liability	9	6.0
	Other	7	4.7
Job title			
	CEO	2	1.3
	MD	14	9.3
	GM	16	10.7
	MD	23	15.3
	OP/PM	48	32.0
	LSCM	40	26.7
Geographical Scope			
	Accra	83	55.3
	Kumasi	48	32.0
	Accra & Kumasi	12	8.0
	Other	1	.7
Digital Technologies			
	Stage 1	42	28.0
	Stage 2	101	67.3
	Stage 3	21	14.0

Source: Field study (2023)

A majority of the research participants, specifically 56.7%, represent the male population, while a total of 38.7% represent females. The perceived gender distribution within the surveyed population under investigation may be indicative that there are more males in the food processing sector.

The age group with the highest proportion of respondents is between 20 and 30 years old, accounting for 42.0% of the total population. Approximately 34.7% of individuals are within the age range of 31 to 40 indicating that the participants surveyed are predominantly young. This may have significant ramifications for several factors such as level of experience, capacity to invest, decision-making processes, innovation, and many others.

A proportion of respondents, specifically 54.7%, hold a degree in higher education, and 30.7% of individuals possess a Secondary education suggesting a potentially high level of educational achievement within the surveyed population. This statement suggests that there is a certain level of skillset within the sector.

The data indicates a significant proportion of Ghanaian ownership, with 76.7% with a substantial portion of firms accounting for 53.3% operating as sole proprietorships. This highlights the prevalence of local entrepreneurs. This finding could have implications for domestic firms, the business environment, and the regulatory framework.

A large percentage of those surveyed (84.7%) have a range of job experience spanning from 0 to 10 years. This observation may suggest the presence of a relatively young workforce. The finding indicates that more respondents were operations/production managers (32.0%), implying that operational positions have considerable importance among the firms studied.

The data indicates that there is a notable representation of value chain members processing starch, dairy, and grain products with a prevalence of 46.7% suggesting their added value in the sector.

The statistics describing the size of employees and annual revenue provide an overview of the scope of the investigated businesses. The presence of a significant proportion, involving yearly revenues ranging from 10,000 to 50,000, may suggest the inclusion of Small to Medium-sized enterprises (SMEs) within the sector.

4.4 Descriptive Statistics for Items

Table 4:2 Items Descriptive Statistics

Items	N	Min	Max	Mean	S.D	Skewness	Kurtosis
Digitalization							
Stage 1 Digital Tech	144	1	7	4.91	2.717	-.656	-1.486
Stage 2 Digital Tech	144	1	3	1.36	.598	1.446	1.046
Stage 3 Digital Tech	138	1	7	2.88	1.340	1.008	1.658
DIFS1	143	1	7	4.34	2.018	-.401	-1.038
DIFS 2	143	1	7	4.69	1.858	-.562	-.656
DIFS 3	143	1	7	4.57	1.770	-.606	-.636
DIFS 4	143	1	7	4.70	1.843	-.679	-.412
DIFS 5	143	1	7	4.87	1.942	-.732	-.556
DICS 1	143	1	7	4.80	1.926	-.618	-.705
DICS 2	143	1	7	4.76	1.846	-.707	-.424
DICS 3	143	1	7	5.02	1.889	-.729	-.540
DICS 4	143	1	7	4.62	1.800	-.569	-.574
DICS 5	143	1	7	4.71	1.981	-.597	-.762
DINS 1	143	1	7	4.49	1.968	-.420	-.887
DINS 2	143	1	7	4.49	1.891	-.478	-.806
DINS 3	143	1	7	4.54	1.974	-.523	-.875
DISS 1	143	1	7	4.97	1.811	-.838	-.197
DISS 2	143	1	7	5.24	1.850	-.957	-.026
DISS 3	143	1	7	5.06	1.759	-.834	-.094
DISS 4	143	1	7	5.11	1.907	-.954	-.060
DITS 1	143	1	7	4.76	1.793	-.592	-.470
DITS 2	143	1	7	4.85	1.792	-.722	-.278
DITS 3	143	1	7	4.80	1.759	-.702	-.180
DITS 4	143	1	7	4.55	1.872	-.468	-.730
DITS 5	143	1	7	4.71	1.902	-.598	-.692
DITS 6	143	1	7	4.70	1.827	-.627	-.570
INF 1	143	1	7	3.67	2.065	.105	-1.271
INF 2	143	1	7	3.64	1.991	.211	-1.162
INF 3	143	1	7	3.99	1.952	-.128	-1.177
INF 4	143	1	7	4.42	1.941	-.258	-1.038
INF 5	143	1	7	3.92	1.937	.014	-1.093
INF 6	143	1	7	3.96	2.000	-.059	-1.157
PLAT 1	143	1	7	4.13	1.881	-.240	-1.019
PLAT 2	143	1	7	4.20	1.860	-.234	-.930
PLAT 3	143	1	7	4.35	1.832	-.411	-.793
PLAT 4	143	1	7	4.16	1.830	-.178	-.917
PLAT 5	143	1	7	3.97	1.885	-.102	-1.009

PLAT 6	143	1	7	4.09	1.744	-.165	-.691
Sustainable Development							
ECK 1	143	1	7	4.99	1.661	-.753	.029
ECK 2	143	1	7	4.98	1.642	-.769	.227
ECK 3	143	1	7	5.15	1.855	-.866	-.251
ECK 4	143	1	7	5.06	1.789	-.874	-.089
SOK 1	143	1	7	5.12	1.722	-.917	.238
SOK 2	143	1	7	5.06	1.733	-.897	.097
SOK 3	143	1	7	4.87	1.815	-.742	-.274
SOK 4	143	1	7	5.36	1.629	-.989	.440
SOK 5	143	1	7	4.92	1.873	-.611	-.624
ENK 1	143	1	7	4.14	2.040	-.227	-1.125
ENK 2	143	1	7	3.51	2.146	.300	-1.268
ENK 3	143	1	7	4.90	1.864	-.685	-.481
ENK 4	143	1	7	4.89	1.914	-.682	-.534
ENK 5	143	1	7	5.13	1.855	-.882	-.148
ECA 1	143	1	7	4.73	1.851	-.525	-.548
ECA 2	143	1	7	4.81	1.943	-.700	-.525
ECA 3	143	1	7	4.50	1.674	-.349	-.341
ECA 4	143	1	7	5.26	1.807	-.983	.170
SOA 1	143	1	7	5.39	1.636	-1.267	1.372
SOA 2	143	1	7	5.46	1.626	-1.146	.849
SOA 3	143	1	7	5.31	1.729	-1.141	.744
SOA 4	143	1	7	5.38	1.618	-1.300	1.376
SOA 5	143	1	7	5.02	1.705	-.845	.067
SOA 6	143	1	7	5.45	1.747	-1.209	.772
ENA 1	143	1	7	3.93	1.970	-.103	-1.169
ENA 2	143	1	7	5.35	1.896	-1.181	.373
ENA 3	143	1	7	5.17	1.754	-.899	.093
ENA 4	143	1	7	4.08	1.970	-.169	-1.073
SOB 1	143	1	7	5.10	1.763	-.967	.287
SOB 2	143	1	7	4.06	1.994	-.093	-1.139
SOB 3	143	1	7	4.54	1.902	-.443	-.777
ENB 1	143	1	7	5.12	1.685	-1.077	.750
ENB 2	143	1	7	5.08	1.773	-.895	.104
ENB 3	143	1	7	4.67	1.920	-.617	-.675
ENB 4	143	1	7	3.30	1.928	.246	-1.188
ENB 5	143	1	7	4.80	1.668	-.716	.065
ENB 6	143	1	7	4.92	1.808	-.870	-.103
Open Innovation							
OI 1	143	1	7	4.42	1.801	-.582	-.526
OI 2	143	1	7	4.60	1.796	-.522	-.500
OI 3	143	1	7	4.84	1.706	-.600	-.296

OI 4	143	1	7	4.66	1.644	-.556	-.292
OI 5	143	1	7	4.64	1.709	-.510	-.367
OI 6	143	1	7	4.63	1.739	-.555	-.275
OI 7	143	1	7	4.62	1.678	-.552	-.169
OI 8	143	1	7	4.83	1.797	-.694	-.320
OI 9	143	1	7	4.41	1.642	-.395	-.386
OI 10	143	1	7	4.55	1.698	-.521	-.333

