International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** XII **Month of publication:** December 2021

DOI: https://doi.org/10.22214/ijraset.2021.39403

Effective Extension Sustainability in the face of COVID-19 Pandemic in Smallholder Agricultural Markets

Enock Siankwilimba[1], Edwell. S. Mwaanga[2], Joshua Munkombwe[3], Chisoni Mumba[4], Bernard Mudenda Hang'ombe[5]

[1]*Musika development Initiatives, Lusaka Zambia*
[2,4]*The University of Zambia, School of Veterinary Medicine, Department of Disease Control, Lusaka, Zambia*
[3]*Musika Development Initiatives, Lusaka, Zambia*
[5]*Africa Centre of Excellence for Infectious Diseases of Humans and Animals (ACEIDHA), Microbiology Unit, School of Veterinary Medicine, Lusaka, Zambia*

Abstract: The effects of COVID-19 have tested and crushed the earlier achievement in sustaining the agricultural and extension delivery system globally. COVID-19 has pressed a reset panel on the extension services more especially among the smallholder farmers who are already underprivileged. Specifically, this review paper aims to analyse studies on the sustainability of agricultural extension delivery systems in face of the COVID-19 crisis. The various theories and factors advanced in discussing sustainable agricultural extension delivery systems, and how they contribute to improved production and productivity to end poverty have been addressed. The COVID-19 mitigation strategies and their effect on agricultural extension sustainability have been laid bare. No single sustainability theory can explain how COVID-19 has disrupted the extension delivery systems. The service providers and farmers have had their effects differently, and all players have followed mitigation to the best of their knowledge. Extension delivery has undergone numerous modifications over the years to better meet the demands of farmers and the changing nature of the markets in which they operate. In order to provide effective service delivery and outcomes to farmers, collective involvement of various stakeholders is necessary since no single player can achieve effective extension sustainability alone due to the diverse nature of the challenges, which are mainly influenced by factors such as geographical location, poverty, and social status among others. Therefore, appropriate approaches should be selected based on the needs of farmers and the market dynamics of a specific economic orientation in a given area. We conclude that effective and sustainable extension delivery systems require many combined theories, support functions, formal and informal rules, and regulations involving all extension-based stakeholders.
Keywords: Sustainability, COVID-19, smallholder farmers, agricultural market systems, extension services

I. INTRODUCTION

Many international summits and conferences, such as the recent Glasgow 'conference of parties number 26 (COP26), have been held to find ways on how to keep global temperature rise below catastrophic levels (1.5ºC) and avoid the climate disaster from triggering even bigger calamities for the world's poorest and most vulnerable citizens (Marambe, 2019; Matthews, 2021). These poorer nations are victims of climate change realities triggered by developed countries' unsustainable development pathways which are the major contributors to global warming.

In addition to climate change, COVID-19 has become one of the most complicated barriers to achieving sustainable agricultural extension service provision across many countries globally. It has reinforced the already stressed ecosystem where climate change and poor political governance systems have been cited as a menace to the increased production and productivity of many smallholder farmers in sub-Saharan Africa (Chapoto et al., 2012; Cook et al., 2021; Haggag, 2021; Maggio & Sitko, 2019; Ngoma et al., 2021; Siankwilimba, 2016; Sitko, 2017)

Many scholars have claimed that smallholder farmers' low production and productivity in their daily farming business results from a failed extension delivery system negatively impacted by the effects of climate change and COVID-19 (Cook et al., 2021; IFAD, 2021; Swinnen & McDermott, 2020). Others blame the current agricultural extension business models that are at fault as they fail to consider the components of sustainability in their pledge to maximise profits in the face of COVID-19 natural calamities (Kumar et al., 2020; Raworth, 2017; Sterman, 1994).

In recent years, the situation has worsened by the combined forces of climate change and the COVID-19 outbreak, which have exerted pressure on many players involved in the extension market ecosystem. The worst-hit population on the impact of unsustainable extension delivery systems arising from this situation are the farmers in sub-Saharan Africa, most of whom live in

abject poverty and depend on agriculture for their livelihoods (Ugochukwu, 2020). The effects of COVID-19 is now overshadowing the impact of climate change. However, it seems COVID-19 is taking centre stage in all local, regional and global summits debates.
The reasons could be attributed to its immediate impact on human, social and economic disruptions compared to climate change (Michelena et al., 2020). However, the core function (demand and supply) of agricultural extension services are not equating well due to many issues such as poor funding and low farmer extension staff ratios (Ritter et al., 2017) thereby subjecting small-scale farmers to perpetual levels of abject poverty. Needless to say that there has been a pronounced deal of attention in attempting to alleviate poverty by providing sustainable agricultural extension services in many developing countries. Such interventions have been aimed at assisting the farmers to increase their production and profit from their operations. This has included the provision of training and promotional programs for farmers, and the introduction of new products and farming techniques such as fertilizers or new varieties of crops and conservation farming, respectively. However, despite governments and international donors committing a significant amount of money to these initiatives, the consequences of these interventions on sustainable food security and economic outcomes are still unknown due to the complexity of the market space. Therefore, the situation has continued to haunt and negatively impact the smallholder farmers in most of these countries despite many corrective interventions in the past.
Therefore, this paper seeks to review the agricultural extension sustainability centring on different theoretical frameworks advanced by scholars worldwide. It also explores different factors that drive and affect agricultural diversification output in the face of COVID-19. To achieve these goals, a review of 90 previously published publications in scientific journals and a 25 supplementary report was carried out from 2019 to November 2021. The authors have also sought to include reports from valid government and private sector website sources. Papers were being included depending on their relevance while others were excluded because they were not relevant to the topic at hand.

II. MOTIVATION FOR THE REVIEW

Sustainable agricultural extension development in developing countries is dependent on the success of smallholder agricultural markets. Consequently, both national and international organizations are pursuing efforts to increase the productivity of smallholder farming through the employment of function and sustainable extension delivery systems. For example, African heads of states committed to investing at least 10% of their national budgets in agricultural development under the Comprehensive Africa Agriculture Development Programme (CAADP) they signed under the Maputo Declaration in 2003 though many states have failed to meet this target.
Similarly, according to Stewart et al. (2015), many donor organisations have redoubled their effort to develop smallholder markets in developing countries. For example, the World Bank (2015) claimed that agricultural development was one of the most potent tools to poverty eradication and raised its lending to agricultural development in Africa to 1.6 billion, a 59 percent increment above the previous lending before 2014. Likewise, the Bill and Melinda Gates Foundation promised more than $2 billion to assist an African Green Revolution initiative in developing countries (Bill and Melinda Gates Foundation, 2015). In addition, China has invested huge sums of money in Africa to train government extension staff and facilitate the transfer of improved affordable technologies to smallholder farmers (Vaidyanathan et al., 2021).
In the light of COVID-19 outbreaks, many smallholder farmers have had a market disruption, which negatively affected their market's production and supply side. It, therefore, means that the smallholder market is more susceptible to both internal and external shocks. If no investments are made to reverse the situation, farmers will likely fail to double their yields and the target 400 million smallholder farmers will not be able to be pulled out of poverty in the next 20 years.
For example, it is projected that by 2050, the 'world's population is expected to exceed 9 billion people, and this population will need to be fully fed by the majority of smallholder farmers that are found in developing countries (Cao et al., 2021; FAO, 2013; Whitmee et al., 2015). However, most developing countries are still using the face-to-face traditional extension service models that have shown limitations in the face of COVID-19 and climate change complexity (Davis, 2020). Sadly, COVID-19, a new entrant on the market, has joined climate change to exert unprecedented negative pressure on human, health, economic, and natural resources that foster sustainable agriculture by disrupting the traditional information sharing mechanisms (Haggag, 2021).

III. WHAT IS THE CURRENT STATUS OF THE AGRICULTURAL EXTENSION SYSTEM IN DEVELOPING COUNTRIES?

Literature indicates that extension systems in many developing countries have been operating for over 60 years, but they are currently facing several complex challenges limiting them to attain a functional and sustainable smallholder market (Osumba et al., 2021). As a result, many developing countries have employed a hybrid extension approach which allows government and private sector players to provide holistic extension service in the smallholder market (Taylor & Bhasme, 2018). Among many extension models being used to transfer information, innovations, and technology is the transfer technology (ToT) model premised on transferring technology and information from scientists to farmers to accelerate development (Baloch & Thapa, 2019).

In the light of COVID-19, many extension service providers have used electronic extension models based on digital technology (Haggag, 2021). However, this kind of extension still promotes bottom-up and top-down extension systems that depend entirely on the available information technology infrastructure (Phillips et al., 2019). This has proved to work during the onset of COVID-19, and it is predicted that the system will continue working even after COVID-19 has subsided (Bank, 2020). However, due to poor information and communication infrastructure in most developing countries, many studies indicate that information delivery network systems could be still 'blacking out' many smallholder farmers under digital extension technology.

The success of the digital extension model is premised on the enabling environment each government put in place for its people. According to Rezaei-Moghaddam and Salehi (2010) and Adnan et al. (2017), a key impediment to developing countries' sustainable development is the lack of public awareness of environmental concerns and an understanding of how market forces work to sustain their agribusiness among the smallholder farmers. While many donors and governments are facilitating a systemic extension delivery system managed by the private sector as key players, smallholder farmers still place the shoulders of responsibility on their governments. This scenario curtails the rapid development of inclusive and sustainable agricultural extension development. As a result, to achieve sustainability, it is necessary to raise people's knowledge and awareness of the environment.

