Strengthening Innovation Ecosystems in Africa:

Seeking out the systemic changes in the wake of COVID-19

Olugbenga Adesida
The Africa Innovation Summit
Geci Karuri-Sebina
Wits School of Governance
and
Krishnie Thaver
Wits School of Governance

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Strengthening Innovation Ecosystems in Africa

Seeking out the systemic changes in the wake of COVID-19

Olugbenga Adesida*, Geci Karuri-Sebina** and Krishnie Thaver***

Abstract

This paper explores continuities and emerging systemic changes taking place within African innovation ecosystems since the onset of the COVID-19 pandemic. The aim is to use the comparative insights about innovation dynamics before and during the COVID-19 pandemic to inform targeted policy recommendations, with the goal of strengthening the innovation ecosystems in African countries. The research uses a mixed-methods approach, utilising two primary data sources: (1) a pre-COVID-19 dataset compiled out of a set of existing databases, and (2) a new dataset collected through an innovation survey undertaken in late 2020 after the advent of COVID-19. Comparative analysis of the two datasets was supplemented by secondary data and literature sources found through desktop study. The study found that global responses to combat the COVID-19 pandemic instigated several changes in the African innovation landscape, shifting some of the obstacles to innovation and innovation practices. However, the nature of the changes varied – some were systemic, and others were non-systemic. It is argued that systemic changes could be leveraged to enhance African innovation ecosystems through targeted policy design and the collaboration of key actors. This paper's primary contribution is in advancing beyond anecdotal generalisations about how the pandemic has affected African innovation ecosystems and beginning to distinguish between systemic and non-systemic changes.

Keywords: African innovation ecosystems, COVID-19, obstacles to innovation, systemic change, start-ups

* The Africa Innovation Summit and Bonako; oadesida@gmail.com
** Wits School of Governance, UCT African Centre for Cities and Africa Innovation Summit; geciks@gmail.com
*** Wits School of Governance; krishnie@gmail.com

1. Introduction

In Africa, the COVID-19 pandemic intersected with an existing socio-economic system that was already heavily stressed with pre-existing developmental challenges, disrupting the lives of millions of people and with a disproportionate impact on poor households and small and informal businesses (Jayaram, et al., 2020a). The pandemic and its emerging aftermath have significantly challenged decision-makers to act quickly (Ashkenas, 2020) to reduce the infection rates whilst finding ways to mitigate the dire local impacts (Beech, 2020). The pandemic has also been recognised as having catalysed innovation across the world (CCEF, 2020), including in Africa, stimulating innovation out of necessity and forming opportunities within the new and unexpected circumstances. Given the challenges brought on by the crisis and the need to increase the resilience and sustainability of economies, the future of Africa is already being reshaped for a post-COVID age (Davies, 2020).

Based on an ongoing enquiry about the state and development of Africa's innovation ecosystems (Adesida, et al., 2016), this paper examines the African innovation space through an ecosystems lens. It aims to identify and understand the systemic obstacles and responses – particularly from the perspective of innovators – prior to COVID-19 that are obstructing the path of effective innovation-driven development. It further seeks to identify new opportunities or challenges for innovation that have been experienced since the advent of COVID-19, as well as examine whether these shifts or changes are systemic to the innovation ecosystems or just transient responses to the pandemic.

Key concepts that are used in this paper are "systemic changes" and "innovation ecosystems". Systemic change can be defined as a transformative change within the instruments and mindsets in a system that leads to changed behaviours within the actors in the system (Jenal, 2020). A change can be seen as systemic once it transforms the primary methods that are used in the system for doing things (ibid). Lomax developed a framework of three components for systematically identifying systemic changes: changes in system states, change in the resilience or capacity of the system, and connectivity to the change impetus (Lomax, 2019).

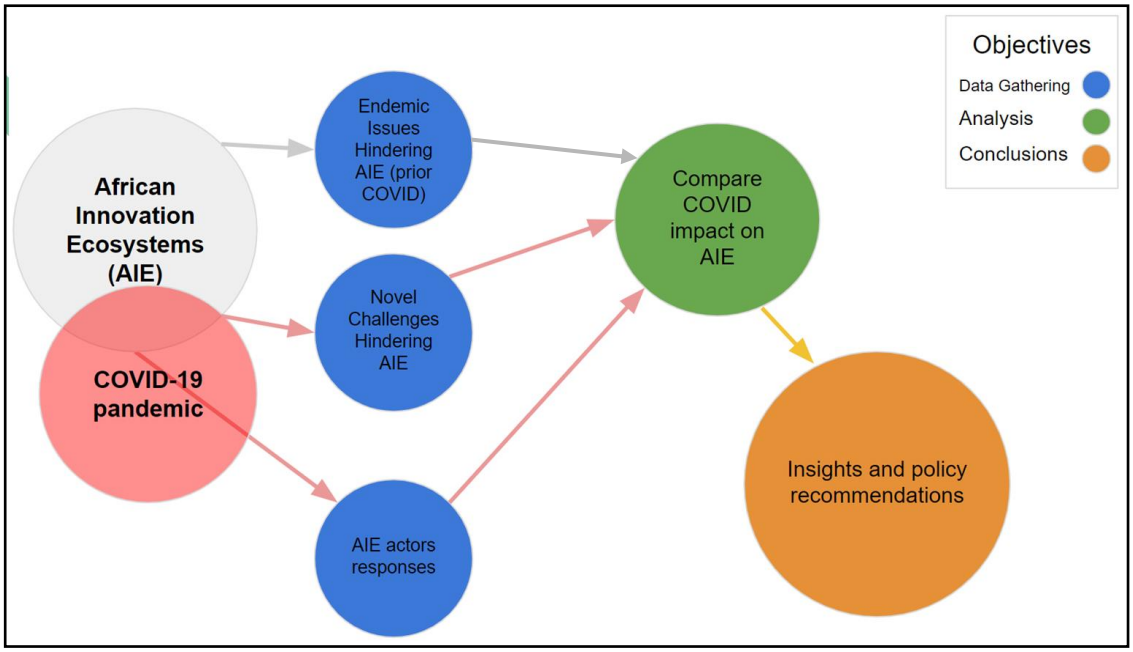
Innovation ecosystems are a dynamic set of actors, practices and infrastructure that govern the performance of initiatives and innovations (Granstrand & Holgersson, 2020; Moore 1996). The innovation ecosystem comprises various actors, including start-ups, hubs, civil society, government, private organisations, and academia, which act together to develop and execute innovation.

The innovations triggered by COVID-19 in Africa provide an opportunity to learn about how some of the challenges Africa has been facing with its innovation ecosystems could be addressed. This research attempts to understand how innovations and lessons from this period can be leveraged towards developing transformative solutions for Africa in a post-COVID-19 world and to assess whether or not substantial changes are emerging in the innovation ecosystems on the continent.

As such, the questions guiding this enquiry with a diagram illustrating the research strategy are listed below:

- What were the systemic issues hindering the African innovation ecosystems prior to COVID-19?
- What are the new challenges facing the African innovation ecosystems in the age of COVID-19?
- How do these changes relate to the previous systemic issues identified?
- Are these changes sustainable, or were some simply reactions and non-systemic?
- What were the useful insights and recommendations learnt, and how can these be translated to robust policies?

Figure 1: Research Objectives Strategy Schematic.



Source: Authors' own.

2. The pre-COVID-19 situation

Africa has a wide range of developmental challenges, which include energy access, water, food insecurity, health epidemics, education, climate change, as well as governance (Adesida, et al., 2018). Many of these developmental challenges pre-date the COVID-19 pandemic and inform the core elements of the United Nations Sustainable Developments Goals (SDG's), which the world has subscribed to achieving by 2030. Innovations were also taking place prior to the onset of COVID-19 on the continent. However, this was in spite of systemic challenges that continue to stunt and hamper Africa's innovation ecosystems (Adesida, et al., 2013; 2018). Addressing these kinds of systemic challenges to the innovation ecosystems would require identifying and breaking the barriers in knowledge, culture, governance, policy, regulations, infrastructure, or resources that prevent the flourishment of innovation (Adesida, et al., 2013; 2018).

The Ebola pandemic in West Africa in 2014 provides valuable insights into the types of changes and obstacles that can be observed during a pandemic. The key obstacles identified during the Ebola crisis were that medical resources were scarce, infrastructure was poor,

and cultural practices, beliefs, and misinformation contributed to the proliferation of the disease (IDS, 2015). The changes in practice as data analytics and simulation were used to improve health systems, and e-learning was used to empower healthcare personnel (ibid). For example, it can be learned that investment programmes are important to rebuilding a less vulnerable society and that education enabled preventative measures.

2.1. Africa's challenged innovation ecosystems

A broad literature identifies and converges around numerous systemic weaknesses that have bedevilled African innovation ecosystems over time, including limited economic infrastructure, weak systems, limited capabilities, and poor policy and governance (Lorenz, 2016). McKinney (2016) identifies systemic obstacles such as access to capital, physical infrastructure, legal systems, and human resources. A lack of skills, innovation capacity, entrepreneurial culture, and support from policymakers have also been noted as impediments to innovation on the continent (IBM Communications, 2013). These observations resonate with the evolving findings from the multi-stakeholder dialogues about innovation systems convened under the Africa Innovation Summit (AIS) platform since 2014[1].

