**Artificial Intelligence** (**AI) Technology Adoption in Healthcare Supply Chain Management System and Sustainable Development: World’s Largest Medical Drone Programme**

**Abstract**

AI has attracted huge literature devoted to AI discussions in different subjects including healthcare. However, AI studies within healthcare have focused extensively on medical diagnosis, operations and prescription – to the neglect of supply chain management (SCM). To bridge this research gap, we draw on corporate social responsibility, corporate sustainability and stakeholder theory as theoretical lenses to explore how AI adoption in healthcare SCM system contributes to sustainable development. Data is collated from documentary and in-depth semi-structured interview from the World’s largest medical drone programme in Ghana. Findings indicate that AI adoption in healthcare SCM system contributes significantly to the host country’ sustainable development and beyond. The findings espouse the importance of cutting-edge technologies such as AI to healthcare delivery and sustainable development. Hence, healthcare SCM practitioners and policymakers will be able to use findings to inform their decisions and AI adoption. This research contributes to research in four ways. First, this study provides for first-time empirical evidence on how AI adoption in healthcare SCM impacts positively on sustainable development in a developing country and beyond. Second, contrary to prior studies, this study provides empirical evidence that proves that advanced technologies such as AI are appropriate in developing countries. Third, this study contributes to the opening of the “black box” of AI technology in the context of SCM in healthcare delivery. Fourth, the research provides an AI adoption and sustainable development assessment criteria framework; which could be adapted/adopted for future studies.

**Keywords:** *Sustainability, Sustainable Development, Artificial Intelligence Technology, Public Healthcare Delivery, Supply Chain Management, Developing Countries*

**1. Introduction**

Extensive evidence suggests that investment in artificial intelligence technology (AIT) is going to be the solution to sustaining development (SD) worldwide as it is an important driver of productivity and economic growth (Lega et al., 2013; Moskwa, 2016). For instance, recent research shows that the sustainability of the US’s economy and national security hinges on AIT (science and technology report, February 2019) [[1]](#footnote-1). Hence, the prospects of many countries’ sustainable development could be tied to AIT investment, adoption and application. It is therefore not surprising that the past two decades have witnessed a significant rise in AIT investment, adoption and application in all human endeavours. AIT investment trend is attracting fast-paced growing attention in the media, organisations and academics (Lega et al., 2013; PwC, 2018; Rakovska and Stratieva, 2018).

Furthermore, research suggests that organisations are now positioning themselves to respond to institutional pressures that are coming from AIT investment prioritisation (Rakovska and Stratieva, 2018). The drive to invest in AIT, particularly by firms could be motivated by an agency theory perspective; which states that the control of markets engineered through objective of positioning within the market to have efficiency (Jensen, 1986); and the extension of firms’ capabilities in an incremental manner (Chang, 1996); means that AIT investment offers the opportunity for corporations to position themselves to be competitive. This suggests that AIT will continue to be trendy in the coming years since it offers not only a competitive advantage within the marketplace but also, to government institutions pursuing efficiency and sustainable development. Therefore, the value of AI technology cannot be overemphasized.

AIT has been applied in many areas of human endeavours since its inception. Prominent among them is healthcare delivery (Ramesh et al., 2016; Hassanzadeh et al., 2019); which is contributing to the transformation of healthcare delivery (PwC, 2018). As a result, extensive studies have been devoted to the discussion of AIT and healthcare delivery. However, the growing literature indicates that researchers have focused extensively on medical diagnosis, operations and prescriptions (Shiraishi et al., 2011; Hamet and Tremblay, 2017) – to the neglect of SCM; an important element in the healthcare delivery system. This study bridges this knowledge gap by focusing on the SCM system.

The adoption of AIT in healthcare SCM system is considered as a sure way forward in enhancing efficiency in the supply chain network of medical supplies (Zhang et al., 2017; Klumpp, 2018). An important argument put forth by Lega et al. (2013) is that technology application in supply chain network improves supply chain efficiency by reducing cost and waste. Similarly, Rakovska and Stratieva (2018) argue that AIT application in the supply chain system (SCS) improves the system by facilitating the SCM system. Based on the important role that AIT plays in SCM, the present research assesses how AIT adoption in healthcare SCS impacts on sustainable development.

We focus on AIT and SD because AIT adoption may offer the opportunity to empower societies’ subjects and their environment capable of empowering society to achieve developments that meet the present and future generational needs (Petrikova, 2014). In the main, SD seeks to improve the social and material well-being of citizens and social institutions to achieve the best level of human development and prosperity (Moore, 2015). Therefore, by focusing on how AIT adoption in healthcare SCS, we espouse how an improved SCS in healthcare delivery through AI-enhanced technology will strengthen the SD goals of societies. To achieve the research objective, the World’s largest commercial medical drone programme in Ghana is used as a case study.

We use the Ghanaian medical drone as a case study because drones (which is also known as Unmanned Aerial Vehicles) use high levels of AIT (Giones and Brem, 2017; Mairaj et al., 2019) and therefore, typifies an example of AIT application in human endeavours. Further, the continuous surge in drone usage in human activities has increased its economic market value significantly. To the extent that its commercial value is expected to rise from $2 billion as at 2016 to $127 billion by 2020 (Moskwa, 2016). An area of a surge in drone usage is within supply chain networks. However, little is known about the commercialisation of drones usage in healthcare SCS and how this contributes to sustainable development.

Moreover, Being the largest commercial medical drone adopted at the national scale (The Guardian UK, 2019); the Ghanaian medical drone programme offers an excellent empirical research context which other countries pursuing similar ventures could learn from. Apart from Rwanda; which has commercialised medical drone at a national scale, countries such as the USA, Nigeria, Kenya and Tanzania have made known their intention to follow suit (Bright, 2019). The on-going buzz in medical drones indicates how this cutting-edge technology may be impacting on humanity; and as such, research into how the medical drone contributes to SD goals.

The remainder of the paper is presented as follows: the next section presents the conceptual foundation of the study. Section three discusses the theoretical framework underpinning the study whilst sections four and five present the research methodology, and results and discussions respectively. The conclusions of the study are drawn at the final section by summarising the findings, implications, contribution to research, limitations and suggestions for future research.

### 2. Conceptual Foundation

### 2.1 Artificial Intelligence: Definition, History, Progress and Applications

Artificial Intelligence (AI) is defined as “a system’s ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation” (Kaplan and Haenlein 2019, 17). Fazal et al. (2018, 246) define AI as ‘’an artificial entity capable of solving problems and learning solutions for new problems.’’. In the main, AI is the ability of machines to carry out tasks by displaying intelligent, human-like behaviour and the ability of machines to behave rationally by observing their environment to take actions to achieve sets of objectives (Min, 2010; Russell and Norvig, 2016; Candi and Beltagui, 2019; Sun and Medaglia, 2019).

AIT is generally accepted as having started with the invention of robots and the term ‘’artificial intelligence’’ is derived from the Czech word *robota*, meaning biosynthetic machines used as forced labour (Hamet and Tremblay, 2017). Historically, the application of AIT in human activities has received mixed – some authors trace it to the 15th Century (Moran (2006) whiles others trace it to the middle of the 20th Century (Russell and Norvig, 2009). However, the modern-day AI was born in 1956 when researchers and students from Dartmouth College launched AI in a conference (McCorduck, 2004). Since then, investment has witnessed a chequered history. During the early 1960s major players such as UK and US invested hugely into AI research (Howe, 1994). However, in the early 1970s, the US and British government reduced their investment drastically; leading to a sharp decline in AI progress (McCarthy, 2000). This era is often referred to as the ‘’AI winter’’ (Russell and Norvig, 2003). A decade later saw a significant revival in the AI-related research and investment resulting from the commercial success of ‘’expert systems’’ (Russell and Norvig, 2003). However, this lasted for a decade due to the Lisp Machine failure, leading to the longest disruption in AIT progress (McCorduck, 2004). From the 1990s till date, there has been a surge in the research, adoption and application in several human activities (McCorduck, 2004; Dirican, 2015; Chui, 2017). As a result, the commercialization of AIT has increased; including SCM systems.

**2.2 When AIT meets SCM**

Since the inception and popularisation of SCM, it has often been described the planning and controlling of the materials, information, cash flows, and the logistics activities in an industry (Cooper et al. 1997; Chen et al., 2019). The SCM activities involve several systems which can be categorised into three main areas – manual, semi-manual and technology-based. However, recent advances in technology and the need to be efficient and environmental-friendly has seen a considerable shift away from (semi-) manual systems to advanced technology-based systems (Feng et al., 2018; Rakovska and Stratieva, 2018). To the extent that authors perceive technology-enhanced such as AI as the only way to ensure environmental sustainability (Klumpp, 2018).

In response, several organisations are adopting diverse AIT into their scheme of SCS (Klumpp, 2018; Rakovska and Stratieva, 2018; Wang et al., 2019). Though AI in SCS is gradually gaining grounds, researchers have not paid attention to how this is contributing to healthcare delivery and their impact on SD. Hence, exploring this subject area will not only inform host countries’ recognition of the important role that AIT adoption in healthcare SCS offers to their sustainable development goals (SDGs) but also the world’s SDGs.

