THE FUTURE OF WORK IN CENTRAL AND WEST AFRICA

Digital Technologies, Climate Change Mitigation and the Future of Work in Agri-based Economies in Central and West Africa: A Research Agenda

A Research Agenda

FutureWORKS COLLECTIVE

Abstract

As countries in the West and Central African (WCA) sub-region prepare for technological advancements and other disruptions caused by climate change impacts, fragility, economic integration, and population transitions that will fundamentally alter their labor landscape, experts predict increased digital technology (DT) adoption will have a positive effect on these agri-based economies. Experts believe that if DTs gain widespread acceptance, the DTs will boost African businesses, creating more jobs. At the same time, the impact of these technologies, combined with existing challenges in Sub-Saharan Africa (SSA) and the WCA sub-region, particularly climate change risks, appears to be exacerbating existing inequalities in the future of work for marginalized groups, particularly women. However, rigorous quantitative and qualitative evidence about the impact of DTs and climate change on the future of work in Africa's agri-based economies, particularly the WCA sub-region, is limited, with many open research questions. We develop a framework for these issues and propose a research agenda to help guide policy and practice.

KEYWORDS

Digital technologies, Future of Work, Agri-based Economies, Marginalized groups, Climate Change mitigation, Informal Sector, Digital Infrastructure, Digital Skills, Social Protection

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1. THE IMPACT OF DTS ON THE FUTURE OF WORK IN WEST AND CENTRAL AFRICA (WCA)

1.1 Introduction

Digital technologies (DTs), including cell phones, artificial intelligence (AI), robotics, the Internet of Things (IoT), and automation, are altering people's social and economic lives, as well as the nature of work (Mulrean, 2020; Ticona, 2022). Assessing these technologies in various sectors of the economy reveals a broad range of applications in mining, agriculture, services, manufacturing, finance, and healthcare, among others (Gaus & Hoxtell, 2019). While DTs are expected to boost productivity, provide better services, and improve user satisfaction, they are likely to disrupt the labor market by replacing human-only jobs in these sectors, resulting in wage cuts and increased inequality (Abdychev et al., 2018). For many industrialized economies where labor supply has been stagnant or decreasing, automation is a viable solution to the limited workforce challenge (Gaus & Hoxtell, 2019). In contrast, the complexities of the African context make the situation in SSA and the WCA sub-region starkly different (Lam et al., 2019).

The interplay between technological advances, climate change impacts, and global economic integration is expected to transform the future of work in Africa, including the WCA sub-region; however, the precise nature of this change remains unclear (Abdychev et al., 2018; Cilliers, 2021). This uncertainty stems from the various developmental challenges which countries in the sub-region face, including the large informal work landscape and the smaller manufacturing base (Hien, 2023; World Bank, 2022); the prevalence of rural poverty among women and young people who have less access to employment opportunities, land, and financial resources (Diagana, 2021; Foresight Africa, 2015); the high vulnerability of the sub-region to climate change impacts (Adeola et al., 2024; Awiti, 2022); having the youngest growing population in the world (World Bank, 2022); and having the poorest human capital outcomes (World Bank, 2021). Despite these challenges, experts anticipate the uptake of digital technologies in SSA and the sub-region will create more employment opportunities for the fast-growing youthful workforce, instead of displacing workers over the coming years (Abdychev et al., 2018; Morgante & Wallace-Stephens, 2021; World Bank, 2019).

Furthermore, DT adoption can help businesses to reduce their costs and prices, enabling them to expand production and employment across all sectors, while access to internet and mobile apps can help low-skilled workers to learn better farming practices or sell more effectively in markets in agri-based economies. All these innovations have been possible because many African countries have adopted and adapted to the new DTs, helping them to leapfrog infrastructure while creating emerging sectors, particularly in services. Leapfrogging occurs when countries skip intermediate stages of technology that other countries have traditionally encountered during their development processes (UNCTAD, 2018). According to Abdychev et al. (2018), African countries leapfrogged fixed telephone lines to mobile telecommunications; a move necessitated by the low fixed costs and minimal infrastructure requirements of mobile networks. In the early 2000s, such countries as Côte d'Ivoire, Gambia, Ghana, and Mali had less than three fixed telephone subscriptions per 100 inhabitants, which was well below the global average of 23.1. Mobile subscriptions were also marginal in these countries (UNCTAD, 2018). However, according to UNCTAD (2018), by 2017, these countries had bypassed the landline infrastructure and reached levels of mobile subscriptions above the global average.

The mobile revolution has accelerated innovation in various sectors of the economy and created new markets. In the agricultural sector, it has enabled farmers to receive real-time weather and market data, as well as advice on seeding, fertilizing, harvesting, pest infestation detection and management; and secure financial transactions, alternative value chain linkages, and risk reduction, among other things (Abdychev et al., 2018). Furthermore, through advances in technology, certain African hospitals rely on medical drones, which offer an inexpensive solution, to expand healthcare access to patients restricted by distance or infrastructure (McCall, 2019). Additionally, these technologies are helping people in Africa to build houses in just a day at relatively cheaper costs (Moghayedi et al., 2024).

This mobile uptake has further led to proliferation of mobile payment systems and digital banking apps, bringing financial services to the unbanked, broadening financial access, and driving economic growth (Morgante & Wallace-Stephens, 2021; Mugume & Bulime, 2022). According to Yayboke and Carter (2020), mobile banking has provided significant gains in financial inclusion, as it allows

African countries to leapfrog the credit-card-based systems that still dominate in most developed countries and adopt a more efficient alternative. In 2017, SSA countries had the highest percentage of adults with a mobile money account, with a regional average of 21%, compared with 4% worldwide (UNCTAD, 2018). Gabon, Ghana, Côte d'Ivoire, and Senegal are among the countries leading mobile financial inclusion in Africa (UNCTAD, 2018).

The rise of mobile payment systems is promoting entrepreneurship, which is helping to reduce unemployment, particularly among women and young people in SSA. This was confirmed by Kedir and Kouame (2022), who found mobile money use was positively associated with self-employment and entrepreneurship among Cameroonian and Burkinabe women, although more likely to benefit urban residents. Increasing use of mobile payments is also accelerating the growth of e-commerce both in SSA and the WCA sub-region. E-commerce enables retailers and entrepreneurs to reach prospective clients via digital platforms, thereby circumventing investment in physical retail (Okeleke et al., 2021). These platforms are boosting inclusivity in labor markets because more women entrepreneurs are operating businesses electronically. For example, women owned one-third (in Côte d'Ivoire) to more than half (in Nigeria) of the businesses on Jumia, Africa's largest e-commerce platform with operations in 11 African countries (IFC, 2021).

Furthermore, mobile telephony in the region and sub-region has led to the proliferation of the gig economy which provides flexible employment opportunities, particularly for women, young people, and low-income groups that would otherwise be excluded (Ng'weno & Porteous, 2018; World Bank, 2023). To Ng'weno and Porteous (2018), the informal sector, including the gig economy, is Africa's present and future source of employment opportunities. The authors assert that although the sector is perceived as being unproductive and tasking for workers, it has been and will continue to be the primary source of employment for the growing labor force in Africa. This is because of the minimal capital required to start an informal business and the negligible losses incurred upon exit (Etim & Olawande, 2020), as well as the low education and skill demands of the sector (Ng'weno & Porteous, 2018).

Despite the many employment opportunities DTs are creating for the African workforce, challenges regarding inaccessible digital infrastructure, poor digital literacy, poverty, and limited social protection mechanisms continue to plague the African workforce, particularly marginalized groups, preventing them from benefiting from these opportunities. Regarding the FinTech space, for example, evidence shows wide digital gender and spatial gaps in access and use of mobile financial services (Awiti, 2022; GSMA, 2023; Rowntree & Shanahan, 2020; UNESCO, 2022). Similarly, Okeleke et al. (2021) observe that a lack of access to mobile internet services for women and low-income rural populations, limited use of online payment services, poor residential address systems in both urban and rural areas, and a difficult business and macroeconomic environment for e-commerce start-ups are the main factors threatening the viability of e-commerce services in the WCA sub-region.

Additionally, while the gig economy may be seen as an avenue for job creation, these digital platforms are also associated with deteriorating working conditions and labor standards (Abdychev et al., 2018; Anwar & Graham, 2019, 2021; Cilliers, 2021). In a study conducted in Nigeria, Ghana, and a few other African countries, Anwar and Graham (2021) discover that the structural and technological design of digital platforms, which resulted in social isolation, high work intensity, wage nonpayment, and unfair dismissals contributed to the precariousness of gig jobs. Furthermore, Mwendwa et al. (2023) indicate that gig workers face a fundamental language barrier since the apps and programs assume English literacy as the internet's lingua franca. They also note that whereas women intending to engage in gig work face barriers in obtaining the requisite devices to reliably access gig platforms, women employed in gig work grapple with discrimination from clients by virtue of being women and the lack of social protection on the jobs.

The distributional implications of DTs and climate change on work prospects and climate change risk resilience constitute a major research gap with implications for policy, particularly in the WCA sub-region. There is the need for rigorous empirical evidence on the digital gender and spatial impact of DTs on labor dynamics and climate change mitigation in agri-based economies to ascertain the potential of these technologies as a catalyst for job creation and resilience building, as well as integrating them with social protection strategies to enhance employment opportunities and support

marginalized groups in the WCA sub-region and similar contexts. We develop a framework for these issues and propose a research agenda to help inform policy and practice. We organize our framework around five key themes: (i) impact of DTs on agri-based economies; (ii) DTs and climate change transitions; (iii) DTs, platformization, and the Gig economy; (iv) Digital skills and education; and (v) policy and practice.

1.2 Impact of DTs on Agri-based Economies

Digital technology has become an important factor in modern agricultural production and is expected to transform Africa's agricultural sector (Kudama et al., 2021). According to Wang et al. (2024), the growth of the digital economy in SSA benefits agriculture by increasing agricultural productivity and human capital. The authors point out that farmers in SSA can improve their economic activities by actively using DTs to access information and obtain necessary services. These technologies make it convenient for farmer to learn best practices in land management, the use of new seeds, and fertilizer use (Kaila et al., 2019).

DTs use is observed to also increase income and improve household welfare among certain countries in SSA. According to Marwa et al. (2020), the use of digital platforms increased household income by 22%. When household incomes increase, it affords farmers the opportunity to invest in more advanced technologies in agriculture, thereby building the farmers' resilience against climate change impacts. The proliferation of smartphones and computers in SSA has also enabled farmers to maintain mutual communication with experts and related institutions and receive more accurate suggestions on agricultural production and climate change risk mitigation (Aker and Dial, 2011).

In addition to the innovations and opportunities created by DTs in the agricultural sector, there have been discussions of whether advances in technology will influence growth and employment opportunities in the manufacturing sector. According to one school of thought, certain SSA countries are experiencing premature deindustrialization as employment in the agricultural sector is slowly declining (Ortiz-Ospina & Lippolis, 2017). The authors add that the emergence of DTs will further hinder prospects for industrialization on the continent in this new era, than it did in the past. This is because current technological demands of the manufacturing sector make it more capital and skill intensive, which has reduced the sector's scope of labor absorption. This means that late industrializer countries and those at the intermediate level of development may no longer benefit from manufacturing as the early industrializers did (Szirmai & Verspagen 2015).

Even though the hike in labor costs in China could open offshoring opportunities for many African countries, these countries could still miss out because they lack the complementary foundational infrastructure, a good working environment, and efficient institutions. Furthermore, the success of other emerging Southeast Asian economies as alternative investment destinations could be problematic for African countries (Cadot et al., 2016; Gelb et al., 2013; Rodrik, 2016).

Therefore, to prepare for the digital future, certain scholars recommend that African countries continue to boost traditional exports, which are more labor-intensive in nature, by moving into sectors less affected by global technological change such as paper and paper products, wood and wood products, basic metals, and non-metallic minerals. It is believed that once the countries have built up industrial capabilities in these sectors, they could move into higher value-added manufacturing and services. These proponents of industry growth model note that the countries would, however, first need to address the basic constraints on manufacturing, notably, improving transport infrastructure and securing reliable access to power. Contrarily, many other scholars and experts are of the view that instead of an overreliance on manufacturing and industrialization, which may not favor the needs of the future of work in the Fourth Industrial Revolution (4IR), there should be a plan to pivot to other sectors, including the green and care sectors (Morgante & Wallace-Stephens, 2021; ILO, 2011),

In the face of all these predictions and fragmentary information on the future of work in Africa, empirical evidence on a large pool of African countries is required to provide a holistic picture of employment prospects in Africa. It is problematic to rely on available literature which rely solely on

a handful of tech-savvy African countries because of the heterogeneity of the continent influenced by country complexities and contextual differences. Hence, the need to expand the scope of the research to other regions and sub-regions in Africa, particularly the WCA sub-region, to understand how DTs would influence job creation, displacement, and overall labor market dynamics, and enhance the resilience of the workforce and the agricultural sector against the impacts of climate change.