The economic and social infrastructure gap has been identified as a significant challenge to Africa's development (Adesida, et al., 2018). In the power generation sector, for example, significant deficits exist. Access and reliability are low, and the cost is quite high. In the meantime, compared to other developing or emerging economies, African countries are not investing as much or as needed (McKinsey, 2016). In light of the outsize importance that digitalisation, automation and artificial intelligence has taken and are expected to take in the future, digital infrastructure is critical for the innovation ecosystems. The good news is that Africa has witnessed significant improvements in its digital infrastructure with increasing access to mobile telephony and the internet (McKinney, 2016). However, significant problems persist with Africa's digital infrastructure, including high costs, low quality, and reliability.

Another critical factor hindering the innovation ecosystems in the continent is inadequate institutional infrastructure. African systems are weak while the institutions are inadequate. Innovation ecosystems actors play important roles in cultivating a thriving and sustainable environment (Edquist 2001). Weak institutions demonstrate broken synergies among actors, which prevent interactive learning and therefore limit the opportunities and potential for innovation (Egbetokun, et al., 2007; Iizuka, et al., 2015; Muok & Kingiri, 2015; Oyelaran-Oyeyinka, et al., 1996). These effects can be translated into weaker policy and control measures enacted and rolled out by the decision-makers (Voeten & Naudé, 2014). According to Mudombi and Muchie (2014), Africa has weak systems that are not ideal for innovation at both the national (and international) levels. Lorenz (2016) has argued that the strength of Africa's systems is negatively impacted by factors like institutional quality, which encompasses the rule of law, corruption, and transparency, and lack of accountability. Ndubuisi Ekekwe, the founder of the African Institute of Technology, argues that although

[1] https://www.africainnovationsummit.com/

Africa has the ability to attract foreign investment, investors are deterred by the inability of African legal systems to offer robust property rights and IP protection (McKinney, 2016).

Africa is also lagging behind in educational capabilities (Mwiti, 2015). Many of the educational systems on the continent are underfunded and underperforming. The relevance and quality of education highlight a disturbing fact that most of Africa's educational systems may not be fit for purpose. Although there are numerous colleges and universities in sub-Saharan Africa, there are significant weaknesses in the programs offered by many of the academic institutions, and many are simply unable to meet global standards (IBM Communications, 2013). Africa requires investment for capability development in various aspects, from research, design, and production, to the marketing processes that relate to innovation (Lorenz, 2016). Lorenz (2016) argues that these constraints are further exacerbated in Africa by the low-income settings of many countries in the region.

Other critical constraints within the continent relate to governance and the lack of access to risk capital. Iizuka, et al. (2015) argue that Africa has weaknesses embedded in governance systems. The result is that innovation policymaking lacks coherence, consistency, and the necessary long-term commitment. Additionally, the lack of coherence in policy across national, regional, and continental levels is problematic. This does not allow for the necessary regional cooperation and collaboration. The lack of access to capital is a common and pressing challenge across the innovation ecosystems in Africa. While there is an increasing flow of investment into Africa, it is not enough. The investment flows into the continent are concentrated mainly in Kenya, Nigeria, and South Africa. The result is the lack of risk capital for scaling up innovations across the continent (Adesida et al., 2018). The challenge of funding is not only at the enterprise level but also affects the ecosystems. Investment in building the various elements of the innovation ecosystems has been far lower than needed.

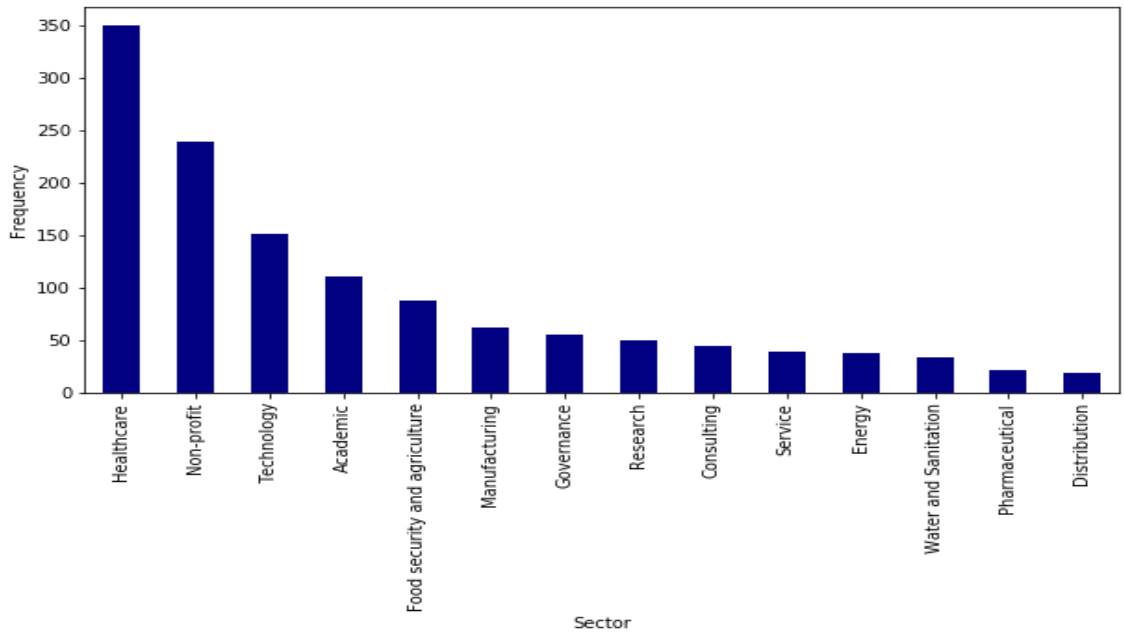
2.2. A Pre-COVID-19 innovation dataset

Two datasets were analysed to gain direct insights into the pre-COVID-19 innovation ecosystems situation with respect to the challenges experienced by start-ups. These datasets came from the African Innovation Summit (AIS) and the World Health Organisation (WHO), the source being the data of the application from their open innovation competitions held in 2018 and 2019, respectively. The call by AIS was part of its program to select 50 start-ups to showcase their innovation during the 2018 Summit. The call focused on start-ups with a minimum viable product (MVP) or innovation ready to scale that was focused on addressing the challenges facing African countries. The AIS used the opportunity to collect data from applicants. Over 500 African start-ups responded to the call, covering 49 countries. Of the applicants, 21% were MVPs, while the ready segment represented 18%. Key sectors represented included: Healthcare, Food security and agriculture, Energy, Water and Sanitisation, Governance, Education, ICT and Financial. The WHO call followed the same approach but focused on innovations in the health sector. Over 2000 start-ups participated in the call by WHO, and applications were received from 81 countries. Of the applicants, 18% were MVPs, while the ready to scale segment represented 19%. Key sectors

represented included: Healthcare, Non-Profit, Technology, Academia, Manufacturing, Research, Consulting, Service, Governance, and Pharmaceuticals.

Both the WHO and AIS calls were managed by the same team using similar platforms. The overlap of content and fields of the datasets allowed for the combination into a singular database. The merged pre-COVID dataset thus totals 3052 unique data records, with data covering solutions from 83 different countries in total. The data from this combined source were categorised through a qualitative coding method and further analysed to collate a baseline on the main obstacles to start-ups in African innovation ecosystems. Figure 2 below indicates the relative representation of the sectors in the pre-COVID dataset.

Figure 2: Activity of sectors within start-ups in the African innovation ecosystems as from pre-COVID-19 dataset.

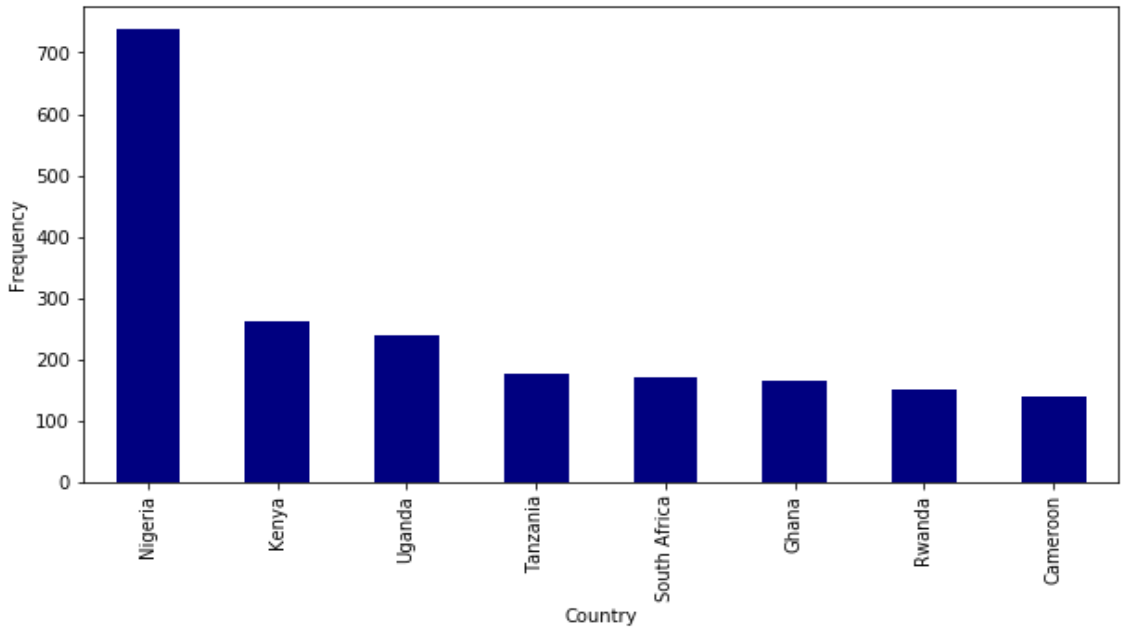


Source: Authors' own.