### 2.3 Sustainable Development (SD): Socio-Economic and Environmental Sustainability Nexus

Sustainable development which is often described as the development that meets the present and future generational needs (Petrikova, 2014) has been one of the most important topics of the 21st century. It has become a major discussion point among world leaders, especially, in the last decade due to the growing disparities in developments among nations. Some academics have predicted sustainability is likely to be the continue top concern for managers and organizations worldwide (Jerónimo et al. 2019). To the extent that environmental legislation and social pressure groups are now compelling organizations to adopt policies and practices in the hope of effectively improving the economic, social, and environmental pillars of sustainability (Jerónimo et al. 2019). Consequently, governments, organisations and institutions around the globe have devised strategies in addressing sustainable development. Notable among them in recent years is the SDGs set out by world leaders at the United Nations (UN, 2017).

The goals of SD are multi-faceted and – spread across many spheres of human lives (Cobbinah et al., 2015; Moore, 2015). The ultimate purpose of SD is to improve on the socio-economic well-being of humanity through the creation of a conducive environment for citizens to develop their full potential and to live productive lives (Moore, 2015). It encompasses an integrated and somewhat intertwined development goal such as protection of the natural environment, promotion of education, production, consumption and well-being of citizens (Addison et al., 2015; UN, 2017). Accordingly, organisational sustainable operations activities are characterized by environmental, social and economic sets of objectives (Longoni et al., 2019). This implies that SD can be approached from different perspectives depending on the focus of the SD agenda being pursued. However, existing literature suggests that SD can be approached from three dimensions. First, approaching sustainable development from the viewpoint of the locals – including the cultural attributes and the sensitivity of the context-specifics of development (Herath, 2009). Second, SD is a multi-dimensional concept and as such, it should be interpreted (Pritchett and Kenny, 2013). Three, SD should be approached in an iterative process that incorporates multi-dimensions facets of activities that promotes the well-being of citizens (Todaro, 2000; Cobbinah et al., 2015). In spite of the divergent approaches to SD, the central pillars that SD rest upon are the promotion of social, economic and environmental well-being of societal subjects (Azmat et al., 2018).

Historically, the concept of SD of the society by firms could be dated to early 1930s, when authors posited the subject of business social responsibility (BSR) (Carroll, 1999). However, until early 1953, the idea of the BSR towards their society and stakeholders was not theorised (Chang et al., 2017). The firms' relationship with society became prominent when Bowen and Johnson published the landmark book on Social Responsibilities of the Businessman (Bowen and Johnson, 1953). The central point of the argument advanced by Bowen and Johnson was that firms have important powers in societies where they operate and as such their activities significantly impact on the society (Bowen and Johnson, 1953; Lee, 2008). Drawing on the concept of SD, we draw on three related theories of (1) corporate social responsibility (CSR), (2) corporate sustainability (CS), and (3) stakeholder theory (ST) as the theoretical lenses in explaining how AIT adoption in healthcare SCS contributes to SD**.**

### 3. Theoretical Foundation

The concept of CSR has received divergent views by authors including Davis (1973) who defines CSR as “the firm's consideration of, and response to, issues beyond the narrow economic, technical, and legal requirements of the firm to accomplish social and environmental benefits along with the traditional economic gains and to fairly balance the needs and concerns of various stakeholders”. Linking CSR to SD, Watts and Holme (1999) describe the CSR as the corporate commitment to sustainable economic development, employees and their families, and the local communities. Similarly, the Business for Social Responsibility (BSR) (2003) describes CSR as the pursuance of corporate activities geared towards the achievement of commercial success in ways that honour ethical values and respect people’s natural environment.

Traditionally, CSR was supposed to be voluntary but in recent years, this means more than voluntary to be tied to the economic prospect of the firm. The paradigm shift is premised on the notion that ‘’real’’ CSR of the firm is to make a profit for shareholders and as such, the suggestion that firms should focus on the society of their operations threatens and weakens the fundamental principles of free enterprise and capitalism ideologies (Chang et al., 2017). Further, opponents CSR voluntariness argue that, if the society in which the firm operates deteriorates, the important structure which supports the activities of the firm will also deteriorate and that will negatively impact on the firm’s (Lee, 2008). This implies that supporting the well-being of society is as important as supporting the long-term objectives, existence and economic prospects of the firm (Baumol et al., 1970).

The contrasting views of CSR presented above suggests that CSR means different things to corporate managers (Dahlsrud, 2008). Empirical evidence suggests that there is a relationship between CSR and economic performance of firms (Orlitzky et al, 2003; Tan et al., 2015); and as such CSR should not only be viewed from just the voluntary perspective, but also as a form of corporate well-being of the firm affecting the long-term objective of the corporation. However, the central theme that runs through the CSR is that corporations are supposed to bear responsibility for their impact on stakeholders associated with their activities (Russell, 2008). Based on the above evidence, we argue that in the case of the Ghanaian medical drone programme, it will not only impact on the socio-economic and environmental SD of the locals, but it will also contribute to the UNs SDGs and the world’s fight against global warming.

Closely related to an aspect of CSR is corporate sustainability (CS). The two concepts are sometimes used interchangeably (Chang et al., 2017). However, CS could be linked to the CSR’s element that pursuance of CSR activities that lead to economic prospects and survival of the corporation. The central focus of CS is on how the corporation devises and/or embarks on strategies and activities which ensures continuous existence. Like CSR, different divergence views about what constitutes CS (see International Institution of Sustainable Development (IISD), 2002; Dyllick and Hockerts, 2002). However, the central them of CS is on how corporations devise strategies that seek to balance the business goals and current and future needs of stakeholders (Artiach et al., 2010). Empirically evidence confirms the direct link between corporations’ pursuance of the stakeholders’ needs and the corporation’s SD (Artiach et al, 2010; Chang et al., 2017). Based on the above CS discussions, and in agreements with prior studies (Horvathova, 2010; Tan et al., 2015), we argue that the corporate sustainability of the medical drone implementation firms would partly depend on their pursuance of the social, economic and environmental needs of the society in which they operate.

Lastly, drawing on the CSR and CS literature discussions, it can be deduced that the central focus of the firm is to pursue SD via the pursuance of stakeholders’ interests, needs and well-being. This goal could be realised through consciously pursuing strategies and activities that meet these objectives; hence, the stakeholder theory is evidence. The concept of ST was first brought to prominence in 1984, when David Edward Freeman, coined the term ‘’stakeholder’’ in his landmark book entitled ‘’Strategic Management: A Stakeholder Approach’’ (Freeman,1984). Even though ST is attributed to Freeman, the concept can be traced to the internal memo report of the Stanford Research Institute in 1963; which described stakeholders as any group(s) without whose support the organization would cease to exist (Fontaine et al., 2006). A stakeholder is any individual or group of individuals(s) who can affect or can be affected by the achievements of the organisation's objectives (Freeman, 1984).

Since the inception ST, there have been divergence views and definitions presented by different authors and practitioners resulting in an extensive debate over the years. In spite of the divergent views, the foundation of ST is that organisations have ‘’an ethical duty to stakeholders above and beyond what is required by law and, in particular, ethical duties that require the firm to operate in ways that will foreseeably reduce long-term profits’’ (Heath and Norman, 2004, 249). Stakeholders contribute inputs to the operations of the ‘’focal’’ organisation and as such, expect an output (Freeman, 1984; Donaldson and Preston, 1995). As a result, stakeholders will act for or against the organisation depending on whether their interests are being pursued or not (Freeman, 1984; Micthell et al., 1997). Consequently, stakeholders associated with an organisation at a point in time may have opposing stakeholders based on whether their interests are being pursued or not.

Drawing on the stakeholder theory which is in agreement with prior studies (Elias, 2003; Pan, 2005; Pan and Pan, 2006; Sæbø, et al., 2011; Damoah et al., 2018), we argue that the adoption of AIT in healthcare SCS will impact on the SD of the stakeholders associated with the AIT-enhanced SCS. Further, the successful adoption of the AIT in healthcare SCS will partly depend on stakeholders.

**4. Methodology**

**4.1 The Case Study: The Ghanaian Medical Drones**

The Ghanaian medical drone was launched in April 2019 to supplement the existing SCS within the public sector healthcare delivery (Nyantakyi, 2019). The purpose is to supply emergency and essential medical supplies to healthcare centres across the country (Sigal, 2019). Specifically, the medical drone is expected to distribute vaccines, blood and life-saving medical supplies to ensure a reduction in death rates relating to childbirth, accidents and snakebite (Asiedu, 2019).