Traditional extension systems are insufficiently effective in promoting the adoption of sustainable agricultural practices, primarily because the traditional roles of transferring and disseminating agricultural technologies and information are proving insufficient in today's global context (Alabi & Ajayi, 2018). From an emphasis on construction at the commencement of the twentieth century to productivity (or efficiency) oriented agriculture in the twenty-first century, and finally, to the more contemporary philosophy of sustainability, the vocabulary of agricultural extension has changed with time, aiming at inclusive and sustainable development (Ugochukwu, 2020). In recent years, extension systems have steadily shifted from a knowledge transfer to a knowledge-share model, with farmers no longer regarded as the sole recipients of new technology and research but rather active contestants in the learning and teaching processes (Quisumbing et al., 2014). A similar shift is occurring in the role of agricultural extension workers, who are transitioning from merely providing knowledge and technology to becoming facilitators, advisors, and consultants of farmer learning processes (Davis et al., 2020).

In the face of the COVID-19 era, all market players in the market system are playing a win-win situation (Cooper et al., 2021) that is highly symbiotic (FAO, 2021). The farmers can mask up themselves to attend extension training and promotions for their benefits. While on the other hand, extension services providers can also provide COVID-19 mitigation materials and reinforce the Five (5) COVID-19 rules so as not to lose the day-to-day interactions and sharing of commercial information with their clients who buy their products and services (Zabaniotou, 2020). Beez (2014) argued that extension has already entered an era of social capital, in which farmers are now viewed as possible solutions rather than problems, and in which the importance of individual capacity is emphasized above all. Therefore, traditional extension strategies are insufficiently effective in promoting the adoption of sustainable agricultural practices, as it has become increasingly apparent that demand-based extension models take the lead (Maulu et al., 2021).

In general, agricultural extension in developing countries does not enjoy a favourable reputation, and it cannot be pushed in the traditional ways of selecting approaches and extension methods, developing objectives and responsibilities, and structural building organizations, among other things (Alabi & Ajayi, 2018). For this reason, a sustainable extension delivery system that recognises the participation of all market play is cardinal for smallholder farmer development (Lenaghan & Heffern, 2021).

For agricultural systems to be sustainable, extension and advisory services must be integrated with healthcare services and products that help people live longer lives now and in the future without harming the environment, social systems, or economic systems. Furthermore, extending and advising services should respond firmly when confronted with COVID-19 by distributing useful and efficient information to human beings to prevent them from succumbing in huge numbers.

Nevertheless, there is compelling evidence that the operations of a healthcare system have a significant impact on the environment, the economy, and societal well-being (Venkatramanan et al., 2019). Furthermore, the arrival of COVID-19 has demonstrated conclusively that most countries' current health systems, particularly in developing countries, are porous and incapable of supporting themselves. Furthermore, the presence of a new COVID-19 strain, the OMICRON, found in South Africa and reported in Zimbabwe, Botswana, Zambia and Eswatini, is causing concern that an emergency will characterize the fourth wave of COVID-19 due to this strain, which is more lethal and difficult to contain. It is, therefore, easier to submit that the current agricultural extension services system is marred with many challenges in its quest to support all the players. Biondi et al. (2021) submitted that the extension system is currently plagued by illness, the death of extension staff and their loved ones, lockdowns, travel restrictions, the transition to online teaching and promotion, school and gathering closures, and the closure of farmer field services, all of which diverted time and attention away from research and extension, particularly during the initial months, when people were caught off guard and needed to adjust quickly, with limited information

IV. VIEWING AGRICULTURAL EXTENSION SYSTEM AS PART OF AN OPEN SOCIAL NETWORK

Today, it is nearly universally accepted that agricultural extension will be more effective and sustainable when it operates inside the framework of a system to service the smallholder market and many other stakeholders (Rahmandad et al., 2021; Sweeney & Sterman, 2000). The past traditional extension model operated in the linear model where extension services providers such as the government and private sector operated a highly hierarchical extension model where the farmers were seen as problems that had to be helped to solve their problems. Conversely, farmers are currently viewed as part of the problem solving as they are critical custodians of indigenous knowledge required to solve the current effects of climate change and possibly the COVID-19 pandemic. Therefore, agricultural extension is currently being viewed as an "open social network system" to drive sustainable and effective information and technology in agricultural extension network systems (Ceschin & Gaziulusoy, 2019). According to systems dynamics, the sustainable extension system should be viewed as a whole rather than a collection of individual elements (Stockmann et al., 2021). As a result, the whole concept entails that extension performance should be evaluated on how a single complete unit composed of many parts works and not based on each performance of individual units (Ferretti & Grosso, 2019). It is assessed based on how the components fit together and relate to one another and how the system relates to its environment and to other systems in that environment (Röling & de Jong, 1998). In a sustainable extension system, the output is determined by the inputs, which are also affected by time and the environment as the components interact internally (Nganga et al., 2020). For example, the recent disruption in the external environment brought by COVID-19 necessitated extension organizations to make necessary adjustments to continue functioning effectively within their state of the environment (Bates et al., 2021). Furthermore, the changes in the working environment advanced by COVID-19 triggered economic, environmental, social, political and technological advancement, among many things (Adnan & Nordin, 2021). Therefore, in order to achieve sustainability, the effects of these forces of change advanced by COVID-19 are extremely important in the dynamism of extension systems because the extension systems are/were either directly or indirectly affected by the fluctuations and, as a result, must make internal and external adjustments in order to keep working at the same or higher levels of efficiency (Baloch & Thapa, 2019). For example, the digital extension model sprung up due to COVID-19 mitigation strategies by local health ministries and World Health Organisation in many developing countries (Barnes, 2020). The primary forces of change affecting extension service provision added to climate change include social distance, lockdown, masking up, sanitizing, and quarantine (Varahachalam et al., 2021). Further to this extension, sustainability is highly affected by market liberalisation, participation, privatisation, decentralisation and breakthroughs in information and communication technology, biotechnological and genetic engineering, cultural norms and behaviour and a holistic perspective (Alabi & Ajayi 2018).

It is very clear that as extension systems evolve, there are intended and unintended feedbacks that need to be observed through changes in the behaviour of people and the social economy. These appear to be cardinal observance determinants of extension social network change.

V. DRIVE TOWARDS SUSTAINABLE EXTENSION DELIVERY SYSTEM

Many scholars have argued that for an extension to be sustainable and efficient, it has to be driven by specific environmental assets readily available during the implementation stage (Hasheminasab et al., 2020). Through its educational programs, agricultural extension has the potential to play a critical role in the promotion of sustainability in a world of complex challenges. The mission of agricultural extension is to provide all sorts of farmers with the knowledge, skills, and resources they require to assist them in running their farms efficiently and becoming good citizens, thereby improving their overall quality and quantity of life continuously and sustainably. Furthermore, both the extension service providers' training and continuous capacity development will better position them to meet the challenges arising from climate change and COVID-19 outbreaks. This helps to drive the necessary institutional and community reorganization required to ensure sustainable agriculture development and assist farmers in adopting the tenets of sustainable agriculture development in their operations despite the disruptions accelerated by the COVID-19 pandemic and climate change

To achieve sustainability, the extension delivery system places various assets in terms of activities and functions to achieve the targeted goal. Therefore, it is critical for the extension system to identify assets, assess their vulnerabilities and susceptibility to internal and external shocks. Then take steps to either enhance or strengthen those assets or reduce vulnerabilities that place stress on those assets either continuously or periodically (Meera et al., 2012).

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

COVID-19 has negatively affected the availability of human capital, social capital, natural capital, financial capital, and built (made) capital assets (Rude et al., 2020; Zambrano-Monserrate et al., 2020). Critically, there is much interdependence between human capital such as skills, abilities, education, indigenous knowledge, and the overall health of a community in an extension delivery system or organization posited by Grove et al. (2020).

These human capital are necessary intangible skills in that they would affect in many ways in sustaining the agricultural extension (Todaro & Smith,2015). Social capital refers to the networks that exist both within and outside of a community, the sense of belonging that people have to their community and the extent to which they may participate in local activities and decision-making. Sima et al. (2020) has broadened the set of human capital development assets to include the following; information, new job opportunities and the Internet; technology; training and education; new skills; automation; communication; innovativeness; professionals; productivity; artificial intelligence; digitalization; e-recruitment; and the Internet of Things. These skills are critical aspects of extension workers, and service providers should manage to sustain service in the smallholder market system.

Todaro & Smith (2015) indicated that human capital needs to be supplemented with natural capital, also known as the environment asset, in good health. Research indicates that the wealth of the environment is in its healthy state (Chinsembu, 2021). Health environment can support and sustain life, and therefore extension should thrive to coin education messages aimed at good stewardship. In most developing countries, natural assets have played a vital role in providing man with other natural resources to increase and sustain lives, such as fertile soils. However, many a time, most private companies and governments have leaned towards emphasising the need for financial capital. Here financial capital entails the community's resources at its disposal within “built capital", which entail a community's infrastructure (Hovmand, 2014). From the above, it is perhaps clear that each type of capital tends to increase the productivity of other types of capital within the realm of systems processes.