Source: Field study (2023) Note: Items are stated in Appendix A

4.5 Exploratory Factor Analysis (EFA)

Table 4:3 Rotated Component Matrix

	Component										
Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Eigenvalues**	**% of Variance**	**Corrected Correlation**	**Cronbach's α if items deleted**
DIFS1	**0.637**	0.221	0.131	0.136	0.305	0.349	0.006			.765	.978
DIFS2	**0.688**	0.255	0.162	0.199	0.237	0.204	0.111			.798	.978
DIFS3	**0.673**	0.186	0.077	0.254	0.285	0.226	-0.033			.756	.978
DIFS4	**0.629**	0.169	0.211	0.215	0.217	0.347	0.238			.805	.977
DIFS5	**0.626**	0.182	0.289	0.172	0.246	0.351	0.167			.821	.977
DICS1	**0.659**	0.290	0.280	0.262	0.132	0.129	0.176			.815	.977
DICS2	**0.696**	0.200	0.316	0.307	0.222	0.070	0.216			.868	.977
DICS3	**0.698**	0.436	0.172	0.199	0.156	0.034	0.243			.843	.977
DICS4	**0.705**	0.258	0.301	0.164	0.204	0.094	0.172			.852	.977
DICS5	**0.716**	0.219	0.240	0.235	0.238	0.004	0.211			.841	.977
DINS1	**0.644**	0.237	0.110	0.346	0.249	0.150	0.090	53.119	19.182	.816	.977
DINS3	**0.569**	0.393	0.017	0.374	0.217	0.143	0.222			.789	.978
DISS1	**0.670**	0.400	0.235	0.153	0.086	0.024	0.322			. 810	.977
DISS2	**0.707**	0.267	0.414	0.196	0.060	0.033	0.117			.810	.977
DISS3	**0.711**	0.326	0.328	0.145	0.137	0.152	0.098			.851	.977
DISS4	**0.713**	0.279	0.270	0.197	0.104	0.132	0.170			.823	.977
DITS2	**0.524**	0.104	0.426	0.298	0.165	0.165	0.295			.777	.978
DITS6	**0.553**	0.162	0.217	0.228	0.418	0.347	0.039			.796	.978
INF1	0.332	0.117	0.148	0.214	**0.769**	-0.073	0.149			.795	.904
INF2	0.250	0.207	-0.018	0.290	**0.749**	0.167	0.057			.787	.905

INF3	0.307	0.082	0.144	0.318	**0.737**	0.057	0.078	2.513	7.559	.819	.901
INF4	0.328	0.261	0.171	0.122	**0.643**	0.135	0.306			.740	.911
INF5	0.199	0.135	0.113	0.451	**0.656**	0.219	0.143			.795	.904
PLAT1	0.315	0.166	0.123	**0.675**	0.236	0.120	0.068			.774	.910
PLAT2	0.412	0.144	0.156	**0.664**	0.275	0.195	0.089			.830	902
PLAT3	0.376	0.236	0.277	**0.639**	0.197	-0.015	0.068	3.427	9.112	.766	.911
PLAT4	0.283	0.213	0.201	**0.752**	0.160	0.134	0.049			.794	.907
PLAT5	0.223	0.139	0.063	**0.776**	0.261	0.205	0.086			.793	.907
PLAT6	0.175	0.266	-0.020	**0.722**	0.185	0.098	0.251			.715	.917
OI2	0.345	0.101	0.354	0.108	0.283	0.388	**0.548**			.785	.938
OI3	0.264	0.202	0.332	0.138	0.120	0.234	**0.629**			.774	.939
OI4	0.332	0.309	0.137	0.210	0.192	0.125	**0.720**	2.119	5.355	.791	.938
OI5	0.372	0.137	0.182	0.219	0.296	0.281	**0.607**			.751	.940
ECK1	0.246	**0.680**	0.374	0.119	0.089	0.125	0.080			.805	.783
ECK2	0.306	**0.639**	0.428	0.188	0.090	0.119	0.003			.754	.805
ECK3	0.320	**0.707**	0.325	0.142	0.036	0.240	0.104			.574	.874
ECK4	0.253	**0.681**	0.379	0.247	0.073	0.130	0.161			.711	.823
SOK1	0.209	**0.782**	0.219	0.156	0.149	0.073	0.211	7.329	14.397	.822	.874
SOK2	0.367	**0.624**	0.261	0.176	0.180	0.235	0.158			.798	.879
SOK3	0.224	**0.734**	0.221	0.118	0.056	0.160	0.298			.796	.879
SOK4	0.164	**0.715**	0.328	0.224	0.149	0.076	0.143			.819	.876
SOK5	0.252	**0.563**	0.329	0.120	0.124	0.046	-0.063			.609	.920
ENK4	0.241	**0.615**	0.144	0.246	0.207	0.341	0.051			.691	.723
ENK5	0.319	**0.638**	0.223	0.114	0.199	0.189	-0.001			.609	.750
ECA4	0.417	0.298	**0.657**	0.081	0.031	0.200	0.151			.711	.823
SOA1	0.326	0.346	**0.700**	0.061	0.090	0.271	0.094			.853	.925
SOA2	0.298	0.378	**0.691**	0.127	0.089	0.224	0.130			.871	.923
SOA3	0.241	0.394	**0.660**	0.269	0.141	0.138	-0.024	3.804	12.604	.809	.930

SOA4	0.249	0.388	**0.744**	0.089	0.044	0.249	0.144			.894	.920
SOA5	0.114	0.311	**0.708**	0.043	0.214	0.104	0.020			.732	.940
SOA6	0.203	0.315	**0.705**	0.063	0.109	0.170	0.214			.772	.935
ENA2	0.267	0.282	**0.673**	0.175	0.017	0.096	0.282			.623	.615
SOB3	0.098	0.201	0.188	0.203	0.186	**0.697**	0.080			.544	.383
ENB1	0.253	0.456	0.352	0.101	0.112	**0.553**	0.262			.784	.774
ENB2	0.210	0.297	0.433	0.101	0.163	**0.545**	0.186	2.440	6.542	.735	.790
ENB3	0.259	0.234	0.241	0.262	-0.024	**0.626**	0.223			.691	.790
ENB5	0.311	0.195	0.452	0.105	0.000	**0.599**	0.202			.750	.781

Source: Field study (2023)

Factor analysis is a crucial tool used in the creation, improvement, and assessment of tests, scales, and measurements (Williams et al., 2010). The EFA is used to analyze, examine datasets, and summarize the main characteristics which aid in identifying underlying latent constructs that explain the patterns of correlations among observed variables (Henson and Roberts, 2006, Pett et al., 2003, Swisher et al., 2004, Thompson, 2004). To come up with the survey scales, we reviewed the literature to identify the available scales used to measure digitalization, sustainable development, and open innovation. From the literature, we found out that there are several scales used to measure the study constructs, but the majority of them measure digitalization, and sustainable development in different industries creating a gap that this study seeks to fill. To fill this gap, we measure digitalization, sustainable development, and open innovation in the food processing sector in Ghana which has not been measured using these constructs. While reviewing the literature, we discovered several items used to measure these constructs, we adapted those we deemed appropriate to measure the study's constructs.

We grouped these items into particular dimensions and those dimensions led us to measure the study's constructs.

Construct ⟶ dimensions ⟶ sub-dimensions ⟶ items

Loading means how well the item is associated with its parent construct. We expect all items under each sub-dimension to load together. We operationalize Digitalization to have three dimensions and seven sub-dimensions, three dimensions and three sub-dimensions for each dimension for sustainable development, while open innovation operationalizes as a construct.

To derive meaning from the outcomes of the EFA, we scrutinize the loadings of individual variables on the extracted components. Variables that exhibit high loadings on a specific component are regarded as having a strong association with that component. The other components with relatively lower loadings may not have clear interpretations or may represent less significant latent constructs in this analysis.

A principal component analysis was conducted to do an exploratory factor analysis (EFA), with a varimax rotation applied. Only factor loadings greater than 0.50 were taken into consideration. A test of commonality of scale was conducted to determine the number of variants present in each dimension, to ensure satisfactory levels of explanation. The findings indicate that commonalities with values greater than 0.50 are deemed significant.