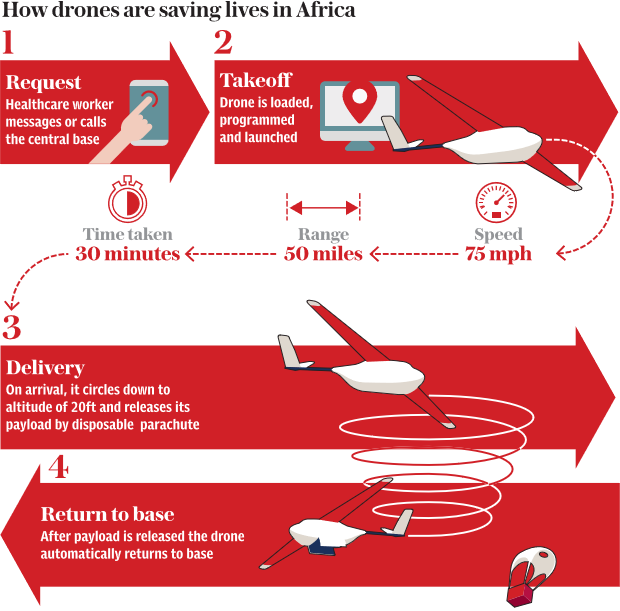
The company executing the medical drone programme is Zipline; a San Francisco-based robotics manufacturer and logistics services provider (Bright, 2019). It is expected that Zipline will do 600 flights a day using four (4) distribution centres across the country as echoed by their CEO, Keller Rinaudo (Bright, 2019; The Guardian UK, 2019).

***4.1.1 How the Medical Drone Operates***

The operations of the drone involve several sets of stakeholders such as healthcare workers and drone operators. It starts when a healthcare practitioner (e.g nurse, doctor, administrator) placing an order using a mobile phone to send a text message to the drone distribution centre where the designated medical supplies are kept in an ultra-modern storage facility (Nuki, 2018). The requested supplies are then packed into a padded box that has parachute by a staff member at the drone distribution centre. The box is then given to a drone flight operator who then fixes it beneath the drone. The flight operator then sets it up ready to fly, when aviation clearance is made, and all is cleared. After that, a mobile phone with an app releases the drone to fly to its destination using a military-grade global positioning system (GPS) to navigate along a pre-programmed route at a maximum speed of 75mph (Nuki, 2018).

Few minutes (approximately 5mins) to the arrival of the drone to the healthcare centre, a text message is sent from the distribution centre to the receiving healthcare centre. The message directs the healthcare practitioner to move to the location where the supply will be dropped. However, the drone uses on-board sensors to measure the speed and direction of the wind, to determine the right location of the drop zone before spiralling down to an altitude of 20ft to release the supplies (Nuki, 2018). Once it returns to its point of departure, the drone lowers a hook that clasps a cable, dragging it down to earth on an inflatable landing pad in a technique often described as “aircraft carrier meets bouncy castle” (Nuki, 2018). Figure 1 depicts the actors and key actors participating in this supply chain.

**Figure 1: Operations of drones in medical supplies in Ghana**



*Source: Nuki (2018)*

**4.2 Research Approach**

Qualitative data is collected from definitive stakeholders (Mitchell et al., 1997) associated with the medical drone’s adoption and operations. They include the Ghana Health Service (the government agency in charge of the drone project, Ministry of Health (the implementing government ministry); Zipline – Ghana (the implementing firm) and beneficiaries. Hence, the philosophical foundation of this study is based on the interpretivist domain — a philosophical position enshrined in the interpretation of social roles and actor’s interaction of the world and their meanings (Saunders et al. 2015; Bryman and Bell 2015). The philosophical position is adopted because it evades unyielding structural frameworks by adopting a flexible research structure that offers a rigorous approach in capturing enough information through interaction (Carson et al. 2001; Black 2006). In this philosophical approach, the researcher and the participants are co-dependent and mutually interact with each other (Hudson and Ozanne, 1988); hence, personal perceptions cannot be separated out-rightly. However, it unearths deeper information, since the researcher can interpret the meanings of the body language of their respondents. Further, in this research approach, the researcher is more interested in gathering saturated information from the respondents — hence; the emphasis is on words rather than quantifiable data (Denzin et al. 2005; Bryman et al, 2015). Research enshrined in this research philosophy often uses a variety of data collation techniques such as focus groups, observations and interviews (Saunders et al. 2015).

**4.3 Data Collection Strategy**

In this study, the researchers used an in-depth semi-structured interview data collection method as this is also appropriate for exploratory research (Saunders et a., 2012; Bryman et al, 2015). It helps in the gathering of deeper information from respondents (Saunders et al., 2015). Further, it gave us the chance to prioritize the important subjects whilst allowing the participants to give relevant and open-ended responses to the questions asked (Collis et al., 2014).

We used purposive sampling to select seventeen (17) informants from Ministry of Health (MoH) (3), Ghana Health Service (GHS) (2) healthcare workers (HCW) (7); Zipline-Ghana (ZL) (3); and patients (2) from different healthcare centres. We used the purposive sampling technique because the target audience could be identified with a specific organisation or government agencies in charge of the project (Bryman, 2012; Saunders et al., 2012). Moreover, these informants are the definitive stakeholders (Mitchell et al., 1997) directly involved in the execution of the Ghanaian medical drone’s project and as such could offer us illuminative information (Patton, 2002) to unpack the sustainable development impact of the project.

The numbers of the participants were not pre-determined before the commencement of the interview but rather they were the only designated people with the most and rich information This is also in agreement with prior literature and authors’ suggestions that, in some situations, even one interviewee would be able to provide information necessary in a given case if they have the required knowledge (Morse, 1995, 2000; Hill et al., 2005; Silverman, 2013; Guest et al., 2006). The respondents’ profiles have been presented in Table 1 below.

The data collection started by designing an ‘’interview questions guide’’ based on the research objectives. Three (3) steps were taken to improve on the validity of data – (1) the researchers reviewed the interview question guide severally, (2) the question was given to two professors with a minimum of 15 years of experience in semi-structured interviews usage, and (3) the questions were piloted on 4 participants (one from each sets of participating stakeholder group); their feedback helped in revising the questions. Further, to strengthen the findings, we conducted a desktop data from reported interviews on YouTube, press conferences and interviews involving GHS, MoH, Zipline, Healthcare practitioners and beneficiaries of the medical drones. This helped to triangulate the findings (Silverman, 2013).

Table 1. In-depth Semi-Structured Interview Respondents’ Profile

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Organisation/Institution | Position | Informant code | Interview minutes | Interview number |  |
| MINISTRY of HEALTH (MoH) | Public Relations Officer  Policy Coordinator  Policy Coordinator | MoH1  MoH2  MoH3 | 45  70  36 | 1  1  1 |  |
| GHANA HEALTH SERVICE (GHS) | Director-General  Coordinator | GHS1  GHS2 | 95  47 | 1  1 |  |
| ZIPLINE-GHANA (ZL) | Head of Systems Integration, Quality Assurance, & supply chain management  Operations Manager  Flight operator | ZL1  ZL2  ZL3 | 65  55  33 | 1  1  1 |  |
| HEALTHCARE WORKERS (HCW) | Hospital Administrator  Hospital Administrator  Hospital Administrator  Doctor  Doctor  Nurse  Nurse | HCW1  HCW2  HCW3  HCW4  HCW5  HCW6  HCW7 | 60  55  70  45  38  25  27 | 1  1  1  1  1  1  1 |  |
| BENEFICIARIES AND FAMILIES (BF) | Patient Kibi Hospital  Patient Tafo Hospital | BF1  BF2 | 35  28 | 1  1 |  |
| Total |  |  |  | 17 |  |

**4.3 Data Collection Procedure**

We followed several protocols in the data collection processes. First, we visited Zipline, GHS, MoH and the healthcare providers to seek interview approval using professional local survey enumerators. Follow up calls and emails were made by one of the researchers to ensure the authenticity of the research. After, extensive protocol procedures, all the targeted audience agreed and issued letters to designated personnel to speak to us. The interview followed by pre-booking with individuals in their convenience and time. This helped in the creation of a cordial relationship during the interview. The interviews were conducted using a variety of forms, which included Face-to-Face, Zoom, Phone and Skype lasting between 25 and 95 minutes with either a professional survey enumerator or one of the researchers. All interviews were either audio recorded and/or alongside note-taking or audio recorded only. The emails were only used after transcribed data have been sent back to interviewees for review of their views. The interview took place between July and November 2019. The interview was structured in such as a way that the most important questions were asked first — which allowed us to ask probing questions for further elaborations. Upon the request of the interviewees, the transcribed data were sent back to the interviewees for review and based on this, few additions were added to the data.

**4.4 Data Analysis Techniques**

The data were analysed using the thematic technique and inductive approach by employing the 6-staged steps prescribed by Braun and Clark (2012). Hence, we observed the following: First, before the coding, we familiarised ourselves with the data after transcription. Second, we uploaded them unto the NVivo software by looking for patterns as shown in appendix 1. Third, we then identified the initial codes by reading through the text line by line. At phase is the setting up of themes by putting similar codes into the same theme. We did this by highlighting the keywords and phrases revealed by the informants. The fourth phase involved insuring of coherency in the data patterns that fall under a theme. To do this, the researcher reviewed the coded themes severally by all researchers (Miles and Huberman, 1994). At the fifth phase, was the mapping of the themes through ‘’thematic map’’. This helped the researchers to identify any relationship(s) that exists between the coded themes. At the penultimate phase is the capturing of the essence of what each theme indicates and to decide if any of the themes fit into the overall narrative which includes how AIT adoption in healthcare SCS impacts on SD.