In face of COVID-19, the increased use of information technology, communication, and internet facilities contributes to improving the efficiency of healthcare systems by enabling the introduction of new services such as telemedicine and by increasing the availability of high-quality services to a larger proportion of the population that is under the surge of the disease (Bakken et al., 2019). Compared to the previous model of information plus knowledge plus innovation, which corresponded to the knowledge economy, the model of human intelligence plus new information technologies plus information plus innovations, which corresponds to the Industry 4.0 age, represents a significant shift that has brought massive advancement in finding human information sharing system (Sima et al. 2020). The development of an individual's creativity and the accumulation of human capital serve as the qualitative foundation for progress at this stage. During the COVID-19 information stage, it is vital to adjust the educational system to meet the new development requirements of smallholder farmers. Under these new conditions, only the knowledge learned will contribute to the development of the information era and its safe development (Sima et al. 2020).

VI. COMPONENTS OF A SUSTAINABLE EXTENSION SYSTEM

As earlier started a system is made up of individual components which give it the shape and structure and overall functions to attain the long term sustainability goals. One of the most significant responsibilities of extension service providers is to determine the goals and objectives of the extension program they will implement (Nedumaran & Ravi, 2019). Sustainability has become a strongly emphasised paradigm shift of many years. Participatory extension system has given a new viable long term sustainability in the current times. This has seen the shift in the extension system towards enhancing adaptive management capacity, emancipation, and social capital at the local level and the development of stakeholder platforms for negotiations and learning processes (Cook et al., 2021). Furthermore, with the intensity of climate change and the COVID-19 variant, adaptive thinking and management become critical in attaining food security through adaptive information learning (Kogo et al., 2020).

According to Ibrahim (2019), extension objectives toward sustainability could range from the effective transfer of technology to establishing strong rural organizations, influencing future research and policy agendas and taking and enforcing collective decisions on resource management. Therefore, resource management will help replenish and refresh the planet, which will promote sustainable agricultural development in the long run. In recent times when there were intensified lockdowns across many countries, natural resources such as wild animals had attained their much-desired freedoms, which they could not get when human beings were at full throttle of development (Roe et al., 2020). Therefore extension system should be seen to provide the adaptive regenerative system to the natural resource (Moguilevsky et al., 2021)

Within this new paradigm, sustainable agriculture cannot be achieved just through conventional extension methods; rather, it necessitates the development of a new type of learning process- the facilitation of learning (Nkuyubwatsi, 2016). Current agricultural extension methods include using groups to exchange and share information, networking to exchange and share information, and social and participatory learning methods. However, it appears it is aimed at emphasizing problem-solving rather than the subject of learning, using indicators to make environmental problems visible, conducting regular field observations as the basis for decision making, and putting emphasis on experiential learning methods (Omulo & Kumeh, 2020). In the field of ecological agriculture, it is hoped that these strategies will assist with the greater facilitation of learning opportunities.

The majority of existing organizations are dedicated to improving output and productivity, equity, or stability. However, a small number of organizations have formed to promote long-term sustainability (Keding et al., 2021) in face of COVID-19 disruption. However, it should be realised that because of the slow progress made in achieving policy objectives such as export, food security, environmental sustainability, and social well-being, public models for providing an agricultural extension is believed to have fallen into disdain in many nations, including the developed countries such as the United States and China (Wang et al., 2020). Therefore, progress has been made to expanding and diversifying extension systems to include both public and private sector organizations and non-governmental organisations that provide a range of services such as technology transfer services, advisory services, training and promotion services, advertising services and information sharing services on a wide variety of subjects like, marketing technology transfer services, agriculture, social organization, education and health services on diseases of pandemic like COVID-19 (Mahmood et al., 2021).

Birner et al. (2009) submitted that decentralization and pluralism are two of the most important features of extension organizations working toward long-term success. It is required that most extension service providers should be adaptive and learning organisations in order to achieve effective and efficient sustainability (Campo et al., 2010). In his earlier submission, Beers et al. (2014) claimed that individuals are expected to "serve as learning agents for the organization, responding to changes in the company's internal and external environments" when joining a learning organisation. Extension service providers that are dynamic always encompass value addition to their extension service tend to empower their clients and customers (Friel et al., 2017). Examples are farmer associations and non-governmental organizations (NGOs) using market system approaches to drive long term sustainability in agriculture development. More importantly, the extension should provide backwards and forward interlink to foster agricultural extension services' growth for all extension market players, including farmers at the community level (Todaro & Smith, 2015). This means that extension should link agricultural messages to health messages, especially for COVID-19, to reduce food supply chain disruptions.

Extension agents should adjust to these changes by moving the philosophical foundations of rural and agricultural development's views and developing new professionals with new concepts, values, methods, and conduct aimed at sustaining the agricultural extension system for the benefit of all, which mainly entails the job of extension facilitation (Tisenkopfs et al., 2015). Therefore, incorporating new COVID-19 messages would be a welcome move by a learning organisation through its agent pivotal facilitation. The new function of managing and promoting learning processes necessitates the development of specialized skills and competencies distinct from the current technical focus of extension agents.

Simplifying for better assimilation of messages for the benefit of stakeholders, especially women and youths, pose a sustainability potential for growth in agriculture. For example, role-play could easily make the farming community understand the COVID-19 messages concerning agricultural development. This would encourage many smallholder farmers, especially women and youth appreciate mitigation strategies for the environment and climate change sound practice, achievements in biotechnology and genetic engineering, trade liberalization, participation, and new communication technologies (Glover et al., 2019).

Therefore, for agriculture and agribusiness to succeed, Lorenzen et al. (2020) state that there is a need to show the balancing or harmonisation of social, environmental, and economic business interests for all stakeholders in the market space while maintaining a balance between short-term and long-term business objectives and with risk reduction strategy. Furthermore, according to Conrad (2018) and Ibrahim (2019), sustainability in agricultural business extension service should attain and include demonstrating ethical values, moral commitment, transparency, and accountability towards all business stakeholders in the agricultural and information system network. There cannot be sustainability in extension delivery systems if health issues such as the negative effects of COVID-19 are not taken care of. Health systems should interconnect with economic, environmental and social systems using the extension and advisory systems. These elements are interconnected and cannot be easily delinked in a standard extension market system (Dean Hunter, 2018).

Therefore, it is evident that the agricultural extension and advisory system is an inclusive component of sustainable expansion in the facade of the COVID-19 pandemic. This is because extension services aim to disseminate improved information on the management and growth of all stakeholders on the path of growth in relation to economic, environmental and social wellbeing and increasing profitability amidst COVID-19 information disruption (Amadu et al., 2020; McNamara et al., 2020). For example, Kangogo et al. (2020); Ingty et al. (2021),) and Nguyen (2018) state that sustainability ensures that extension support services add value to the improvement of most agricultural projects in terms of output quality, increased productivity, profitability, cost reduction throughout any given 'project's business life cycle, and resilience enhancement. Moreover, in face of COVID-19, the dissemination of risk reduction messages to all market players using sustainable extension models such as digital technologies leads to the 'industry's transformation (Jouanjean, 2019; Şahin, 2020).

Therefore, the extension is vital in transferring and sharing knowledge on the dangers of diseases such as COVID-19 and how to mitigate without causing depletion in the natural environment while maintaining fair play on the producers and suppliers of the agricultural market system. Therefore, education, which comes from the social side of the components of sustainable development should take the lead to place the other two elements (environment and economic) to remain afloat.

VII. COVID-19 FUNDING

While COVID-19 has threatened to wipe out the human race from the face of the planet by crushing global economies and education systems that are cardinal to sustainable agriculture and livelihoods, many nations through science have resorted to finding quick mitigation strategies to reduce the spread of the virus. World Health Organisation (WHO) recommended and commended many nations for adhering to social distance, lockdown, sanitising and now mass vaccination without leaving anyone behind (Sheth, 2020). Furthermore, to mitigate COVID-19 and attain economic sustenance globally, WHO has released over US$50 billion towards health, trade and finance roadmap to end the pandemic (World Health Organisation, 2021), which has been termed as the highest funds in the history of disease control and management ever. However, reports indicate that many development experts criticise the mode and channel of funding for improving agricultural extension to benefit all the players (Jane et al., 2011).

Financing agencies such as Swedish International Development Corporation Agency (SIDA), United Kingdom Aid - Department for International Development (UKAID-DFID), United States. Agency for International Development(USAID), Australian AID and many more believe that sustainability in agricultural extension development compasses the interaction of the private sector players and the farmers while being supported by rules and regulations and other support functions such as research and information osmotic movements(Springfield,2015). They believe that the traditional past extension models were not sustainable because most cooperating partners were skewed towards funding extension through the government with no business. They claimed that private agricultural-based firms need to demonstrate both the willingness and the ability to develop strong and constructive commercial relationships with the lower end of the agricultural market, defined as the poor smallholder farmers. Their role as donors and governments is to assist in the development of those relationships that have a 'value addition' component such as the incorporation of extension information, technology transfer, transparency and formalisation of contracts, and assured market off-take, all of which provide market-based incentives and confidence to smallholder farmers to invest in and improve their production and productivity (Beez, 2014). In such cases, the role of donors and governments could be around stimulating and deepening the commercial appointment with the rural poor and seeks to fundamentally change the way agricultural markets benefit the smallholder sector through high-quality technical support and a range of smart, catalytic investments aimed at reducing the initial risk involved in exploring, testing and developing new markets (Beez, 2014; DFID & SDC, 2014). In COVID-19 era, the private sector involvement in sensitising and mitigating their commercial clients at the bottom of the pyramid is cardinal (Howell et al., 2018; Prahalad, 2005).