One crucial procedure entails evaluating the overall importance of the correlation matrix using Bartlett's Test of Sphericity. This test assesses the statistical likelihood that the correlation matrix reveals strong correlations between certain components. The obtained result, 8964.641, reveals statistical significance, suggesting that the data is appropriate for doing factor analysis. The Kaiser-Meyer-Olkin (KMO) statistic, which assesses the Sampling Adequacy (MSA) as well as determines the suitability of the data for factor analysis, generated a value of 0.931. In this context, data sets with MSA values of 0.800 are deemed suitable for conducting factor analysis. Eventually, the investigation revealed a factor solution consisting of seven factors that accounted for 53.119% of the variations observed.

Component 1: This component has strong loadings on variables associated with digital literacy skills. The variables in question exhibit loadings ranging from moderate to high on this particular component, indicating a significant degree of shared variance about the notion of interpersonal skills. Component 2: This particular component exhibits strong correlations with variables associated with the constructs of socio-economic and environmentally sustainable knowledge. The items could potentially serve as indicators of a construct that is associated with digital infrastructure. Component 3: This analysis reveals that this particular component exhibits notable loadings on variables associated with social and environmentally sustainable attitudes. The latent variables appear to embody an underlying concept that encompasses abilities and actions linked to digital platforms. Component 4 has strong loadings on variables associated with the domains of digital platforms. This concept perhaps pertains to the capacity of individuals to effectively handle work and maintain organizational skills. Component 5 exhibits substantial loadings on variables associated with the concepts of digital infrastructure. The latent variables appear to encompass an underlying construct that represents the ability to make effective decisions. Component 6 has strong loadings on variables associated with the constructs of social and environmental sustainability behaviors. The construct in question pertains to the problem-solving talents and critical thinking capabilities exhibited by individuals. Component 7 exhibits a less pronounced pattern of loadings in open innovation, hence presenting difficulties in discerning a distinct interpretative theme. This particular component may potentially embody a hidden construct that is less conspicuous or narrowly defined.

It is crucial to acknowledge that the interpretation of the components is highly contingent upon the contextual factors and theoretical framework underpinning the data. To enhance the precision and significance of the interpretation, it is necessary to possess knowledge regarding

the designations and substance of the items inside each component, as well as the particular survey setting. In addition, researchers need to take into account theoretical frameworks, existing knowledge within the field, and the research objectives to achieve a full understanding of the components that have been extracted.

Nevertheless, the EFA analysis revealed that out of 36 items measuring "Digitalization", 29 loadings were significant, 24 were significant out of 37 for sustainable development, and 4 out of 10 were equally significant for open innovation.

Table 4:4 Summary of Exploratory Factor Solutions

Digitalization	Items	Loads	Sustainable Development	Items	Loads	Open Innovation	Items	Loads
DigLit			ECK	4	4	OI	10	4
DIFS			SOK	5	5			
DICS			ENK	5	2			
DINS	23	17	ECA	4	1			
DISS			SOA	6	6			
DITS			ENA	4	1			
INF	6	5	SOB	3	1			
PLAT	6	6	ENB	6	4			
Total	**35**	**28**		**37**	**24**		**10**	**4**

Source: Field study (2023)

4.6 Confirmatory Factor Analysis (CFA)

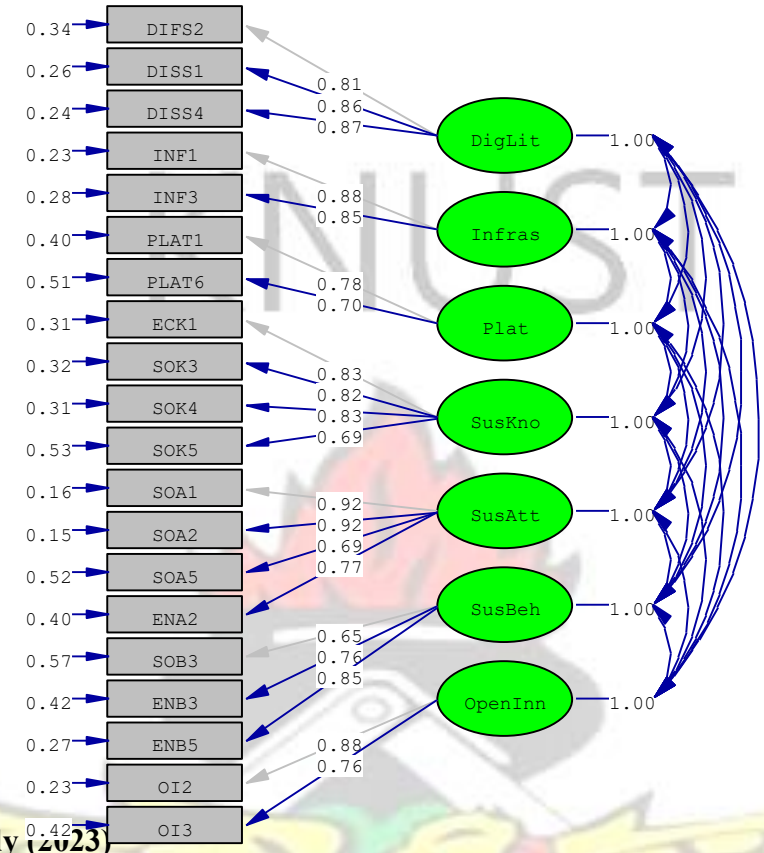
Confirmatory factor analysis (CFA) is a statistical technique that analyzes how well the study's indicators measure the unobserved constructs (commonly referred to as a factor) and if the unobserved constructs are uniquely different from one another. These unobserved constructs from the EFA were analyzed under CFA to determine any issue from the variable factors. This analysis was run with Lisrel version 8.8.

Table 4:5 Summary of Factor Solution

Degrees of Freedom	149
Minimum Fit Function Chi-Square	447.73 (P=0.0)
Root Mean Square Error of Approximation (RMSEA)	0.071
Non-Normed Fit (NNFI)	0.93
Comparatve Fit Index (CFI)	0.94
Standardized RMR	0.037

Source: Field study (2023)

Figure 4:1 Factor Solution Diagram



Source: Field study (2023)

In a diagrammatic format, an unobserved variable is represented by an oval circle, the indicators are represented in a rectangle, and the arrows emanating from the factor represent the influence of the unobserved construct on its indicators. Statical estimates of these direct effects are called factor loadings and are interpreted as regression coefficients.

Each factor loading showed statistical significance at a level of 1%. The confirmation of convergent validity measures is supported by the significant and positive loadings, as demonstrated in the study conducted by Boso et al. (2013).

4.7 Measurement Model Analysis

Before proceeding with the modeling of the theoretical model for the study, it was imperative to evaluate both the convergent and discriminant validity of the items employed in measuring the constructs. Convergent validity is a technique employed to evaluate the extent to which a measurement tool has a strong correlation with other metrics that test a similar underlying construct (Hair Jr et al., 2021). Discriminant validity is an essential element of construct measurement, as it confirms how the parameter is distinct and experimentally captures specific trends that are significant that are not accounted for by other indicators within a structural

equation model (Hair Jr et al., 2021). Three procedures were implemented. This study employed reliability testing, exploratory factor analysis (EFA), and confirmatory factor analysis (CFA) techniques. Convergent validity is established when factor loadings indicate positive values.

Table 4:5 Summary of Construct Reliability and Validity

No.	Retained Construct	No. items	Loading	AVE	CR	CA
1	**Digital Literacy (DigLit)**			0.717	0.884	.883
	Information is accessed from the digital environment.		0.81			
	Ensure messages do not cause bad feelings to other stakeholders	3	0.86			
	We are concerned about the protection of privacy and security		0.87			
2	**Digital Infrastructure (INFRAS)**			0.748	0.856	.853
	There exists sufficient Internet broadband access	2	0.88			
	There exists a sufficient internet penetration rate		0.85			
3	**Digital Platform (PLAT)**			0.549	0.708	.700
	Our Internet of Things platform is effectively driven by logistics	2	0.78			
	An efficient platform has triggered revenue growth		0.70			
4	**Sustainability Knowledge (SusKno)**			0.6315	0.772	.865
	Responsible acts towards stakeholders are needed for sustainable development		0.83			
	Engaging in social issues is needed for sustainable development	4	0.82			
	Respecting cultural diversity is needed for sustainable development		0.83			
	Fighting diseases is required for sustainable development		0.69			
5	**Sustainability Attitude (SusAtt)**			0.690	0.884	.865
	Acquiring skillset is needed for sustainable development		0.92			
	The future generation should enjoy a quality life as today	4	0.92			
	Government decisions are based on sustainable development		0.69			
	The environment needs stricter laws and regulations		0.77			
6	**Sustainability Behavior (SusBeh)**			0.574	0.800	.796
	Working in committees improves work		0.65			
	We recycle as much as possible	3	0.76			
	Food waste is always separated before thrashing		0.85			
7	**Open Innovation (OpenInn)**			0.676	0.806	.799
	Joint decision with stakeholders improves creativity	2	0.88			
	Expanded new market opportunities and customer base		0.76			

Source: Field study (2023)

Table 4:5 displays a collection of maintained items, together with their standardized loadings, Average Variance Extracted (AVE), Composite Reliability (CR), Cronbach Alpha (CA), and t-values.