**5. Results and Discussions**

**5.1 The Success Story of the Ghanaian Medical Drones Programmes**

The findings show that the first AI-driven supply chain network of health delivery in Ghana has been deemed successful so far. The interview data corroborate the media report on the success of drone adoption in healthcare SCS. The findings show that milestone has been linked to governments effort to provide timeous essential medical supplies to very remote environs in Ghana and reduce deaths associated with lag periods in the restocking of medical supplies. The policy adviser of the project and the public relations officer for the Ministry of Health (MoH1) explained that the success and the gains from the medical drone project are not just to save lives but to offer sustained support to the livelihood of the ordinary Ghanaian. ZL2 added:

You know since our launch we have done over 1000 flights and supplied over 5000 essential various medical supplies. We have had no accidents or problems so far; so, I can say that it has been a success. For the impact let me start by saying that the government does public policy to improve the life of everybody. That is the essence of governance. So [the drone] is just bringing speed, reliability and in time supplies and it is only used for essential communities. Yes! We are able to link very remote communities by providing some emergency supplies which is transforming the lives of the people. I am excited when I hear the testimonies on YouTube and other social media platforms.

Indeed, all the participants documentary evidence indicates that the medical drone so far has been a success. The introduction of AIT in the form of the medical drone system, with existing supply chain structure, is an action which meets the present and future generation needs not only in the cities and towns but in remote rural communities. Thus, the introduction of the medical drone programmes into the SCS of healthcare delivery has significantly boosted the distribution of medical supplies to where they are needed most.

We are not like Koforidua, so we can’t store a lot of stock of medicines like that require constant refrigeration … say like blood. So, if the drones are here can concentrate on storing other none perishables so that we can avoid medicine going bad … I think that is good for everyone. (HCW2).

This positions the medical drone as a SD activity that impacts directly on the social, economic and environmental sustainability in Ghanaians and beyond. As a result of the impact of the medical drone project on the ordinary Ghanaian in a sustained way, the researcher adopt the success and life-changing stories from both desktop and empirical data to form the basis for the argument that the medical drones project is contributing to SD in the country and beyond; and in line with the SD – social, economic, and environmental sustainability in our next sub-section.

**5.2 The Medical Drone and Sustainable Development**

***5.2.1 Social Sustainability***

The finding revealed that the medical drone project is contributing significantly to the saving of many lives (ZL1, ZL2, MoH3, HCW1-3, MoH1, MoH2). This is premised on the grounds that, since the introduction of the medical drone into the supply chain of essential and emergency supplies, requests have been successfully delivered on time, thereby, allowing healthcare practitioners to use the supplies on their patients (ZL1, ZL2; HCW4-7). One ex-patient interviewed (BF2) expressed gratitude to the implementing stakeholders for the introduction of the medical drone project ‘’ my very existence depended on the medical drone’s timely delivery of blood when I was in labour’’. To echo this, HCW2 said that:

There is no price put on the life of a human being … So that if somebody has flu or a woman has given birth and she is bleeding and on a brink of death and immediately we [healthcare workers] know that medicines can be made available within few minutes to save that life, then the returns that come to the society is enormous….[And] … when medicines are needed in emergencies such as accidents or snake bites in the remotest areas where it can take more than a day to transport [using cars] to these areas; that is when you realise the importance of the [drone] project to the saving of human life.

HCW2 added that:

The drone adoption in the supply chain in the Ghana healthcare is really saving lives … within the coverage of service [healthcare centres who are part of the scheme], we are able to request for the products to be sent quickly in order to save lives and they are able to deliver it within a short period of time with just a mobile phone, through text message. In our facility, we have saved a lot of lives even though we started the scheme in just over six months ago. You can go to the community and ask them; they are the best people to give you the most information about how the scheme is helping them [save their lives].

They mainly linked saving lives to the timely delivery of emergencies and essential products by arguing that; in the past, a lot of people have died through labour, snake bites and in fatal accidents, and they (healthcare practitioners) could not save patients’ lives because there were no blood or emergency supplies.

Medical drones were introduced to complement the medical supply chain system so that we can act more quickly during emergencies, like accidents and surgery. The drone project is delivering exactly that; (resolving emergency situations) so, I will urge you and other academics, as well as the media to talk positively about this scheme. I feel proud of being associated with this project as one of the main drivers of the scheme. My team here (GHS) are happy and proud about it [drone]. (GHS1).

Not surprisingly, one of the key informants from the ministry of health highlighted that:

Since the drone project was introduced, we (ministry) have received a lot of positive response on how lives are being saved, …I think this is making an impact on the lives of the very Ghanaian. We are very happy about such responses. It means we have done something good and as you asked, this impacts on the lives of the ordinary people. (MoH2).

Similarly, MoH1 reiterated MoH2’s observations and stated that:

Government is committed to saving lives. The [medical supplies] shortages at the medical store had to be addressed.[and] we have successfully launched and operationalised the drone project. I think Ghana is the winner when it comes to the impact. The stories from people whose lives have been influenced [impacted positively] by the drone project speak volume of the impact of the project on their lives. We have cases of infant mortality, maternal mortality among others… they didn't die so they can contribute to the country and the community they come from.

To reiterate this, the Ghanaian president said that “ No one in Ghana should die because they can’t access the medicine they need in an emergency,” and ‘That’s why Ghana is launching the world’s largest drone delivery service ….a major step towards giving everyone in the country universal access to lifesaving medicine” (Bright, 2019). Similarly, Dr Seth Berkley, the CEO of Gavi, the vaccine alliance, the company supporting routine immunisation on demand will allow us to make sure that there will always be enough life-saving vaccines for every child in Ghana” (The Guardian UK, 2019).

Further, the findings show that in saving time by delivering medical supplies on time; eases up congestion from the larger hospitals and enable the small clinics and medical centres to operate properly. Thus, referrers to teaching hospitals in the cities have been reduced since the supplies needed in carrying out medical operations that are often at the big hospitals, due to lack of appropriate storage facilities in the smaller clinics, have reduced drastically. Informants (particularly healthcare workers and the Ghana Healthcare Service) argued that smaller medical centres would not need to refer patients to larger facilities, due to lack of essential medicines or logistics for treatment. With the medical drones complementing the supply of medicines, most ailments would be treated without the patients and their families having to travel to teaching hospitals for treatments (HCW1-5; GHS1-2). In effect, this makes the smaller healthcare centres equally efficient in addressing the patient's emergency conditions. To buttress these points raised by the HCW and GHS respondents, ZL1 added that:

Some patients are referred by the smaller hospitals and clinics … and this is because smaller healthcare facilities do not have the drug that they need [to treat the patients]. So, now that the medial drone has been introduced, overcrowding at the bigger hospitals such as 37 [military hospital] has been reduced to a larger extent. There is no need to refer someone to Accra because there is no blood at say Tafo.

A beneficiary added:

This time the nurse said some machine will bring some of the blood. Every time my father comes to visit me [at the Kibi Government Hospital], the nurses will tell my dad that, the medicine and the blood are in Koforidua, so my dad is sent there [Koforidua; the capital city in the Eastern region] to go and buy blood. But now, if I go there and they have to treat me and they don’t have the medicine, they just tell me that they are requesting from drone [operational] centre. It is good for those of us that have to visit the hospitals all the time due to our conditions (BF1).

Another finding that emerged was the fact that a timely supply of essential medical needs at medical centres reduces anxiety among health care professionals directly treat patients. ‘’For we the doctors and nurses we deal directly with patients so when we need very essential supplies and we don’t get it to save a life we are anxious’’ (HCW4). With the introduction of the medical drone mechanism, health professionals can just call the centres for the distribution of critical medical supplies within a short period. ‘’So, when the blood type wanted was confirmed sent through the drone it was reassuring and we were very hopeful the baby will survive’’(HCW6). Indeed, participants believe that the situation is motivating and providing job satisfaction (HCW6-7).

Similarly, patients and their families, for fear of not getting adequate medical treatment, commute a long distance to other hospitals outside their regions. Participants argue that there are intangible costs associated with seeking medical care in other regions, which increases the overall frustration (BF1, BF2). The impact associated with the medical drone projects means that there is a just-in-time supply which minimises the need for an ambulance or patient movement across regions with its attendant risk. As a result, the hustle of commuting by patients and their loved ones. BF2, for instance, stated that:

I heard the machines (drones) bring the medicines … I won’t have to go (to) Koforidua for treatment any longer, because travelling all the way for one injection every week is even making me unwell. This is good news so I can now save some cash and not run into [adifficulty not knowing how I would get to Koforidua when the week is approaching.

Social empowerment is an integral part of SD (Van Marrewijk and Were, 2003; Artiach et al., 2010; Chang et al., 2017) is the experiences with healthcare centres minimising overcrowding, healthcare workers, and patients and their families minimise the level of anxiety. This empowerment is central to the life-saving benefits that the medical drone programme is offering. The thought of spending overnight to be able to submit one's report to the healthcare workers (HCW) is debilitating for patients and their families. Therefore, a reduction in such intangible constraints offers greater confidence for society.