According to Marambe (2019), the issue of Agriculture and sustainability of extension and advisory service as an input to global food provision have been substantially tabled in the 1992 United Nations Framework for Climate Adaptation(UNFCA) and associated legal agreements, notably the Paris Agreement. From 2012 to 2017, the Subsidiary Body for Scientific and Technological Advice (SBSTA), one of the United Nation Framework Convention on Climate Change (UNFCCC)'s two permanent subsidiary bodies, reviewed matters relating to agriculture and sustainable extension services. The first significant outcome and COP decision was made at the 23rd COP in Bonn, Germany, in November 2017 (Matthews, 2021). It also highlighted the role of agriculture in climate change adaptation and mitigation through the Koronivia Joint Work on Agriculture (KJWA). The KJWA road map was discussed at COP 26 in Glasgow, the UK, in 2021, with COVID-19 as another complex challenge to sustained agricultural and extension development. Glasgow COP 26 indicated that sustainability issues in the face of COVID-19 are critical to providing access and affordable food security for all globally (Matthews, 2021).

VIII. OTHER THEORIES DEFINING SUSTAINABILITY

Many scholars have defined sustainable development and sustainability in line with their different views and contexts (Albert, 2019; Millan et al., 2019; King et al., 2011; Klerkx & Begemann, 2020; Markard et al., 2015; Shaukat et al., 2021). Shaukat et al.(2021) argue that differing in defining sustainability by scholars is a sure way to show that it is complex and critical, indicating an urgent problem the world is facing today that needs to be solved quickly. However, search, and synthesis on literature show that sustainability and sustainable development are often used interchangeably concerning agricultural extension services (Giroud &

Ivarsson, 2020; Keating, 2020; Murray et al., 2017). Therefore, sustainability is often defined as " a condition of infinite continuation despite complex challenges on the pathway, while sustainable development is also defined as " a process of growth from where we are now towards that future ideal state (Mutambara, 2015; Shaukat et al., 2021; Todaro & Smith, 2015).

The Brundtland Study, published by the World Commission on Environment and Development (WCED) in 1987, was the first report to bring the phrase "sustainable development" to the world's attention comprising the general public and policymakers (FAO, 2018). From these three elements of sustainability, different scholars, depending on their worldwide view or orientation, have defined sustainability and sustainable development differently depending on their objectives and goals. For those in economic and business fields, sustainability and sustainable development in extension systems are when demand and supply forces interact to produce a competitive market system based on profit gains, people, and finally, the planet (Bensch et al., 2021; Sterman, 1994). For the ecologists, sustainability in extension is where natural resources should have regenerative development design systems, which economist Raworth (2017) and biologist Savory Butterfield et al. (2019) defined an extract to use and re-use again without wasting the product to cause pollution due to earth refill. Messages should resonate with climate-smart agricultural development. Economists Raworth (2017) and (Butterfield et al., 2019) are concerned with the deepening degradation of the planet on which human beings live. To them, every development should consider environment stewardship at all levels of development. They are also concerned about how much human activity exerts unprecedented stress on 'earth's life-giving systems unsustainably. These two experts from different fields argue that the current economic development is shaped by the traditional economics that has massively contributed to the high level of corruption, hunger and famine, climate change and many more complex outcomes negatively affecting planet earth and living creatures that include human beings. Savory et al. (2019, 2017) have proposed and used a holistic regenerative management framework to help manage the environment and the erosion tied practical messages for all. Therefore, sustainable extension services should be able to green the earth whilst providing support services to mankind, claims Savoury (2019). This agrees with FAO (2013) climate-smart agriculture extension system, which hinges on using the natural resources prudently with a view of reduced pollution emission up to the maximum of Zero net (Roberts et al., 2021). Agriculture and livestock farming remain the centre hallmark of pollution reduction, according to the recent Glasgow COP26 meeting (Matthews, 2021), while the farmers seem to be sitting on scanty mitigation actions and information.

IX. DIGITAL EXTENSION SERVICES AND SUSTAINABILITY

However, with the outbreak of COVID-19, the agricultural extension information delivery system is being redefined globally enroute to sustainable development. The interactions and interrelationships between public and private traditional extension delivery models are being modified to fit diseases and other drivers driving humanity. In this vein, extension is being defined on how it is implemented and driving information and technology to farmers and many other stakeholders (Alvi et al., 2021). For example, COVID-19 pushes extension service providers to mix centralisation and decentralisation as the most sustainable pragmatic models. In recent times the value of information and product quality requires the virtue of transparency, governance and accountability on the source, quality and quantity of the extension delivery ecosystem (Chen et al., 2020). With such a school of thought, the issue of sustainability lies in the traceability of information and goods they are willing to pay a premium price. For example, in the case of the blockchain extension model, it may be that each market player can have the right to view every transaction happening in the ledger system as long as they are trusted and abide by the terms of references. Democratisation, transparency and accountability are the drivers of traceability in electronic trade (Moser et al., 2018; Patil & Puranik, 2019). However, as good as the digital system is for many farmers, it might take a long time to develop and spread across all smallholder farmers because of infrastructure barriers and the human factors that arise from the high level of illiteracy among many rural farmers. Nonetheless, it appears extension systems based on the digital business model has proved to dissect the impediments caused by COVID-19 beyond nations.

X. EXTENSION WORKERS AND SUSTAINABILITY

Within the global agricultural market system, extension workers are a significant component in the extension service system that interface with research and farmers downstream. However, as indicated earlier, they are faced with many challenges in their quest to accomplish their assigned roles. One such challenge is inadequate numbers to carry out their work effectively and efficiently (Lamontagne-Godwin et al., 2017; Ministry of Agriculture, 2016; Pambudy, 2018). For instance, the United States of America currently has over one million public and private extension officers whose roles are defined by the digital adopted extension models to drive sustainability (Davis et al., 2020). Whereas China has 7,134 million local agriculture extension personnel, 2,87 million work at the national level, 35,100 work at the district level, and 3,913 million work at the village and town level (Miller & Lu, 2019; Nedumaran & Ravi, 2019), In addition, according to Nedumaran & Ravi (2019), 49.7% of the workforce has a junior college education or above, with 67.9% holding professional titles which are critical for information delivery systems. India has around 143,863 extension professionals, representing an extension farmer ratio of 1: 1162, below its recommended ratio of 1:400-750 depending on geographical settings.

Furthermore, 'India's consecutive budgetary has been below the World 'Bank's recommendable 2% toward agricultural extension and advisory funding(Nedumaran & Ravi, 2019). Unfortunately, with the rapidly growing population, it may require to increase the number of extension officers on the ground to be commensurate with the demand. However, sustainability might come in when electronic delivery systems take the leading role within the extension delivery ecosystems threatened by the onset of COVID-19.

According to the United Nations Development Programme, agricultural extension networks in Ethiopia are among the most densely populated globally, with a ratio of 21 workers per 10,000 farmers, translating into 1:476 (Agriculture-Ethiopia, 2014). It is believed that the Ethiopian extension system employs a farmer-based agricultural extension approach that is based on Farmer Training Centres (FTCs) in conjunction with farmer groups such as one-in-five and development units that serve as an entry point for grassroots extension services and a bottom-up extension (Agriculture-Ethiopia, 2014; Bouët et al., 2020; Otsuka & Fan, 2021). Far above most countries, to date, over 70,000 extension workers have been trained and graduated, while around 45,000 of them are currently working in agricultural extension programs. However, it is not surprising to see that Ethiopia, one of the 'world's countries with the highest number of extension systems globally, is one of the countries still grappling with massive poverty and inequality and fairly disrupted by COVID-19. In addition, the ratio between male to female extension is still very low, and the COVID-19 has crippled its extension system partially because of the reductionist extension model they use (Chakraborty & Maity, 2020). Surprising, when analysed from the World Health Organisation report on countries receiving COVID-19 emergency funds, Ethiopia is the highest in Africa at US$ 7,414,142, and the least are Madagascar, Guinea Bissau, and Côte 'd'Ivoire receiving about US$500,000 each\(World Health Organisation, 2020). If several extension services were the driver of sustainability, then Ethiopia could have been a well-advanced country in terms of agriculture compared to Malawi.

According to reviewed literature (Agriculture-Ethiopia, 2014; Birner et al., 2009; Davis & Franzel, 2018a), Tanzania has about 7000 extension workers with a ratio of between 1: 500-1172, while Zimbabwe has about 6159 with a farmer ratio of 1: 1800. Kenya extension workforce is 5,470 with an extension farmer ratio of 1: 1,093. On the other hand, Zambia has 2,523 agricultural extension workers who are in charge of 2,701 agricultural camps covering almost 2,500 million farmers (Makanday Centre, 2020), giving a severe extension worker to farmer ratio of 1:1,136, far from the Food and Agriculture Organization (FAO) 's recommended ratio of one officer to 400 (1:400) farmers (Mwanamwenge & Cook, 2019; Ng'ombe et al., 2020). According to Davis & Franzel (2018), Malawi has 2,415 out of 2,900 field and office staff employees employed by the Malawian Department of Agricultural Extension Services in 2012, representing 1:1642 to 1:1279 depending on the district. This ratio range is slightly higher than Ethiopia (70,000), Kenya (5,470) and the Democratic Republic of Congo. In addition, there are also about 12,000 lead farmers with the government and over 4,000 leader farmers in the private sector. However, with the outbreak of COVID-19, which contributed to the contraction of the global economy, other extension workers likely died out of COVID-19, and most likely, they have not been replaced yet, aggravating the whole situation further. According to our desk review, Mozambique is the only country that has a much better extension worker to farmer ratio. The country has 1,063 extensions with a ratio of 1:320, beating the FAO ratio of 1:400. A summary of the extension to farmer ratio is given below in table 1.