Construct reliability was assessed using Cronbach's Alpha. The results in Table 8 revealed that Digital Literacy with three items of α =.883 is good, Digital Infrastructure with two items of α =.853 is good, Digital Platform with three items of α =.700 is acceptable, Social Sustainability Knowledge with four items of α =.865 is good, Social Sustainability Attitude with four items of α =.865 is good, social sustainability Behavior with three items of α =.779 is acceptable, and Open Innovation with two of α =.779 is acceptable.

4.8 Correlation Matrix

The primary objective for performing correlation analysis is more or less consistent across all studies. Correlation analysis is predominantly employed to determine the causal association between control and observed variables under investigation; When considering the presence of a mediating variable, the regression model must include a minimum of three variables, one of which should be the control variable (Senthilnathan, 2019). That is, a basic correlation analysis determines the level of proximity between two interconnected variables. The correlation coefficient, denoted as r or R, serves as a quantitative metric that offers insights into the degree of proximity between two variables. In an instance where variable "B" functions as a mediating variable in the transformation of certain data from variable "A" to predict variable "C," it is expected that the coefficient estimates for both variables "A" and "B" will be statistically significant at a certain level when $p<0.05$ (Senthilnathan, 2017).

Table 4:6 Correlation Matrix and Discriminant Validity Results

Variables	1	2	3	4	5	6	7
Digital Literacy	**.847**						
Digital Infrastructure	.562**	**.865**					
Digital Platform	.585**	.589**	**.740**				
Sustainable Knowledge	.661**	.404**	.490**	**.795**			
Sustainable Attitude	.661**	.400**	.397**	.727**	**.831**		
Sustainable Behavior	.591**	.317**	.474**	.572**	.647**	**.758**	
Open Innovation	.606**	.474**	.466**	.534**	.654**	.671**	**.822**

Source: Field study (2023) **. Correlation is significant at the 0.01 level (2-tailed).

Note: The diagonal line is the square root of the AVEs, the other entries represent the correlation.

Table 4:6 demonstrates the output of composite reliability and discriminant validity that were significant and accepted in Table 4:5 with values >.60 (Bagozzi and Yi, 2012).

4.9 Reliability and Validity Analysis

Validity and reliability are two main important concepts in the acceptability of the use of our instrument for appropriateness and consistency in measuring our study. While validity is the strength of the conclusions, inferences, or proportions; reliability is the degree to which our research instruments were measured the same way each time it was used under the same condition with the same subjects. The estimated values of validity and reliability coefficients adopted depend on the study. However, conventionally, a coefficient value of ≥ 0.70 or 70% is acceptable in research (Hair Jr et al., 2020, Kathuri and Pals, 1993).

4.10 Regression Analysis

The increasing attention by scholars toward regression-based evaluation of contexts can be attributed to their recognition of the significance of addressing the challenge of developing suitable theories that represent the correlation involving the system's variables and external variables, particularly in the presence of uncertainties (Seraya and Demin, 2012). The issue of measuring the variables of regression models in scenarios where test findings and control variable estimates are subject to measurement inaccuracies has also been extensively examined and proven biased (Seraya and Demin, 2012). Hair et al. (2006) asserted that it is essential to allow data to conform to both non-linear and non-normal distributions, since deviations from these distributions may affect the quality of the data and subsequently impact one or more inferences that could have been generated (Hair Jr et al., 2014).

4.10.1 Linear Regression

The correlation of the propositions has been examined using linear regression. Moreover, linear regression plays a fundamental role in several existing statistical methods. Despite the existence of several criticisms relating to employing linear regression, many aspects were factors that led to its consideration within the present research. For example, in cases where the number of samples examined is small or the degree of signal strength is low, linear regression often offers a satisfactory estimation for the underpinning analysis function (Su et al., 2012). Reasons the researcher opted for linear regression. Consequently, a small number size of 136 was deemed suitable for conducting linear regression analysis. The study selected the linear model due to its straightforward parametric structure and comprehensibility. Moreover, a significant number of researchers possess a strong understanding of statistically advanced concepts related to linear models. Also analyzing linear regression data is widely regarded as one of the greatest uncomplicated and often employed methods for assessing correlations as

against simple regression that involves a single analysis with just one predictor and outcome variables (Hope, 2020).

Table 4:7 Regression Analysis

Controls	**Sustainable Development**					
	Model1	**Model2**	**Model3**	**Model4**	**Model5**	**Sign**
	β(t-values)	β(t-values)	β(t-values)	β(t-values)	β(t-values)	
Age	.169(1.382)	.215(2.326)	.164(1.951)	.159(1.891)	.201(1.919)	.169
Ownership	.118(.421)	.154(.730)	.193(1.005)	.184(.961)	.100(.416)	.276
Education	.161(1.093)	-.011(-.094)	-.035(-.345)	-.031(-.304)	.069(.545)	.675
Direct Path						
Digitalization		.595(10.344)				.000
Digital Literacy			.462(5.584)			.000
Digital Infrastructure				-.136(-1.416)		.159
Digital Platform					.428(7.205)	.000
R^2	.023	.452	.554	.560	.292	
Adjusted R^2	.002	.436	.537	.541	.271	
R^2 Changed	.023	.428	.102	.007	.268	
F	1.092	107.000	31.180	2.005	51.914	

Source: Field study (2023)

Linear regression was employed to analyze the direct relationship between the variables in the study starting with some of the control variables (age, ownership, and education) on digital literacy, digital infrastructure, and digital platform. The output reveals an insignificant relationship between the control variables and the explanatory variables indicating the control variables do affect the relationship between digitalization and sustainable development. The output also indicates that digitalization, digital literacy, and digital platforms significantly affect sustainable development, while the relationship between digital infrastructure and sustainable development is insignificant.

4.10.2 Mediation Analysis

Researchers employ mediation analysis to examine the impact of an independent variable over an intervening variable, which further affects the outcome variable. Most scholars employ direct correlation and overlook the effects of intervening variables, which can lead to bias of output (MacKinnon et al., 2012). The PROCESS procedure for SPSS was developed by Hayes. It is now recognized as the prevailing method in statistics widely employed to run modern-day mediation and moderation analysis. The tool provides detailed paths, such as mediated moderation, which are not available in additional estimation techniques like structural equation modeling (SEM). The PROCESS software enhances the range and complexities of modeling integrating both a moderator and a mediator while integrating the functionalities of existing programs into a unified and simple-to-operate command (Edwards and Lambert, 2007).

One feature of this instrument for statistics is its ability to specify several mediator variables that have to act simultaneously, distinguishing it from other methods of analysis. The mediation process is culpable for generating both direct and indirect effects. It is generally advised to have a sample size of at least 200 for doing structural equation modeling (SEM) (Kline, 2023). Consequently, the utilization of PROCESS for the mediation analysis was deemed suitable due to this specimen of participants in the present research being 150, therefore dropping less than the threshold of 200.

It may appear redundant to conduct additional investigation into the presence of a mediated effect in the event there is no apparent impact on the intervening variable. However, this assertion is valid only in instances where complementary mediation is observed within a theoretical framework (Zhao et al., 2010). Complementary mediation occurs when the mediator path aligns with the same positive or negative effect direction as the indirect path connecting the independent variable (IDV) and the dependent variable (DV) (Hayes, 2009). Therefore, in the process of generating mediating predictions, the main interest lies in examining the impact of the independent variable (X) on the dependent variable (Y) through the mediating variable (W) (Baron and Kenny, 1986). According to Preacher and Hayes (2008), the summarized method suggests that variable W acts as a mediator when variable X has a substantial influence on both variable Y and variable W and when W considerably explains the variability observed in variable Y. The researchers have identified a concern regarding the limited incidence of a mediator, which is contingent upon the fulfillment of specific requirements. Considerable challenges have been posed to this method.