***5.2.2 Economic Sustainability***

Indeed, from the findings, participants believe that socially, the introduction of the medical drone is empowering. They argue that, with a well-functioning medical supply system that ensures that whichever essential medicine can be flown to the point of need, the society will be confident socially and therefore, pursue their economic endeavours with minimal worry. Even though the social and economic benefits are somewhat related, informants specifically cited some direct economic benefits that contribute to economic sustainable development. These include time-saving due to shorter supply chain schedule reduction, cost reduction through medical supplies wastage reduction, employment creation, knowledge transfer, and reduction in the total cost of supplies due to a reduction in overhead cost.

Regarding time savings or man-hour savings, informants opined that relative to the traditional medical SCS; the adoption of the medical drones in healthcare delivery saves a lot of time. They were of the view that the use of vehicles offers longer times, sometimes days for essential and emergency supplies to reach healthcare delivery centres. ZL3 said:

… if you have a place like Ekyi Amanfrom which is beyond the Afram Plains; which takes longer time to reach there, the drones ]are able to reach there in less than 30 minutes. Let’s say if you are travelling from here [Accra] to Ekyi Amanfrom, just this scenario you are going to spend four and a half hours…. Yea! Let assume somebody there [Ekyi Amanfrom] has a snake bite and the nearest medical facility doesn’t have Anti-venom drug or medicine for injection, and the closest place [teaching hospital with the emergency supplies] is Koforidua, and it will take the hospital or the family member of the patient approximately 9 hours to go and purchase the medicine from the teaching hospital in Koforidua, what do you think will happen? Assuming, they will use an ambulance or a car or whatever to get to the hospital, the nurse or healthcare worker has to suspend all other activities and go and buy the medicine … [but] with the zipline drones, it may take less than 50 minutes to get the medicine.

All the sets of informants highlighted that, time is essential in administering medicine and that, the medical drone scheme is offering timely stock replacement that brings stability in the supply chain schedule. While it takes a month to update stocks, the drones can offer timely support to the delivery process and make the health facilities continue to function effectively and efficiently. This ensures that wastage in supplies is drastically reduced and/or avoided.

An important economic SD finding revealed by informants is cost reduction. However, they relate cost reduction to a series of factors. These are non-overstocking, timely delivery of medical supplies, wastage reduction and reduction in overhead costs associated with traditional delivery of medical supplies. Concerning non-overstocking of emergency medical supplies, respondents were of the view that due to the essential nature of these medical supplies, smaller hospitals and clinics often overstock supplies to avoid unavailability of these supplies in time of need. However, with the introduction of the medical drones in the supply of emergency and essential supplies, healthcare centres do not have to stock these supplies. Hence, there is a drastic reduction in stock wastage due to expiration.

So, you realize because of product going bad, because they don’t want to run out of stock. [But] now that they know they have Zipline service, they order just enough because they know that even if they run out of a product, Zipline can supply them until their normal supply comes in. So, they end up not overstocking product this reduces the overall wastage within the health care system and saves the government money. (GHS2).

Further, the issue of cost reduction was regarded as important economic sustainability is not only to the government but patients and their families (BF1, BF2). In the main, cost reduction saves the government sector ministry and agencies significant sums of money. MOH2 said:

Overall, the drone helps in the reduction of healthcare cost in the country and to a larger extent impacts positively on the government budget and economic prospects of the country in the long-term. People (citizens) do not recognize the overall impact that the (medical) drones will have on the development of the country. If it is sustained for a long-term, of which I believe, it will, it can impact on the overall economic development of the country.

The findings show that the need to meet urgent medical needs across the entire country requires the use of ambulances and employing more medical personnel (ZL1, ZL2). This can be greatly minimised to ensure that patients can economically sustain their medical care. GHS2 added that:

When you talk about sustainability in terms of economic as you [interviewer] put it, then I can tell you, there are a lot of them. People do not realise this, … the country will develop economically knowing that they are confident in going about their daily activities, … knowing that if they face emergency health conditions, the drones will provide timely supplies to healthcare centres [to treat them].

The policy adviser to the project, and the public relations officer for the Ministry of Health (MoH1) explained that the success and the gains from the medical drone programme as a complementary supply chain network does not only save lives but also offers sustainable support to the livelihood of the ordinary Ghanaian. The findings show that the medical drone project assembled different calibre of professionals ranging from field engineers to auxiliary staff. One of the resource personnel from the ministry of health explained that:

Economically, I think that it [medical drone adoption and operations] has also helped in employing some of our Ghanaian trained engineers, pharmacists and other paramedical staff including some local people in the [local] community [where healthcare centres are located]. So, economically, I think it is benefitting the nation …. the two centres that are in operational are fully run by Ghanaians with the support of few Rwandans; they have been trained to do the work and they are doing it excellently. (MoH3).

Respondents are of the view that employment creation by Zipline Ghana will not only provide economic sustainable development to the citizens employed but also will enhance the overall economic sustainability of the country. The premise the view because the government can tax the workers and the workers can improve the lives of their family members through family support.

Look, the economic benefits to sustainable development are many and I think they are like a vicious cycle. If you employ Mr A, the government will tax him, and then he will also help this family, as you are aware, this is Africa and that we help each other [in the family you belong to], so they repel effects of employment cannot be easily quantified. (ZL2).

Closely related to employment is knowledge transfer. Even though this is more or fewer citizens' empowerment to the provision of soft and hard skills through the drone activities, however, the economic impact on both the citizens' lives and the country cannot be overemphasised. Staff from all the three definitive stakeholders were either sent to the United States and Rwanda learn the technology (MoH1, MoH2, MoH3) or were trained intensively at home (ZL1, ZL2). The desire was to transfer critical new knowledge from abroad to ensure that Ghana medical drone services are self-sustaining (MoH2). This requires an intensive training programme to bring these recruits up to speed with the AIT that would be used in running the drones. These recruits have a fair appreciation of the local Ghanaian terrain and conditions better and could relate. ZL1 explained that:

Shortlisted staff were intensively trained for a longer period before starting the test runs in the two main centres currently operating. We wanted to minimise errors within the timelines of our operations; now these trained persons are running the entire medical drone system in Ghana.

These findings indicate that AIT adoption can unlock economic potentials and offer more sustainable economic development (Horváthová, 2010; Tan et al., 2015). In the main, by improving on the socio-economic conditions of the employees and beneficiaries, it addresses the ultimate purpose of SD in relation to the socio-economic well-being of the society in which an organisation operates by creating a conducive environment for citizens to develop their full potential and to live a productive lives (Moore, 2015). By pursuing this SD of the society also will ensure the economic prospect of the implementation firm (Artiach et al, 2010; Chang et al., 2017).

***5.2.3 Environmental Sustainability***

Regarding environmental SD, all four sets of informants, bar beneficiaries and families indicated that the medical drone project is environmentally friendly. Three key areas of environmental friendliness of the drone were cited by the respondents. These include: reduction of air and noise pollutions, and carbon emission; and the attributed to either the use of the drones or the reduction in the use of cars as means of transportation of emergency and essential medical supplies The reduction in pollution and carbon emission do not only impact on the lives of locals but also the world at large, hence, contributing to efforts by the government to reduce environmental hazards affecting the worlds’ environmental sustainability.

Taking air pollution, for instance, respondents were of the view that the use of the traditional means of supply chain system such as cars causes a lot of air pollution as compared to the medical drones. In the words of MoH3:

The [medical] drones do not pollute the air … because it does not use fuel. It uses batteries and these are pollution-free. I understand that we have not substituted the traditional supply chain system with the [medical] drones but in one way or the other, it is contributing to the reduction of air pollution. This is because, the journeys that cars or motorcycles would have gone taking hours, thereby using a lot of fuel are now being supplied by the drones that use batteries. On a facial value, you might think, it’s insignificant but I can tell you that, it is significant. Assuming every country is doing something similar (reducing air pollution), don’t you think global warming problems would have reduced significantly?

Further, the respondents (mainly the implementing firm) indicated that ''the design of the drone is such that they emit a very minimal sound when they are in mid-air and may pass without notice compared to ambulances and other medical supply vehicles currently in the supply chain.'' (ZL1). ZL3 added that the drones currently used in Ghana differ slightly from that of Rwanda [in that] they [the Ghanaian ones] produce minimal sound when even closer [to you]. ZL2 also added that:

Our drones are very quiet so no sound pollution is emitted during flight … you may not even notice it passing by, so we monitor its movement from the radar and our operating centres using [an] app.

Lastly, running on batteries means that, emission of carbon is reduced drastically, if not avoided altogether. Respondents, Zipline and GHS were of the view that the medical drones are contributing to the reduction of carbon emissions, not only in the country and region but worldwide. GHS1, for example, stated that:

We [Ghana] are contributing significantly to the reduction of carbon emissions affecting the ozone layer. I believe you are aware that the world's leaders have been meeting over the years to find solutions to global warming affecting the world. There are increasing in flooding and droughts around the world and that is why world leaders have been campaigning and making efforts to reduce carbon emissions, so this [medical drones’ adoption] is our contribution to this call.