The data indicates a high activity in the Healthcare, Non-profit and Technological[2] sectors. This may be partly attributed to the relatively larger WHO dataset, which focused on health, resulting in a combined dataset in which health emerges as the dominant innovation sector among the start-ups. However, the AIS dataset also highlights a significant amount of activity in the health sector, as well as within the Food Security sector

[2] Enterprises that categorised themselves as in the technology sector typically produce software applications.

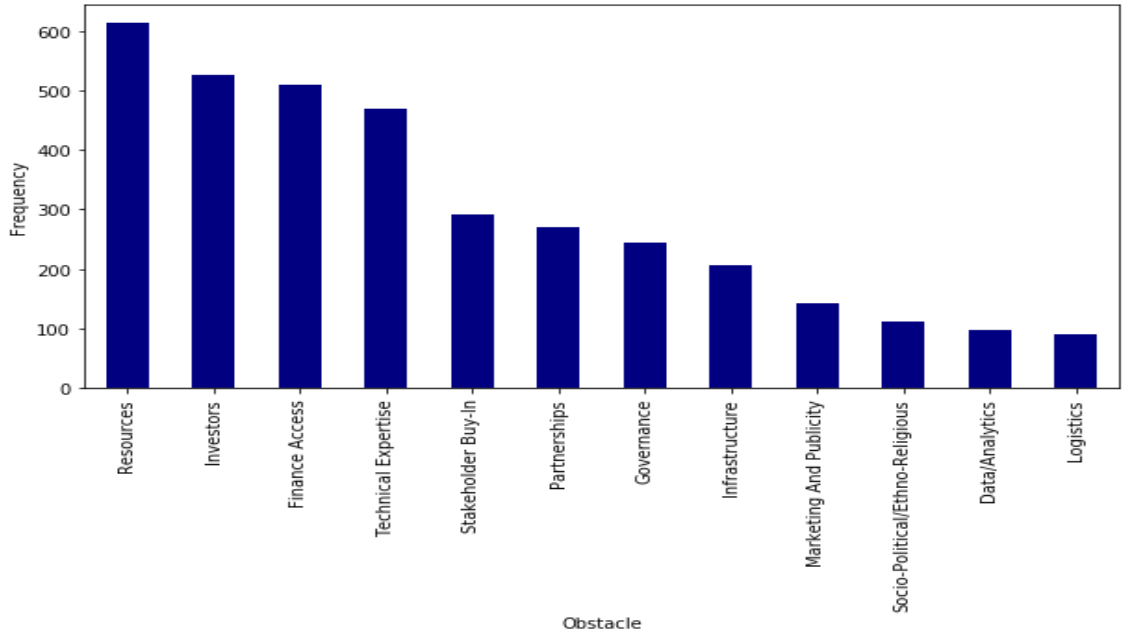
Figure 3: Activity of start-ups by country within the African innovation ecosystems in the pre-COVID-19 dataset.



Source: Authors' own.

The findings highlight Nigeria as a major hub of activity in the start-up innovation space in Africa. This is also corroborated by Kazeem (2019), who lists Nigeria as having the most tech hubs in Africa in 2019. While the activity in the ten most active countries correlates well between the two datasets, the only exception is Rwanda which is significantly better represented on the AIS dataset than the WHO dataset. This can partly be explained by the fact that the AIS in 2018 was held in Rwanda. There is also an acknowledgement of Rwanda's emerging role as a major innovation actor on the continent (Forbes Africa, 2018; Kazeem, 2019). Overall, the AIS and WHO data appear to have the same kind of breakdown in terms of countries and sectors. In terms of which countries were fostering the most innovations, the dataset indicates that Nigeria is leading the way in cultivating a stronger innovation environment, followed by Kenya, Uganda, Tanzania, and South Africa. This would be expected given that Nigeria and South Africa are the biggest economies on the continent (AfDB, 2020), and Nigeria is the most populous country in Africa. Kenya, with its famed mobile tech innovations (including MPESA), is not a surprise as a leading country in the African innovation scene. Uganda and Tanzania are also witnessing significant growth in their innovation spaces, with fast-growing hubs and start-ups.

Figure 4: Ranking of the frequency of obstacles that are experienced in initiatives in Africa from the pre-COVID-19 dataset.



Source: Authors' own.

Figure 4 depicts the obstacles faced by African start-up innovators from the pre-COVID-19 dataset. Based on the rankings, the main identified obstacles to innovation in Africa were insufficient resources, lack of investors, lack of financial access, technical expertise, poor stakeholder buy-in, requirements for partners, weak governance, and poor infrastructure. The resources category includes new or additional manufacturing facilities, equipment, materials, manpower, and land, whilst the infrastructure category is about the requirement of improving access to basic necessities like water and electricity, better road and transportation systems, as well as improving the technology infrastructure landscape.

Though it ranks lower, the data/analytics or the information sector category requires close attention in the context of an emerging fourth industrial revolution. Improvements in this category are tied to improvements in the other categories. For example, improving financial access, investment, mentorship, resources, and digital infrastructure is likely to reduce the obstacles posed by data/analytics. This dependence may explain why it ranks lower than the other main categories.

The Socio-Political/Ethno-Religious obstacle identified in the pre-COVID-19 dataset may also require closer inspection. This issue encompasses how culture and religious beliefs, political instability, linguistic barriers, and a lack of trust in technology can impact the innovation ecosystems (Magezi, 2015). Many innovators are looking for methods to help foster trust in innovations by their consumers. Figure 4 (above) is an indicator of the main to medium rankings of the challenges identified by the pre-COVID-19 dataset. Worth noting is the fact that bureaucracy was identified as an obstacle but was indicated as a lesser challenge than logistics.

3. Methodology: studying innovation in Africa amid COVID-19 response

2.3. Innovation catalysed

The COVID-19 pandemic has stimulated innovation in Africa and has created opportunities to harness emerging technologies. There have been innovative solutions in the creation of new products, processes, business models, the adoption of emerging technologies, as well as the leveraging of established technologies. These solutions have emerged to directly tackle the pandemic, as demonstrated in the health sector or are indirect consequences to policy regulations used to mitigate and control the spread of the disease. There are more than 120 health technology innovations developed in Africa that are being used to combat the pandemic (WHO Africa, 2020).

According to the WHO Africa (2020), Africa has innovated significantly in the fields of applied disease surveillance, contact tracing, treatment, and other healthcare spheres. From all the technology innovations worldwide that are aimed at the COVID-19 pandemic, Africa represents 12.8% (ibid). Some of the noteworthy innovations are re-purposing drones, face shields, hand sanitiser, semi-automated hand-washing machines, reusable face masks, diagnostic testing kits (AI Chatbots and diagnostics robots), oxygen delivery products (respirators), e-commerce platforms, and COVID-19 trackers (United Nations Development Programme [UNDP], 2020a; 2020b; 2020c; 2020d; 2020e). It should also be noted, though, that innovations were happening in the fields of technology in telemedicine, Information and Communication Technologies (ICTs), Artificial Intelligence (AI), robotics, even prior to the arrival of COVID-19 (ibid) – so it is an augmented rather than a new phenomenon.

2.4. The study informants

The primary data sources were not constrained to any specific actor within the innovation ecosystem. However, the data sources primarily represent innovators, start-ups, and technology hubs (self-defined as such). These data allow identifying some of the challenges and obstacles faced by the African innovation ecosystem. Start-ups and small businesses face particular resource bottlenecks in the ecosystem, which means that they face considerably more problems than other ecosystem actors (Jackson, 2021).

In the largely low- and middle-income African continent of nations, it is argued that the roles of start-ups are even more critical as they count as an 'engine' for innovation (Doruk & Söylemezoğlu, 2014). Start-ups play a significant role in innovation ecosystems as they can have the ability to solve several of Africa's endemic challenges due to their way of bringing new thinking and solutions to financial inclusion, e-health, market access, etc. (Moore, 2019). Start-ups can solve critical challenges for various actors in the ecosystem from the private sector, government, civil society, as well as stimulate economic growth (ibid).

2.5. A New COVID-era innovation survey

The primary dataset regarding changes experienced in African innovation ecosystems due to COVID-19 was obtained through the use of a rapid online survey that was developed by the authors using Google Forms and deployed under the AIS banner. The target population was innovators and technology, and innovation hub actors in Africa identified through AIS, and the survey was distributed both online through email and by mobile phone via WhatsApp. The main database of contacts comprised the contacts from the AIS and WHO databases (approximately 2500 unique email contacts).