In light of these drawbacks, scholars have examined alternative methodologies for analyzing mediating effects. These methodologies involve first assessing the indirect effect, followed by

evaluating the strength of the indirect effect, and finally employing a bootstrap test to determine the statistical significance of the indirect effect of variable X on variable Y (Preacher and Hayes, 2008, Shrout and Bolger, 2002, Zhao et al., 2010).

The consideration of the relationship between X and Y is not necessary when assessing whether W mediates the effect of X on Y, as this path is not included in the mediated effect unless it is supported by relevant theories (Aguinis et al., 2017).

Indirect effect (X*Y) = total effect(w)-direct effect (w')

This study aims to assess the statistical significance of the indirect effect of variables X and Y in the context of examining the mediating effect. When the indirect effect is significant, it is recommended to evaluate the direct effect (w') as well. If the coefficient of w' is found to be statistically insignificant, it can be concluded that full mediation is present (Hayes and Rockwood, 2017). Conversely, if the direct effect is found to be statistically significant, it indicates partial mediation.

Table 4:7 Mediation Analysis Summary

TOTAL, DIRECT, AND INDIRECT EFFECTS OF X, Y, AND W

Model Summary

R	R-sq	MSE	F	df1	df2	P
.810	.656	.550	28.254	5.000	74.000	.000

Model

	Coeff	**Se**	**t**	**P**	**LLCI**	**ULCI**
Constant	1.463	.721	2.031	.046	.027	2.899
Digit	.295	.069	4.277	.000	.158	.433
OpenInn	.463	.061	7.579	.000	.342	.585
Age	.062	.094	.660	.512	-.125	.248
Ownership	-.112	.191	-.585	.561	-.493	.269
Education	-.003	.116	-.022	.983	-.233	.228

The control variables were introduced to examine if they could have an impact on the mediation results, but Table 4:7 shows all their p-values are insignificant.

Direct Effect(s) of Digitalization on Sustainable Development

Effect	Se	T	P	LLCI	ULCI
.295	.069	4.277	.000	.158	.433

Indirect Effect(s) of Digitalization on Sustainable Development

	Effect	BootSE	BootLLCI	BootULCI
W	.250	.070	.117	.391

Source: Field study (2023)

Note: Digitalization-Digit (X), Sustainable development (Y) Open Innovation-OpenInn (W)

In testing for mediation using Hayes PROCESS, one of the fundamentals that should be met is that, zero (o) should not appear between the BootLCI and the BootULCI of the indirect path. Also, for there to be a partial or full mediation, the indirect effect should disappear or weaken provided there is a statistical significance ($p \leq 0.05$).

The data revealed that there is partial mediation because the indirect effect of digitalization on sustainable development is significant, both BootLCI and BootULCI have positive values and zero (0) is absent between the limits; also, because the coefficient of indirect is less than the total effect.

When digitalization was run on sustainable development, the direct effect(s) was .295, but when OI was introduced as an intervening variable into the equation, it reduced the direct effect(s) from .295 to .250 indicating open innovation plays a role in mediating the effect of digitalization on sustainable development. This is one of the contributions to the literature from the study.

Table 4:8 Hypothesized Paths

Hypotheses	Path	Coefficient	T-value	P-value	Remark
H1	Digit→SD	.595	10.344	.000	Supported
H2	DigitLit→SD	.462	5.584	.000	Supported
H3	DigitPLAT→SD	.428	7.205	.000	Supported
H4	DigitInfras →SD	-.136	-1.416	.159	Not Supported
H5	Digit→OpenInn→SD	.250	3.57	.000	Supported

Source: Field study (2023)

Note: Digitalization (Digit), Digital Literacy (DigitLit), Digital Platform (DigitPLAT), Digital Infrastructure (DigitInfras), Sustainable Development (SD), Open Innovation (OpenInn).

4.11 Discussion of Findings

The notion of digitalization and sustainable development has become the core focus of transforming businesses and society. The holistic drive of digitalization on sustainable development mediated by open innovation has not yet received much attention, especially in food processing in Ghana. Literature posited that this sector is flooded by very small-scale business owners and particularly the female workforce who are largely unskilled in producing high-value products and some of the businesses are sole/family owned which employ traditional tools and also lack adequate knowledge in food processing (Owoo and Lambon-Quayefio, 2017); making it very difficult for the government to achieve its flagship programs such as the "Planting for Food and Jobs," "an e-registration platform for farmers", "an electronic, agricultural input distribution system with barcodes" and “One District One Factory (1D1F)” initiatives have failed to meet its objectives (Ali et al., 2021). Coupled with a lack of seamless flow of information sharing between stakeholders using emerging digital technologies, poor digital infrastructures, digital platforms plagued with cyber criminality, a remarkable shift in taste of fast food without corresponding demand to meet supply (Agyapong, 2021, Andam and Silver, 2016). Consequently, this study sought to answer the research question of what measures of digitalization drive sustainable development? By way of objectives, the study sought to determine the relationship between digitization and sustainable development, the relationship between current digital skills and sustainable development, and the mediating role of open innovation in the relationship between digitization and sustainable development. From the dynamic capability theory perspective and Theory of Acceptance and Use of Technology perspective, a cross-sectional design and modified questionnaires from the literature was used to collect data from respondents of food processing firms in Ghana. Measurement validation was done by the covariance-based confirmatory factor analysis using Mplus 7.5 software. Statistical Package for Social Sciences (SPSS) version 25, and Hayes Process Model analysis.

In assessing the association between digitalization and sustainable development, the statistical output revealed that there is a significant relationship confirming the first hypothesis probably because of the motivation by the World Bank’s requirement to have all African companies digitalized by 2030 as well as the advancement in its literacy skills advocacy on digitization to minimize post-harvest food waste, boost good dieting, and improve business networking opportunities; and also considering the importance of sustainable development to abate poverty, trigger performance seeks ways of streamlining operations by an appropriate

implementation using advanced technologies (Bag et al., 2021). Based on other findings, it can be established that digitalization has a positive significance on sustainable development. It has been argued that the prevailing perspective on digitalization mostly focuses on profit motives, indicating a limited focus on sustainability. This preference towards prioritizing business objectives has the potential to contribute to the deterioration of non-sustainable trends in development, hence hindering the achievement of sustainable development, although this particular perspective was identified across various organizations, albeit with varying levels of prevalence (Niehoff, 2022). Even though the adoption of digitalization is not a guarantee for sustainable development (Cui et al., 2022).

The output also indicated that digital literacy significantly affects sustainable development supporting hypothesis two. In today's technologically focused world, the development of the digital economy and the prevalence of the "Internet of Things" have made computer skills and competencies very useful resources for sustaining people's ambitions, especially in their local vernacular (Radovanović et al., 2020). Notwithstanding a systemically established technological disparity in most parts of Africa especially some sampled populations of this study (Sharma et al., 2016). Again, the results showed that digital platforms significantly affect sustainable development supporting hypothesis three.

Recent findings claimed that developing operating systems centered around digital platforms may effectively balance economic and environmental goals, hence boosting sustainable development (Reuter, 2022). It is nevertheless important to note that relying solely on digital platforms is insufficient for attaining an edge over our competitors. The full benefits of digital platforms are only achievable once they are integrated into the resources and competencies of a business (Wang et al., 2022a). Sadly, however, it is inevitable that several cybercrimes in safeguarding private policy in the internet-based ecosystem cannot be mitigated (Stepanova et al., 2020).

While the relationship between digital infrastructure and sustainable development is insignificant. In line with the literature, considering the emergence of technological innovation, the research community has consistently emphasized the significant role played by internet connectivity and digitalization in facilitating exchanges across multiple tiers (Forman, 2005, Mack, 2014, Maiga et al., 2015, Vial, 2021). Moreover, research demonstrated that the key elements that enhance the development of technology also comprise factors outside the business like the environment, which hold significant influence (Kraus et al., 2019, Orlandi et al., 2021, Scott, 2007). This implies digital infrastructure does not drive sustainable development.

Lastly, the output indicated that open innovation plays a role in mediating the effect of digitalization on sustainable development confirming hypothesis five. It has been established that innovative sustainability and value co-creation can be achieved when organizations implement OI programs between all stakeholders, therefore paving the way for a sustainable community (Aquilani et al., 2020). Another study posited that while open innovation has a very strong relationship between academia and practitioners, it can however make a considerable sustainable contribution to innovation depending on the circumstance and rate of implementation (Osorno-Hinojosa et al., 2022).