This finding is not surprising given the available evidence suggest that sustainable SCM has become an increasingly important driver of business performance (Cousins et al., 2019). Consequently, adopting green sustainable cutting-edge technology like AIT in healthcare delivery will not only impact positively on the fight against global warming but also improve healthcare delivery.

**6. Conclusions**

**6.1 Summary of Findings, Implications and Recommendations**

Taking into consideration the importance of investing in cutting-edge technologies, AIT is viewed as driving the creation of the industries of the Future. Consequently, significant efforts have been made by industries and governments around the world to invest in AIT. Hence, attracting extant literature to its discussions. One prominent area of AIT discussion is healthcare delivery systems. However, the literature in this domain has focused extensively on medical diagnosis, operations and prescriptions (Shiraishi et al., 2011; Hamet and Tremblay, 2017), to the neglect of SCM. To bridge this research gap, this study explored how AIT adoption in healthcare SCM systems contributes to the SD of the host country and beyond. The world’s largest commercial medical drone adoption and operation programme in Ghana is used as a case study by drawing on documentary evidence and in-depth semi-structured interviews with definitive stakeholders were solicited to achieve the research objectives.

Drawing on SD literature, three central themes of SDGs indices (social, economic and environmental) were used as the assessment tool. Findings indicate that AIT adoption in healthcare SCS contributes significantly to the host country’ SD and beyond. This study provides the importance of cutting-edge technologies such as AI to healthcare delivery and sustainable development. The findings have several implications to sustainable development in developing countries and beyond, as well as AIT enthusiasts, SCM and cutting-edge technology advocates and definitive stakeholders of AIT adoption processes.

***(1) Appropriateness of Cutting-edge Technology in Developing Countries***

The success of the medical drone adoption in healthcare SCS in Ghana indicates that cutting-edge technology such as AI is not only appropriate to SCM networks but also appropriate in developing countries. Hence, contradicting the existing literature that posits that advanced technologies are inappropriate in developing countries due to infrastructural deficits (Emmanuel, 1982; Stewart, 1982, Eckaus, 1987; Kaplinsky, 2011). To the extent that major countries such as the US are currently working in collaboration with Ghana in adopting the similar scheme in the US also implies that the times when developing countries and sub-Saharan Africans always learn from the west in terms of technology and knowledge transfer may be nearing its end. Further, on the backdrop of this, it is suggested that developing countries such as those in Africa should take lead in major cutting-edge technology adoption in their scheme of work as this will impact on their efforts towards SDGs.

***(2) Definitive Stakeholders associated with the Ghanaian Drone Programme***

The findings also indicate that stakeholders such as definitive stakeholders (Mitchell et al., 1997) played a major role in achieving the success of the AIT adoption in healthcare SCM. The implication is that SD depends largely on the role the key stakeholders play in the technology adoption process. Specifically, the role played by the central government and its ministries and agencies, sectors regulators, the implementing firm, and the local community are vital to the successful adoption and operations of the scheme. This implies that achieving SDGs through public sector policy and programme/projects initiatives depends on the key stakeholders associated with the policy or programme/project. As a result, there is a need for the various definitive stakeholders to continue to get involved with the operations of the scheme to maintain the long-term sustainability of the scheme. Further, the findings have implications for healthcare practitioners, and patients – due to the confidence that they have in going about their businesses due to the medical drones, we recommend that, if other governments around the world adopt similar schemes, it will go a long way to achieving their SDGs that relate to the social life of the practitioners and their patients.

***(3) Collaborative Efforts between AIT Enthusiasts and Governments in Developing Countries***

The appropriateness of the AIT in developing countries also implies that those interested in extending AIT to other developing countries can use this as a case to assure themselves that when they move into such ventures, it will work. This will, therefore, attract major technology players around the world to explore AI and other related cutting-edge technologies to developing countries. We, therefore, recommend that AI enthusiasts and governments in developing countries should foster collaborations to bring new and emerging technologies to the doorsteps of developing countries as this will bring improvements in achieving their SDGs.

***(4) Adoption of Cutting-Edge Technology into Supply Chain Management***

In the wake of the demand and calls by practitioners and researchers (Lega et al., 2013; Rakovska and Stratieva, 2018) to adopt cutting-edge technology in SCM networks to improve SCS. This finding implies that AIT could help in the provision of this improved SCS. The implication is that AIT is not only necessary and important in SCS in healthcare operations but also relevant in other areas of human endeavours as this could lead to achieving SDGs. Hence, the researchers recommend the use of AIT and other cutting-edge technologies in healthcare SCS in developing countries and beyond.

***(5) Enhancing SDGs in Developing Countries through AIT***

The findings also show that cutting-edge technologies such as AI can catapult developing countries such as Ghana to SD. As indicated in the findings, AIT in healthcare SCS does not only improve the environmental quality of life, but it also offers some form of socio-economic development. Further, this shows that for developing countries to catch-up with developed countries in terms of SD, there is a need for governments and major development players to adopt cutting-edge technologies such as AI. To do so, governments in developing countries must foster collaborative efforts with developed countries where most of these technologies are invented. This will ensure that technologies are not just ''dumped'' on developing countries but those technological transfers strategies are consciously embedded in such collaborative arrangements.

***(6) Fostering SD around that World through AIT***

Finally, the study has implications for worldwide SD that revolves around social, economic and environmental SD. As AIT is being predicted to be the next good invention that has happened to mankind just like electricity and the internet. Accordingly, these research findings imply that AI will not only offer SD to developed countries but also SD worldwide. This means that governments and policymakers around the world would be assured that AI is a worthy course to supporting the achievement of the United Nations (UN) SDGs set out in 2017 (UN, 2017). In view of this, we recommend that there is a need for the major players in the UN development agenda to invest in AIT. Thus, AIT investments should not be left in the hands of private firms, but that governments and international financial institutions such as world bank and the international monetary fund should be involved.

**6.2 Contributions to Research**

This research contributes to AIT, SCM and SD in several ways. First, the findings show that contrary to the views held by researchers that cutting- edge technologies are inappropriate in developing countries due to the infrastructural deficit (Eckaus, 1987; Kaplinsky, 2011). The present study shows that cutting-edge technologies such as AI is appropriate in developing countries. Hence, this study offers different dimensions to the debate on the appropriateness of advanced technologies in developing countries.

Second, unlike previous studies in the AI adoption in healthcare delivery that have focused mainly on medical diagnosis, prescriptions and operations (Shiraishi et al., 2011; Fazal et al., 2018; Hassanzadeh et al., 2019), this study for the first time focus on SCM in the context of healthcare delivery. Though Klumpp (2018) looked at AI in SCM in healthcare delivery, this looked at automation driving and human collaborations in logistics delivery. Hence, this researcher offers an important dimension to the on-going literature on AIT adoption in the healthcare delivery system.

Third, by exploring how AI technology contributes to sustainable development in developing countries and beyond using medical drones as a case study for AI-enhanced technology in healthcare SCS, we contribute to the opening of the “black box” of AIT (Desouza et al., 2017) in the context of healthcare SCM. This deepens our understanding of how AIT adoption in healthcare SCS contributes to SD in developing countries.

Lastly, by clearly categorising the findings into the three central themes of SD theme, we provide an AI-enhanced technology adoption and SD assessment criteria framework; which could be adopted/adapted for future studies.

**6.2 Limitations and Future Research**

This research has a few limitations. First, the main caveat of this research is the use of an in-depth semi-structured interview to solicit the views of informants; which implies that our findings may only be valid if their views are correct and well-informed. Nevertheless, we do not have any reason to doubt informants’ views, since they are the definitive stakeholders directly involved in the adoption and operations of the drone. Further, to reduce the impact of this caveat, we triangulated the findings using documentary evidence.

Second, because the AIT (drone) adoption and application in the medical supply chain in Ghana is at its infancy- (less than a year into operations), it is possible that all the possible contributions that the operations of the drone offers might not have been known by informants at the time of the data collation. Accordingly, the identified SD matrix might not be exhaustive. Therefore, there is a need for further studies after more years of operations. A quantifiable data and research could be conducted to compare the SD between pre-and post-implementation periods

Three, care needs to be taken in the generalisation of the findings since this study used only one case study. However, this offers an important exploratory study that can be used as the basis for further studies.

**Conflict of Interest**

There is no conflict of interest.

**Reference**

Artiach, T., Lee, D., Nelson, D., & Walker, J. (2010). The determinants of corporate sustainability performance. *Accounting and Finance*, 50(1), 31–51.

Addison, T., Niño‐Zarazúa, M. & Tarp, F. (2015). Aid, Social Policy and Development. *Journal of International Development*, 27(8), 1351-1365.

Asiedu, K. G. (2019). An ambitious drone delivery health service in Ghana is tackling key logistics challenges. *Quartz Africa*, Available at <https://qz.com/africa/1604374/ziplines-drone-delivery-launches-in-ghana-with-vaccines/>. (Accessed 19 September 2019).

Azmata, F., Ferdous, A., Rentschler, R. & Winstona, E. (2018). Arts-based initiatives in museums: Creating value for sustainable Development. *Journal of Business Research,* 85, 386–395.