1.3 Impact of DTs on Socio-economic Groups

Africa's Internet access has increased over the last two decades, owing to widespread deployment of connectivity infrastructure and mobile communication devices that have brought millions of Africans online and are creating new economic opportunities. The World Bank reports that 160 million Africans gained broadband Internet access between 2019 and 2022.

As a result, most of the poor have gained access to social media, independent information channels, mobile banking, and e-commerce, among other things. The introduction of new economic opportunities, such as pay-as-you-go businesses and increased flow of information, has boosted people's self-esteem, sense of belonging, and citizenship. The smartphone has become the primary source of internet access, bridging the geographic divide between urban and rural communities. Digital technologies could reduce income inequalities by contributing to economic growth, providing a multifaceted approach to fighting poverty and strengthening economic development, and improving both social and human capital (Waverman et al., 2005).

Reducing inequalities in technology access and use and promoting inclusive DT diffusion are beneficial in facilitating access to resources and information. It also allows firms to increase their productivity and improves income-generating opportunities for poor people and households (Aker & Mbiti, 2010; Qureshi, 2011). Furthermore, as Downes (2009) demonstrates, equal access to new technologies has particularly significant positive network impacts, limits rent accumulation, and reduces existing wealth concentrations (Antonelli & Gehringer, 2017; Richmond & Triplett, 2018).

However, in environments marked by inequalities in opportunity, education, gender, and wealth, increased distribution of DTs could further broaden disparities in wealth (Lindsay, 2005). Here, the privileged can broaden their opportunities at the expense of the underprivileged who are increasingly marginalized and excluded from the advantaged class (Tewathia et al., 2020). According to Acemoglu (2002) and Piketty and Saez (2003), this ever-increasing income inequality in most developed countries could be traced back to the diffusion of information technology, which increased the sources of income for people who had access to DTs. Nowadays, DT-enabled services are focused more on usage than access due to the lack of skills and resources required to use them. Furthermore, Aghion et al. (2019), conclude that the recent evolution of income inequality in the upper brackets is largely attributed to innovation. According to Aghion et al. (2019), when Forbes magazine ranked the richest people in America, 11 out of 50 were inventors and US patent holders, while the majority were owners of trademarked companies.

Based on these, one wonders how DTs can act as a catalyst for job creation, particularly for vulnerable groups, in the agriculture in the WCA sub-region. Experts have recommended robust reforms to bridge the digital gap to stem income inequality and achieve Sustainable Development Goal 10, which calls for the reduction of inequality of all kinds. To do so, the experts explain that these reforms must ensure inclusive access to and use of digital technologies, as well as improve digital skills. To facilitate access, scholars note that the policies must ensure individuals can afford the purchase and maintenance of digital technologies. It has acknowledged that once people have easy access to DTs, usage becomes easy. However, improvement in digital literacy will facilitate effective use.

Expanding digital infrastructure is one of the most significant challenges African governments face (Fox & Signé, 2022). Africa's infrastructure deficit, including electricity, is long-standing and dates back to colonial times. The impact on employment and earnings, especially in the informal sector, is well documented (Begazo et al., 2023; Bond, 2016; Caldarola et al., 2023; IFC, 2020). Data from Nigeria, the largest mobile market in Africa, indicates that

extreme poverty decreased by about 4% after one year of mobile broadband coverage, and about 7% after two or more years (IFC, 2020). Bridging the physical and digital infrastructure gap requires adopting new technologies that offer less expensive solutions, such as reducing electricity infrastructure scarcity.

1.4 DTs and Gender Impacts

For the past three decades, women participation in Africa's labor force has consistently been estimated to be around 60%, according to the World Bank. Yet, this statistic only tells part of the story. The majority of women in Africa's labor force remain in low-income but labor-intensive jobs such as agriculture, which lacks value-addition and growth opportunities and contributes to keeping many women in poverty. Nevertheless, African women continue to lead the world as entrepreneurs and business owners. Despite being the only region in the world with more female entrepreneurs than men, SSA's female-owned businesses are overwhelmingly microenterprises. Furthermore, women-owned businesses generate 34% less profit than those owned by men (Aseidu et al., 2023).

In the 4IR era, work in the agricultural sector is gradually shifting toward renewable energy, sustainable agriculture, and conservation, with the green economy creating more jobs, particularly for women. The energy, construction, and agricultural sectors are expected to create the most jobs (UN Women, 2021). According to the UN Women (2021) report, women currently hold a number of jobs in agriculture, forestry, and tourism, all of which have high female employment rates and are key growth sectors for green jobs in the region. A positive development is that women are carving out niches in male-dominated sectors, often as small women-led businesses in indirect jobs such as green construction, renovation, and energy efficiency.

However, there is still a lack of women in key sectors of the green economy that provide the best green jobs, such as energy (particularly wind and solar), transportation, construction, and certain niche fields of services such as green consulting. Women are more concentrated in agriculture, waste management, and specific fields of renewable energy such as biomass, which are more likely to generate low-wage jobs (ANRC, 2022). This is not unique to the African continent. The global participation of women in tech sectors remains low. Still, compared to record rates of women's entrepreneurship, African women participation in the tech industry is woefully low.

A key cause of the digital gender divide is a lack of access to mobile internet, which is linked to not owning a smartphone. In 2022, the GSMA found that women in SSA were 30% less likely to own a smartphone than their male counterparts and 20% less likely to use mobile internet than men. Women consistently have less access to internet and mobile phones than men for two key reasons: women receive lower levels of education and, partly as a result, earn less on average. A GSMA (2022) study found that literacy and digital skills, particularly basic literacy, were the second most-cited barriers to smartphone ownership in SSA. The report identified five sub-barriers, with reading and writing difficulties being the most reported by female respondents. The second most-reported reason was a lack of knowledge about using mobile internet. While this was also true of men of similar socioeconomic status, the disparity can be particularly pronounced for women. For instance, 36% of women surveyed in Senegal cited reading and writing as a barrier to mobile access compared to 12% of men.

The cost of internet connectivity is also observed to deter usage. The cost of both fixed and mobile broadband connections in SSA is the highest compared to other regions (Abdychev et al., 2018). In Senegal, 61% of women and 46% of men who are not online cite the cost of a smartphone and internet connectivity as a primary reason (Rowntree & Shanahan, 2020). Further research has revealed that gender pay disparities and women's lower employment rates mean that smartphones are already more expensive for women than men (Women Business and the Law, 2022). A GSMA digital gaps analysis discovered that, on average, the cost of an entry-level smart phone represented 25% of women's monthly income in SSA, compared to 15% for men (GSMA, 2022). Similarly, Begazo et al. (2023) observe that 40% of Africans falls below the global extreme poverty line, meaning the cost of basic mobile data plans would represent about one-third of their incomes. Only about 5% of extremely

poor households have access to the internet.

Access to digital banking and identification remains a barrier for women in many countries and presents a challenge for women entrepreneurs who want to break into the digital economy. In developing economies, women remain 9 percentage points less likely than men to have a bank account. Across Africa, it is estimated that 60% of the 400 million people who have access to digital financial services are women. Women who own small- and medium-sized enterprises (SMEs) but have no access to mobile phones or digital banking are unable to take advantage of digital payment applications that could significantly scale their businesses to reach new markets. Additionally, digital banking platforms provide a range of value-added services such as risk estimation which enables further investment. Women are also excluded from digital jobs, networks, and business associations that connect job seekers to the tech industry. Exclusion from job networking opportunities means that women-led tech startups have a more difficult time finding funders to pitch to them, impeding their ability to start and scale digital businesses.

In terms of literacy, women and girls are not only excluded from access to training and education in STEM, but also education that promotes general digital literacy. UNESCO estimates that only 30% of women in SSA receive STEM training and participates in the tech sector. Fewer girls than boys possess the critical digital skills needed to compete in the modern labor force. An estimated 230 million jobs in SSA will require digital skills by 2030. Therefore, not having equal access to digital education systematically prevents girls from being part of the fastest-growing sectors of the economy which could dampen job growth and entrepreneurship opportunities overall. Patterns of gendered exclusion are intersectional, meaning that structures of power and inequality affect women from different backgrounds in compounding and overlapping ways.

Economically-marginalized groups, especially women living in the most remote settings, face multiple barriers to digital access, including network availability, device, data affordability, low levels of awareness, literacies, and agency. This is particularly true for women in SSA and the WCA sub-region who are the most underserved, including those with low literacy or incomes, those who live in rural areas, or those with disabilities. Older women are at greater risk of exclusion as they often have lower levels of digital literacy and access to internet and mobile phones.

Recent experience shows that using digital solutions along the social protection delivery chain yields a range of benefits. Indeed, it is observed that digitalization promotes awareness of social protection schemes and access to several benefits and services without having to apply for each one separately. Digitalization also reduces travel time and transportation costs when applying for programs and collecting benefits, while facilitating access to information about programs. At the same time, the use of digital technologies for implementing social protection programs faces several challenges in rural areas. The main risk lies in the potential exclusion of individuals or households deprived of access to the required digital technologies or basic infrastructure and hardware, or lacking the knowledge on how to use them. This may especially affect women, elderly people, migrants, ethnic minorities, and indigenous peoples. Other obstacles and risks worth considering in connection with digital social protection include data privacy concerns, the lack of physical addresses or personal identification, and the lack of digital ecosystems that accept digital payments. While these obstacles are not unique to rural areas, they tend to manifest themselves more acutely among rural populations.

Social protection access is extremely limited in SSA where only an average of 17% of the total population receive a form of social protection benefit in comparison with the global average of 47% (ILO, 2020). The share of the population without social protection falls into the category termed the ‘missing middle’. Workers in the informal economy make up a significant share of the ‘missing middle’. According to the ILO’s social protection platform, public expenditure on social protection is 0.7% in Nigeria, 1.2% in Cote d’Ivoire,1.6% in Ghana, and 1.8% in the DRC. Reasons for such low expenditures include the fact that in many SSA countries, social assistance, which is government-funded or publicly-provided benefits, in cash or in kind, is mainly disbursed as a form of emergency relief (ILO Social Protection Platform). Also, less than 10% of the population in SSA is covered by social insurance due to low employment levels and a high level of informal employment and self-employment (ILO, 2020).

Over the last decade, and especially in more recent years, African governments have made efforts to develop a range of contributory social protection schemes to cover workers in the informal economy (Guven, 2019; ILO, 2019). In a UNDP (2021) report on the social protection schemes covering informal workers in seven African countries, including Ghana and Togo, it was revealed that some promising strides had been made. These include the collection of national statistics on informal employment and engagement with informal workers to inform program design and implementation. Efforts to lower and allow for more flexible contributions improve the benefits packages available and draw on the power of technological innovation to reduce transaction costs (although this should proceed with care to ensure the inclusion of those unable to access DTs). Some governments have been ambitious and intentional about building trust and awareness regarding contributory social protection schemes.

However, the report also highlights significant challenges and gaps. Many of the schemes reviewed were perceived as vulnerable because they solely targeted informal workers. This meant that the risk pool was too narrow, and the benefits of cross-subsidization between formal and informal workers were absent from these schemes. The authors proposed that more conscious attempts be made at linking contributory and non-contributory schemes. They believed that doing this could have a significant impact on bringing more women into the social protection system. Moreover, they noted that institutional representation through tripartite structures and bottom-up approaches were critical for informal workers to perceive the Government as a collaborator in this process. The authors additionally recommended that greater representation by informal workers' organizations, particularly in sectors where women dominate – such as agriculture, street vending and market trading, and domestic work – may give rise to more demands for maternity protections which are currently missing from most of these schemes.

1.4 Research Questions

- How will DTs influence job creation, displacement, and overall labor market dynamics in agri-based economies?
- How will DTs enhance the resilience of the WCA sub-region's workforce and agricultural sector against the impacts of climate change?
- How can DTs be made accessible to the information poor in agri-based economies in the WCA sub-region?
- How can DTs act as a catalyst for job creation, particularly for vulnerable groups, in agriculture in the WCA sub-region?
- To what extent do DTs influence the evolving labor landscape within the agricultural context, considering the ecological shifts caused by climate change adaptations?
- What is the role of social safety nets in the evolving digital and environmental context?

2. DTS AND FOOD SYSTEMS TRANSFORMATION IN WEST AND CENTRAL AFRICA: OPPORTUNITIES AND CHALLENGES

2.1 Significance of DTs in food systems

Digital technologies are playing an increasingly crucial role in transforming food systems by offering innovative solutions to complex challenges in agriculture and food supply chains. The integration of DTs, such as data-driven technologies and digital platforms, presents opportunities to enhance sustainability across food systems (Macpherson et al., 2022). These technologies enable the digitalization of agriculture, providing new ways to improve production efficiency, reduce costs, and overcome barriers to market access for small farmers (Vasilevska et al., 2019).