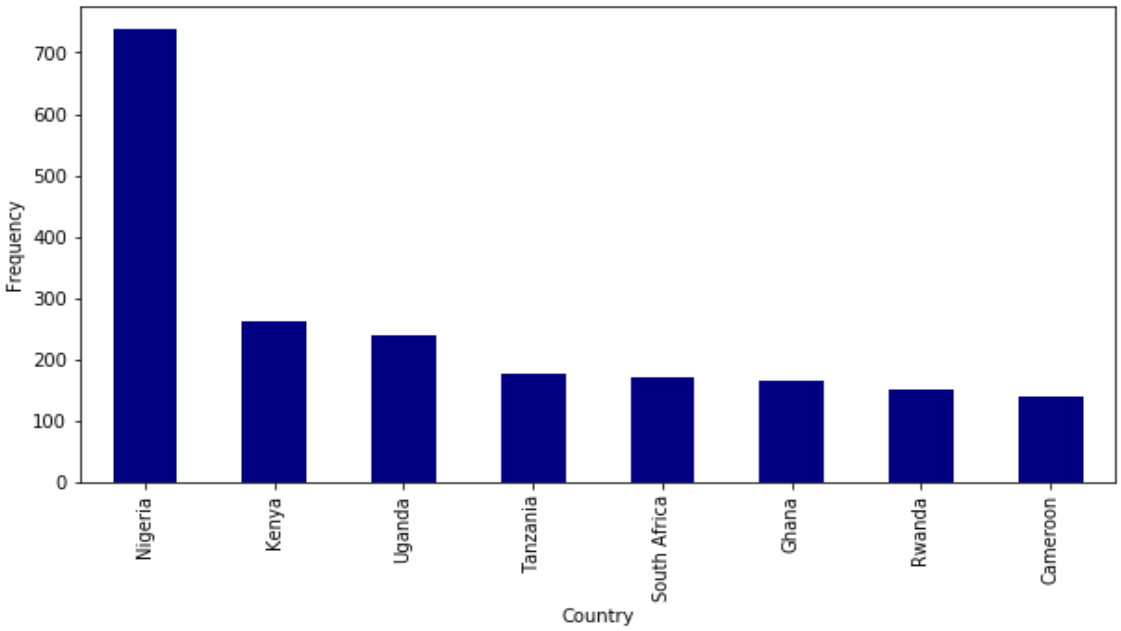
The aim of the survey was to gather data from actors in innovation ecosystems around Africa with respect to new experiences, observed differences in practices, and possible emerging recommendations since the advent of COVID-19. There were five main enquiry areas in the survey:

1. The effect of COVID-19 on the challenges facing African innovation ecosystems
2. The effect of virtualisation on African innovation ecosystems
3. Practice changes due to COVID-19 (except for virtualisation)
4. Policy changes due to COVID-19
5. Recommendations and opportunity areas.

The survey was conducted in October 2020 and was shared with the list of email addresses of the responders in the pre-COVID-19 dataset. It was also extended through networks to relevant innovation communities. There were 96 valid responses to the survey (out of 103 submissions) by actors who are active across 37 countries. The most represented country in the survey is Nigeria, followed closely by Kenya, as indicated in Figure 5 below. The number of unspecified countries, as well as the under-representation of South Africa, were noted.

One of the main biases in the data is self-selection bias as the respondents choose whether to respond to the survey, which was only available online and in the English language. This implies a probable bias towards English-speaking, more formal innovators. As the survey was distributed to the lists collected through the AIS and WHO processes, this may also introduce a bias into the type and networks of the respondents, in particular a likely skew towards health and technological innovations.

Figure 5: Countries where responders to the survey operate.[3]



Source: Authors' own.

4. Findings: comparative experiences

From the data obtained from the rapid survey and pre-COVID dataset, we aim to explore the differences between the two periods as we seek to understand the effects of COVID-19 on African innovation ecosystems. The survey data reflects experiences with existing obstacles that the actors have experienced (negative and positive), as well as the impact of the adoption of new practices. The survey also gathered information on what policy changes have affected the innovation ecosystems and where there are opportunities for actors to effect positive lasting change in African innovation ecosystems.

The following sections expound on which policies have had the greatest impact on the innovation ecosystems and how obstacles and practices changed in order to adapt to the new conditions. The recommendations and opportunities of actors have also been analysed to determine where underlying patterns can be used to guide policy recommendations.

4.1. Policy changes due to COVID-19 identified from the survey

The survey elicited responses on government policy changes or regulations that impacted the African innovation ecosystems during this time. These were shown to have been lockdowns, social distancing, travel ban restrictions, mitigation and control measures to prevent infections, relief funds and subsidies, easier access to loans, tax reductions, online education support, and reduction in electricity costs. This is confirmed by Ngomsi, et al. (2020), who state similar interventions by governments throughout Africa. These policy changes were necessary to contain the spread of COVID-19 and to limit the economic

[3] The data were analysed through coding to develop additional fields of context based on the open questions in the survey.

downfall that ensued. These measures were the drivers that enhanced the use of practices like virtualisation and other digital technologies and drove the local manufacture of medical equipment.

4.2. Changing obstacles to innovation and scaling

In order to provide a substantive basis for the analysis of the survey data, a systemic categorisation methodology was applied to categorise the nature of the changes to the African innovations ecosystems caused by the COVID-19 pandemic.

4.2.1. Systemic categorisation methodology

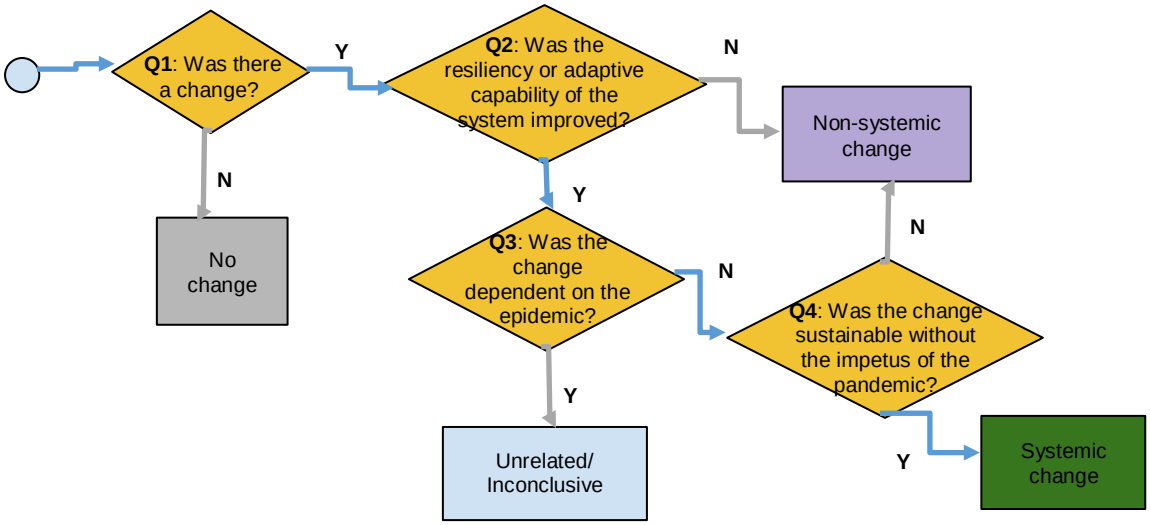
The categorisation of changes as systemic or non-systemic was done according to a three-component model (Lomax, 2019). Effectively the following questions were asked:

1. Was there a change to the operations of the innovation ecosystems?
2. Was the resilience or adaptive capacity of the system improved?
3. Was the change driven by (instigated or significantly accelerated by) the epidemic?
4. Is the change sustainable in light of a post-epidemic future?

These questions apply the three-component model (Lomax, 2019) that identifies the three key components as to whether or not there was a change, whether the change improved the resiliency or capability of the system, and how strong the links between the change in the system and the cause of the change are. In summary, the aim was to identify which changes improve the ecosystems and are sustainable in a post-COVID-19 environment.

The following flow chart indicates the process followed in categorising the changes as systemic or non-systemic.

Figure 6: Change categorisation flow chart.



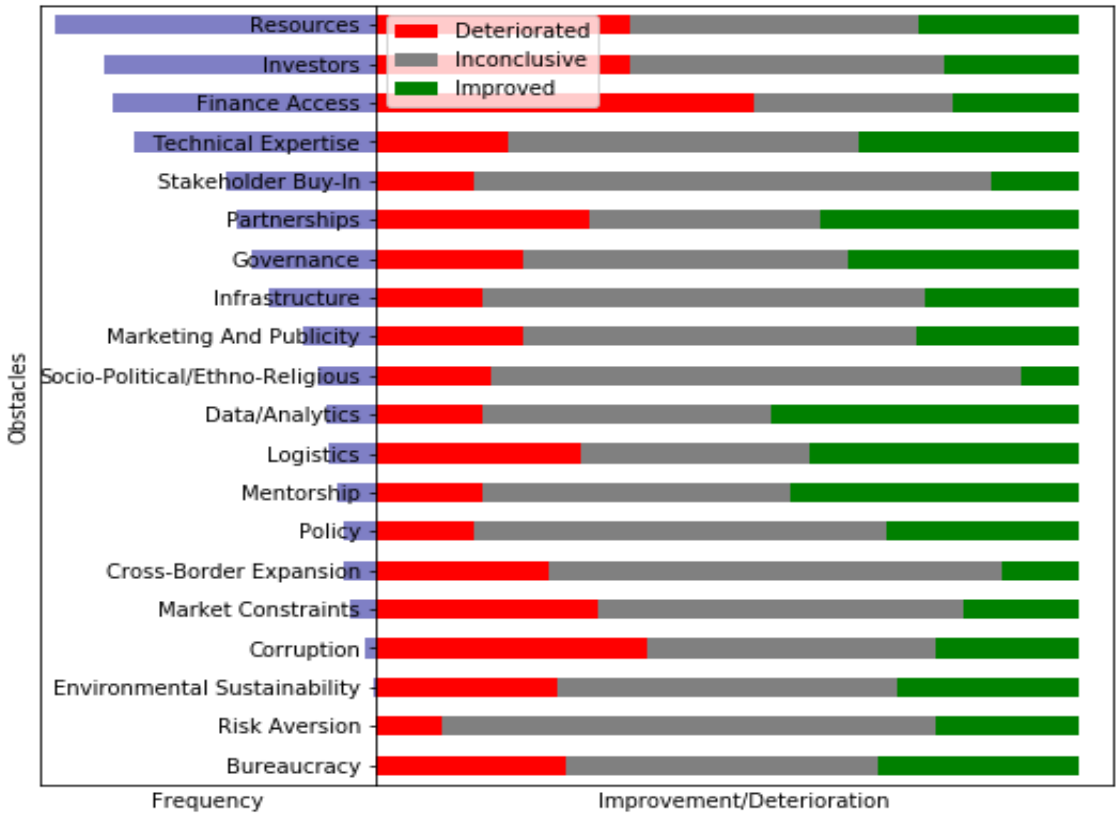
Source: Authors' own.