Baumol, W. J., Likert, R., Wallich, H. C., & McGowan J. J. (1970). *A new rationale for corporate social policy*. Heath Lexington Books.

Bright, J. (2019). Drone delivery startup Zipline launches UAV medical program in Ghana. TechCrunch. Available at: <https://techcrunch.com/2019/04/24/drone-delivery-startup-zipline-launches-uav-medical-program-in-ghana/>. (Accessed 19 September 2019).

Bowen, H. R, & Johnson, F. E. (1953). *Social responsibility of the businessman*. New York: Harper.

Business for Social Responsibility (BSR) (2003). Overview of Corporate Social Responsibility. Available at: http://www.bulentsenver.com/yeditepe/htm/BSR%20%BB%20Business%20for%20Social%20Responsibility%20-%20Overview%20of%20Corporate%20Social%20Responsibility-b.htm. (Accessed 14 December 2019).

Candi, M., & Beltagui, A. (2019). Effective use of 3D printing in the innovation process. *Technovation*, *80*, 63-73.

Carroll, A. B (1999). Corporate social responsibility evolution of a deﬁnitional construct. *Business & Society*, 38(3), 268–295.

Chang, D-Y. (1996), ‘’Applications of the extent analysis method on fuzzy AHP. *European Journal of Operational Research*, 95(3), 649-655.

Chang, R-D., Zuo, J., Zhao, Z-Y., Zillante, G., Gan, X-L., & Soebarto, V. (2017).Evolving theories of sustainability and ﬁrms: History, future directions and implications for renewable energy research. *Renewable and Sustainable Energy Reviews*, 72, 48-56.

Chen, X., Liu, Z., & Zhu, Q. (2019). Reprint of" Performance evaluation of China's high-tech innovation process: Analysis based on the innovation value chain". *Technovation*, 102094, In Press .

Chui, M. (2017). Artificial intelligence: The Next Digital Frontier? (47), McKinsey and Company Global Institute.

Cobbinaha, P. B., Erdiaw-Kwasie, O. M. & Amoateng, P. (2015). Rethinking sustainable development within the framework of poverty and urbanisation in developing countries. *Environmental Development*, 13,18-32.

Cousins, P., Lawson, B., Petersen, K. & Fugate, B. (2019). Investigating green supply chain management practices and performance: The moderating roles of supply chain ecocentricity and traceability. *International Journal of Operations & Production Management*, 39(5), 767-786.

Damoah, I. S., Mouzughi, Y. & Kumi, D. K. (2018). The effects of government construction projects abandonment: stakeholders' perspective. *International Journal of Construction Management*, DOI: https://doi.org/10.1080/15623599.2018.1486172.

Dahlsrud, A. (2008). How corporate social responsibility is defined: an analysis of 37 definitions. *Corporate Social Responsibility and Environmental Management*, 15, 1-13.

Dasandi, N. & Esteve, M. (2017). The politics-bureaucracy interface in developing countries. *Public Administration and Development,* DOI: 10.1002/pad.1793.

Davis, K. (1973). The case for and against business assumption of social responsibilities. *Academy of Management Journal*, 16, 312–22.

Desouza, K. C., Krishnamurthy, R. & Dawson, G. S. (2017). Learning from public sector experimentation with artificial intelligence (Brookings). Washington, D.C.: Brookings. Available at: <https://www.brookings.edu/blog/techtank/2017/06/23/learningfrom-public-sector-experimentation-with-artificial-intelligence/>. (Accessed 12 November 2019).

Dirican, C. (2015). The impacts of robotics, Artificial intelligence on business and economics. *Procedia - Social and Behavioral Sciences*, 195, 564–573.

Donaldson, T. & Preston, L. E. (1995). The stakeholder theory of the corporation: Concepts, evidence, and implications. *Academy of Management Review*, 20(1), 65-91.

Dyllick, T., & Hockerts, K. (2002). Beyond the business case for corporate sustainability. *Business Strategy and the Environment*, 11(2),130–41.

Eckaus R. S. (1987). Appropriate technology: The Movement Has Only A Few Clothes On. *Issues in Science and Technology*. Winter, 62-71.

Emmanuel, A. (1982). *Appropriate or under-developed Technology?.*  John Wiley, Chichester, 3-22.

Elias, A. A., Cavana, R. Y. & Jackson, L. S., (2002). Stakeholder analysis for R & D project management. *R&D Management*, 32(4), 301-310.

Fazal, M. I., Patela, M. E., Tye, J. & Gupta, Y. (2018). The past, present and future role of artificial intelligence in imaging. *European Journal of Radiology*, 105, 246–250.

Fontaine, C., Haarman, A. & Schmid, S. (2006). The stakeholder theory. *Edlays education*, 1, 1-33.

Freeman, R. E. (1984). *Strategic Management: A Stakeholder Approach*. (Latest ed.), Boston: Pitman.

Giones, F. & Brem, A. (2017). From toys to tools: The co-evolution of technological and entrepreneurial developments in the drone industry. *Business Horizons*, 60(6), 875-884.

Guest, G., Bunce, A. & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*, 18(1), 59-82.

Hamet, P. & Tremblay, J. (2017). Artificial intelligence in medicine. *Metabolism*, 69, S36-S40.

Hassanzadeh, P., Atyabi, F. & Dinarvand, R. (2019). The significance of artificial intelligence in drug delivery system design. *Advanced Drug Delivery Reviews*, <https://doi.org/10.1016/j.addr.2019.05.001>.

Heath, J. & Norman, W., (2004). Stakeholder theory, corporate governance and public management: what can the history of state-run enterprises teach us in the post-Enron era?. *Journal of Business Ethics*, 53(3), 247-265.

Herath, D. (2009). The Discourse of Development: has it reached maturity?. *Third World Quarterly*, 30(8), 1449-1464.

Hill, C. E., Knox, S., Thompson, B. J., Williams, E. N., Hess, S. A. & Ladany, N. (2005). Consensual qualitative research: An update., *Journal of Counselling Psychology*, 52, (2), 1-30.

Horváthová, E. (2010). Does environmental performance aﬀect ﬁnancial performance? A meta-analysis. *Ecological Economics*, 70(1), 52–9.

Howe, J. (1994). Artificial Intelligence at Edinburgh University: a Perspective. Revised June 2007. Available at: http://www.inf.ed.ac.uk/about/AIhistory.html. (Accessed 17 September 2019).

International Institution of Sustainable Development (IISD) (2002). Business strategy for sustainable development: leadership and accountability for the 90s. Available at: <https://www.iisd.org/library/business-strategy-sustainable-development>. (Accessed 14 December 2019).

Jerónimo, H. M., Henriques, P. H., & de Lacerda, T. C., da Silva, F. P., & Vieira, P. R. (2019). Going green and sustainable: The influence of green HR practices on the organizational rationale for sustainability. *Journal of Business Research,* DIO: <https://doi.org/10.1016/j.jbusres.2019.11.036>.

Kaplan, A. & Haenlein, M. (2019). Siri, Siri in my Hand, who is the Fairest in the Land? On the Interpretations, Illustrations and Implications of Artificial Intelligence. *Business Horizons*, 62(1), 15-25.

Kaplinsky, R. (2011). Bottom of the pyramid innovation and Pro-Poor Growth. *IKD Working Paper,* (62) 2-17. www.open.ac.uk/ikd/publications/workinq-papers

Klumpp, M. (2018). Automation and artificial intelligence in business logistics systems: human reactions and collaboration requirements. *International Journal of* *Logistics Research and Applications*, 21(3), 224-242.

Lee, M. D. P. (2008). A review of the theories of corporate social responsibility: its evolutionary path and the road ahead. *International Journal of Management Review*, 10, 53–73.

Lega, F., Marsilio, M. & Villa, S. (2013). An evaluation framework for measuring supply chain performance in the public healthcare sector: evidence from the Italian NHS. *Production Planning & Control*, 24(10-11), 931-947.

Longoni, A., Pagell, M., Shevchenko, A. & Klassen, R. (2019). Human capital routines and sustainability trade-offs: The influence of conflicting schemas for operations and safety managers. *International Journal of Operations & Production Management,* 39(5), 690-713.

Mairaj, A., Baba, A. I., & Javaid, A. Y. (2019). Application specific drone simulators: Recent advances and challenges. *Simulation Modelling Practice and Theory*, 94, 100–117.

McCarthy, J. (2000). A Review of Artificial Intelligence: A General Survey. Available at: <http://www-formal.stanford.edu/jmc/reviews/lighthill.pdf>. (Accessed 17 September 2019).

McCorduck, P. (2004). *Machines Who Think*. (2nd Ed.), Natick, MA: A. K. Peters, Ltd.

Miles, M. B. & Huberman, M. (1994). *Qualitative Data Analysis: A Sourcebook of New Methods*. (2nd Ed.), Beverly Hills, CA: Sage Publications.

Mitchell, R. K., Agle, R. B., & Wood, J. D., (1997). Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts. *The Academy of Management Review*, 22(4), 853-886.

Min, H. (2010). Artificial intelligence in supply chain management: theory and applications. *International Journal of Logistics: Research and Applications*, 13(1), 13-39.