The adoption of DTs in food systems leads to significant improvements in various areas. For instance, the digitalization of agricultural supply chains through technologies like IoT enhances traceability and safety, contributing to the high-quality development of food supply chains (Jin & Xie, 2023). Furthermore, DTs empower farmers by accelerating information flow and enhancing their access to agricultural value chains, ultimately strengthening the agricultural sector (Panggabean et al., 2023). Moreover, the use of DTs in agriculture management supports sustainable development by enabling monitoring and control systems for production processes (Tsvetkova & Vakhovskaya, 2023). These technologies not only aid in improving operational efficiency but also play a vital role in promoting sustainable agricultural practices and enhancing food security (Duan, 2024). Additionally, the digital transformation of agriculture aims to achieve sustainable development by leveraging DT and services (Qin et al., 2022).

2.2 Overview of West and Central Africa's food systems

West and Central Africa's food systems are intricately linked to various factors such as climate, agriculture, nutrition, and poverty alleviation. The region faces challenges and opportunities in ensuring food security and sustainable livelihoods for its populations. In recent years, persistent challenges have hindered efforts to reshape Africa's food systems. Adverse natural events, severe climate occurrences, socioeconomic disruptions, and conflicts are exacerbating food insecurity, undermining livelihoods, and threatening economic progress (Adeola et al., 2024; Awiti, 2022). These challenges are compounded by Africa's unique circumstances, including shifts in the population due to the rise of an urban middle class, changes in dietary preferences, and high levels of youth unemployment (World Bank, 2022). A sustainable transformation of Africa's food systems will depend on developments in rural areas and a more competitive and efficient food and agricultural sector (Malabo Montpellier Panel report, 2021).

The current policies in the sub-region have been unable to keep up with the rapid changes in food systems, resulting in challenges such as increased obesity, low productivity and incomes, rising greenhouse gas emissions, and deteriorating ecosystems (OECD, 2021). Hunger affected one in every five Africans in 2019, marking a significant increase from previous years and hindering progress towards achieving Sustainable Development Goal 2—zero hunger by 2030 (FAO et al., 2020). The COVID-19 pandemic is anticipated to exacerbate the situation, causing more people to experience hunger, and reversing the progress made in reducing poverty and malnutrition. Interestingly, the pandemic has not significantly impacted food production, with farming and livestock production emerging as crucial fallback options, particularly for urban poor populations who relocated to rural areas (Amankwah et al., 2021). However, government measures to control the pandemic have revealed the vulnerability of Africa's food systems, disrupting supply chains, domestic and export markets, and informal food systems in urban areas, resulting in higher retail prices, reduced incomes, and difficulties in accessing nutritious food (Montpellier Panel report, 2021).

Agricultural development is identified as a crucial step in creating efficient approaches to poverty alleviation in West Africa (Osinowo et al., 2022). The region has witnessed changes in climate since 1970, impacting rainfall patterns and agricultural productivity (Mahé et al., 2013). The genetic diversity and evolutionary history of species in WCA differ from those in other parts of the continent (Bertola et al., 2011). The importance of micronutrient supplementation during pregnancy

and iron-folate programs is highlighted as a priority for West Africa (Alobo et al., 2021). The challenges of pests, such as the variegated grasshopper, in agricultural production systems are noted in the humid forest zones of WCA (Kekeunou et al., 2006). Foreign Direct Investment (FDI) inflows are influenced by natural resource endowments in Central Africa (oil) and West Africa (metals and oil) (Anyanwu & Yaméogo, 2015). These factors underscore the complex interplay of environmental, economic, and social elements that shape the food systems in WCA.

The sub-region's food and agricultural sectors are currently at a critical juncture, facing complex challenges in transforming food systems. There is the need for a more comprehensive and interconnected approach to address these issues, involving various sectors, industries, and stakeholders. Effective policymaking will require a more holistic and refined approach that integrates traditionally separate policy domains such as agriculture, health, education, and the environment.

2.3 Impact of DTs on food systems transformation in WCA

DTs have significantly impacted food systems in various ways. Precision agriculture technologies have been shown to reduce greenhouse gas emissions by optimizing agricultural inputs based on the specific needs of fields (Balafoutis et al., 2017). These technologies not only enhance farm productivity but also contribute to economic benefits. Additionally, the integration of digital technologies in food systems, such as through the use of high-tech equipment and data analytics tools, improves efficiencies, reduces food waste, and enhances nutritional content (Fraser, 2021) and empower firms to produce products that align with consumer preferences (Samoggia et al., 2021).

In such countries as Nigeria, mobile platforms have been leveraged to provide farmers with crucial information on weather patterns, market prices, and best agricultural practices. This has contributed to improved crop yields and better access to markets for smallholder farmers. In Ghana, the use of digital platforms for payments has enhanced financial inclusion for rural farmers, allowing them to access financial services and receive payments more efficiently. Additionally, e-commerce platforms have facilitated the direct sale of agricultural produce to consumers, reducing the role of intermediaries and increasing farmers' profits. Also, in Cameroon, digital mapping and data analytics have been employed to improve land management and optimize agricultural production. This has led to more efficient land use, better crop planning, and improved natural resource management in the region.

Moreover, technologies such as IoT have been instrumental in developing food safety traceability systems, ensuring the safety and quality of food products from farm to fork (Ruan & Chen, 2023). Similarly, leveraging blockchain and IoT technologies in the Halal food industry has the potential to enhance traceability, certification, and trust in Halal products, thereby boosting the Halal economy (Davids & Sabrain, 2022). DTs offer opportunities to address challenges faced by global agro-food systems. The use of digital tools can improve efficiencies, reduce food waste, increase nutritional content, (Fraser, 2021). Furthermore, digital technologies contribute to the resilience of food supply chains by enhancing visibility, traceability, and adaptability, particularly in the face of such crises as the COVID-19 pandemic (Kumar, 2024; Musa et al., 2022; Amentae & Gebresenbet, 2021).

On the consumer side, the acceptance and adoption of DTs in the food industry have reshaped consumer behaviors and expectations. For instance, fast-food restaurants have leveraged digital ordering systems and mobile apps to provide customers with more convenient and personalized experiences (Helal, 2023). Moreover, a study on consumers' acceptance intention of using mobile food delivery services highlights the importance of understanding and utilizing technology acceptance models to meet consumer needs effectively (An et al., 2023).

The incorporation of DTs in food systems is seen as a means to support more sustainable food systems and food cultures, addressing concerns regarding the sustainability and ethics of mainstream food systems (Frawley et al., 2014). These technologies enable a transition towards personalized digital food systems that prioritize functionality, taste,

safety, and minimal environmental impact (Smykov, 2023). Additionally, digitalization in food systems enhances food and nutrition security by making food businesses more efficient, sustainable, and transparent (Raheem et al., 2019). DTs improve food safety governance by enhancing supervision and knowledge among food producers and consumers (Xi et al., 2021). They also offer unprecedented opportunities to revolutionize risk assessment and mitigation in food supply chains, contributing to the overall resilience and efficiency of the system (Sharma, 2024). Moreover, DT adoption in agriculture and food production systems enables the application of advanced data processing techniques, leading to increased production and consumption (Nasirahmadi & Hensel, 2022; Uttama, 2021).

DTs have impacted agricultural and food production systems, offering various benefits to farmers and stakeholders in the food supply chain. These technologies, including apps and digital platforms, have strengthened relationships among agro-food chain actors, promoting urban and regional food systems, and expanding market reach for farmers (Samoggia et al., 2021). The adoption of DTs in the agri-food system has been noted to occur during a period of organizational instability, potentially playing a crucial role in the reconfigurations of the food regime (Prause et al., 2020). Furthermore, DTs have been recognized as tools that can enhance sustainability — economic, social, and environmental — of global agro-food systems(Bahn et al., 2021).

In the context of food supply chains, DTs have revolutionized risk assessment processes, offering opportunities to identify and mitigate risks more effectively (Sharma, 2024). Additionally, the use of DTs in the food industry has improved supply chain management flexibility by enhancing information flow among stakeholders (Kumar, 2024). DTs have also been proposed to be utilized to enhance food safety supervision, improve the knowledge of food producers, and encourage consumers to utilize digital tools for food safety (Xi et al., 2021). Digital technologies have become essential tools in addressing challenges within the global agro-food systems. The Food and Agriculture Organization (FAO) acknowledges the significant potential of DTs in improving various aspects of the food supply chain (Samoggia et al., 2021). These technologies are being introduced into the agro-food system during a period of organizational instability, where they are expected to reshape the current food regime (Prause et al., 2020). Utilizing digital tools such as e-commerce, mobile technology, and AI can enhance the resilience of the global food system post the COVID-19 pandemic (Musa et al., 2022).

The impact of digitalization on agriculture and food production systems has been profound, enabling the application of advanced technologies and data processing techniques in the agricultural sector (Nasirahmadi & Hensel, 2022). Digitalization is anticipated to tackle challenges faced by the agro-food industry, including meeting the increasing food demand and optimizing resource utilization, thereby contributing to sustainable development (Annosi et al., 2020). In the context of complex and globalized food supply chains, digital solutions are vital to mitigate risks, prevent fraud, and enhance the resilience of food supply chains (Sharma, 2024). Furthermore, digital technologies provide opportunities for food start-ups to address challenges post-pandemic by adopting innovative e-business models and digital marketing strategies (Almansour, 2022). Concerns regarding the sustainability and ethics of mainstream food systems have led to an interest in utilizing DTs to promote more sustainable food systems and cultures (Frawley et al., 2014). The advancement of technologies, computing power, and analytics presents new possibilities for overcoming challenges through the digitalization of agriculture (Shepherd et al., 2018).

Digital food technologies have the potential to revolutionize food production systems, enabling personalized and functional food systems with minimal environmental impact (Smykov, 2023). Retailers are leveraging DTs to ensure safe, healthy, efficient, and sustainable food supply chains ("The impact of digital transformation on the retail food business", 2022). Additionally, integrating digital technology into food safety governance improves supervision and consumer awareness, thereby enhancing food safety standards (Xi et al., 2021). The incorporation of digital technologies in food systems has been observed to improve efficiencies, reduce food waste, increase nutritional content, and enhance food production and consumption (Fraser, 2021). Digitalization in food systems has been associated with benefits such as traceability, sustainability, resilience to such crises as the COVID-19 pandemic, and reducing food waste across different food commodities (Amentae &

Gebresenbet, 2021). Again, digital platforms and FinTech ensure the safety and undisrupted food supply, particularly for local small-scale farmers and MSMEs (Musa et al., 2022).

Studies show that DTs improve access to healthcare in rural areas by overcoming geographic barriers to care (Okobi et al., 2023). The application of digital empowerment in rural areas can lead to increased farmer income, industrial development, and educational progress, drawing from the experiences of urban areas (Sun et al., 2023). However, disparities in DT access between rural and urban populations exacerbate existing inequalities in economic well-being (Whitacre & Mills, 2010). The digital divide, which refers to the gap in access to information and communication technologies between rural and urban areas, has significant implications for mental health, with rural populations potentially facing challenges due to limited access to technology (Cheshmehzangi et al., 2022). Access to digital infrastructure may also influence physical activity and screen time trends among children and adolescents, with rural areas potentially experiencing increased screen time due to disparities in digital infrastructure (Nigg et al., 2022).

Digital technologies have been increasingly integrated into food systems, impacting various aspects of agriculture, food safety, retail, and consumer experiences (Bronson & Knežević, 2016; Xi et al., 2021; Fraser, 2021; Helal, 2023). Aside from improving efficiencies and reducing food waste, these technologies have the potential to enhance food safety supervision and provide personalized experiences for consumers (Bronson & Knežević, 2016; Xi et al., 2021; Fraser, 2021; Helal, 2023). However, DT disparities between rural and urban populations affect the adoption and benefits derived from these advancements (Thomson et al., 2021; Liu et al., 2013; Okobi et al., 2023; HUNG, 2023; Freeman et al., 2019).

2.4 Opportunities for DTs in food systems transformation in WCA

The use of DTs to transform food systems in WCA presents several opportunities across different sectors. These technologies encompass a range of tools and platforms, including mobile applications for agricultural support, data analytics for informed decision-making, IoT devices for monitoring and automation, and e-commerce platforms for improved market access. When implemented effectively, these digital solutions have the potential to revolutionize agricultural productivity, streamline supply chain management, enhance market access for smallholder farmers, and facilitate direct consumer engagement. Embracing DTs in WCA's food systems can lead to greater efficiency, inclusivity, and sustainability, benefiting both producers and consumers throughout the region.