Figure 1: showing the different 'countries' extension work to farmer ratio (Busungu et al., 2019; Kristin Davis & Franzel, 2018b; A. Kassam et al., 2019; Makanday Centre, 2020; Feed the Future, 2018; Moore et al., 2015; Pazvakavambwa & Hakutangwi, 2018)

country	Number of extension workers	Worker-farmer ratio
USA	1,000,000	
China	7,134,000	
India	143,863	1-1,162
Malawi	2,415	1:1279-1642
Tanzania	7,000	1:500-1172
Kenya	5,470	1-1093
Mozambique	1,068	1-320
Ghana	1,244	1-1500
Ethiopia	70,000	1-476
Zimbabwe	6,159	1-1800
Zambia	2,523	1-1136

Source: Author,2021

It appears that using the extension work-to-farmer ratio to evaluate the success of extension provision in an extended ecosystem is to agree that digital extension has a long way to go before it can be adopted on a long-term basis in most developing nations. More optimistically, with the digital extension model coming as a means of information and technology delivery systems, we expect the extension worker to farmer ratio to shrink further and further. It is against this background that even the traditional extension delivery models, such as farmer to farmer and farmer field school, should integrate digital technology to remain sustainable extension tools in the face of COVID-19. In a bid to sustain the extension delivery ecosystem, Davis et al. (2020) posited that widespread digitalisation redefines the roles of extension workers and lead farmers in different countries.

XI. CONCLUSION

Sustainability theories and frameworks are critical to understanding how rural agriculture extension services are evolving in the face of many crises such as COVID-19. COVID-19 has impacted the sustainability of extension and advisory service delivery in achieving smallholder production and productivity. Sustainable extension services are critical in information and product delivery systems in the ecosystem for the benefit of all players. On the other hand, the most difficult duty for a sustainable extension is to endure significantly in a rapidly changing world and pose new unforeseen challenges in the extension ecosystem. COVID-19 has accelerated digital platforms despite its negative effect on sustainable service and product delivery systems. The sustainability of extension lies in its adaptive approach to continue offering information even in stressed circumstances. It is stated that agricultural extension systems that aim to achieve sustainability should move away from reductionist thinking and instead adopt a holistic and systemic approach. System-based extension models' success and dynamic nature depend on identifying the environment and context of systems and their interactions. Therefore, a rethinking of agricultural extension components are required, and we must endeavour to identify new functions, methods, and objectives for extension systems that will lead to their long-term viability. We urge future research to pay more attention to the current digital extension delivery system to reduce disruption and pave the way to a solution-based delivery system to benefit all the players.

XII. ACKNOWLEDGEMENTS

The authors appreciate the constructive feedback provided by the anonymous reviewers.

A. Funding

There was no financing for this project.

B. Conflicts of Interest

There are no conflicts of interest declared by the authors

REFERENCES

[1] Adnan, N., Md Nordin, S., Rahman, I., & Noor, A. (2017). Adoption of green fertilizer technology among paddy farmers: A possible solution for Malaysian food security. Land Use Policy, 63, 38–52. https://doi.org/10.1016/j.landusepol.2017.01.022
[2] Adnan, N., & Nordin, S. M. (2021). How COVID 19 effect Malaysian paddy industry? Adoption of green fertilizer a potential resolution. In Environment, Development and Sustainability (Vol. 23, Issue 6, pp. 8089–8129). Springer Science and Business Media B.V. https://doi.org/10.1007/s10668-020-00978-6
[3] Agriculture-Ethiopia, M. of. (2014). National Strategy for Ethiopia's Agricultural Extension System Vision, Systemic Bottlenecks and Priority Interventions Federal Democratic Republic of Ethiopia Ministry of Agriculture ii.
[4] Alabi, O. S., & Ajayi, A. O. (2018). Assessment of desired competencies of agricultural extension agents in sustainable agriculture development activities in southwest Nigeria. Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development, 18(3), 11–20. https://www.researchgate.net/profile/Olabode-Alabi/publication/349494293_assessment_of_desired_competencies_of_agricultural_extension_agents_in_sustainable_agriculture_development_activities_in_southwest_nigeria/links/603387d7299bf1cc26e0e160/assessment-o
[5] Albert, M. (2019). Sustainable frugal innovation - The connection between frugal innovation and sustainability. Journal of Cleaner Production, 237. https://doi.org/10.1016/j.jclepro.2019.117747
[6] Alvi, M., Barooah, P., Gupta, S., & Saini, S. (2021). Women's access to agriculture extension amidst COVID-19: Insights from Gujarat, India and Dang, Nepal. Agricultural Systems, 188, 103035. https://doi.org/10.1016/j.agsy.2020.103035
[7] Bakken, S., Marden, S., Arteaga, S. S., Grossman, L., Keselman, A., Le, P.-T., Masterson Creber, R., Powell-Wiley, T. M., Schnall, R., Tabor, D., Das, R., & Farhat, T. (2019). Behavioral interventions using consumer information technology as tools to advance health equity. Ajph.Aphapublications.OrgPaperpile, 109, 79–85. https://doi.org/10.2105/AJPH.2018
[8] Baloch, M. A., & Thapa, G. B. (2019). Review of the agricultural extension modes and services with the focus to Balochistan, Pakistan. Journal of the Saudi Society of Agricultural Sciences, 18(2), 188–194. https://doi.org/10.1016/j.jssas.2017.05.001
[9] Bank, W. (2020). Accelerating Digital Transformation in Zambia. Accelerating Digital Transformation in Zambia. https://doi.org/10.1596/33806
[10] Barnes, S. J. (2020). Information management research and practice in the post-COVID-19 world. International Journal of Information Management, 55. https://doi.org/10.1016/J.IJINFOMGT.2020.102175

[11] Bates, A. E., Primack, R. B., Biggar, B. S., Bird, T. J., Clinton, M. E., Command, R. J., Richards, C., Shellard, M., Geraldi, N. R., Vergara, V., Acevedo-Charry, O., Colón-Piñeiro, Z., Ocampo, D., Ocampo-Peñuela, N., Sánchez-Clavijo, L. M., Adamescu, C. M., Cheval, S., Racoviceanu, T., Adams, M. D., … Duarte, C. M. (2021). Global COVID-19 lockdown highlights humans as both threats and custodians of the environment. Biological Conservation, 263, 109175. https://doi.org/10.1016/J.BIOCON.2021.109175

[12] Beers, P. J., Hermans, F., Veldkamp, T., & Hinssen, J. (2014). Social learning inside and outside transition projects: Playing free jazz for a heavy metal audience. NJAS - Wageningen Journal of Life Sciences, 69, 5–13. https://doi.org/10.1016/j.njas.2013.10.001

[13] Beez, P. (2014). the Operational Guide for the Making Markets Work for the Poor (M4P) Approach Why the Need for an Updated Operational Guide?

[14] Bensch, G., Kluve, J., & Stöterau, J. (2021). The market-based dissemination of energy-access technologies as a business model for rural entrepreneurs: Evidence from Kenya. Resource and Energy Economics, 66. https://doi.org/10.1016/J.RESENEECO.2021.101248

[15] Biondi, B., Barrett, C. B., Mazzocchi, M., Ando, A., Harvey, D., & Mallory, M. (2021). Journal submissions, review and editorial decision patterns during initial COVID-19 restrictions. Food Policy, 105, 102167. https://doi.org/10.1016/j.foodpol.2021.102167

[16] Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., Mbabu, A., Spielman, D. J., Horna, D., Benin, S., & Cohen, M. (2009). From Best Practice to Best Fit: A Framework for Designing and Analyzing Pluralistic Agricultural Advisory Services Worldwide. The Journal of Agricultural Education and Extension, 15(4), 341–355. https://doi.org/10.1080/13892240903309595

[17] Bouët, S., Odjo, P., & Zaki, C. (2020). Africa agriculture trade monitor 2020. In African Growth & Development Policy Modeling Consortium. https://www.resakss.org/sites/default/files/AATM-Report-2020-final-1009.pdf%0Ahttps://ebrary.ifpri.org/digital/collection/p15738coll2/id/134009

[18] Butterfield, J., Bingham, S., & Savory, A. (2019). Holistic Management Handbook, Third Edition: Regenerating Your Land and Growing Your Profits. https://islandpress.org/books/holistic-management-handbook-third-edition

[19] Campo, P. C., Bousquet, F., & Villanueva, T. R. (2010). Modelling with stakeholders within a development project. Environmental Modelling and Software, 25(11), 1302–1321. https://doi.org/10.1016/j.envsoft.2010.01.005

[20] Cao, S., Xia, C., Suo, X., & Wei, Z. (2021). A framework for calculating the net benefits of ecological restoration programs in China. Ecosystem Services, 50, 101325. https://doi.org/10.1016/j.ecoser.2021.101325

[21] Ceschin, F., & Gaziulusoy, İ. (2019). Design for sustainability: A multi-level framework from products to socio-technical systems. In Design for Sustainability: A Multi-level Framework from Products to Socio-Technical Systems. Taylor and Francis. https://doi.org/10.4324/9780429456510

[22] Chakraborty, I., & Maity, P. (2020). COVID-19 outbreak: Migration, effects on society, global environment and prevention. Science of the Total Environment, 728. https://doi.org/10.1016/j.scitotenv.2020.138882

[23] Chapoto, A., Haggblade, S., Hichaambwa, M., Kabwe, S., Longabaugh, S., Sitko, N., & Tschirley, D. (2012). Agricultural Transformation in Zambia: Alternative Institutional Models for Accelerating Agricultural Productivity Growth and Commercialization.