These four questions will be referred to as Q1, Q2, Q3 and Q4 as labelled and are used to determine whether a change is systemic or transient. A change is only categorised as systemic if all four questions have a positive response.

4.2.2. Survey summary on changes to obstacles

The survey on changes in the African innovation ecosystems due to COVID-19 sought to determine which of these obstacles were being shifted positively or negatively or if at all. Figure 7 below illustrates the results from the survey regarding changes to obstacles in African innovation ecosystems. The blue bar represents the frequency that an obstacle was identified in the pre-COVID-19 dataset. In contrast, the red and green bars respectively indicate relative deterioration of an obstacle and relative improvement of an obstacle.

Figure 7: Changes to obstacles in the African innovation ecosystems from the pre-COVID-19 dataset compared to the COVID-19-survey dataset.[4]



Source: Authors' own.

4.2.3. Access to finance

According to the survey responses, access to finance was the challenge that became more difficult for the highest number of innovators, with about 50% of respondents indicating

[4] Source: Based on the survey – "Changes to the African Innovation Ecosystem in the age of COVID-19". Data collected between 2020-10-09 and 2020-10-25. "Section 1: The Effect of COVID-19 on the Challenges Facing the African Innovation Ecosystem".

that financial access has become more difficult to attain. This is likely due to several factors that would have come into play during the COVID-19 pandemic. For instance, the lockdown and social distancing protocols that were popular responses (OECD, 2020) have simultaneously created economic conditions for profits to decrease across entire markets (Stats SA, 2020) and increased competition for the few funding activities that are available. This double-barrelled effect on the operating finances of any enterprise will be experienced practically as a decrease in access to finances, and the smaller operators (which is the majority, given that most innovations are from start-ups and SMEs) are disproportionately affected (Kalemli-Ozcan, et al., 2020; Stats SA, 2020). During the pandemic, there have been numerous funding opportunities created to support innovation practices (GDC, 2020; Golubski & Heitzig, 2020). However, these initiatives appear to be COVID-19 related and therefore yields a negative response to Q4 (sustainability), indicating that these are non-systemic changes to the innovation landscape. The availability of finances for innovations in Africa is a pre-existing condition, and the strain placed on all economies by the pandemic is simply exacerbating the financing issue that is endemic to the innovation ecosystems in Africa. This challenge in the African ecosystems has always existed, and it is likely to carry on being an important issue for the foreseeable future.

4.2.4. Corruption

The second most identified issue that became more of a hurdle during the COVID-19 response was corruption. Though the pre-COVID-19 dataset did not indicate corruption as a major obstacle, literature indicated that legal systems are a factor that hinders innovation in Africa (McKinney, 2016). Corruption is an endemic problem to the existing African ecosystems, and while further opportunities for corrupt behaviour is likely facilitated by the responses to the COVID-19 pandemic, the corruption is not caused by the pandemic. In terms of the categorisation model, Q1 (whether there is a change) is inconclusive or negative, indicating that there is no change to the system due to the COVID-19 pandemic.

4.2.5. Market access

Another set of obstacles that are most affected by COVID-19, according to the survey, are market constraints/access and logistics. The types of policies implemented to combat the COVID-19 pandemic exacerbated these problems. They have significantly worsened during the pandemic due to the closing of borders, lockdowns, etc. (OECD, 2020). The impact on these issues should decrease once policies relax back to their previous states. These changes would be non-systemic as they do not improve the resiliency/capacity of the system (Q2) and are not sustainable in a post-COVID-19 environment (Q4).

These issues have also seen some positive effects, particularly with regard to logistics. The improvement could be due to the accelerated adoption of technologies such as e-commerce and the digitalisation of logistics (Jackson, 2020; UNDP, 2020a). The positive movement seen in the market constraints and logistics space is systemic according to the categorisation methodology, as there is a confirmed change that improves the adaptive capacity of the ecosystem that is sustainable in a post-COVID-19 environment. In the pre-

COVID-19 dataset, marketing, logistics, and market constraints were identified as issues. However, they were not among the top five problems mentioned.

4.2.6. Partnerships

Partnerships were also negatively impacted during the COVID-19 pandemic. This is likely due to partners becoming distracted due to the effect of COVID-19 on their own operations. This is classified as a non-systemic change, as it is not beneficial to the system (Q2) and is not likely to be sustained beyond the pandemic (Q4). An interesting insight is that partnerships actually improved as well during COVID-19; partners would have been forced to improve their relationship in many cases in order to better weather the conditions induced by COVID-19 on the innovation ecosystems. The positive changes in the innovation ecosystems regarding partnerships, particularly in respect of improved communications, are systemic as there is a change that has sustainable benefits.

4.2.7. Data/analytics

The obstacle to innovation related to "data and analytics" is identified as improving the most during the COVID-19 pandemic, which is corroborated by literature (Liu, 2020). The COVID-19 epidemic has multiple effects on the data, analytics, and artificial intelligence space, one of these is that decisions concerning responses to the pandemic need to be made quickly and accurately, which increases the demand for data and analysis (Rao & Butterfield, 2020). Another possibly larger effect is due to the lockdown and social distancing protocols (OECD, 2020) used by governments to contain and slow the spread of COVID-19. The social distancing policies have forced the use of technologies to maintain operations of business and government. Examples of this are the tracking and tracing systems that are used to identify spread vectors for COVID-19; this produces an enormous amount of data that need to be analysed in order to warn potential carriers and those infected by the virus. This has created an environment where data is generated in mass, and there is a primary drive to optimise business processes and operations, and a data-rich, resource-constrained environment is where the value of data science can readily be observed (Some, 2020). The technologies and practices used are not novel; however, the adoption of these technologies has been accelerated by the pandemic. This shift in practice towards data and analytics is one that is systemic as it has positive benefits to the resilience and adaptive capacity of the ecosystem while also being sustainable once COVID-19 and its responses have passed.

4.2.8. Technical expertise

The obstacle of technical expertise was indicated to have both improved and deteriorated during the pandemic. The sudden need for technical expertise has led to both a surge in technical expertise as well as a shortage. Another explanation for improved technical expertise would be the widespread use of e-learning (Jackson, 2020) to facilitate education. The shift in the ecosystems towards more technical work and knowledge indicates that the requirements and technical knowledge are a systemic change that will persevere after the pandemic as there is a clear shift to higher demand and availability of technical skills, which improves the capacity of the ecosystem.

4.2.9. Bureaucracy

In the pre-COVID-19 dataset, bureaucracy was identified as an obstacle to the innovation ecosystems. However, it ranked lower compared to the other identified obstacles. It is interesting to note that bureaucracy has gotten more attention from the survey responses. Bureaucracy seems to have both a positive and negative perception from the survey. There has been a necessary increase in bureaucracy since COVID-19, as a number of procedures and permits were put into place in order to enact the various response plans (OECD, 2020). This means that the pandemic directly creates more bureaucratic processes to be followed. The other effects of the pandemic include virtualisation and data analysis (Some, 2020), which lead to improved tools to manage and administer the various processes. This will also give a mixed impression to the various actors within the innovation ecosystems. While the procedures created due to COVID-19 are non-systemic as they will not be sustainable in a post-COVID-19 environment (Q4), the improvements to the bureaucratic processes are systemic as they improve the resilience of the ecosystem while being sustainable.

4.2.10. Stakeholders buy-in

In the pre-COVID-19 dataset, stakeholder buy-in was identified as a significant obstacle to innovation ecosystems in Africa; this would be customers, investors, and other ecosystems actors. The survey indicates that there have been both positive and negative changes to stakeholder buy-in during COVID-19. According to the categorisation model, the buy-in is systemic as the system becomes more resilient and can be sustained. The survey does suggest that digital buy-in has increased due to changes in the environment because of COVID-19 and that value from these technologies have been realised. The survey also indicates higher acceptance of technology among actors and customers. Buy-in can be thought of as a major change as all of the other changes in practices and obstacles are simply a matter of buying into a previously existing practice or technology. This systemic change in the view of the technologies used is something that will survive past the policies and responses to the pandemic itself and can be used to develop new innovative products and services.

4.2.11. Infrastructure

The survey indicates that infrastructure has become more critical but less of an obstacle. Infrastructure was identified in the pre-COVID-19 dataset as being an obstacle to innovation, and it aligns with the literature (McKinney, 2016). The shift to using digital technologies during COVID-19 restrictions has led to higher requirements on electricity distribution and internet connectivity infrastructures which will present itself as an issue in areas that are underserved, hence infrastructure becoming more of an issue (Chinye-Nwoko, et al., 2020; Ndonga, 2012). However, the use of these same technologies allows for others to overcome some of their infrastructural challenges. There are major infrastructural hurdles in the African continent, and COVID-19 has highlighted some of those deficiencies while forcing innovation and behavioural change to work around these shortfalls. The permanent nature of infrastructure means that while the lack of infrastructure is a systemic obstacle, there have been no systemic changes to infrastructure or the lack thereof.

4.2.12. Obstacle change summary

In the following table, the summary of the changes to the obstacles in the innovation ecosystems for small businesses and start-ups is presented.

Table 1: Systemic categorisation model obstacle change summary.