4.12 Conclusion

This chapter presents the findings of the statistical assessment conducted for the study and the results were discussed. The demographic and descriptive analysis was performed on the firm's characteristics. The reliability and validity of the construct were subsequently analyzed using a standardized measure. The subsequent section focuses on the examination and verification of the factor analysis, measurement model analysis, correlation matrix, regression analysis, mediation effects, and research hypotheses about the interrelationships of digitalization on sustainable development mediated by open innovation

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

This chapter serves as the conclusive part of the study, providing an overview of comprehensive outcomes, a summary of findings, and implications. Additionally, it lays a foundation for future research endeavors. After the analysis is conducted, recommendations for future study are later presented to support the formulation of policy directions aimed at establishing a robust digitalization that drives sustainable development mediated by open innovation.

5.2 Summary of Findings

The findings are summarized according to the study's objectives:

5.2.1 Digitalization and Sustainable Development

Objective one of the studies analyzed the relationship between digitalization and sustainable development. The outcome of the analysis indicated that there is a strong significant relationship between digitalization and sustainable development as hypothesized and also confirmed in a previous study by (Jovanović et al., 2018). Despite the clarity that digitalization provides innovative possibilities as well as challenges for the management of businesses and for achieving their sustainable targets, the relationship between the two has only been the focus of negligible studies (Ionescu-Feleagă et al., 2023).

5.2.2 Digital Literacy and Sustainable Development

Objective two of the studies analyzed the relationship between digital literacy and sustainable development. The analyzed data showed that there is a strong significant relationship between digital literacy and sustainable development as posited by hypothesis two and confirmed by Radovanović et al. (2020) who argued that acquiring digital skills constitutes a manifestation of a person's digital capital and holds significant importance in the realms of continuous education, prospects, enhanced quality of life, and sustained progress. However, this analysis does not support this hypothesis in areas where there is still a disparity in the digital divide (Sharma et al., 2016).

5.2.3 Digital Platform and Sustainable Development

The study again hypothesized that there exists a relationship between digital platforms and sustainable development. The analyzed data showed that there is a strong significant relationship between digital platforms and sustainable development as presumed. Literature

affirmed that digital platforms represent three key qualities: technological mediation, facilitating of relationships across a variety of stakeholders, as well as enabling them to achieve sustainable development (Bonina et al., 2021, Cusumano et al., 2019, Gawer, 2021).

5.2.4 Digital Infrastructure and Sustainable Development

The study further hypothesized that there exists a relationship between digital infrastructure and sustainable development. The analyzed data showed that the relationship between digital infrastructure and sustainable development was insignificant and did not support this proposition. Digital "infrastructure" stimulates inclusive high-tech enlightenment (Sharma et al., 2016), and has a great influence on sustainable development (Remondino and Zanin, 2022). Nevertheless, it is commonly acknowledged that the apportionment of wireless internet infrastructures displays heterogeneity, resulting in varying speeds throughout different environments. This geographically specific technological gap provides opportunities to businesses that possess access to superior infrastructures (Mack, 2014).

5.2.5 Digitalization, Open Innovation, and Sustainable Development

Lastly, the study hypothesized that the indirect relationship between digitalization and sustainable development through open innovation has a strong positive effect. The output showed that this indirect relationship has a strong positive effect on digitalization and sustainable development. This presumption has been confirmed in the literature (Kilay et al., 2022, Pundziene et al., 2023, Silva et al., 2023, Travaglioni et al., 2020, Yun et al., 2020).

5.3 Summary of Tests of Hypotheses

The findings are also summarized based on the prepositions before data collection.

Table 5. 1: Summary of hypotheses

Hypothesis	Estimates	Remarks
H1	β =.595; t=10.344	Supported
H2	β =.462; t= 5.584	Supported
H3	β =.428; t= 7.205	Supported
H4	β =-.136; t= -1.416	Not Supported
H5	β =.250; t= 3.57	Supported

Source: Field study (2023)

5.5 conclusion

The objective of our study was to systematically examine the effect of digitalization on sustainable development mediated by open innovation in the agri-food industry, focusing on the food processing sector in Ghana. By reviewing existing scholarly works, the study established the obstacles that hinder the utilization and implementation of digitalization by firms in the sector and further explored the implications of these challenges in terms of managerial, theoretical, and policy actions.

5.6 Implications of Findings

Upon conducting the study, a wide range of problems was uncovered through literature that might have the potential to retard the adoption of digitalization to drive sustainable development mediated by open innovation within the food processing sector in Ghana. These constraints include a broad range of issues, including challenges related to accessing the required resources for an application, digital illiteracy, managing the extensive amount of information, a limited or absence of financial resources to consult suitable technologically savvy institutions for technical support and motivation for digitization, and the necessity for developing innovative economically digitalized viable company structures. A combination of these challenges and more creates a complex setting for both companies and persons involved in this sector. Consequently, there are implications for managers, theoretical frameworks, and policy frameworks.

5.6.1 Managerial

The results of this study provide valuable insights for managers who are seeking sustained advantages over others through the effective application of digitization, collaborative partnership with stakeholders in the Agri-food value chain, and open innovation.

The findings of this study suggest managers should prioritize the collaborative relationships approach, which involves assimilating third-party information and technology, to improve internal technological skills and foster open innovation. This approach is crucial for achieving improved sustainable development. With sectors such as food processing, where information as well as smart virtual interaction play a crucial part in a company's capacity to accomplish essential everyday operations, technological innovations bring new difficulties and present a wealth of potential. The appropriate adoption of technological innovations by food processing professionals is essential for effectively addressing emergencies and improving the sustainable transformation of the value chain operations. Nevertheless, the process of digitization is often complex and challenging. Although its adoption could appear suitable for sustainable

development, it is important to note that the real-life results may not align with initial expectations

The implementation of appropriate digitalization makes a fundamental contribution to many firms' sustainability in their financial operations such as the effective adoption of advanced technologies with an uninterrupted cyberspace streamlines operations. This leads to financial performance, facilitating financial transactions across stakeholders, and many other novelties in performing financial operations across many segments of society to enhance opportunities for businesses and achieve sustainable development.

In today's technologically global world, the development of the digital economy and the prevalence of the "Internet of Things" have made computer skills and competencies very useful resources for sustaining the business environment. Not all employees need digital literacy skills, focusing limited financial resources to train those with high intelligence quotient to become experts to become digitally savvy will drive the company to sustainable development. Professionals in the food processing sector need to acknowledge the potential of leveraging digital literacy skills and digital platforms in fostering both collaborative relationships approach and open innovation. It is of utmost significance for organizations to fully appreciate the crucial role played by proficiently implementing an open innovation approach in the growing business environment. Hence, it is realistic for managers to achieve collaboration through the implementation of a collaborative relationship approach, which leverages the relationships that exist among all aspects of open innovation. The findings of this research have the potential to enhance managerial awareness and utilization of digitalization capabilities that are accessible in developing nations.

The finding has been established by this study that open innovation serves as a mediator between digitalization and sustainable development. Therefore, the practice of OI should be regarded as a consideration that decision-makers ought to take into account before the implementation of digitalization to drive sustainable development. Managers can strategically leverage OI in an organized manner since it has been observed that it produces greater effectiveness in enhancing a digitalization drive for sustainable development.

Firms operating within the food processing sector are required to effectively recognize and proactively address risks related to finances, as these risks have a significant impact on their operational activities. They should have an organized strategy for acquiring and implementing

digitalization that enhances their competitiveness in terms of resource utilization. Since literature established that the food processing sector in Ghana is flooded with inexperienced and unregistered companies, managers have to conform to legislation and function effectively in a manner that optimizes the usage of resources, as these strategies exhibit a significant relationship with financial risk management. As a result of stringent restrictions within the food processing sector, companies are compelled to take measures to prevent sanctions that might potentially damage their reputation. Hence, owners and managers must develop suitable company strategies to mitigate their risks.

5.6.2 Theoretical

This study employs the dynamic capability theory to examine the underlying process of DTA's impact on improving digitization productivity through the effective implementation of OI of firms in the food processing sector from the standpoint of effective resource utilization. The Unified Theory of Acceptance and Use of Technology (UTAUT) framework combines two significant determinants for OI to indirectly drive digitalization to sustainable development.