For example, in Nigeria, such mobile applications as FarmCrowdy and ThriveAgric connect smallholder farmers with investors and provide access to agricultural resources. In Senegal, the use of data analytics for weather forecasting and market trends has empowered farmers to make informed decisions, leading to improved yields and income. Additionally, in Côte d'Ivoire, IoT devices are being utilized to monitor crop conditions and automate irrigation processes, leading to enhanced productivity. Furthermore, in Ghana, the Esoko mobile application provides farmers with real-time market prices and weather information, enabling them to make better decisions. Programs, such as the e-Payment System for smallholder farmers in Liberia, have facilitated transparent and efficient transactions through digital platforms. In the Democratic Republic of the Congo, such initiatives as AgriWap leverage mobile technology to provide agricultural advisory services and market information to rural farmers. Moreover, in Chad, the use of e-commerce platforms has enabled small-scale producers to access wider markets for their products.

2.5 Challenges of DTs in transforming food systems in WCA

Digital technologies, as has already been stated, have the potential to revolutionize food systems by improving efficiency, increasing productivity, and reducing waste. However, several challenges

exist that hinder the widespread adoption and implementation of these technologies in WCA.

One primary challenge is the limited access to digital infrastructure and technology. Many countries in WCA lack adequate internet coverage, which restricts DT adoption in agriculture. Without reliable internet access, farmers and other stakeholders in the food system do not fully benefit from digital tools and platforms that could help them improve productivity and market access (Robinson et al., 2020). Limited digital literacy and technical skills among farmers and other food system actors remains a challenge (FAO et al., 2020). Many individuals in WCA are not familiar with the use of digital tools or lack the necessary skills to leverage these technologies effectively. This hinders the integration of digital solutions into agricultural practices and value chains (World Bank, 2021).

Another challenge is the high cost of digital technologies and related services. The initial investment required to implement digital solutions is prohibitive for smallholder farmers and other actors in the food system. The cost of digital infrastructure, equipment, and software often presents a barrier to adoption, particularly in resource-constrained environments (Okobi et al., 2023). Issues related to data privacy, security, and governance need to be addressed to build trust and facilitate the uptake of DTs in food systems. Concerns about data ownership, protection, and misuse deter stakeholders from embracing digital tools and platforms, especially in the absence of robust regulations and enforcement mechanisms (Wang et al., 2023).

Despite these challenges, certain WCA countries are adopting DTs to transform their food systems. For example, Nigeria has seen the emergence of various agricultural technology startups that leverage digital platforms to provide farmers with access to market information, financial services, and extension support (Okobi et al., 2023). Similarly, Ghana has implemented mobile-based solutions for agricultural extension services, allowing farmers to receive timely information and advice on best practices (Amankwah, et al., 2021).

In conclusion, the challenges of DTs in transforming food systems in WCA are complex and multifaceted. Therefore, addressing these challenges will require concerted efforts from governments, the private sector, and development partners to improve digital infrastructure, enhance digital literacy, lower the cost of technology adoption, and strengthen data governance frameworks. By overcoming these barriers, WCA can unlock the full potential of DTs to create more resilient, efficient, and sustainable food systems.

2.5 Research Questions

1. How can access to digital infrastructure and technologies be improved to ensure their adoption into the agricultural sector?

2. In what ways can digital literacy be promoted to ensure the integration of digital solutions into agricultural practices and value chains?

3. How can social protection systems be redesigned to ensure that actors within the agricultural value chain transition into emerging digital jobs?

4. How can issues of data privacy, security, and governance be addressed to build trust and facilitate the uptake of DTs in food systems?

5. What are the potential risks and challenges associated with the digitization of food systems in WCA, including issues related to data privacy, cyber security, and digital divide?

6. What are the environmental impacts of digital agricultural technologies, such as precision farming and IoT sensors, on land use and resource management in WCA?

3. DTS AND CLIMATE CHANGE TRANSITIONS (GREEN ECONOMY) IN AGRI-BASED ECONOMIES

3.1 Introduction

The effects of climate change in the WCA sub-region are diverse and severe. The region encounters several issues, including droughts, coastal floods, desertification, and decrease in agricultural output resulting in food shortages (Anugwom, 2021). These environmental changes have a direct impact on public health, leading to an escalation of vector-borne illnesses such as malaria, and other health hazards (Opoku et al., 2021). The WCA sub-region undergoes alterations in precipitation patterns, with a predicted rise in the amount of woody plant covering that may impact future variations in evapotranspiration and soil moisture levels (Erfanian et al., 2016). Research indicate that these impacts will have adverse impacts on agricultural yields (Roudier et al., 2011; Wang & Alo, 2012).

The sub-region's vulnerability to climate change impacts is deepened by their limited ability to adapt (Ayodotun et al., 2019). More so, the sub-region's overreliance on agriculture as a primary source of income renders it vulnerable to the adverse impacts of climate change (Olofin, 2016). The exposure of the sub-region to climate change impacts has increased climate-induced migration in the area (Teye & Nikoi, 2022).

3.2 Climate Change Transition (Green Economy)

The adverse effects of climate change on many African countries, together with the digital revolution on the continent, have led many countries to shift towards climate change transition, also known as green economy. The green economy is an economy that is low-carbon, resource-efficient, and socially-inclusive (Bulkeley, 2010; Boyd & Juhola, 2014). Primarily, six main sectors contribute to the green economy – renewable energy, green buildings, sustainable transport, water management, waste management, and land management.

While climate change has compelled many countries to rethink their commitment to the environment along with economic growth, the COVID-19 pandemic, followed by the war in Ukraine, has exposed many economies worldwide to the shocks of supply chain disruption, highlighting the futility of a 'growth-only' paradigm. This has pushed countries to realize the importance of a more sustainable and greener economic pathway, with many now seeking a different approach towards economic growth which is not decoupled from environmental protection and social justice.

Africa is in a great position to harness the benefits of transitioning to an inclusive green economy. In fact, more than 83% of national climate plans include greenhouse gas reduction targets, with focus areas including energy, agriculture, waste, land use and forestry—which are also the main sectors for green economy interventions. The continent is endowed with natural resources, specifically lithium, graphite, cobalt, nickel, copper, and rare earth minerals—all are key components of the e-mobility transition and represent new market opportunities for net-zero targets as well as sustaining livelihoods.

Seven African countries are predicted to be in the world's top-ten fastest growing economies: Uganda, Kenya, Tanzania, Madagascar, Senegal, Malawi, and Zambia. This means a large increase in energy demand from households, industry, transport, and power generation. A green economy approach allows African countries to transition to a greener energy generation pathway and cater to their growing energy demand at the same time, supported by falling renewable energy costs, with solar panel prices dropping by 80% in the last decade and wind energy prices by 40%.

The UN estimates the annual investment gap for renewable energy infrastructure to be between US$380 billion and US$680 billion. With focused policy interventions on green economy, African countries have a huge potential to close the financing gap. So far, Nigeria has tapped the green, social, and sustainable bond market to raise finance. Direct policy measures are required to attract such financing for more African countries. Burkina Faso, for example, has implemented a new investment code that lowers the performance obligations for investors in green and renewable energy sectors. Africa is also likely to embark on rapid urbanization which needs better planning to develop more compact, resource-efficient cities.

Transitioning to a green economy would create newer jobs as well as bring in more investment to

Africa. This is crucial for Africa as approximately 70% of the population are below the age of 30 and newer entrants joining the workforce every year. For instance, UNEP estimates that the expansion of solar and wind capacity in Senegal will create up to 30,000 additional jobs by 2035.

The downside of the transition includes high initial investment costs, low capacity (skills and technology) for implementation, the projected insignificant rise in real GDP in the short term, and a general increase in carbon emissions as Africa develops. Stakeholders who lose out in the transition may need to be compensated. In Kenya, for example, despite costs associated with green economy investments, growth in GDP would not be substantially different from business as usual in the short term (between 2010 and 2020). Employment in certain sectors may also suffer from a green transition. While overall employment is set to increase, such sectors as coal mining will inevitably suffer a loss of jobs. Governments will, therefore, need to support such segments of the population during the transition.

Overall, the green economy offers an opportunity to address poverty, economic stagnation, unemployment, and vulnerability to environmental risks and ecological scarcities. Existing studies on certain African countries in both small and larger economies with different resource endowments, demonstrate positive and significant impacts. However, the transition to a green economy will not happen automatically. It needs to be facilitated by various enabling conditions, including financing, capacity development, green technology development and transfer, policy instruments, and institution and policy frameworks.

3.3 The Impact of Climate Change Transition on Traditional Jobs in Agriculture

In Africa, agriculture remains the mainstay of the economy, with over 60% of the population working in agriculture, far beyond the global average of 13% (FAO, 2017). However, 227 million people (a fifth of the population) in Africa face chronic food security problems. Africa has 15% of the world's population but nearly a third of the world's famine population (Carlos Lopez and Jun Liu, 2015). It is not difficult to speculate that the reasons behind this phenomenon are closely related to the characteristics of current African agriculture, including being a smallholder economy with poor agricultural practices, resulting in low food production (Carlos Lopez and Jun Liu, 2015). For example, maize yields in Africa were 2t/hm2 in 2018 while those in the Americas and Europe were 8t/hm2, with a global average of 6t/hm2 (FAO,2018).

Traditional agriculture is the first evidence of increased greenhouse gas emissions (Paustian et al., 2016) as 50-60% of nitrous oxide (N2O) and methane (CH4) are derived directly from human agricultural activities (Awais et al., 2021). The misuse of pesticides and manure on the continent releases excessiveN2O , which has 300 times greater impact than carbon dioxide (CO2) on global warming. In addition, farmers often destroy surrounding vegetation to provide more light for their arable land and prevent fertilizer run-off, further exacerbating global warming (Wenjiao Shi and Fulu Tao, 2014).

The first drive for green economy transition in African agriculture is the attempt to offset the effects of climate vulnerability on agriculture. This would mean adopting best practices and embracing DTs that ensure efficiency and productivity and minimize any harmful effects on the environment. Ultimately, the smallholder model will be replaced. While this move will benefit African agriculture, the digital divide regarding access to infrastructure, skills, and social protections must be addressed to tackle the challenges of financing, climate change mitigation, and meet changing consumer demands in agri-based economies.

3.4 Creating Opportunities in Green Sectors.

The agricultural sector (including forestry, fisheries, and the entire system of food production is both the highest GHG-emitting sector in SSA and the most vulnerable to climate change. The sector is also the largest employer, with 53% of jobs, 22 and a large employer of women across the continent. It accounts for an estimated 20% of the region's GDP

in 2021. According to the ILO, more than 217 million jobs in Africa relied on agriculture in 2014 (ILO, 2018). The number of agricultural jobs in Africa is expected to grow for the next several decades (Christiansen & Brooks, 2018), even though other sectors are growing faster.

The agricultural sector needs to shift fundamentally to more sustainable practices in order to reduce GHG emissions and enhance resilience to climate change. Green agriculture involves shifting both industrial and subsistence farming towards sound ecological practices such as efficient water use, extensive use of organic and natural soil nutrients, optimal tillage, and integrated pest control. Building green agriculture requires physical capital assets, financial investments, research, and capacity-building. In addition to the progressive greening of conventional agriculture through the promotion of a more efficient use of resources, a shift towards conservation and organic farming is another important path. Conservation agriculture is a farming system that encourages minimum soil disturbance, safeguards permanent soil cover, and diversifies plant species (FAO, 2021)

In terms of job quality, the shift to sustainable agriculture may boost the productivity of agricultural labor in low- and middle-income countries. Green practices in agriculture help to increase workers' incomes by lowering input needs, increasing yields, and fetching higher prices or a combination of these factors. This has been seen for small farms in Africa, where use of synthetic inputs (fertilizers and pesticides) is limited (ILO, 2013).

The sectors likely to provide the most promising economic potential in relation to the green economy in SSA are agriculture, energy, forestry, fisheries, tourism, transport, construction, and waste management (UN Women, 2021). In the agricultural sector, areas such as trade in biodiversity-based businesses or biotrade and organic agriculture are identified as niche markets for the sector, even though these are still in their infancy in the region.

Green jobs are likely to be concentrated in the above sectors and subsectors, and at the same time are likely to generate or regain the most jobs in post-COVID-19 SSA. Thus, a shift to greener processes and products and overall job growth may have a synergistic effect in these sectors. In general, the areas likely to produce most green jobs are the energy and construction sectors, the circular economy and sectors related to ecosystems – agriculture, forestry, and tourism.

3.5 Potential for New Sustainable Green Jobs for Women

Agriculture is the biggest source of women's jobs in SSA, estimated in 2019 as employing 53% of working women (ILO, 2021). Women's prominent role in the sector often does not translate into economic gains, however, women are employed mostly in informal, vulnerable jobs at the early, low-productivity stages of agricultural value chains (ILO, 2020).