[24] Chen, T., Ding, K., Hao, S., Li, G., & Qu, J. (2020). Batch-based traceability for pork: A mobile solution with 2D barcode technology. Food Control, 107. https://doi.org/10.1016/j.foodcont.2019.106770

[25] Chinsembu, K. C. (2021). Phytomedicines and nutraceuticals in the clinical management of COVID-19. International Science and Technology Journal of Namibia, 14, 1–8. https://doi.org/10.32642/ISTJN.V14I.1534

[26] Cook, B. R., Satizábal, P., & Curnow, J. (2021). Humanising agricultural extension: A review. World Development, 140, 105337. https://doi.org/10.1016/j.worlddev.2020.105337

[27] Cooper, G. S., Rich, K. M., Shankar, B., Rana, V., Ratna, N. N., Kadiyala, S., Alam, M. J., & Nadagouda, S. B. (2021). Identifying 'win-win-win' futures from inequitable value chain trade-offs: A system dynamics approach. Agricultural Systems, 190(April 2020), 103096. https://doi.org/10.1016/j.agsy.2021.103096

[28] Davis, Babu, S. C., & Ragas, C. (2020). Agricultural Extension: Global Status and Performance in Selected Countries. In International Food Policy Research Institute (Vol. 38, Issue 975).

[29] Davis, K. (2020). Thinking about the future is challenging but liberating !". Journal of International Agricultural and Extension Education, 23(1), 1–45. https://doi.org/10.5191/jiaee.2016.23101

[30] Davis, K., & Franzel, S. (2018a). Extension and advisory services in 10 developing countries : A cross-country analysis (Issue September).

[31] Davis, K., & Franzel, S. (2018b). Extension and advisory services in 10 developing countries : A cross-country analysis (Issue September). http://www.digitalgreen.org/wp-content/uploads/2017/09/EAS-in-Developing-Countries-FINAL.pdf

[32] DFID, & SDC. (2014). The Operational Guide for the Making Markets Work for the Poor (M4P) Approach, 2nd Edition.

[33] FAO. (2013). Climate Smart Agriculture Sourcebook.

[34] FAO. (2018). Shaping the future of livestock (Report No. I8384EN). In The 10th Global Forum for Food and Agriculture (GFFA) (Issue January). http://www.fao.org/3/i8384en/I8384EN.pdf

[35] FAO. (2021). The White/Wiphala Paper on Indigenous Peoples' food systems. In The White/Wiphala Paper on Indigenous Peoples' food systems. https://doi.org/10.4060/cb4932en

[36] Feed the Future. (2018). Mozambique: Desk Study of Extension and Advisory Services. January.

[37] Ferretti, V., & Grosso, R. (2019). Designing successful urban regeneration strategies through a behavioral decision aiding approach. Cities, 95. https://doi.org/10.1016/J.CITIES.2019.06.017

[38] Friel, S., Pescud, M., Malbon, E., Lee, A., Carter, R., Greenfield, J., Cobcroft, M., Potter, J., Rychetnik, L., & Meertens, B. (2017). Using systems science to understand the determinants of inequities in healthy eating. PLoS ONE, 12(11). https://doi.org/10.1371/journal.pone.0188872

[39] Giroud, A., & Ivarsson, I. (2020). World Investment Report 2020: International production beyond the pandemic. Journal of International Business Policy, 3(4), 465–468. https://doi.org/10.1057/s42214-020-00078-2

[40] Glover, D., Sumberg, J., Ton, G., Andersson, J., & Badstue, L. (2019). Rethinking technological change in smallholder agriculture. Outlook on Agriculture, 48(3), 169–180. https://doi.org/10.1177/0030727019864978

[41] Grove, Benjamin; Archibald, Thomas; Davis, K. (2020). GAP OCTOBER 2020 EXTENSION AND ADVISORY SERVICES : SUPPORTING COMMUNITIES BEFORE , DURING , AND AFTER CRISES. Global Agriculture Productivity Report, 1–4. www.globalagriculturalproductivity.org

[42] Haggag, W. M. (2021). Agricultural digitalization and rural development in COVID-19 response plans: A review article. International Journal of Agricultural Technology, 17(1), 67–74.

[43] Hasheminasab, H., Gholipour, Y., Kharrazi, M., Streimikiene, D., & Hashemkhani, S. (2020). A dynamic sustainability framework for petroleum refinery projects with a life cycle attitude. Sustainable Development, 28(5), 1033–1048. https://doi.org/10.1002/sd.2054
[44] Hovmand, P. S. (2014). Community based system dynamics. In Community Based System Dynamics (Vol. 9781461487). https://doi.org/10.1007/978-1-4614-8763-0
[45] Howell, R., van Beers, C., & Doorn, N. (2018). Value capture and value creation: The role of information technology in business models for frugal innovations in Africa. Technological Forecasting and Social Change, 131, 227–239. https://doi.org/10.1016/j.techfore.2017.09.030
[46] Ibrahim, A. M. (2019). A Method to Support Leadership Effectiveness in a Construction Project Organisation in Nigeria. In PQDT - UK & Ireland. https://search.proquest.com/docview/2307265608?accountid=17242%0Ahttp://livrepository.liverpool.ac.uk/3035901/
[47] IFAD. (2021). Transforming food systems for rural prosperity RURAL DEVELOPMENT REPORT 2021.
[48] Jane, M., Gibbon, D., Ingram, J., Reed, M., Short, C., & Dwyer, J. (2011). Organising collective action for effective environmental management and social learning in Wales. Journal of Agricultural Education and Extension, 17(1), 69–83. https://doi.org/10.1080/1389224X.2011.536356
[49] Keating, B. A. (2020). Crop, soil and farm systems models – science, engineering or snake oil revisited. In Agricultural Systems (Vol. 184). Elsevier Ltd. https://doi.org/10.1016/j.agsy.2020.102903
[50] Keding, G. B., Gramzow, A., Ochieng, J., Laizer, A., Muchoki, C., Onyango, C., Hanson, P., & Yang, R.-Y. (2021). Nutrition integrated agricultural extension—a case study in Western Kenya. Health Promotion International, 2021, 1–13. https://doi.org/10.1093/HEAPRO/DAAB142
[51] Kogo, B. K., Kumar, L., & Koech, R. (2020). Climate change and variability in Kenya: a review of impacts on agriculture and food security. Environment, Development and Sustainability 2020 23:1, 23(1), 23–43. https://doi.org/10.1007/S10668-020-00589-1
[52] Kumar, A., Luthra, S., Mangla, S. K., & Kazançoğlu, Y. (2020). COVID-19 impact on sustainable production and operations management. Sustainable Operations and Computers, 1, 1–7. https://doi.org/10.1016/J.SUSOC.2020.06.001
[53] Lamontagne-Godwin, J., Williams, F., Bandara, W. M. P. T., & Appiah-Kubi, Z. (2017). Quality of extension advice: a gendered case study from Ghana and Sri Lanka. Journal of Agricultural Education and Extension, 23(1), 7–22. https://doi.org/10.1080/1389224X.2016.1230069
[54] Lenaghan, T., & Heffern, A. (2021). How Donor-Funded Economic Growth Projects are Adapting to the Challenges of COVID-19. DAI. https://dai-global-developments.com/articles/how-donor-funded-economic-growth-projects-are-adapting-to-the-challenges-of-covid-19
[55] Maggio, G., & Sitko, N. (2019). Knowing is half the battle: Seasonal forecasts, adaptive cropping systems, and the mediating role of private markets in Zambia. Food Policy, 89. https://doi.org/10.1016/j.foodpol.2019.101781
[56] Mahmood, N., Arshad, M., Mehmood, Y., Faisal Shahzad, M., & Kächele, H. (2021). Farmers' perceptions and role of institutional arrangements in climate change adaptation: Insights from rainfed Pakistan. Climate Risk Management, 32. https://doi.org/10.1016/j.crm.2021.100288
[57] Makanday Centre. (2020). Data shows extension services the most neglected in agriculture - Makanday Center for Investigative Journalism - Zambia. https://makanday.com/government-data-shows-extension-services-the-most-neglected-in-agriculture/
[58] Marambe, B. (2019). Agriculture negotiations under the United Nations Framework Convention on Climate Change (UNFCCC). Sri Lanka Journal of Food and Agriculture, 5(2), 1. https://doi.org/10.4038/SLJFA.V5I2.71/GALLEY/145/DOWNLOAD/
[59] Matthews, A. (2021). Are the COP26 Climate Change Negotiations Ready to Embrace Agriculture? EuroChoices, 20(2), 4–10. https://doi.org/10.1111/1746-692X.12325
[60] Maulu, S., Hasimuna, O. J., Mutale, B., Mphande, J., & Siankwilimba, E. (2021). Enhancing the role of rural agricultural extension programs in poverty alleviation: A review. Cogent Food and Agriculture, 7(1). https://doi.org/10.1080/23311932.2021.1886663
[61] Meera, S. N., Balaji, V., Muthuraman, P., Sailaja, B., & Dixit, S. (2012). Changing roles of agricultural extension: Harnessing information and communication technology (ICT) for adapting to stresses envisaged under climate change. Crop Stress and Its Management: Perspectives and Strategies, 9789400722200, 585–605. https://doi.org/10.1007/978-94-007-2220-0_19
[62] Michelena, X., Borrell, H., López-Corbeto, M., López-Lasanta, M., Moreno, E., Pascual-Pastor, M., Erra, A., Serrat, M., Espartal, E., Antón, S., Añez, G. A., Caparrós-Ruiz, R., Pluma, A., Trallero-Araguás, E., Barceló-Bru, M., Almirall, M., De Agustín, J. J., Lladós, J., Julià, A., & Marsal, S. (2020). Incidence of COVID-19 in a cohort of adult and paediatric patients with rheumatic diseases treated with targeted biologic and synthetic disease-modifying anti-rheumatic drugs. Seminars in Arthritis and Rheumatism, 50(4), 564–570. https://doi.org/10.1016/j.semarthrit.2020.05.001
[63] Millan, A., Limketkai, B., & Guarnaschelli, S. (2019). Financing the Transformation of Food Systems Under a Changing Climate. https://cgspace.cgiar.org/handle/10568/101132
[64] Miller, B. A., & Lu, C. D. (2019). — Special Issue — Current status of global dairy goat production: An overview. Asian-Australasian Journal of Animal Sciences, 32(8), 1219–1232. https://doi.org/10.5713/ajas.19.0253
[65] Ministry of Agriculture. (2016). THE NATIONAL AGRICULTURAL EXTENSION & ADVISORY SERVICES STRATEGY 2016-2020. https://doi.org/10.4324/9780203703465-6
[66] Moguilevsky, D., Fernández, N. V., Puntieri, J. G., Outes, V., & Fontenla, S. B. (2021). Surviving after an eruption: Ecosystem dynamics and mycorrhizae in Nothofagus pumilio forests affected by the 2011 Puyehue Cordón-Caulle tephra. Forest Ecology and Management, 479. https://doi.org/10.1016/j.foreco.2020.118535
[67] Moore, A., Ferguson, O., & Lolig, V. (2015). Assessment of Extension and Advisory Services in Ghana's Feed the Future Zone of Influence. July, 56.
[68] Moser, A., Korstjens, I., In, S. B., Ballandies, M. C., Dapp, M. M., Degenhart, B. A., Helbing, D., Klauser, S., & Pardi, A. (2018). Finance 4 . 0 — A Socio-Ecological Finance System :A Participatory Framework to Promote Sustainability. In European Journal of General Practice (Vol. 24, Issue 1). Springer International Publishing. https://doi.org/10.1007/978-3-030-71400-0
[69] Murray, A., Skene, K., & Haynes, K. (2017). The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. Journal of Business Ethics, 140(3), 369–380. https://doi.org/10.1007/s10551-015-2693-2
[70] Mutambara, S. (2015). Making Markets Work for the Poor (M4P) Approach and Smallholder Irrigation Farming. Irrigation & Drainage Systems Engineering, 04(01), 1–9. https://doi.org/10.4172/2168-9768.1000130
[71] Mwanamwenge, M., & Cook, S. (2019). Beyond maize - Exploring agricultural diversification in Zambia from different perspectives.
[72] Nedumaran, S., & Ravi, N. (2019). Agriculture Extension System in India: A Meta-analysis. Research Journal of Agricultural Sciences, 10(3), 473–479. www.rjas.org