5.6.3 Policy

This study has become timely to inform decision makers to adhere to the World Bank requirements for all African countries and companies to be digitalized by 2030 as well as the advancement in its literacy skills advocacy on digitization to minimize post-harvest food waste, boost good dieting, and improve business networking opportunities.

Considering the provision of relevant assistance from policymakers, integrating and applying digital technologies within the agri-food industry and specifically the food processing sector has the potential to facilitate a significant shift, leading to sustainable development. In the absence of adequate governmental support, the process of digitization has the potential to adversely impact the industry by shrinking job possibilities, worsening social inequities, and intensifying the exploitation of already limited resources. It is imperative for decision-makers to promptly, extensively, and prudently undertake measures that guarantee that the digitization of the Agri-food industry yields collaborative benefits for all interested parties and society. Policies should not only aim to promote the integration of digital technology but also tackle issues related to equal opportunity, transparent use, protecting information, as well as safeguarding from potential negative workforce consequences. The government's response ought to be designed to effectively address the current and pressing demands, while also capitalizing on the most favorable prospects for digitization in the food processing sector which

has not received considerable support from policymakers in the adoption and usage of emerging technologies to drive sustainable development.

5.7 Recommendation for Future Study

Undoubtedly, the achievement of sustainable advancement requires a fundamental transformation in the operational dynamics of organizations. Oftentimes, the achievement of successful progress is contingent upon collaborative initiatives and integration, both of which assume a pivotal function in these proceedings.

Future research should be directed towards effective collaboration in the food processing value chain. To facilitate the advancement of digitalization to drive sustainable development, our findings reveal that the adoption and implementation of open innovation become imperative. The incorporation of economic and socio-ethical factors is crucial when implementing digitalization, especially with the concept of "responsible innovation" (Long and Blok, 2018). According to this suggestion, the adoption of effective open innovation strategies is essential in fostering partnerships and stimulating the pursuit of economic and societal objectives, hence contributing to sustainable development.

Future research should also be directed to spread their investigation to bigger companies in the sector and do a comparative study while extending to other regions in the country.

Future research should further consider extending this study by incorporating supply chain integration in the Agri-food industry. The literature reviewed indicated that many studies have been conducted in the industry leaving out the food processing sector.

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Appendix A

SURVEY QUESTIONNAIRE

Thank you for participating in this survey, designed to collect data for our research at the Kwame Nkrumah University of Science and Technology School of Business, Department of Supply Chain Management and Information Systems. The purpose of this survey is to examine the measurable effects of digitalization on sustainable development, and the moderating role of innovation in the food processing sector using data from Ghana.

The survey is anticipated to take about 10-20 minutes to complete. Your participation is important to us, and your time is highly appreciated. The data is for research purposes; all the collected information will be anonymous with no attempt to identify individual responses. In generating unbiased data, the researcher believes that top management staff (CEO, G.M, M.D, Operations/Production manager with sufficient knowledge regarding the firm's operations) can provide candid responses. Although some questions may appear similar, they are also unique in many ways. If you have questions or concerns about the questionnaire, please contact the principal investigator, satabe@st.knust.edu.gh or Tel. 0506716475.

SECTION A: Instructions on respondent's Biography, select by checking (✓) all that apply

1	*Gender*	Male [ ]	Female [ ]	Age: <20	20-30	31-40	41-50	51 and above	
2	*Educational Background*	No formal [ ]	Primary [ ]	Vocational [ ]	Secondary [ ]	Tertiary [ ]	Other (specify)		

SECTION B: Instructions on company profile: Please kindly write in ink in the box that corresponds to the statement, which in your opinion is the most appropriate answer to the related question. For the following questions, kindly select by checking (✓) all that apply.

3	*Name of Company:*		Title or Job Position in the Company:	
4	*Ownership:* □Ghanaian □Foreign	State-run Enterprise: □Yes □No	How long have you worked in this company_____	
5	*Number of Employees*[ ]<6; [ ] 6-29;[ ] 30-59;[ ] 60-99; [ ] 100+		When was the company incorporated in Ghana? __	
6	*Please place a check in your company's corresponding operations.*	□Processing & preservation of meat & fish products; □ Processing of beverages & vegetables (fruit juice, vegetables, salad, smoothies..) ; □Manufacturing starch/dairy/grain products; □Manufacturing animal oils & fat; □Manufacturing bakery & other food products (restaurants & other fast food vending...); □ Manufacturing & processing cash crops(chocolate, cashew…); □Manufacturing & processing of noodles & similar products; □Manufacturing of malt, liquors & wines; □Manufacturing of sugar; □Manufacturing of animal feed; □Cannery & other processed products (species etc.); □Other (specify)		
7	*Please indicate the Revenue of the Company in New Ghana cedis*	□<10,000; □10,000-50,000; □50,000-110,000; □100,000-150,000; □150,000-200,000; □200,000-500,000; □500,000-1,000,000; □>1,000,000		
8	*Company orientation*	□Locally street vended; □Solely Ghanaian; □Foreign Owned; □Joint venture ship; □Other (specify) _____		
9	*Legal form of Entity*	□Sole Proprietorship; □Limited Liability; □Partnership; □Public Limited Liability; □Other (specify) _____		
10	*Title or Job Position in the Company*	□CEO; □M.D; □G.M; □O.M/P.M; □LSCM; □Other (specify) _____		
11	*Geographical Scope*	□Accra; □Kumasi; □Accra & Kumasi; □Tamale, □Other		

SECTION C: Instructions: Indicate your opinion for the following statement by placing a checkmark (✓) in the right column.

Our company uses these digital technologies (Nhamo, 2022)

Stage 1	**Stage 2**	**Stage 3**
□ Mobile phones	□ Social media	□Artificial intelligence (AI)
□ Databases	□ Technological Applications (Apps)	□ Machine learning
□ Remote sensing	□ Cloud computing	□ Internet of Things (IoT)
□ Geographic Information System (GIS)		□ Blockchain
□ The Internet		□ Big data
□ Satellite imagery		□ Robotics

Dimensions for digitalization Digital skills (DS) (Fan and Wang, 2022, Ng, 2012)	**7-point Likert Scale where: *1 = Strongly Disagree, 2 = Moderately Disagree , 3 = Disagree, 4 = Neither Agree nor Disagree, 5 = Agree, 6 = Moderately Agree, 7 = Strongly Agree***

	Measuring items	1	2	3	4	5	6	7
	Information skills							
IS12	My company has Apps and websites that keep me up to date with job-related activities.							
IS13	My company searches for and accesses information from digital environments.							
IS14	My company uses different tools to store and manage information online							
IS15	My company searches for relevant information on the Internet							
IS16	My company understands information gotten from the Internet							
	Communication skills							
CS17	My company can communicate with others efficiently using digital different technologies							
CS18	My company has excellent communication with others using different digital technologies							
CS19	My company knows how to communicate with others in different ways (e.g. images, text, voice, videos)							
CS20	My company often communicates ideas faster to stakeholders through different digital technologies							
CS21	My company knows how to share information and content via digital tools or website							
	Inventiveness skills							
IS22	My company knows different ways to create and edit job-related digital content (e.g. text, images, voice, videos…)							
IS23	My company can transform information and organize it in a different format							
IS24	My company can create and present reports in different formats							
	Digital safety skills							
DSS25	My company is careful and tries to ensure that messages do not cause disharmony to others in the value chain							
DSS26	My company is careful with personal information.							
DSS27	My company is careful with information from other stakeholders.							
DSS28	When sharing digital information, my company is concerned about the protection of privacy and security.							
	Technical skills							
TS29	My company knows how to solve technical problems.							
TS30	My company can learn new technologies easily.							
TS31	My company keeps up with important new technologies							
TS32	My company knows about a lot of different technologies to improve tasks							
TS33	My company has the technical skills needed to use ICT which demonstrates understanding							