Greening conventional agriculture will produce green jobs for which women are well positioned to take. However, these are likely to be low-quality jobs as the majority of jobs in the sector. The shift to conservation agriculture may reduce employment in net terms, but the jobs created are likely to be of higher quality, and women are also well positioned to access these jobs. Data limitations make it difficult to assess the potential of the forestry sector to create green jobs in SSA and to assess women's participation in certain types of jobs/areas of forestry (for example, reforestation). However, there is evidence that in sustainable forestry, working conditions are better and the quality of jobs is higher than those in conventional forestry, and women are well positioned in niche markets and as community forestry managers. There are important opportunities through payments for environmental services and other mechanisms to assign economic value to women's unpaid work in this sector.

There is also a dearth of data on the fisheries sector, but aquaculture seems to be an area where significant opportunities are likely to emerge for women. However, there is a risk of women being marginalized in low-quality jobs, judging by the current high levels of informality in the sector, and co-option of new opportunities by men, as seen in other countries. This is a critical sector to open up opportunities for women in rural and/or poor areas, and it, therefore, deserves the attention of policymakers. Women make up the majority of workers in the tourism sector, and the

potential for greening the sector is large. Currently, women's participation in green tourism activities is driven mainly by their entrepreneurship and by community-based tourism initiatives (Hamilpurka, 2021).

Women's opportunities for green jobs in the tourism sector are numerous, both as self-employed and wage workers. Women are well positioned, as their participation in the tourism sector is already high. However, informality and poor working conditions in conventional tourism indicate that new jobs for women arising from the greening of the tourism industry may be of low quality (ILO, 2011) At the same time, tourism offers plenty opportunities for self-employment. Women's green job opportunities in tourism

The substantial potential for entrepreneurship, including by women, may mitigate poor working conditions to some extent. Examples of women creating new positions as climbing guides and park rangers suggest that there are interesting opportunities from the point of view of changing perceptions about women's jobs and for role-modelling. Quick-win opportunities for women can be realized by addressing issues such as informality and lack of financing for micro, small, and medium-sized enterprises for women entrepreneurs. Overall, measures to support the development of women-led MSMEs in this sector would help more women to take up jobs in this area of the green economy.

While the number of green jobs created is not comparable to other sectors, the circular economy can create significant high-quality jobs. Women are important actors in the sector, and while data to assess the full extent of their participation is lacking, women will be well positioned to access jobs in the sector in a number of cities across SSA. Opportunities in sustainable waste management and waste-to-energy will also exist for women. The quality of those jobs will depend on the extent to which policies and programs for formalization in the sector take place. Innovative women-led SMEs are active in the recycling sector in the region. Thus, with the necessary economic incentives from governments, this could be another quick win for women. The shift to more efficient public transport will create new green jobs in SSA, but not a significant number. These jobs will be to some extent, of good quality (for example, public bus drivers), but ones for which women are not necessarily well positioned, given their limited current participation in the sector. Promoting women's entry into public transport, particularly sustainable municipal transport, might have value by creating visible positive role-models of women's incursion into a male-dominated area of employment.

Renewable energy, as a distinct subsector within the energy sector, may open up opportunities for increased women participation and for breaking into male-dominated areas of employment. Existing data supports this potential: women participation is higher in renewable energy than in conventional energy. Investments in mentoring and promoting women's organizations in the sector (see examples in Box 9) can help consolidate this trend. The quality of jobs varies across renewable energy subsectors, and women are better positioned to seize opportunities in solar power, which is expected to create high-quality jobs; and bioenergy, where jobs are likely to be low-quality. Women are less well-positioned in the wind industry in the region, but the growing potential of this subsector provides long-term opportunities for increasing women's presence if the right policies are implemented.

Although a difficult sector for women to enter, the imminent shift to green building will create opportunities for women. Areas such as renovation, solar panel installation, insulation and energy efficiency are likely to grow as the green building market expands. These areas may present much lower entry barriers – an advantage to women entrepreneurs – than large construction projects. Women also may find job opportunities in indirect jobs associated with construction, many of which are mid- to high-level in terms of pay, stability, and working conditions. These jobs include architecture, landscape design, urban planning, energy auditing, solar panel installation and sustainability consulting. The new green skills required will be learned mostly through training rather than on the job, as most conventional building trades skills are learned. Some of these jobs require advanced academic qualifications, while a high school or a technical and vocational education and training (TVET) diploma might suffice to enter other jobs. The need for schooling should put women on a more equal footing with men competing for construction jobs in the green building sector. A number of women-led businesses are already seizing this opportunity across the region.

3.6 Barriers to Women Participation in Green Jobs

Women are underrepresented in key sectors of the green economy that offer the best green jobs. The sectors most likely to create higher-end green jobs include energy (especially wind and solar), transportation, construction, and certain niche areas of services (e.g., green advisory). Women are overrepresented in agriculture, waste management, and certain areas of renewable energy (biomass) which are likely to create lower-end jobs. The mix will depend to a certain degree on country policies.

Skill mismatch is one of the major obstacles women face to obtaining green jobs, particularly as wage employees and especially, in higher-end jobs. The analysis in Section 3 shows that several new jobs with a technical profile will be created across different sectors (for example, as engineers and architects). Given current gender segregation in education systems and labor markets in most African countries, these new opportunities are currently accessible to a narrow pool of women who have the necessary skills and qualifications. For example, in 2013, women represented only 7-12% of engineering students in Africa. Approximately, 30% of tertiary-level engineering students in Niger are women, while in Mali, women constitute 6% of engineering students. Across sectors, the gender gap in skills training is more evident in areas such as construction, transport, and certain areas of energy where women currently participate in very low proportions. These also are some of the sectors where the highest numbers of green jobs, including higher-end jobs, will be created.

Women face several barriers that will limit their full access to green jobs in the coming years. Some of these barriers are sector-specific, such as social norms that deem construction jobs inappropriate for women. Others permeate all sectors, including barriers to women's and women-led businesses' access to land, finance, and technology; gender segregation in the education system and labor market; laws that limit women's access to certain tasks and jobs; and structural inequalities reflecting social norms dictating that women should shoulder the great majority of unpaid carework, effectively depriving them of opportunities for other jobs.

Improving gender inclusivity in Africa's growing tech sector is essential for harnessing innovation and leadership potential across the continent. Eliminating gender discrimination and exclusionary patterns in entrepreneur access to start-up and growth capital will make markets more dynamic and competitive. Women's full participation in the digital and tech economy will result in more diverse product creation, higher financial returns, and access to new markets and sectors. Given current trends, a gender inclusive tech sector will require policymakers and African development institutions to prioritize equitable access to STEM education and digital education for all girls, including those in underserved communities and rural areas. This would mean integrating more STEM requirements into the national curriculum and providing more digital learning opportunities in the classroom, in addition to guaranteeing basic numeracy and literacy skills - the foundation for digital inclusivity.

There would also be the need to build equitable infrastructure for internet access in communities and schools. Furthermore, national governments and public institutions need to promote regional collaboration across DTs. The African Continental Free Trade Area (AfCFTA) has the potential to open new opportunities for digital trade among countries. The digital regulatory environment and architecture should focus on gender inclusion. In addition, there should be investment in public-private partnerships that are mutually beneficial to achieving gender inclusion in tech. Private sector technology and telecommunications companies have a shared interest in improving internet access and digital learning to promote a more gender-inclusive workforce. Finally, policymakers should collaborate with the private sector to collect consistent and transparent data on women in tech to accurately measure disparities and account for progress moving forward.

3.7 Research Questions

- How can women and girls be prepared for the green economy?
- How can we take advantage of the opportunities offered by the green transition to improve gender equality and women's empowerment?
- How can gender segregation in education be

undone to promote women's participation in science, technology, engineering, and mathematics (STEM)?

- How can the playing field be leveled for a gender-responsive green economy?

- In what ways can women's transition towards the formal economy be supported to facilitate their movement into better-paying green jobs with better working conditions?

4. DTS, PLATFORMIZATION, AND THE GIG ECONOMY

4.1 The rise of the gig economy

In recent years, the gig economy has gained significant momentum across Africa, driven by several factors such as technological advancements, increased internet penetration, and changing consumer behavior. This shift has been particularly noticeable in the transportation and delivery sectors, where motorbikes have emerged as a popular mode of transportation due to their flexibility, speed, affordability, and ability to navigate congested urban areas. Digital gig work is becoming increasingly important as a potential pathway to socio-economic development and unemployment alleviation. This promise is important given SSA's and the WCA sub-region's dual status as the region with the youngest population but the highest youth unemployment rate – a potential socio-political threat.

There are already about 300 active digital platforms in Africa, employing close to five million workers (Morawczynski & Porteous, 2019). A case in point is Jumia, an e-commerce company established in Nigeria and now operates in 14 African countries. The rise of such platforms has intensified the debate about the demise of the traditional employment contract and the persistence of widespread informal employment in Africa (Morawczynski & Porteous, 2019)

The gig economy has several benefits for workers, businesses, and governments. For workers, it offers the flexibility to work when and where they want and the opportunity to earn more money than they would as traditional employees. Such platforms as Uber have provided opportunities for individuals to offer their skills and services on a freelance basis. For businesses, it can be a cost-effective way to get work done without having to hire full-time employees. It also helps businesses to formalize certain sectors and promote compliance and adherence to rules and regulations.

Africa's growing gig economy is considered a gift to millions waiting for non-existent formal sector jobs. Following the economic downturn faced by many African nations, unemployment has steadily increased, making job creation in the traditional sector difficult. However, with the introduction of the gig economy, there has been an impressive increase in employment opportunities. The COVID-19 pandemic spurred the growth of the gig economy in Africa even more, serving as a stopgap for consumers when businesses shut down, and offering employment for those shut out from both formal and informal opportunities.

The gig economy provides the freedom to work and live more efficiently. Smit et al. (2019) demonstrate that in seven SSA countries, including Ghana and Nigeria, there were 4.8 million workers deriving income from digital platforms. Heeks et al. (2020) argue that, work linked to platform-mediated engagements is growing at 30% per year in SSA. The growth in mobile phone subscriptions and apps has resulted in additional jobs and new business opportunities in SSA (Boateng et al., 2017).

A recent trend is to open more traditional professions and occupations for offshoring and remote work, including radiography, medical diagnosis, and accountancy (Beerepoot & Lambregts, 2015). Unfortunately, it appears Africa is losing in terms of its relative position globally in respect of knowledge economy, with other developing (especially Asian) countries improving faster. Reasons for this phenomenon include a lack of R&D funding, eroding educational systems, brain-drain, and corruption (Asongo, 2017).

4.2 Challenges to Job Security and Workers' Rights

As with the informal sector, the conditions of gig workers are marginalized, and for crowd working, those in Africa are placed at the end of the business process outsourcing model that utilizes surplus labor to support advanced economy businesses such as data entry (Anwar, 2017). In terms of the conditions of gig work, ILO's survey on global online work reported that workers from Africa receive the lowest hourly rates of pay (Berg et al., 2018). They also face delays in payment and even non-payment, long search processes that are unpaid, occasional and unpredictable assignments, and aggressive rating and control processes (Heeks, 2017a, 2017b). In Africa, while there are large numbers of registered participants on digital work platforms, the numbers

receiving assignments are less than 10%. Evidence suggests that SSA is not a recipient of professional and well-paid gig jobs (Berg et al., 2018; Tsibolene et al., 2018). Many gig jobs are routine, low-paid, and require limited skill (Berg et al., 2018). Furthermore, the gig economy is relatively unregulated in many African countries, leaving workers vulnerable to exploitation and unfair treatment.

In terms of the impact of gig work on the economy, while it appears to be creating employment opportunities, it deprives governments of substantial tax revenues. According to the ILO, 85% of workers in Africa are employed informally, and, therefore, does not declare income or register the businesses. This revenue loss affects governments' ability to invest in education, health, and basic infrastructure, all of which boost productivity and sustain broader economic growth.

In the context of persistent labor surpluses and minimal labor regulations, SSA is ready for business process outsourcing that requires large and cheap labor supplies (Anwar & Graham, 2020a). There are, however, constraints to the development of gig work in SSA. Firstly, infrastructural limitations, especially around computer and internet access (Asongu & Le Roux, 2017), create disparities in participation. Secondly, skill shortages limit the types of job SSA workers can access (Tsibolene et al., 2018). The skill limitations extend to IT training across the workforce and, hence, limit the ability to take advantage of the potential offered by digital professional freelancing (Kässi & Lehdonvirta, 2018). Thirdly, the global gig work is a winner-take-all process, so there are other regions and countries in Asia and South America with large supplies of surplus labor and extensive IT infrastructure are also competing for the available jobs (Anwar and Graham, 2021) and SSA has a low share of crowd work employment (Berg et al., 2018).