[73] Ng'ombe, J. N., Tembo, M. C., & Masasi, B. (2020). "Are they aware, and why?" Bayesian analysis of predictors of smallholder farmers' awareness of climate change and its risks to agriculture. Agronomy, 10(3). https://doi.org/10.3390/agronomy10030376

[74] Nganga, W. B., Ng'etich, K. O., Macharia, M. J., Kiboi, N. M., Adamtey, N., & Ngetich, K. F. (2020). Multi-influencing-factors' evaluation for organic-based soil fertility technologies out-scaling in Upper Tana Catchment in Kenya. Scientific African, 7.

[75] Ngoma, H., Finn, A., & Kabisa, M. (2021). Climate Shocks, Vulnerability, Resilience and Livelihoods in Rural Zambia. http://www.worldbank.org/prwp.

[76] Nkuyubwatsi, B. (2016). Positioning Extension Massive Open Online Courses (xMOOCs) within the Open Access and the Lifelong Learning Agendas in a Developing Setting. Journal of Learning for Development, 3(1), 14–36.

[77] Omulo, G., & Kumeh, E. M. (2020). Farmer-to-farmer digital network as a strategy to strengthen agricultural performance in Kenya: A research note on 'Wefarm' platform. Technological Forecasting and Social Change, 158.

[78] Osumba, J., Recha, J., & Oroma, G. (2021). Transforming Extension and Service Delivery through Bottom-Up Climate Resilient Farmer Field School Approach to Agribusiness in Eastern Africa. https://www.preprints.org/manuscript/202102.0070

[79] Otsuka, K., & Fan, S. (2021). Synopsis. Agricultural Development New Perspectives in a Changing World. In O. Keihiro & F. Shenggen (Eds.), Agricultural Development New Perspectives in a Changing World (First, pp. i–iv). The International Food Policy Research Institute (IFPRI). https://doi.org/https:// doi .org/10.2499/ 9780896293830

[80] Pambudy, R. (2018). The development of adopting innovation on entrepreneurship status of Madura cattle farmers. Tropical Animal Science Journal, 41(2), 147–156. https://doi.org/10.5398/tasj.2018.41.2.147

[81] Patil, S. S., & Puranik, P. Y. L. (2019). Blockchain Technology. International Journal of Trend in Scientific Research and Development, Volume-3(Issue-4), 573–574. https://doi.org/10.31142/ijtsrd23774

[82] Phillips, P. W. B., Relf-Eckstein, J. A., Jobe, G., & Wixted, B. (2019). Configuring the new digital landscape in western Canadian agriculture. NJAS - Wageningen Journal of Life Sciences, 90–91. https://doi.org/10.1016/J.NJAS.2019.04.001

[83] Prahalad, C. K. (2005). The fortune at the bottom of the pyramid. In Choice Reviews Online (Vol. 43, Issue 02). https://doi.org/10.5860/choice.43-1063

[84] Quisumbing, A. R., Meinzen-Dick, R., Raney, T. L., Croppenstedt, A., Behrman, J. A., & Peterman, A. (2014). Closing the knowledge gap on gender in agriculture. Gender in Agriculture: Closing the Knowledge Gap, 3–28. https://doi.org/10.1007/978-94-017-8616-4_1

[85] Rahmandad, H., Lim, T. Y., & Sterman, J. (2021). Behavioral dynamics of COVID-19: estimating underreporting, multiple waves, and adherence fatigue across 92 nations. System Dynamics Review, 37(1), 5–31. https://doi.org/10.1002/sdr.1673

[86] Raworth, K. (2017). Doughnut Economics: Seven ways to think like a 21st century economist. In Chelsea Green Publishing. Chelsea publisher.

[87] Rezaei-Moghaddam, K., & Salehi, S. (2010). Agricultural specialists' intention toward precision agriculture technologies: Integrating innovation characteristics to technology acceptance model. African Journal of Agricultural Research, 5(11), 1191–1199. https://doi.org/10.5897/AJAR09.506

[88] Ritter, C., Jansen, J., Roche, S., Kelton, D. F., Adams, C. L., Orsel, K., Erskine, R. J., Benedictus, G., Lam, T. J. G. M., & Barkema, H. W. (2017). Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. Journal of Dairy Science, 100(5), 3329–3347. https://doi.org/10.3168/jds.2016-11977

[89] Roberts, R., Elkington, J., & Rodrigues, J. (2021). ALIGNING FINANCE FOR THE NET-ZERO ECONOMY : INNOVATION AND TRANSFORMATION : WHAT IT WILL TAKE TO FINANCE NET ZERO-new ideas from leading thinkers.

[90] Roe, D., Dickman, A., Kock, R., Milner-Gulland, E. J., Rihoy, E., & 't Sas-Rolfes, M. (2020). Beyond banning wildlife trade: COVID-19, conservation and development. World Development, 136. https://doi.org/10.1016/j.worlddev.2020.105121

[91] Röling, N., & de Jong, F. (1998). Learning: Shifting paradigms in education and extension studies. The Journal of Agricultural Education and Extension, 5(3), 143–161. https://doi.org/10.1080/13892249885300281

[92] Rude, J., Beninger, S., Francis, J. N. P., Adhikari, J., Timsina, J., Khadka, S. R., Ghale, Y., Ojha, H., Pan, D., 1☯, I. D., Yang, J., Zhou, G., Kong, F., & 2☯, I. D. (2020). COVID-19 impacts on agriculture and food systems in Nepal: Implications for SDGs. Business Horizons, 186(2), 102990. https://doi.org/10.1016/j.bushor.2021.02.048

[93] Shaukat, M. B., Latif, K. F., Sajjad, A., & Eweje, G. (2021). Revisiting the relationship between sustainable project management and project success: The moderating role of stakeholder engagement and team building. Sustainable Development. https://doi.org/10.1002/sd.2228

[94] Sheth, J. (2020). Impact of Covid-19 on consumer behavior: Will the old habits return or die? Journal of Business Research, 117, 280–283.