Changes in Innovation Ecosystem Obstacles	Q1	Q2	Q3	Q4	Result
Access to Finance					
Funding opportunities	Y	Y	Y	N	Non-systemic Change
Corruption	Y	Y	Y	Y	No change
Market Access					
e-commerce	Y	Y	Y	Y	Systemic Change
Lockdowns	Y	N	Y	N	Non-systemic Change
Partnerships					
Distracted partners	Y	N	Y	N	Non-systemic Change
Improved communications	Y	Y	Y	Y	Systemic Change
Data/Analytics					
Technology buy-in	Y	Y	Y	Y	Systemic Change
Technical expertise	Y	Y	Y	Y	Systemic Change
Bureaucracy					
Additional policies	Y	N	Y	N	Non-systemic Change
Digitised practice	Y	Y	Y	Y	Systemic Change
Stakeholder Buy-in	Y	Y	Y	Y	Systemic Change
Infrastructure	N	N	N	N	No change

Y represents a "Yes" response and N a "No".

Source: Authors' own.

4.3. Opportunities and suggestions

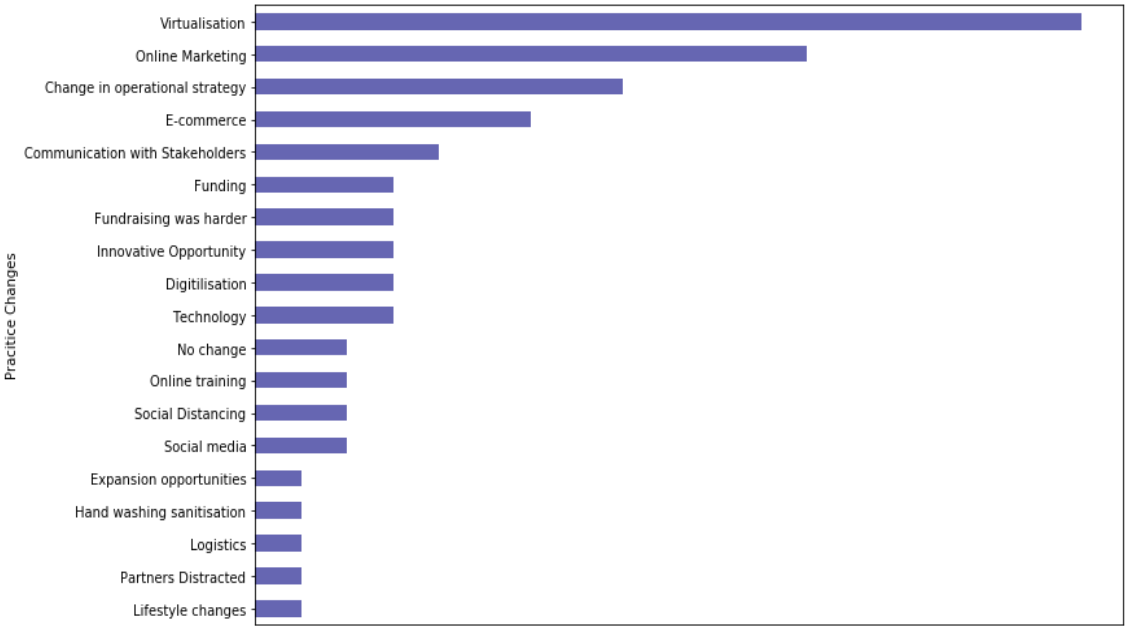
The survey elicited responses from many innovators around Africa with respect to solutions and recommendations for the future. Among themes that emerged were suggestions that policies supportive of small and medium enterprises need to be developed within the African innovation ecosystems; the need to recognise and support developments in the virtualisation of processes and services, including for e-commerce, telemedicine, and other digital and ICT technologies; as well as the local manufacturing of products that are usually imported.

Small and medium enterprises are especially vulnerable during an economic crisis since they generally do not have access to as many resources as larger entities to adapt to changing conditions (International Trade Centre, 2020). The survey responses corroborate that small enterprises require assistance to survive the current economic climate through funding, technical expertise, and mentorships. Furthermore, suggestions were made about improving the digital infrastructure footprint, digital literacy, education, technical expertise, and addressing privacy matters in order to improve the buy-in and development of virtualisation of processes and services across Africa. Also, Africa will be required to adopt better systems to increase resilience in handling future crises.

4.4. Innovation practices adopted in the age of COVID-19

The survey gathered information regarding changes in practices in the innovation ecosystems due to responses to the COVID-19 pandemic. The figure below outlines which changes in practice have been experienced, and it can be observed that, unsurprisingly, virtualisation is the most common change that happened in the ecosystems, followed by online marketing and changes in operational strategy. The majority of changes identified by the respondents are correspondingly in the adoption of digital technologies, and this is corroborated by literature (Ajadi, 2020; Jackson, 2020; UNDP, 2020a; UNDP, 2020e).

Figure 8: Changes observed in African innovation ecosystems.

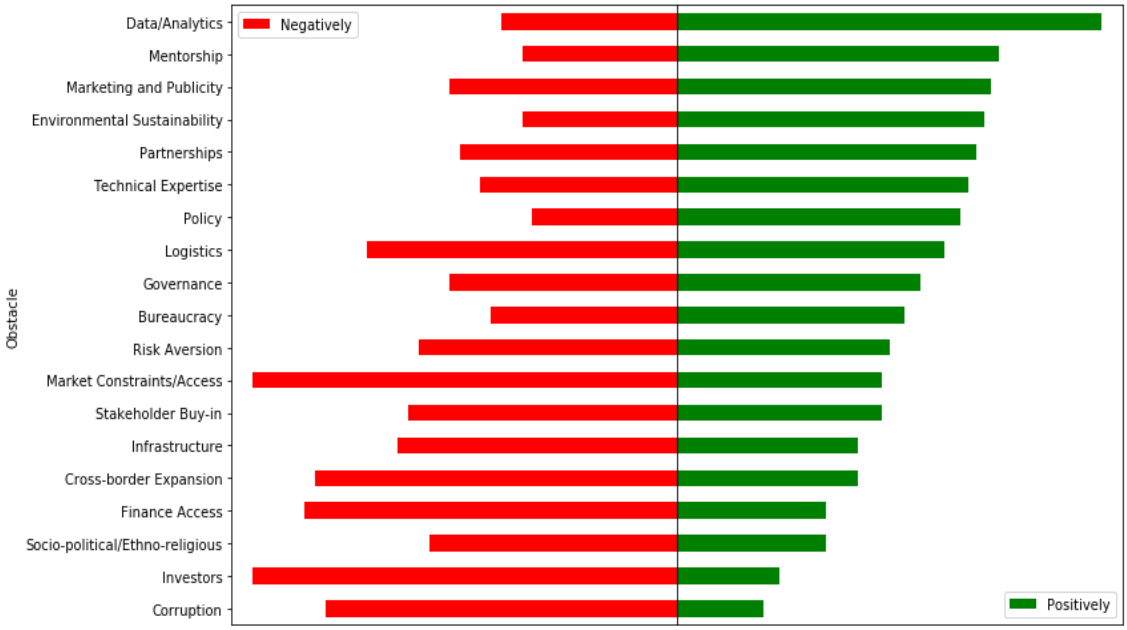


Source: Based on survey "Changes to the African Innovation Ecosystem in the age of COVID-19". Data collected between 2020-10-09 and 2020-10-25. "Section 3: The Effect of COVID-19 on the Practices within the African Innovation Ecosystem".

Notes: 1) Difference between 'Funding' and 'Fundraising got harder': Respondents who were being more general about changes to financing availability or methods responded under finance while respondents being more emphatic about non-availability of finance specifically are fundraising was harder. 2) 'No change' represents respondents who did not feel that there were any changes that they could observe in the innovation ecosystems.

In general, the virtualisation of operations and services has become a ubiquitous change during the COVID-19 pandemic (Soto-Acosta, 2020). According to the survey, virtualisation is the most significant change in practice, and the use of telemedicine, e-learning, and e-commerce is a subset of the virtualisation phenomena. However, while these aspects appear to be the most relevant to the innovators in start-ups and small businesses in Africa, virtualisation is a broader process that involves the movement of work processes to internet-based infrastructure, as well as remote work and attendance (e.g. for meetings), especially for knowledge workers. Figure 9 below depicts the perceptions of innovators from the survey in terms of positive or negative impacts of virtualisation on African innovation ecosystems issues.

Figure 9: The effect of virtualisation on obstacles in the African innovation ecosystems.[5]



Source: Authors' own.

The responses to the survey indicate that the virtualisation of activities has improved the availability of partnerships, mentorships, technical expertise, and marketing whilst also negatively impacting access to finance, logistics, bureaucracy, governance, and infrastructure. Virtualisation requires a distributed and well-maintained technological network – which reinforces the need for adequate digital infrastructure. There appears to be a paradoxical view of how data and analytics are viewed through virtualisation. This could be attributed to the availability of technical resources to work with the large amount of data that virtualisation creates; if there are sufficient technical resources, then there would be a positive impact on the analytics. Governance and bureaucracy are ongoing problems as identified in the pre-COVID-19 datasets. The evolution of new systems while making some aspects easier may make systems more complex until integrated correctly with existing

[5] Source: Based on the survey – "Changes to the African Innovation Ecosystems in the age of COVID-19". Data collected between 2020-10-09 and 2020-10-25. "Section 2: Virtualisation and the African Innovation Ecosystems".

systems. On the surface, there does not appear to be a reason that virtualisation negatively impacts logistics and corruption. Virtualisation for those who have not yet virtualised their services will be seen as creating logistical problems for their product distribution and services as they would rely on physical presence, and if competitors and customers rely on virtualisation, then this can be seen as a negative. The issue of corruption is a very complex one, and questions such as 'did corruption really get worse?' or 'were the effects of corruption more readily apparent?' arise. In order to do justice to this issue, further research specialised in corruption will be necessary to understand the full origin of this perception.