These constraints have led to calls for better labor laws and protections for gig workers, a situation major stakeholders, institutions of higher learning, and research bodies must focus on to unearth practical solutions to address the ever-growing gig economy in Africa. This is achievable through a combination of government regulations, industry standards, and individual initiatives such as advocating for fair labor practices, promoting financial literacy, and expanding access to resources such as affordable healthcare and retirement options. Additionally, creating platforms for networking, skill development, and mentorship can empower informal workers to thrive in their chosen fields.

Gig workers are increasingly putting pressure on employers to rethink outdated models of compensation and benefits. Uber, for instance, has recently lost series of lawsuits in the United Kingdom instigated by drivers seeking basic benefits such as minimum wage and holiday pay. In an effort to appease their workers, platforms are experimenting with additional incentives for contract workers. For example, drivers working for ride-hailing company Lyft in the United States get a voucher giving them a discount when they visit a doctor, while TaskRabbit workers are provided with liability protection of up to US$1 million. But these perks are still a far cry from the healthcare and retirement benefits that companies traditionally offer full-time employees.

With digital commerce estimated to benefit at least 80 million young Africans by 2030, opportunities for gig workers will increase (Morawczynski & Porteous, 2019). If access to valued benefits, from health insurance to pensions, is made conditional on registering businesses and paying taxes, gig workers will be motivated to formalize their work. Furthermore, digitization would enable the formal sector to offer benefits for workers and responsibilities for employers. African labor-market regulators and tax authorities can play a role in recognizing and incentivizing progress along this spectrum. This means taking stock of the benefits workers value most, and then designing effective policies to encourage digital platforms to offer them. Moreover, such policies should ensure benefits are portable and tied to the worker rather than the platform, so that workers can choose what suits them.

4.3 Women and the Gig Economy in Africa

African women, often assuming dual roles as caregivers at home and providers for their families, perceive gig work as a new market that affords the flexibility to choose when and how much they want to work, striking a balance between professional and family life. The spectrum of jobs available in the gig economy is vast, meaning that women from various

backgrounds, both educated and uneducated, urban and rural, can find gigs suited to their skills. With every gig, women are not just earning money, but independence as well. They are becoming entrepreneurs, decision-makers, and contributors to their families and societies. This empowerment often transcends the economic realm, leading to greater voice and agency in personal and community decisions.

Working on digital gig platforms enables women to earn higher incomes, especially if engaged in remote work which affords the opportunity to collaborate with foreign clients and receive payment in foreign currencies. This is particularly advantageous in countries with unstable economies or high living standards. The gig economy offers an alternative path to financial independence for women facing limitations in traditional jobs, where earning potentials may be restricted. In Africa, evidence suggests that people join gig platforms because they are unemployed (ILO, 2021) and are struggling to find sustainable paid income (Anwar, 2022), and these platforms afford them the opportunity to earn extra income (Graham et al., 2017). Despite these benefits and employment opportunities, certain scholars believe that the gig economy's contribution towards African workers' long-term livelihoods remains questionable (Anwar, 2022), highlighting the economically-insecure nature of the platforms (Anwar et al., 2022a, 2022b; ILO, 2021; Otieno et al., 2020). For example, the scholars note how ride-hailing offers extremely low hourly rates, and remote gig work could be footloose, that is, workers' tendency to easily lose contracts when they demand higher wages.

While African workers face precarious working conditions in the gig economy, African women face an even dire situation. For instance, the ILO (2021) reports that ride-hailing remains a male-dominated area in the gig economy, although in recent times, a few women-only platforms have emerged, such as An-Nisa Taxi and Dada Ride (Kenya) and Local (South Africa). Nevertheless, many women still prefer to use Uber as their main gig platform, highlighting the network effect and market dominance which the platform enjoyed (Anwar, 2022). Further, whereas women operate these platforms as their main source of livelihood, their male counterparts usually have multiple streams of income (ILO, 2021). According to Anwar (2022), most of these women are single mothers who engage in gig work to make ends meet. However, night times, which are usually more lucrative periods because of the less traffic, high demand, and high rates, are rarely available to women because of security concerns. Additionally, customers often patronize the services of male drivers, with the excuse that they are more experienced than women. Consequently, women earn lower income than their male counterparts (Anwar, 2022).

For these reasons and more, while ride-hailing may offer economic opportunities for Africa's workforce, the sector's sustained income-generating potential, particularly for African women, has been questioned. Again, the low levels of women participation in the remote gig economy is reflective of gender-based inequalities that exist in society such as education and ICT access. Women are more likely to drop out of school, and although more women graduate from universities in the region, there is a clear discipline bias. More women pursue humanities degrees than STEM. Yet, remote work depends on information technology infrastructure and digital skills, hence, women are more likely to be excluded. Evidence suggests that despite the touted potential of creating a level playing field, remote work is known for gender role differentiation prejudices, which adversely affect women's access to paid work (Leung & Koppman, 2018). To improve their earnings, certain women diversify their livelihood opportunities, although constantly living in fear that their contracts could be terminated unannounced (Barzilay & David, 2016; Galperin, 2021).

Based on the aforementioned factors, the gig economy's contribution towards development remains unconvincing, particularly for African women, as it is perceived as perpetuating existing inequalities. Research confirms that women face higher precarity than men due to the unequal division of unpaid care and domestic work (Gerber, 2022). According to Gerber (2022), in a comparative study between Germany and the USA, it is highlighted that in institutional contexts where welfare policies better protect labor, gig workers face lower risks.

Many African governments and private organizations have bought into the promise of digital gig work, if not in action (or policy), then at least in words; but, from the sparse and approximate data available, the actual incidence and impact of digital gig work has been rather limited and is

below what, for instance, many Asian developing countries are experiencing. Apart from the lack of reliable or comparative statistics, the lack of critical and Africa-specific academic research also severely constrains both the macro- and micro-level understanding of the desirability, dynamics, promise, and means to elevate digital gig work into a means for development. Although the overall macro-level barriers and issues to leveraging digital gig work have been enumerated and are widely understood, ways of addressing these through theoretical contingency models or pragmatic policy recommendations relevant to specific country contexts have not been forthcoming. At the micro-level, an even larger knowledge gap exists and the little empirical data is almost purely anecdotal, often biased by researchers' objectives. It is hoped that with more research on the gig economy and labor dynamics in Africa, governments can direct policy interventions that target vulnerable groups, particularly women.

4.4 Research Questions

- In what ways can gig work be elevated into a means for development in Africa?
- How have women's online gig workers' experiences changed over time?
- How does gender intersect with other axes of social difference (class, race, age, ability, and sexuality) to generate different platform worker outcomes?
- In the absence of widespread trade unionization of gig workers, what individual and collective strategies and tactics are both men and women gig workers developing to reduce precarity on gig work platforms, to resist and challenge structures of algorithmic constraint, improve platform incomes, and determine better conditions of work?
- How can available social protection mechanisms be made more inclusive and effective for all workers?
- How can DTs be made more accessible to the information and resource poor in agri-based economies in the WCA sub-region?

5. DIGITAL SKILLS AND EDUCATION/TRAINING

5.1 Demand for New Skills

DTs are reshaping the skills people require to access markets, operate factories, or run their own businesses. Evolving job markets are demanding new skills such as digital literacy, technical skills for green jobs, and soft skills to meet future work demands. Digital literacy involves the appropriate use and comprehension of electronic devices, programs, and information to access information, communicate effectively, find work, think critically, and navigate the digital landscape responsibly. The technical skills for green jobs, referred to as green skills, entail skills aimed at fulfilling the requirements of green jobs and supporting the transition to a green economy (Kwauk & Casey, 2021). There is growing recognition of the importance of soft skills (such as communication, teamwork, adaptability, and problem-solving) for the job market. Developing soft skills is a key element for improving the effectiveness of ongoing efforts to address youth unemployment in Africa and elsewhere.

5.2 Factors Contributing to Skill Gap in Africa

Although it is recognized that these skills impact growth and are needed for jobs in the emerging "tech world", the development of digital literacy, green skills, and soft skills has not been fully nurtured in Africa (Omoniyi, 2013). Explaining the source of the digital divide between advanced and developing countries, James (2019) points to the origin of DTs which were designed for consumers in wealthy Western countries. They were also designed to suit the socio-economic circumstances prevailing in these countries, including the available skills, incomes, infrastructure, and attitudes. As such, these technologies tended not to run too far ahead of what is available in terms of digital skills, although even in these countries there is a mismatch between the elements of the technology package among marginalized groups — such as people living in poverty, the elderly, and certain minority groups — who may not possess the necessary digital skills to use the internet effectively.

On the other hand, when these technologies are imported into Africa, especially in rural areas, the skills to match these technologies become scarce. Evidence shows a significant relationship between the rurality of a place and the level of the digital skill of the population (ITU, 2018). Highly-rural or poor countries are observed to have a lower percentage of their populations having basic and standard skills (James, 2019). According to GetBundi (2024), the plight of these countries is exacerbated by outdated educational curriculum, the lack teachers proficient in digital skills, the lack of appropriate educational infrastructure, low awareness of the benefits of digital skills, and insufficient digital training opportunities.

5.3 Impact of the Skills Gap

African young people's lack of skills is a major hindrance to their chances of securing jobs. Business managers' feedback indicates the difficulties in finding appropriate skills in Africa. In January 2019, PricewaterhouseCoopers International Limited (PwC) issued its 22nd Annual Global CEO Survey, and 79% of CEOs expressed worry about the skills gap. This percentage increased to 87% among African business leaders, with 45% expressing "extreme concern". There are actual repercussions for the present skills gap. Of the CEOs who expressed major concern about the availability of essential skills, 59% of African CEOs (global: 47%) acknowledged their quality standards and customer experience were being compromised, and 65% of African CEOs (global: 55%) claimed the skills deficit was hindering companies from successful innovations. Furthermore, 54% (global: 44%) acknowledged insufficient skillset was preventing them from meeting their growth objectives. Just 3% of African CEOs (global: 4%) indicated the growth and profitability of their companies were unaffected by the lack of skills.

Developing the foundations for the continent's present and future labor force necessitates a strategic governmental approach, the dedication of the private sector, and institutional changes. To meet future skill demands, all sectors must invest in skill development, not just for the present, but also to create a talent pipeline that will last.

5.4 Need for Upskilling and Reskilling Initiatives

Upskilling is one of the skills enhancements that has become necessary in the technological age. Employees are almost always assigned to new responsibilities that require upskilling. Upskilling is enhancing an employee's present knowledge and abilities to either better their performance in their current role or position them for future career chances. It entails learning novel methods or devices, gaining an understanding of new processes, or building soft skills (Chaaya et al., 2019). Technological developments, shifts in the nature of work, and the desire to stay competitive in the labor market are some of the factors that necessitate upskilling. For instance, people must acquire new skills to remain relevant in the wake of automation and AI (Chaaya et al., 2019).

Upskilling has both beneficial and detrimental effects. Positively, upskilling improves earnings, job fulfillment, and productivity. It may also result in a more resilient and diversified workforce. The drawbacks of upskilling include the potential expense and time commitment, as well as the possibility that not all employees will have equal access to these chances, which might worsen already-existing disparities in the workforce. Furthermore, the need to continuously acquire and adjust to new technologies and abilities may cause some employees to feel overburdened or worried (Chakrabarti, 2022; Jaiswal et al., 2021; Li, 2022).

Reskilling refers to learning new skills or improving current ones in order to execute a new role or adjust to modifications in business procedures or technology. According to Penesis et al. (2017) and Sawant et al. (2022), reskilling demands equipping employees with new skills so they do a different job or adjust to changes in the labor market. The necessity to adjust to changing laws or industry standards, shifts in the organization's strategic goals or priorities, the creation of new job positions or sectors, and technological advancements are just a few of the many reasons reskilling is necessary. For instance, to collaborate with robots, workers need to learn new technical skills.

On the other hand, workers need to pick up new soft skills such as agility and teamwork if company models shift (Gowrie Vinayan et al., 2020). Reskilling often has favorable effects on businesses and employees. Learning new skills leads to better job satisfaction, professional progression prospects, and higher remuneration, which ultimately culminate in increased productivity, improved employee engagement and retention, and a more agile workforce capable of responding to market changes (Jaiswal et al., 2021; Yaseen et al., 2022).

According to Payton (2017), traditional hierarchical organizational arrangements do not reflect 21st century skills. Ayentimi and Burgess (2019) state that knowledge skills play a central role in both job experience and compensation. Organizations are adapting and preparing for the future of work. According to Yusuf et al. (2020), there are now flatter organizational structures, more communication between and within firms, more individuals choosing to work remotely, and telecommuting is becoming the norm. Organizations must get ready for the imminent changes in order to stay competitive in the future. The World Economic Forum (2016) asserts that creating a multiskilled, adaptable, and flexible workforce is one main difficulty facing human resources professionals in the new global order.