TS34	My company has good ICT skills (abilities to understand and operate a wide range of technology software)							
Digital Infrastructure (DI) and Digital Platforms (DP)								
Digital Infrastructure (Ren et al., 2023, Yang et al., 2022)		1	2	3	4	5	6	7
DI35	My company has sufficient internet broadband access per workers							
DI36	My company has a high rate of personal computers hooked to the internet							
DI37	My company has a sufficient internet penetration rate							
DI38	My company has a sufficient mobile phone penetration rate							
DI39	My company is subscribed to the internet bandwidth in Mbits/s							
DI40	My company has secured internet servers							
Digital Platforms (Hautala-Kankaanpää, 2022, Queiroz et al., 2020, Saryatmo and Sukhotu, 2021)								
The following questions examine the benefits that firms accrue from digital platforms that are effective in supporting the company's strategic objectives. To what extent do the following statements reflect your current situation efficiency of the Company's digital platforms?								
DP41	My company has Internet of Things (IoT) platforms that control production, logistics, and managing data							
DP42	My company's IT platform has capabilities to support business strategy							
DP43	Overall, the IT platform meets the needs of the business strategy							
DP44	My company's IoT provides a platform for interaction between customers and the company							
DP45	My company's IoT provides a platform for all devices to the internet associated with operations processes							
DP46	Our revenue growth exceeds that of our competitors							

Dimensions for Sustainable Development (Gericke et al., 2019)								
Economic Sustainability knowledge								
ESK47	Sustainable development requires that companies act responsibly toward their stakeholders.							
ESK48	Sustainable development requires a fair distribution of goods and services across the food processing value chain.							
ESK49	Paying fair wages and salaries to employees is necessary for sustainable development.							
ESK50	Sustainable development demands that you understand how the business operates.							
Social Sustainability Knowledge								
SSK51	Improving people's chances for a long and healthy life contributes to sustainable development.							
SSK52	A culture where conflicts are resolved peacefully through discussion is necessary for sustainable development.							
SSK53	People who exercise their democratic rights are necessary for sustainable development (for example, they involve themselves in social issues, and express their opinions).							
SSK54	Having respect for other cultures is necessary for sustainable development.							
SSK55	For sustainable development, major infectious diseases such as HIV/AIDS and malaria must be stopped.							
Environmental Sustainability Knowledge								
EnSK56	Reducing water consumption is necessary for sustainable development.							
EnSK57	Preserving nature is not necessary for sustainable development.							
EnSK58	Sustainable development demands that we humans reduce all sorts of waste.							
EnSK59	Sustainable development requires a shift to renewable natural resources.							
EnSK60	For sustainable development, people need to be educated on how to protect themselves against natural disasters.							
	Economic Sustainability Attitudes	1	2	3	4	5	6	7
ESA61	I think that companies have a responsibility to reduce the use of packaging and disposable articles.							
ESA62	I think it is important to reduce poverty along the food processing value chain.							

ESA63	I think that financially buoyant companies should give less financially buoyant companies along the food processing value chain the same conditions as them							
ESA64	I think that people who pollute land, air, or water should pay for the damage they cause to the environment							
	Social Sustainability Attitudes							
SSA65	I think that everyone ought to be allowed to acquire the knowledge, values, and skills that are necessary to live sustainably.							
SSA66	I think that we who are living now should make sure that people in the future enjoy the same quality of life as we do today.							
SSA67	I think that the government should provide financial aid to encourage more people to make the shift to green food processing.							
SSA68	I think that it is important that people in society exercise their democratic rights and become involved in important issues.							
SSA69	I think that the government should make all its decisions based on sustainable development.							
SSA70	I think that women and men throughout the world must be given the same opportunities for education and employment							
	Environmental Sustainability Attitudes							
ESA71	I think that using more natural resources than we need does not threaten the health and well-being of future generations.							
ESA72	I think that we need stricter laws and regulations to protect the environment.							
ESA73	I think that it is important to take measures against problems that have to do with climate change.							
ESA74	I think it is OK that each one of us uses as much water as we want.							
	Social Sustainability Behaviour							
ESB75	When I use a computer or mobile for work purposes I always treat others in the value chain respectfully.							
ESB76	I often make lifestyle choices that are not good for my occupational health.							
ESB77	I work on committees (e.g., ad hoc) to improve my job.							
	Environmental Sustainability Behavior	1	2	3	4	5	6	7
EnSB78	Where possible, I encourage environmental sustainability in the workplace.							
EnSB79	I don't waste water.							
EnSB80	I recycle as much as I can.							
EnSB81	I don't think about how my actions may damage the natural environment.							
EnSB82	I always separate food waste before putting out the rubbish when I have the chance.							
EnSB83	I have changed my lifestyle to reduce waste (e.g., throwing away less food or not wasting materials)							
	Open Innovation (OI) (Rosa et al., 2020)							
OI84	We have been able to create more value because our new product and services are jointly developed by our value chain members							
OI85	We have opened up new market opportunities and expanded our customer base							
OI85	Our company uses new ideas and skills acquired from partners to create value by improving its products and services							
OI86	Within the value chain, this alliance has led to more efficient deployment and utilization of resources leading to continuous improvement of products							
OI87	We frequently scan the environment for new technologies and information							
	Reasons for Adopting Open Innovation							
OI88	To provide a window of opportunity for new technologies							
OI89	To test and/or develop new technologies in unknown markets							
OI90	To explore new capabilities and business opportunities							
OI91	To share risks and costs of innovations							
OI92	Because it shortens the time to market and makes the business "cheaper"							

SUSTAINABILITY PERFORMANCE (Source: Zaid, Jaaron, and Talib Bon 2018; Raza, et al., 2022; Çankaya and Sezen, 2018)								
	Economic Sustainability Performance	1	2	3	4	5	6	7
ESP93	There is a reduction in the cost of purchasing materials in my company.							
ESP94	There is a reduction in the cost of energy consumption in my company.							
ESP95	There is a reduction in cost for treatment and discharge of waste in my company.							
ESP96	There is a reduction in cost for environmental mishaps in my company.							
ESP97	There is an average profit growth in the company.							
ESP98	There is an average growth in market share in the company.							
Social Sustainability Performance								
SSP99	My company has improved concerning employees' occupational health and safety.							
SSP100	My company has improved in lowering the adverse impact of products and processes on the local community.							
SSP101	My company has strengthened its relationship with the community and stakeholders							
SSP102	My company actively communicates with its consumers about sustainability values.							
SSP103	My company has improved the living quality of the surrounding communities.							
Environmental Sustainability Knowledge								
EnSP104	My company operates on low discharge of noxious chemicals into the air and water.							
EnSP105	My company operates on less waste and recycling of materials during the manufacturing process.							
EnSP106	My company increases the consumption of renewable energy and sustainable fuels.							
EnSP107	My company reduces the frequency of environmental mishaps.							
EnSP108	There is an enhancement in the firm's environmental state.							

Kindly consider the Chief Executive Officer (CEO); General Manager (GM); Managing Director (M.D); Operations Manager (O.M); Production Manager (PM), and Logistics & Supply Chain Manager (LSCM).
Kindly consider the Chief Executive Officer (CEO); General Manager (GM); Managing Director (M.D); Operations Manager (O.M); Production Manager (PM), and Logistics & Supply Chain Manager (LSCM).

Thank you very much. Your participation is greatly appreciated.

Appendix B

Introduction Letter

Kwame Nkrumah
University of Science
and Technology, Kumasi

College of Humanities & Social Sciences
SCHOOL OF BUSINESS

DEPARTMENT OF SUPPLY CHAIN AND INFORMATION SYSTEMS

KSB/SCIS/1.4

May 8, 2023

TO WHOM IT MAY CONCERN

Dear Sir/Madam

LETTER OF INTRODUCTION-MR. SHADRACK AYUL TABE

This is to introduce to you **Mr. Shadrack Ayul Tabe**, Mphil. student reading Logistics and Supply Chain Management in the Department of Supply Chain and Information Systems, KNUST School of Business.

As part of course requirements, students are to undertake a field study on a topic of their choice. Mr. Shadrack Ayul Tabe has chosen to undertake his study in your organization on the topic, **"The Effects of Digitization on Sustainable Development: The Moderating effects of Innovation in the Food Processing Sector in Accra Metro Ghana**

It will be greatly appreciated if you would allow him to administer questionnaires to members of your staff and offer him any other assistance needed so that his research can advance the frontiers of learning.

For any further clarification, please do not hesitate to contact the Department via email: scis@knust.edu.gh or call 0322 495436. You may also reach **Mr. Shadrack Ayul Tabe** on cell phone number **+233 506 716 475.**

I count on your co-operation.

Sincerely

Prof. David Asamoah
Head

PMB UPO, KNUST, Kumasi, Ghana. **Tel:** +233 (0) 3224 95436 / 95445 **Email:** scis@knust.edu.gh
Website: www.business.knust.edu.gh