The survey has shown that access to the marketplace has been an endemic issue in African innovation ecosystems and has gotten significantly worse due to the policy efforts to contain and manage the COVID-19 pandemic (OECD, 2020). The survey has revealed that the logistics and obstacles to access markets have become worse, which is a direct result of the restrictive policies (such as lockdowns and travel restrictions) applied during the pandemic (United Nations, 2020). E-commerce and online marketing are two of the key areas where practices have changed during the pandemic. The use of e-commerce helps address many of the existing problems to the African innovation ecosystems, such as the access to market and the type of resources and infrastructure required (Shahjee, 2015). Some of the more attractive benefits of e-commerce to the African innovation ecosystems are the access to a larger marketplace and the decrease in operational costs (storefronts, etc.) (Shahjee, 2015). The adoption of e-commerce is, however, not a silver bullet without drawbacks; there is a heavy reliance on existing logistic, electrical and communications infrastructure, which, if not adequately developed, does not allow for the effective adoption of e-commerce (Ndonga, 2012).

The adoption of e-commerce as an adaptation mechanism during the age of COVID-19 may have been one driven by necessity, but in the long run, it may result in an enduring e-commerce culture. As stated by Jackson (2020, p. 1), "Crisis accelerates change. Many people were forced to try e-commerce due to lack of alternatives, and once we get out of recession, many of them will stick to the new behaviour". The categorisation model indicates that the change is systemic.

The systematic categorisation, however, also shows changes that do not seem to be systemic (see Table 2 below). The survey indicated a shift in practice from face-to-face learning to transit to e-learning during the pandemic. Literature indicates that e-learning has been adopted more widely than it has previously (Jackson, 2020). This increased use of educational technology is a direct response to policies surrounding COVID-19, indicating that it is unlikely that the current popularity of e-learning will continue. Mpundgose (2020) indicates that there are various challenges that have hindered disadvantaged students from realising the full potential of e-learning during the pandemic because of the digital divide that exists. This is more prevalent in African countries such as South Africa, where there was a forced transit from face-to-face learning to e-learning (ibid). Our survey indicates that there has been an adoption of e-learning during the COVID-19 pandemic. From the survey and the literature, it can be inferred that the adoption of e-learning is non-systemic as it has challenges that make it unsustainable in a post-COVID-19 environment (Q4).

The survey has also indicated the use of telemedicine as an opportunity area and recommendation. Telemedicine has been another area where there has been a rapid growth in a short amount of time due to responses to COVID-19. The nature of the COVID-19 infectiousness has driven the medical community's incentive to embrace virtual consultation where there has previously been resistance to change (Jackson, 2020). The amount of telemedicine has increased significantly from a pre-COVID-19 basis; however, in comparison to the total of all medical services that are performed, telemedicine may constitute a very small portion. It seems reasonable to assume that the vast majority of medical practitioners have still not adopted telemedicine as a solution as there have been no policy shifts where regular medical services have been limited. This supposition makes the immediate future of telemedicine unclear as it appears that the main obstacle to the adoption of telemedicine is regulation or governance, not just buy-in from practitioners (Oluwakemi, 2020). The survey and literature indicate that there was an appetite for telemedicine during the COVID-19 pandemic. However, there is insufficient support to indicate that the change is sustainable (Q4); hence the use of telemedicine as a change in practice during COVID-19 can be considered non-systemic.

Respondents made recommendations to locally manufacture products as opposed to importing. Jayaram, et al. (2020b) point to the pandemic as an opportunity for Africa to boost local manufacturing. There have been multiple innovations (UNDP, 2020b; 2020d; 2020e) in the category of medical hardware out of necessity, as the medical infrastructure of the entire world has been strained by the COVID-19 pandemic, meaning that the supply of hardware from the usual suppliers was limited. These innovative operations are likely to have a lasting impact in a post-COVID-19 world if the cost of the products created by these initiatives remains competitive once the market forces normalise. Some of the innovations are short-term, such as the face shield and personal protective equipment (PPE) producers that are currently in high demand. However, that demand is likely to fall away when the COVID-19 pandemic passes. The short-term innovations are not sustainable (Q4) without the impetus of the COVID-19 pandemic and are non-systemic changes. The longevity of the innovations that are manufactured locally once the stressful conditions of the COVID-19 pandemic end will depend entirely on whether the locally made products are able to compete with the foreign imports. Due to the uncertain nature of the COVID-19 climate, it is difficult to determine precisely how the local innovations will fare in the post-COVID-19 world. The categorisation model yields an inconclusive result as the question of whether this change is sustainable cannot be adequately answered. Effectively, some local manufacturing will be a systemic change, and some will be non-systemic.

The adoption of new technology was a theme that came out of responses in the survey. There are a few innovations using drones to perform a variety of tasks. In Cape Verde and Malawi, there are initiatives that are looking at using drones to deliver light packages of medicine, samples or equipment, as well as disinfecting public areas to help combat the spread of COVID-19 (UNDP, 2020e). These types of applications are likely to continue in a post-COVID-19 environment since the logistical issues in remote areas will remain. Therefore, this type of innovation can be categorised as systemic. However, the disinfection

innovation is distinctly a demand-based application (non-sustainable Q4) which is a feature of the COVID-19 pandemic and, therefore, a non-systemic change in operations.

Along with the growth of data and analytics during the pandemic, the expansion of robotics, artificial intelligence, and machine learning has also been promoted. Examples of applications would be medical chatbots and robots that assist with diagnoses (UNDP, 2020c). These applications represent a systemic shift in methodology for medical first contact for a patient and further medical services, as these innovation types will maintain their value once the pandemic has run its course. The adoption and dispersal of these technologies would be limited by electrical and connectivity infrastructure as well as the basic digital literacy of the target consumers. Another invaluable area is the increase in the availability of various African languages on applications (UNDP, 2020c). This change has future applications in transforming the innovation landscape by addressing existing language barriers in Africa with respect to technology. The advances in artificial intelligence, machine learning, and natural processing language are systemic changes used in chatbot applications (ibid) with the positive implication of adapting to use local African languages.

Table 2: Systemic categorisation model practice change summary.

Change in Innovation Ecosystem	Q1	Q2	Q3	Q4	Result
Virtualisation					
e-learning	Y	Y	Y	N	Non-systemic Change
Telemedicine	Y	Y	Y	N	Non-systemic Change
e-commerce	Y	Y	Y	Y	Systemic Change
Local Manufacturing					
Medical Supplies	Y	Y	Y	N	Non-systemic Change
Medical Equipment	Y	Y	Y	N	Inconclusive
Technology					
Drone disinfection	Y	Y	Y	N	Non-systemic Change
Drone Delivery	Y	Y	Y	Y	Systemic Change
Robots/AI applications	Y	Y	Y	Y	Systemic Change
AI translation	Y	Y	Y	Y	Systemic Change

Y represents a "Yes" response and N a "No".

Source: Authors' own.

5. Discussion: changes and continuities

African innovation ecosystems have undergone disruptions due to the COVID-19 pandemic – some of which have highlighted certain pre-existing issues in the ecosystems. However, the pandemic has also brought about new issues and possibilities.

Prior to COVID-19, a number of key obstacles to innovation in Africa were identified in the pre-COVID-19 dataset. These obstacles agreed with the existing literature and included resources (be it material or human), investors, access to finance, technical skills, infrastructure, stakeholder buy-in, and partnership availability (Adesida, et al., 2018).

The COVID-19 pandemic has been a driver of some changes in the African innovation ecosystem. However, one cannot rely on external shocks to catalyse change. There are many areas where the pandemic has not led to transformative change. Among these pre-existing conditions that have not undergone transformational change are finance and infrastructure, which both continue to be major constraints to effective African innovation ecosystems. These issues are not amenable to quick fixes and will require a multiplicity of instruments (Abraham & Schmukler, 2017). In fact, building and deepening the financial sector in order to ensure that there are alternative funding products to scale innovations in Africa calls for systemic solutions. This must be a key element of the agenda of African countries, given that finance has consistently been identified as a binding constraint to innovation (Adesida, et al., 2018; Ayalew & Xianzhi, 2020). Addressing the finance challenge will require emphasis on providing incentives to the private sector and individuals to invest in innovation. There is also the need for African governments to serve as catalysts when needed, as well as a need for putting in place a robust policy and regulatory environment to sustainably build the financial sector over the long term. Similarly, the huge infrastructure deficit in most African countries calls for substantial investment over time and a robust policy environment. It is a gap that will require consistency in approach over a period of time. It needs significant resources, both capital and human, to fund, design, and build over time. The fact is that COVID-19 is still evolving. Solutions are largely focused on prevention and trying to minimise its impacts. It is therefore logical that the COVID-19 responses have not had any significant impact on the complex challenges of ensuring access to finance or dealing with the huge infrastructure gap in African countries. More importantly, the response to COVID-19 has not focused on seeking opportunities for a new beginning, new development vision, and new policymaking.

For areas where there is systemic change, there will be a need to consider implications for the future and policymaking. The COVID-19 pandemic has created a favourable environment for virtualisation (Soto-Acosta, 2020), as well as the use of remote technologies due to the need for social distancing. Similarly, it has increased the demand for local manufacturing (UNDP, 2020b; 2020d) as the local need for basic necessities such as personal protection equipment (PPE) increased when the pandemic brought global supply chains to a standstill at some stage (OECD, 2020).

Among the systemic changes that have been observed are the accelerated adoption of virtualisation phenomena, particularly in the areas of remote working, AI, robotics, and e-commerce, which have been incorporated into the operations of many of the actors in the

innovation ecosystem (Soto-Acosta, 2020). The adoption of drones for use in delivery will be a systemic change in logistics, especially in remote areas with poor road infrastructure.