African developing nations, having comparatively low rates of human capacity growth, are greatly impacted by the implementation of Industry 4.0 technologies. Adepoju and Aigbavboa (2021) offer insightful data to reinforce the argument that Africa's labor force needs to be reskilled and upskilled for the Industry 4.0 workplace. Nigeria, Africa's most populous and economically-developed nation contributing roughly 55% of West Africa's GDP and 35% of SSA's GDP, is recognizes as one of Africa's fastest-growing digital-savvy countries. Nonetheless, Nigeria struggles with a lack of human capital (Adepoju & Aigbavboa, 2021), therefore, retraining and upskilling the workforce is essential to the nation's economic progress.

Rwanda employs public-private partnerships (PPPs) to enable the private sector to support youth employment and skill development. As a result, the nation now has a workforce with higher levels of competence, a more consistent supply, and more robust networks for effective and efficient operations. Major formal sector companies, such as manufacturers and service providers, participate in training programs to upskill workers and offer job placement assistance. Moreover, by coordinating

employer signals regarding required standards for knowledge acquisition, the Ministry of Education's National Qualifications Framework (NQF) —which improves youth labor market functioning — and the PPP model guarantees that skills are in line with both present and future labor market demands (African Centre for Economic Transformation, 2022)

5.5 Widening Gap in Access to Quality Education and Training

Education is essential to the development of societies, as it establishes social norms. High-quality education offers new ideas, methods of implementing different technologies, and many other things that empower societies in all spheres (Swati Desai, 2010). 'Educate a man, and you educate an individual; educate a woman, and you educate a whole nation' - education is not only a human right for girls, but a necessity that drives economic growth and technological advancement for them (Oxfam, 2000; Klasen, 2002). However, long-standing institutional, political, and cultural impediments have brought about and maintained the gender gap in educational access. Girls make up two-thirds of the 125 million 6–11-year-olds who are not in school in developing countries, and 148 million (54%) of the projected 273 million 12-17-year-olds not in school. Once more, women make up two-thirds of the 876 million illiterate people globally, and females make up two-thirds of the 100 million children who drop out of school before finishing their four years of education (FAWE, 2000; Oxfam, 2000).

Women in developing countries face widespread discrimination in access to education. Within Africa, the level of discrimination against women in accessing education is even more pronounced compared to men. (Evans & King, 1991; Evans, 1995; Odaga, 1995; World Bank, 1996). Across the continent, women between the ages of 15 and 49 typically have fewer years of education than men, while women between the ages of 15 and 60 have far greater rates of illiteracy than men (Bloch & Vavrus, 1998). Males benefit from the general quality of curricular programs at the expense of females. While certain nations have attained gender enrollment parity in elementary and secondary education, female involvement in higher education is still low and institutions do not offer an even playing field (Bloch & Vavrus, 1998; GSS, 2000).

As a result, women in Africa remain the least educated globally, frequently falling behind their counterparts in East Asia, Latin America, and the Caribbean. In SSA, 16 out of the 22 nations have at least 70% of their women lacking literacy (UNICEF, 2000). More than 90% of the women in two of the 16 countries lack literacy (UNICEF, 2000a). Women's access to formal education and, as a result, literacy, varies among countries. Even more alarming are the educational statistics from Senegal, Burkina Faso, Niger, and Mali. For example, 84% of females in Mali do not go to school, and of those who do, 60% dropped out in the first grade. Less than 30% of females between the ages of six and fifteen are enrolled in school in Burkina Faso, Niger, and Senegal. Adolescent males and females are generally enrolled in elementary schools at comparable rates. However, in almost every SSA nation, by the age of sixteen years, fewer females than males attend school (Friedman,1992; Carr, 1994; FAWE, 1995). In Ghana, one in three females lacks formal education, but one in five males does. Compared to 66% of males 65 years and older, 89% of women have no formal education. This huge gap is a major hindrance to women regarding the future of work.

According to African Centre for Economic Transformation (2022), several countries have worked hard to develop TVET programs and curriculum focused on industry and market demands. While certain courses are out of alignment and do not provide the requisite skills, others are officially mandated by the industry. This is explained by the constant shifting requirements in the market as well as the significant transition costs related to using current technologies to meet labor market expectations. Students and industry stakeholders have voiced concerns about the school-to-work transition, specifically TVET graduates' preparedness for the workforce. TVET education has been viewed less highly than traditional secondary education in the majority of SSA nations. TVET institutions deal with the belief that vocational courses are exclusively for people unable to achieve secondary school entrance requirements, even though there is a strong demand for TVET graduates. One of the biggest problems that nations constantly face is the

poor perceived value of TVET.

Despite having inadequate technical skill set, most graduates from technical institutes in Rwanda report having little trouble finding employment. However, many parents think children who attend TVET colleges do so as a last alternative after being turned down for admission to universities. Participants in a survey from Côte d'Ivoire, Ethiopia, Ghana, Niger, and Uganda have comparable opinions. In Ghana, the TVET sector is perceived by the public as a haven for students with poor academic standing, despite the government's efforts to promote enrolment to prepare the nation's workforce with practical skills. In addition, obsolete equipment and courses, a lack of standards, inadequate funding, and a disjointed environment affect vocational schools (African Centre for Economic Transformation, 2022)

Although governments in these nations have taken steps to enhance the relevance and quality of TVET programs, the problem with teacher quality remains. Teacher pedagogical skills, industrial experience, and technical knowledge are the three essential requirements in TVET. Sadly, TVET graduates are ill-prepared for the workforce since teachers often lack these foundational skills, contributing to the widening gap between those with and without access to quality training. Ghana has four TVET teacher training programs that result in recognized qualifications. According to Ghana's Ministry of Education (2017), 71% of teachers at public TVET colleges have teaching degrees, while 52% have technical qualifications. Private TVET institutions have less qualified teachers, with 40% holding teaching certificates and 25% being technically qualified. Again, poor working conditions cause significant absenteeism and turnover rates (African Centre for Economic Transformation, 2022).

In the context of constant changes in labor markets and dynamic skill requirements as a result of globalization, technological advancement, demographic transformation, and climate change, the demand for high-quality TVET is stronger to facilitate effortless job transitions and also bridging the gap between those with and without access to technical training as it is one of the easiest ways through which one can acquire technical skills (ILO,2023). TVET education enhancement in WCA can be achieved by improving the relevance of curricula by strengthening partnerships with the private sector; investment in teacher training and equipment; improving inclusivity by targeting female students and other excluded vulnerable groups; sustainable TVET financing; and digitalizing TVET by investing in digital infrastructure and STEM uptake.

Researchers agree that the relationship between school and work is an important feature of Vocational Education and Training (VET) (Mulder et al., 2015). Many countries have an educational system that maintains a large vocational schooling system as part of their secondary-level education (Eichhorst et al., 2015). In these countries, the schooling system is characterized by the duality between general and vocational education. While the latter provides the youth with practice-oriented knowledge and skills required in certain occupations, the former provides general knowledge for those wishing to further their education. It has, therefore, become important for governments to supply VET through the educational system as it improves the opportunities of youths lacking the skill set demanded by the labor market. Many countries that make vocational schooling compulsory perceive it as an alternative to equip youths who may have dropped out of school or are not academically inclined with the right skill set to fit into a technologically-inclined field of work (Neman & Ziderman, 1999).

5.6 Ensuring Equal Access for Women and Girls in Education, Training, and Employment

Despite legislations prohibiting gender discrimination in education, training, and employment, and limited initiatives encouraging women to pursue a range of work opportunities, gender segregation persists in many parts of WCA. According to Thewlis et al. (2004), males dominate agriculture, manufacturing, and financial services, whereas women mostly work in the services sector (e.g., health, social work, and education). Thewlis et al. (2004) indicate that males continue to dominate the IT and scientific, engineering, and technology (SET) sectors in Europe. In SSA, women are underrepresented in politics, the government, the larger workforce, and the fields of science and technology in particular. Masanja (2010) finds that

57.5% of women in the Rwandan labor market are unpaid, whereas 20.2% of males are unpaid since 2006.

In agriculture, 55.2% of women work as unpaid family workers, whereas 41.6% of males are self-sufficient farmers. Women hold 18.3% of paid occupations, while males hold 40.5%. Men make up 10.3% of the higher education workforce, while women make up 5.7%. Also, a 2009 survey of 1,345 women who had graduated from SMT programs by Aderemi shows that the commonest areas of employment are (i) academics (9.4%), (ii) administration (37.5%), (iii) research and development (44%), (iv) finance (3.4%), (v) medical (0.5%), and (vi) security/ solicitors (0.1%). Of those surveyed, the majority (53%) were married, and they stated that their spouses' limitations were a factor in their mobility. Additionally, Aderemi (2009) discovers that a 30% of these women work in scientific and technology divisions.

The distribution of non-science and technology department employees is as follows: 43.3% work in administration, 33.4% in finance, 22% in public relations, and 1.4% in other departments (including libraries). The reasons for the non-participation in science and technology departments were that no other option was available due to limited mobility (40%); that a career change was desired (20%); and that a career in science and technology was extremely demanding with low pay, causing women to leave the field for better opportunities or more appealing environments (20%). Only 0.2% of workers changed positions for reasons related to domestic matters. Most respondents claimed to know more than ten female coworkers who had earned degrees in science and technology.

According to the African Union Commission (2004), majority of African nations have included gender equality in their constitutions within the past two decades. These states have ratified regional and international agreements and made additional commitments to advancing gender equality at the regional and global levels. Compared to the past two decades, more girls are now enrolled in all levels of education, and more women are working in a range of economic areas. Finally, many African nations are witnessing a rise in the proportion of women participating in different spheres of administration. According to Klasen and Lamanna (2019), there are several reasons to be worried about current gender disparities in crucial well-being-related factors such as education, health, employment, and compensation.

From a well-being and equity standpoint, such gender discrepancies are problematic since they diminish well-being and constitute unfairness under most definitions of equality or justice. Equal access to education and employment for men and women in WCA will go a long way to reducing poverty and unemployment. Apart from concerns about equality of opportunity, gender segregation in job settings leads to two additional problems: gender segregation contributes to the persistent skills gaps in the WCA sub-region, which governments acknowledge concerning sectors such as ICT; and gender segregation in different fields remains a major factor in the gender wage gap (Forth, 2002). Segregation can take place horizontally, with people concentrated in certain careers, or vertically, with people concentrated in the lowest ranks of an organization (Hewitt, 2001). In both types, women are disadvantaged.

Gender inequality in work is presently a pressing development concern facing countries worldwide (Anyanwu & Darline, 2014). In 2011, the global male employment-to-population ratio was predicted to be at 72.7%, while the female employment-to-population ratio was 47.9%. The gender disparity in employment between males and females keeps widening, hence, WCA governments must consider policies that can bridge the gap (Anyanwu & Darline, 2014).

5.7 Research Questions

- What digital infrastructure is necessary for Africa?
- What new skills will be required, and to what extent will the existing jobs change?
- What kind of upgrade will the educational and professional training need?
- What is the way forward in ensuring equity between men and women at the workplace?
- What innovative ways can be leveraged to finance digital skills training?

- In what ways can DTs be harnessed to make limited demands on the scarce supply of digital skills in poor regions?

6. CONCLUSION

We reflect on four broad emerging FoW issues of importance to policy makers, researchers, educators, and industry players in the WCA sub-region: i) impact of digital technologies on work in agri-based economies; (ii) climate change transitions; (iii) platformization and the rise of the gig economy; and iv) digital skills gap and education. We highlight unique socio-economic and gender issues that are emerging as a result of the uptake of DTs in SSA and WCA. Several hypotheses are proposed on how DTs and climate change impacts would potentially affect employment prospects, particularly for women, in agri-based economies. Again, emphasis is placed on certain open research questions that remain to be answered. These call for rigorous qualitative and quantitative approaches to generate actionable evidence and to justify commercial interventions, policies, and regulations. Pursuing these requires meaningful partnerships between policymakers, educators, researchers, industry players, CSOs, private sector, and local actors.

7. HYPOTHESIZED INTERVENTIONS

Hypothesis

Digital technologies can promote an inclusive future of work for marginalized groups in agri-based economies while helping to mitigate climate change impacts; but how?

A. Improving access to digital and physical infrastructure in low-income areas

What interventions—public and commercial—will help in the expansion of digital infrastructure to underserved areas? How far into poor areas should this expansion be? What existing technology are available? How can existing technologies be improved to offer services to people? How can these technologies be made affordable and accessible to more information-poor groups? How can the use of these technologies be sustained? How can the infrastructure be sustainably financed? How can public-private partnerships benefit this course? Examples of plausible hypothesized interventions:

- Promoting governance that strengthens and sustains an open, interoperable, reliable, and secure digital ecosystem.
- Improving access to stable electricity.
- Reducing no-economic cost and risk of market entry and investment.
- Providing public/donor funding support for larger, high-cost infrastructure investments to reduce risk and increase commercial viability.
- Expanding the market through government procurement and implementation of broadband-based digital services, networks, and facilities.
- Providing direct funding support to extend affordable broadband access to commercially-challenging rural and remote areas, to women, and low-income users under a Mobilizing Finance for Development approach.
- Increasing ICT market commercial attractiveness through demand stimulation and affordability initiatives.
- Promoting long-term sustainability by ensuring that appropriate technical skills to operate and maintain digital infrastructure are increasingly available.