Moran, M. E. (2006). The da Vinci robot. *Journal of Endourology*, 20 (12), 986–90.

Moore, H. L. (2015). Global Prosperity and Sustainable Development Goals. *Journal of International Development*, 27(6), 801-815.

Morse, J. M. (1995). The significance of saturation. *Qualitative Health Research*, 5(2), 147-149.

Morse, J. M. (2000). Determining sample size. *Qualitative Health Research*, 10(1), 3-5.

Moskwa, W. (2016). World drone market seen nearing $127 billion in 2020, PwC says. Available at: <https://www.moneyweb.co.za/news/tech/world-drone-market-seen-nearing-127bn-2020-pwc-says/>. (Accessed 11 October 2019).

Nuki, P. (2018). Pointing the way: how medical drones are saving lives in Africa. *The Telegraph*, Available at: <https://www.telegraph.co.uk/global-health/women-and-girls/pointing-way-medical-drones-saving-lives-africa/>, (Accessed 23 November 2019).

Nyantakyi, K. (2019). Ghana medical drone delivery successfully delivers first package to the Tafo Government Hospital. Available at: <https://www.jbklutse.com/ghana-medical-drone-delivery-successfully-delivers-to-tafo-hospital/>. (Accessed 19 September 2019).

Orlitzky, M., Schmidt, F. L. & Rynes, S. L. (2003). Corporate social and ﬁnancial performance: a meta-analysis. *Organisational Studies*, 24(3), 403–441.

Pan, G. S. C., (2005). Information systems project abandonment: a stakeholder analysis. *International Journal of Project Management*, 25(2), 173-184.

Pan, G. & Pan, S. L. (2006). Examining the coalition dynamics affecting IS project abandonment decision-making. *Decision Support Systems*, 42(2), 639-655.

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. (3rd Ed.), Thousand Oaks, California: Sage Publications.

Petrikova, I. (2014). The short- and long-term effects of development projects: evidence from Ethiopia. *Journal of International Development*, 26(8), 1161-1180.

Pritchett, L. & Kenny, C. (2013). Promoting Millennium Development Ideals: The Risks of Defining Development Down - Working Paper 338. Centre for Global Development.

PwC, (2018). No longer science fiction, AI and robotics are transforming healthcare. Available at: https://www.pwc.com/gx/en/industries/healthcare/publications/ai-robotics-new-health/transforming-healthcare.html. (Accessed 21 November 2019).

Rakovska, M. A. & Stratieva, S. V. (2018). A taxonomy of healthcare supply chain management practices. *Supply Chain Forum: An International Journal*, 19(1), 4-24.

Ramesh, K., Gupta, S., Ahmed, S. & Kakkar, V. (2016). A comprehensive study on design trends and future scope of implantable drug delivery systems. *International Journal of Bio-Science and Bio-Technology*, 8(6), 11-20.

Russell, S. J. & Norvig, P. (2003). *Artificial Intelligence: A Modern Approach*. (2nd Ed.). Upper Saddle River, New Jersey: Prentice Hall.

Russell, S. J. & Norvig, P. (2009). *Artificial Intelligence: A Modern Approach.* (3rd Ed.). Upper Saddle River, New Jersey: Prentice Hall.

Russell, S. J. & Norvig, P. (2016). *Artificial intelligence: A modern approach*. (Global Ed). Englewood Cliffs, New Jersey: Pearson Higher Ed.

Saunders, M., Lewis, P. & Thornhill, A. (2015). *Research methods for business students.* (6th Ed). Harlow [etc.], Pearson Education Limited.

Shiraishi, J., Li, Q., Appelbaum, D. & Doi, K. (2011). Computer-Aided Diagnosis and Artificial Intelligence in Clinical Imaging. *Seminars in Nuclear Medicine*, 449-462.

Sigal, S. (2019). Ghana’s new lifesaving drones: like Uber, but for blood. Available at: <https://www.vox.com/future-perfect/2019/6/4/18647685/medical-drones-ghana-africa-zipline-global-health>. (Accessed 19 September 2019).

Silverman, D. (2013). *Doing Qualitative Research*. (4th Ed), Sage Publication, London.

Stewart, F. (1982). *Technology and Underdevelopment*. (2nd  Ed,), 1-30, London, Macmillan.

Sun, T. Q. & Medagli, R. (2019). Mapping the challenges of Artificial Intelligence in the public sector: Evidence from public healthcare. *Government Information Quarterly*, (36), 368–383.

Tan, Y., Ochoa, J. J., Langston, C. & Shen, L. (2015). An empirical study on the relationship between sustainability performance and business competitiveness of international construction contractors. *Journal of Cleaner Production*, (93), 273–8.

The Guardian UK, (2019). Vaccines by air as drone medicine service takes off in Ghana. Available at: <https://www.theguardian.com/global-development/2019/apr/25/medical-delivery-drones-cleared-for-takeoff-in-ghana-zipline>. (Accessed 19 September 2019).

Todaro, M. P. (2000). *Economic Development*. (7th Ed), Addison Wesley Longman.

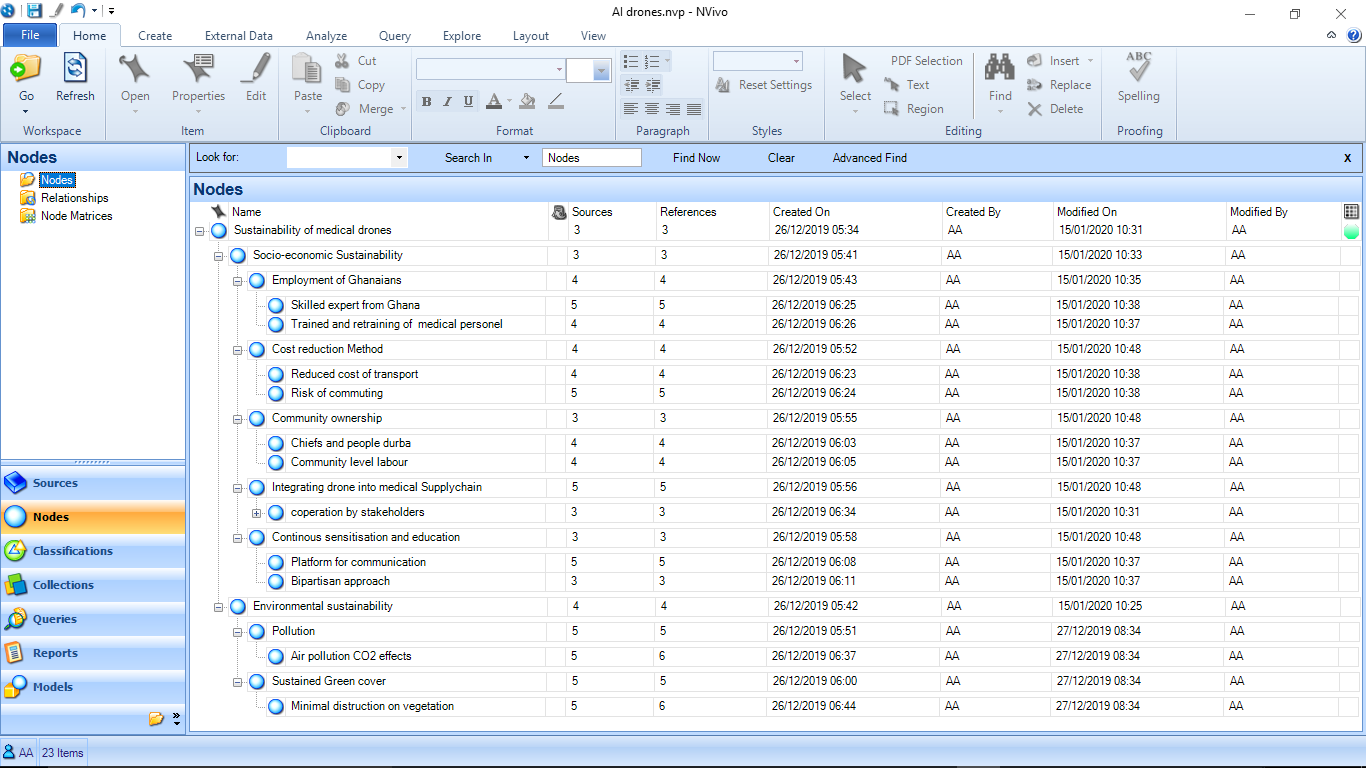
Tzafestas, S. G. (2016). Artificial intelligence. In S. G. Tzafestas (Vol. Ed.), *Roboethics,* 79, 25–33.

Watts, P. & Holme, R. (1999). Corporate Social Responsibility: Meeting Changing Expectations. *World Business Council for Sustainable Development*. Geneva.

Zhang, H., Jackson, J. K. & Chiao. M. (2017). Microfabricated drug delivery devices: Design, fabrication, and applications. *Advanced Functional Materials*, 27, 1703606, 1-31.

**Appendix**

1. **NVivo Quotes Showing Data Analysis**



1. <https://www.whitehouse.gov/articles/accelerating-americas-leadership-in-artificial-intelligence/> [↑](#footnote-ref-1)