[95] Siankwilimba, E. (2016). Title Effects of Climate Change induced electricity load shedding on small holder agricultural enterprises in Zambia: The case of Five Southern Province Districts. Journal of Agriculture and Research, 8(8), 1–151.

[96] Sima, V., Gheorghe, I. G., Subić, J., & Nancu, D. (2020). Influences of the Industry 4.0 Revolution on the Human Capital Development and Consumer Behavior: A Systematic Review. Sustainability 2020, Vol. 12, Page 4035, 12(10), 4035. https://doi.org/10.3390/SU12104035

[97] Sitko, N. J. (2017). The Politics of Food Security. In The Politics of Food Security. https://doi.org/10.2307/j.ctt1df4hv5

[98] Sterman, J. D. (1994). Learning in and about complex systems. System Dynamics Review, 10(2–3), 291–330. https://doi.org/10.1002/sdr.4260100214

[99] Stockmann, C., Winkler, H., & Kunath, M. (2021). Robustness assessment in production systems. Journal of Manufacturing Technology Management, 32(4), 932–951. https://doi.org/10.1108/JMTM-06-2020-0223

[100] Sweeney, L. B., & Sterman, J. D. (2000). Bathtub dynamics: Initial results of a systems thinking inventory. System Dynamics Review, 16(4), 249–286. https://doi.org/10.1002/sdr.198

[101] Swinnen, J., & McDermott, J. (2020). Covid-19 and Global Food Security. EuroChoices, 19(3), 26–33. https://doi.org/10.1111/1746-692X.12288

[102] Taylor, M., & Bhasme, S. (2018). Model farmers, extension networks and the politics of agricultural knowledge transfer. Journal of Rural Studies, 64, 1–10. https://doi.org/10.1016/J.JRURSTUD.2018.09.015

[103] Tisenkopfs, T., Kunda, I., šūmane, S., Brunori, G., Klerkx, L., & Moschitz, H. (2015). Learning and Innovation in Agriculture and Rural Development: The Use of the Concepts of Boundary Work and Boundary Objects. Journal of Agricultural Education and Extension, 21(1), 13–33. https://doi.org/10.1080/1389224X.2014.991115

[104] Todaro, M. P., & Smith, S. C. (2015). Economic development: The Addison-Wesley series in economics (Twelfth ed). Pearson.

[105] Ugochukwu, N. C. (2020). A Review of Agricultural Extension and Advisory Services in sub-Saharan African Countries: Progress with Private Sector Involvement. Journal of Agribusiness and Rural Developmen, 5772. www.preprints.org

[106] Vaidyanathan, V., Cheelo, C., Chulu, M., Nalwimba, N., Muyobozi, G. T. M., Tong, S., & Agarwal, W. M. (2021). CHINA-ZAMBIA ECONOMIC RELATIONS Perspectives From the Agricultural Sector CONTRIBUTORS-Monograph Number 6,March 2021 (V. Vaidyanathan (ed.); 6th ed., Vol. 6). Institute of Chinese Studies. www.icsin.org

[107] Varahachalam, S. P., Lahooti, B., Chamaneh, M., Bagchi, S., Chhibber, T., Morris, K., Bolanos, J. F., Kim, N. Y., & Kaushik, A. (2021). Nanomedicine for the SARS-CoV-2: State-of-theart and future prospects. In International Journal of Nanomedicine (Vol. 16, pp. 539–560). Dove Medical Press Ltd. https://doi.org/10.2147/IJN.S283686

[108] Venkatramanan, V., Shah, S., & Prasad, R. (2019). Global climate change and environmental policy: Agriculture perspectives. In Global Climate Change and Environmental Policy: Agriculture Perspectives. https://doi.org/10.1007/978-981-13-9570-3

[109] Wang, Y., Wang, R., & Yao, Z. (2020). Mechanism of action of policy networks on the performance of university-based agricultural extensions. Https://Doi.Org/10.1080/1389224X.2020.1748668, 26(5), 423–441. https://doi.org/10.1080/1389224X.2020.1748668

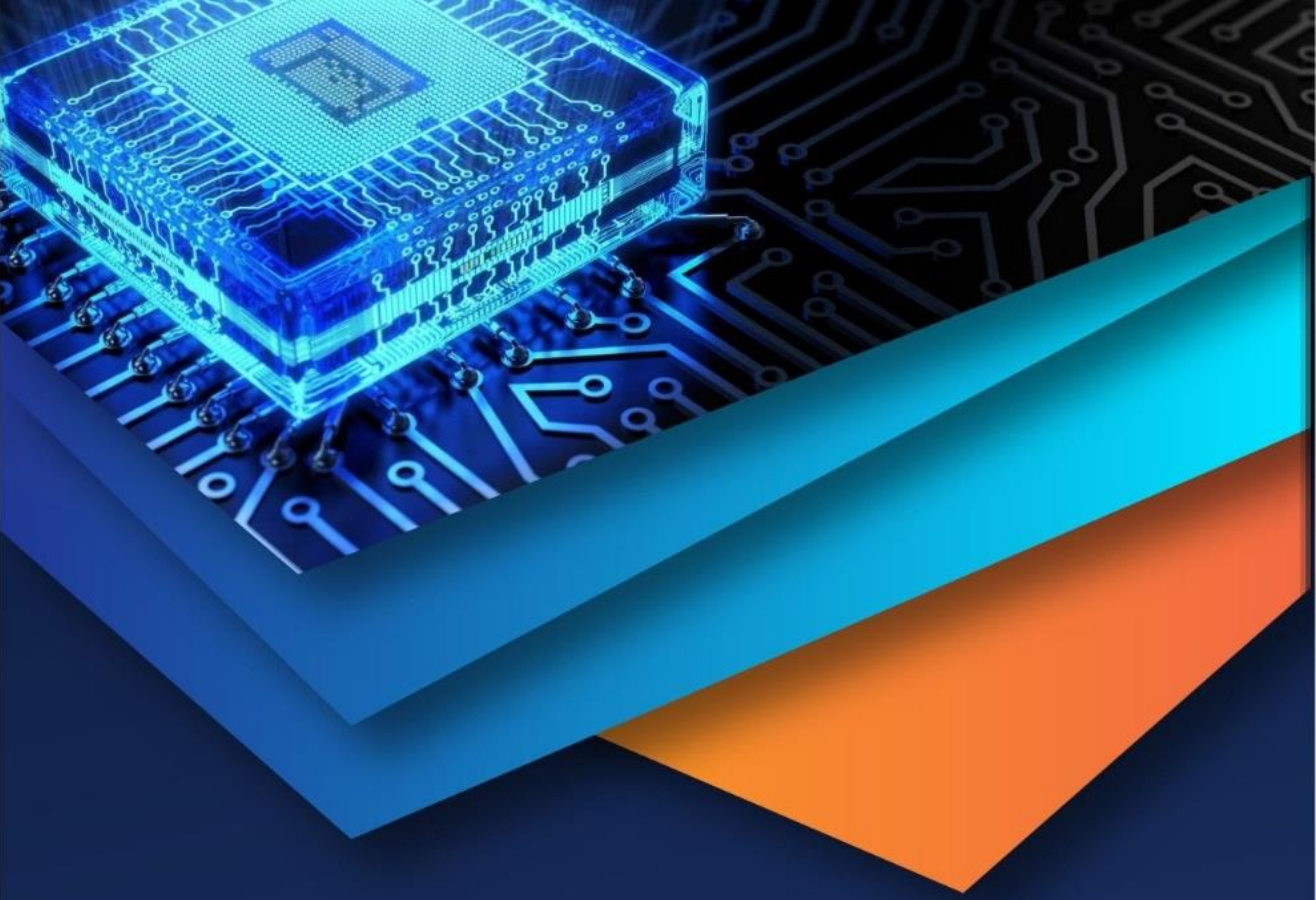
[110] Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., De Souza Dias, B. F., Ezeh, A., Frumkin, H., Gong, P., Head, P., Horton, R., Mace, G. M., Marten, R., Myers, S. S., Nishtar, S., Osofsky, S. A., Pattanayak, S. K., Pongsiri, M. J., Romanelli, C., … Yach, D. (2015). Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation-Lancet Commission on planetary health. In The Lancet (Vol. 386, Issue 10007, pp. 1973–2028). Lancet Publishing Group. https://doi.org/10.1016/S0140-6736(15)60901-1

[111] World Health Organisation. (2020). Coronavirus disease (COVID-19) donors & partners: WHO says thank you! Coronavirus Disease 2019. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/donors-and-partners/funding

[112] World Health Organisation. (2021). New US$50 billion health, trade and finance roadmap to end the pandemic and secure a global recovery. WHO Web Page. https://www.who.int/news/item/01-06-2021-new-50-billion-health-trade-and-finance-roadmap-to-end-the-pandemic-and-secure-a-global-recovery

[113] Zabaniotou, A. (2020). A systemic approach to resilience and ecological sustainability during the COVID-19 pandemic: Human, societal, and ecological health as a system-wide emergent property in the Anthropocene. Global Transitions, 2, 116–126. https://doi.org/10.1016/J.GLT.2020.06.002

[114] Zambrano-Monserrate, M. A., Ruano, M. A., & Sanchez-Alcalde, L. (2020). Indirect effects of COVID-19 on the environment. Science of the Total Environment, 728. https://doi.org/10.1016/j.scitotenv.2020.138813



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