B. Enabling the collection of gender-disaggregated data on digital transformation, climate change, and quality of employment in agri-based economies

What interventions—public and commercial—will create an enabling environment for the collection of gender-disaggregated data on the interwoven impacts of digital transformation, climate change, and quality of employment in agri-based economies?

- Strengthening the capacity of statistical departments to include collecting gender-disaggregated data on emerging technological, climate change, and quality employment impacts at the national and sub-national levels.
- Sensitizing relevant ministries and agencies on the importance of mainstreaming gender into policies.
- Promoting gender-sensitive training for data collectors and respondents to ensure gender data accuracy, confidentiality, and anonymity.
- Supporting local initiatives that supplement supply-side data from mobile service providers with open-source demand-side data directly from consumers.
- Incentivizing and supporting rigorous quantitative and qualitative research on gender, technology, and society (by academics, non-profits, think tanks, etc.).

C. Creating new skills and employment pathways that can create more employment opportunities

What interventions—public and commercial—

will help to develop digital skills, especially among marginalized groups in agri-based economies? What skills will be complementary to technology? What skills are needed to develop and/or use technology? What innovative ways can be leveraged to finance digital skills training? How can disparities in access to education, including digital skills, be minimized? How can we use DTs that make only limited demands on the scarce supply of digital skills to respond to the acute shortage of digital skills in many poor countries? Hypothesized interventions include the following:

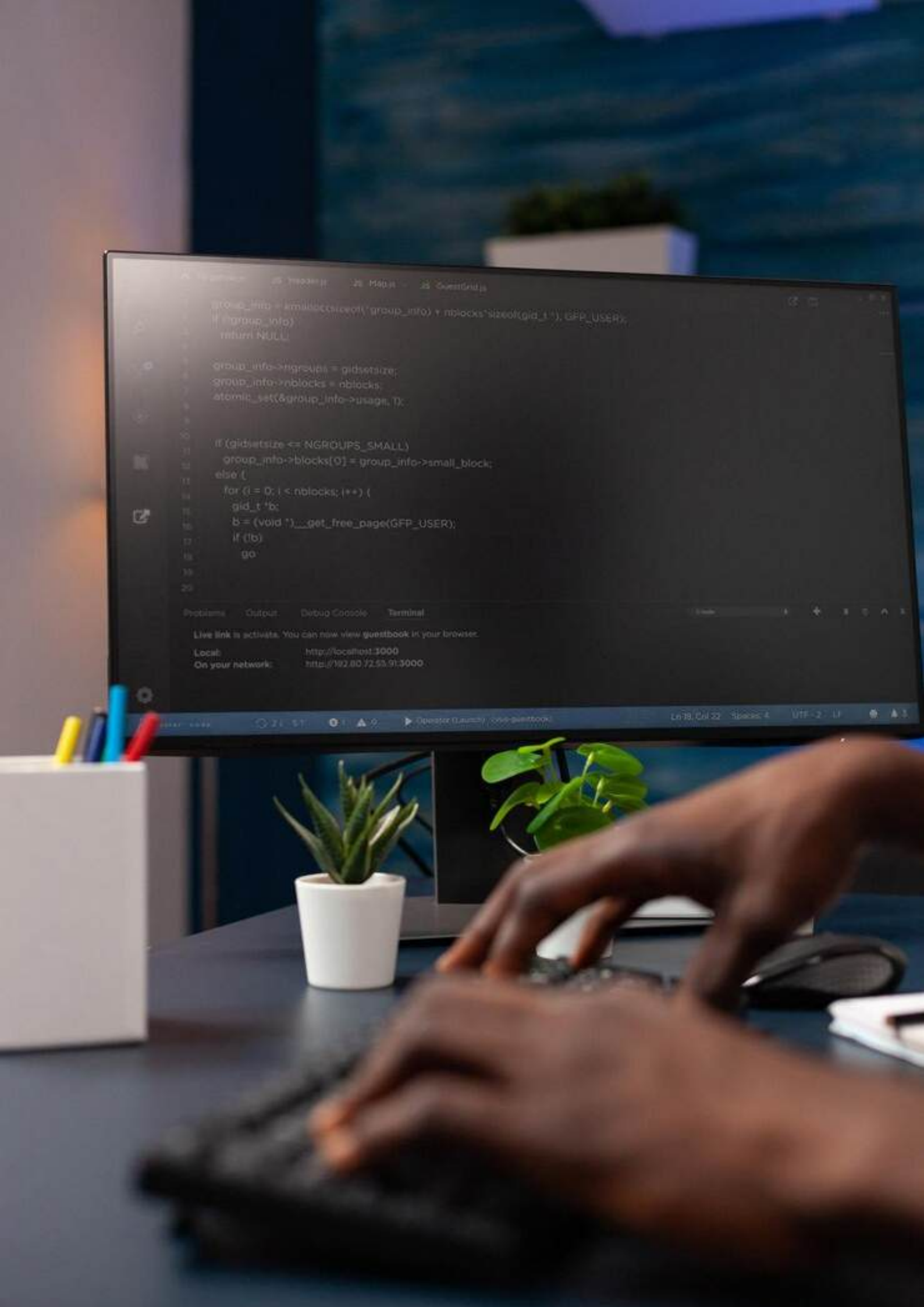
- Governments should explicitly prioritize national budget allocations for achieving education outcomes through concrete medium-term budget plans and encourage the private sector to contribute more.
- Investment in flexible education systems.
- Formalizing technical and vocational training and other informal and non-formal skilling avenues, including apprenticeships, to lift people out of poverty and bring about economic development.
- Developing tailor-made teaching and learning materials to complement the available jobs in specific contexts.
- Enabling a new model of digital skills supply where intermediaries bring information from the Internet to those who need it.
- Diversifying student financing options to support marginalized and vulnerable youths.
- Involving industry-leading organizations in skills building (i.e., curriculum development, hosting internships, contributing equipment, and training of faculty) and providing such benefits as public funding of the training program, or first pick of training graduates for staff to sustain commitment to and support for educational reforms agenda.

D. Reshape/redesign social protection programs/systems to support players to transition into emerging jobs

What interventions—public and commercial—will help to reshape or redesign social protection programs or systems to support players into emerging jobs? What social protection measures are currently available to workers in agri-based economies? How can these safety nets be made stronger, more resilient, and better funded? What new forms of social protection systems can be leveraged for agri-based workers? How can new social protection programs complement existing ones?

Examples of plausible hypothesized interventions:

- Integrating social protection with measures to increase agricultural productivity and production.
- Financing social protection programs through revenues from taxes, including earmarked taxes or replacing subsidies benefiting the non-poor primarily with targeted transfers.
- Redesigning social protection programs to respond to local conceptualizations and prioritization and not on imported models.
- Ensuring regular and predictable cash transfers to reduce liquidity constraints and encourage spending on agricultural inputs.
- Leveraging on digital solutions for collecting, cross-referencing, and managing data to improve the effectiveness of targeting and identification of beneficiaries, as well as the definition of benefit levels.
- Employing digital systems, especially mobile money, to reduce the operating costs of the schemes and make saving more accessible for the informal economy.


group_info->ngroups = gidsetsize;
group_info->nblocks = nblocks;
atomic_set(&group_info->usage, 1);
if (gidsetsize <= NGROUPS_SMALL)
group_info->blocks[0] = group_info->small_block;
else {
for (i = 0; i < nblocks; i++) {
gid_t *b;
b = (void *)__get_free_page(GFP_USER);
if (!b)
go
Problems
Output
Debug Console
Terminal
Live link is activate. You can now view guestbook in your browser.
Local:
http://localhost:3000
On your network:
http://192.80.72.55.91:3000

8. SUMMARY OF QUESTIONS, IDENTIFIED ACTORS, AND METHODOLOGY

QUESTIONS	RELEVANT ACTORS	METHODOLOGY
Impact of DTs on Agri-based Economies		
How will DTs influence job creation, displacement, and overall labor market dynamics in agri-based economies?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews. Assessment
How will DTs enhance the resilience of the WCA sub-region's workforce and agricultural sector against the impacts of climate change?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews
How can DTs be made accessible to the information poor in agri-based economies in the WCA sub-region?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews
How can DTs act as a catalyst for job creation, particularly for vulnerable groups within the agricultural context in the WCA sub-region?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews
To what extent do DTs influence the evolving labor landscape within the agricultural context, considering the ecological shifts caused by climate change adaptations?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Quantitative survey, Assessment
How can the use of DT infrastructure be sustainably financed?		Qualitative interviews Assessment
What is the role of social safety nets in the evolving digital and environmental context?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews

QUESTIONS	RELEVANT ACTORS	METHODOLOGY
DTs and Food Systems Transformation in West and Central Africa: Opportunities and Challenges		
How can access to digital infrastructure and technologies be improved to ensure their adoption in the agricultural sector?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews
In what ways can digital literacy be promoted to ensure the integration of digital solutions into agricultural practices and value chains?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews
How can social protection systems be redesigned to ensure that actors in the agricultural value chain transition into emerging digital jobs?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews, assessment
How can issues on data privacy, security, and governance be addressed to build trust and facilitate the uptake of digital technologies in food systems?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews

What are the potential risks and challenges associated with the digitization of food systems in WCA?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews, assessment
What are the environmental impacts of digital agricultural technologies, such as precision farming and IoT sensors, on land use and resource management in WCA?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews, assessment

QUESTIONS	RELEVANT ACTORS	METHODOLOGY
DTs and climate change transitions		
How can women and girls be prepared for the green economy?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Assessment
How can the opportunities offered by the green transition improve gender equality and women empowerment?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews
How can gender segregation in education be undone to promote women participation in science, technology, engineering, and math (STEM)?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews Assessment
How can the playing field be leveled for a gender-responsive green economy?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Assessment
In what ways can women's transition towards the formal economy be supported to facilitate their movement into better-paying green jobs with better working conditions?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews

QUESTIONS	RELEVANT ACTORS	METHODOLOGY
DTs, platformization and the Gig economy		
How have women's online gig worker experiences changed over time?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews
How does gender intersect with other axes of social difference (class, race, age, ability, and sexuality) to generate different platform worker outcomes?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews

In the absence of widespread trade unionization of gig workers, what individual and collective strategies and tactics are both men and women gig workers developing to reduce precarity on gig work platforms, to resist and challenge structures of algorithmic constraint, improve platform incomes, and determine better conditions of work?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Survey; qualitative interviews
How can available social protection mechanisms be made more inclusive and effective for all workers?	Policymakers, educators, private sector, NGOs, industry players, and researchers	Assessment; administrative data
How can DTs be made more accessible to the information and resource poor in agri-based economies in the WCA sub-region?	Policymakers, private sector, NGOs, industry players, researchers, and local actors	Survey; qualitative interviews
In what ways can gig work be elevated into a means for development in Africa?	Policymakers, private sector, NGOs, industry players, researchers, and local actors	Survey, qualitative interviews

QUESTIONS	RELEVANT ACTORS	METHODOLOGY
Digital skills and education		
What digital infrastructures are necessary for the African context?	Policymakers, CSO, private sector, industry players, researchers, and local authorities	Survey; qualitative interviews
What new skills will be required?	Policymakers, educators, private sector, industry players, and researchers	Survey; qualitative interviews
To what extent will the existing jobs be altered as a result of the interplay between DTs and climate change?	Policymakers, educators, private sector, industry players, and researchers	Survey; qualitative interviews
What kind of upgrade will the educational and professional training need?	Policymakers, educators, private sector, industry players, and researchers	Assessment
What innovative ways can be leveraged to finance digital skills training?	Policymakers, educators, private sector, NGOs industry players, and researchers	Survey; qualitative interviews
In what ways can DTs be harnessed to make limited demands on the scarce supply of digital skills in poor regions?	Policymakers, educators, private sector, NGOs, industry players, researchers, and local actors	Survey; qualitative interviews

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ABOUT

The Future of Work Research Initiative West and Central Africa Hub aims to deepen understanding of the challenges posed by the rapidly evolving landscape of work in the region. It forms part of the IDRC-funded FutureWORKS Collective, a five-year interdisciplinary research initiative focusing on the future of work in the Global South. Led by five regional hubs, with ISSER serving as the hub for West and Central Africa, the Initiative seeks to generate high-quality research, promote evidence-based policymaking, and strengthen regional capacity, with a particular emphasis on social protection for marginalized groups and climate change mitigation strategies.