However, the increased local manufacture of medical supplies (PPE, hand sanitiser, etc.) is a reflexive change in the innovation ecosystem; this change resulted from increased demand due to the pandemic and is non-systemic. They are products that do not need to be innovated further, and demand is likely to drop drastically once the COVID-19 response is over. E-learning is also a non-systemic change as there still exist challenges hindering the realisation of e-learning at this stage in Africa. Telemedicine is also a non-systemic change as the obstacles to the deployment of telemedicine (Chinye-Nwoko, et al., 2020) have not been addressed. For these non-systemic changes, the status quo is likely to return once the pandemic is over.

The local manufacture of medical goods and equipment (respirators, etc.) is uncertain, as future market conditions will govern the longevity of these initiatives as well as the capacity of the local producers (if any) to compete with established global manufacturers. The implementation of supportive policies is likely to be key to whether these changes in the innovation ecosystems will become systemic or not.

The survey and subsequent analysis revealed that these obstacles had not witnessed any systemic change due to responses to the COVID-19 pandemic. The changes in practices that have become systemic (such as virtualisation and e-commerce) are not sufficient on their own to affect the large shifts necessary to strengthen African innovation ecosystems over the long term.

With the understanding that the changes in the innovation ecosystems due to COVID-19 are insufficient to fuel the strengthening of the ecosystems, the challenge before policymakers is finding ways to ensure the transient changes become systemic over time. It will be important to implement policies that can extend and encourage the positive impacts of the new practices.

The findings of the study lead us to a series of recommendations, including policy proposals. The focus of the recommendations is on addressing the constraints that continue to hinder innovation in Africa, as well as the need to seize the emerging opportunities brought by COVID-19 to ensure that the transient shifts become systemic as well as transformative.

First, *infrastructure* remains a hindrance, and it makes a major difference as to whether some changes remain transient or become systemic. Key areas include virtualisation and online education as well as telemedicine. As such, there is a need to prioritise infrastructure development, especially with respect to electricity and the internet. Also important will be the need to invest in developing quality educational materials for use in flexible and affordable e-learning across the continent in order to leverage the new technologies for skills development in light of the capacity deficit in critical areas in African countries.

Second, the issue of availability of or access to *finance* has always been the most identified constraint to innovation in Africa. It has become a systemic hindrance for the innovation ecosystems in Africa, and there is no systemic change in the issue of finance discernible from studying the responses to the COVID-19 pandemic. The momentum gained in funding during the pandemic can be made systemic if supported by policymakers through the development of co-financing models between the public and private sectors and the creation of incentives such as tax rebates to facilitate funding for start-ups (Moore, 2019).

Third, policies that accelerate and improve *digital infrastructure* will allow the innovation ecosystems to maximise the value of the systemic changes that are happening within Africa's innovation ecosystems. The digital infrastructure of priority would be electricity and internet coverage (Moore, 2019).

Fourth, a robust educational policy can also contribute greatly to addressing the lack of *technical skills*, which pose significant constraints to innovation and development (Moore, 2019). The availability of the required technical skill is a major obstacle, and much study and analysis are required to develop effective educational policies and incentives that will facilitate the growth of the relevant skills in the innovation ecosystems.

Fifth, the temporality or the non-systemic nature of the changes – especially in manufacturing, online learning, and telemedicine – can be addressed through policies. That is, efforts can be made through policies to attempt to shift the transient changes in manufacturing towards becoming more systemic. There is a need for policies that prioritise *local manufacturing* over imports, such as using fiscal incentives, lower taxation on locally produced goods, and building an economic environment that is more business-friendly. The non-systemic changes in telemedicine and e-learning can also be made systemic by formulating more enabling policies and regulatory environments. A general challenge faced is that the cost of *access to digital systems* may be too high for a significant portion of the population, even if the infrastructure is fully available (Manyuchi & Ouma-Mugabe, 2020). A robust regulatory regime for public utilities is a must to promote access while ensuring economic returns for investors. Governments could also sponsor access to certain basic information or sites to which consumers would have a right to digital platforms for education, public health as well as other essential services.

6. Conclusion

The study affirms that the COVID-19 pandemic has impacted African innovation ecosystems. The pandemic has triggered several innovations to directly respond to the pandemic itself, to the changes in the environment brought about by shifting government policies and regulations, as well as to innovation funding responses to the pandemic.

However, it is argued that it is important to distinguish between long term systemic changes and shorter-term non-systemic changes. The latter may not sustain beyond pandemic conditions but may offer opportunities for purposeful policy attention.

Prior to the pandemic, there were a pre-existing set of endemic obstacles or challenges faced by innovators in African innovation ecosystems (Adesida, et al., 2013; 2018). This is supported by the evidence in the primary pre-COVID-19 dataset as well as confirmed by the existing literature. The new survey demonstrated that virtually all the key ecosystem obstacles remain in spite of innovations in times of COVID-19.

However, there have also been systemic changes to some of the identified obstacles within the African innovation ecosystems, such as improvements to partnerships, mentorships, logistics, technical expertise, and stakeholder buy-in. This is due to the heightened use of Information and Communications Technology (WHO Africa, 2020) that allows effective communication at a distance and helps mitigate some of the difficulties placed on social and economic systems by the social distancing and lockdown protocols.

With the harsh market and economic conditions imposed by the responses to the COVID-19 pandemic, a need arose to find methods and technologies to allow innovators to weather the storm. Some of these practices have led to systemic changes in the innovation ecosystems, such as the use of technology to perform remote services and communication. The survey and literature identify examples of how such systemic changes could lead to the growth and adoption of e-commerce technologies, drone usage, virtualisation, machine learning, artificial intelligence, and natural language processing applications.

The practices deemed as non-systemic that have emerged during the pandemic include the local manufacture of products that have a heightened demand during the pandemic, such as hand sanitisers, personal protective equipment, as well as e-learning and telemedicine platforms. The local manufacturing will need to be able to compete with global manufacturers when the demand (and competition) for these products normalises, either when the pandemic passes or when the globalised competition kicks in. It is therefore not a given whether opportunities or practices that have been adopted will be sustained or not. Such transient dynamics may be insufficient on their own to signal significant shifts in the necessary strengthening of African innovation ecosystems (Adesida, et al., 2018). However, they can still be leveraged to create improvements in the ecosystems by taking advantage of the opportunities that they represent. This will require purposeful use of policy and regulatory instruments, partnership incentives, and the prioritisation of the development and accessibility of digital infrastructure in order to strengthen the innovative and scale-up capabilities of the innovators in Africa.

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Appendices

Appendix A: Acronyms

Table 3: Nomenclature.

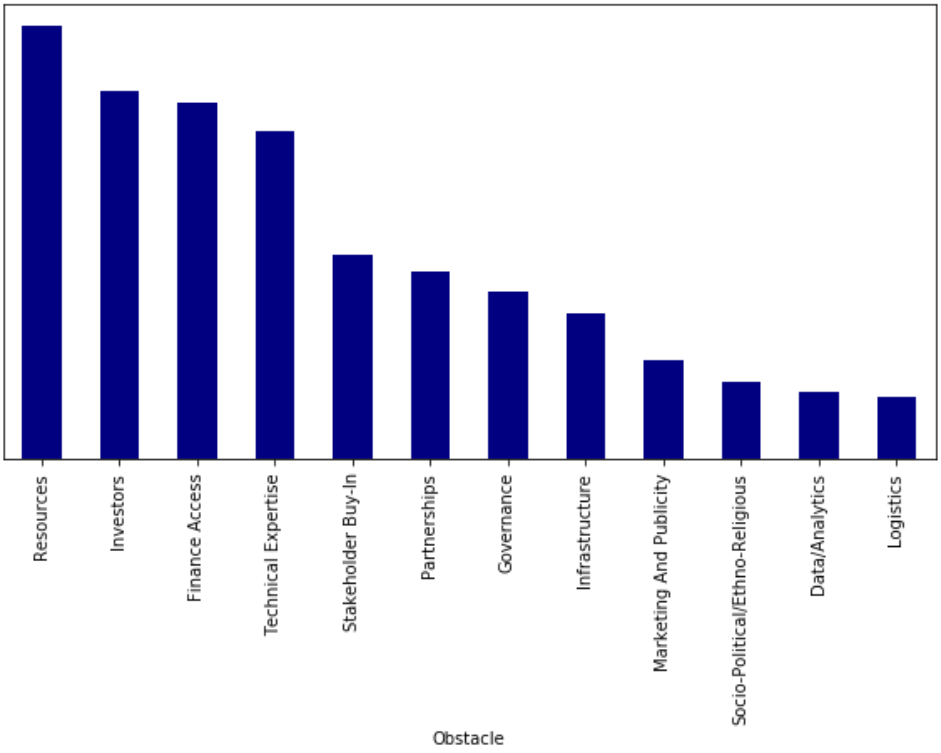
Abbreviation	Definition
AIS	African Innovation Summit
COVID-19	Coronavirus Disease 2019
ICT	Information and Communication Technology
LCEFEF	Low Carbon Enterprise Fund Economic Forum
UNDP	United Nations Development Programme
REPP	Renewable Energy Performance Platform
WHO	World Health Organisation

Source: Authors' own.

Appendix B: AIS & WHO Data analysis

The WHO and AIS innovation datasets revealed the following information about the relative frequency by which different obstacles are encountered in the African innovation ecosystems.

Figure 10: Obstacles to innovation development and scale-up (pre-COVID-19 Dataset).



Source: Authors' own.

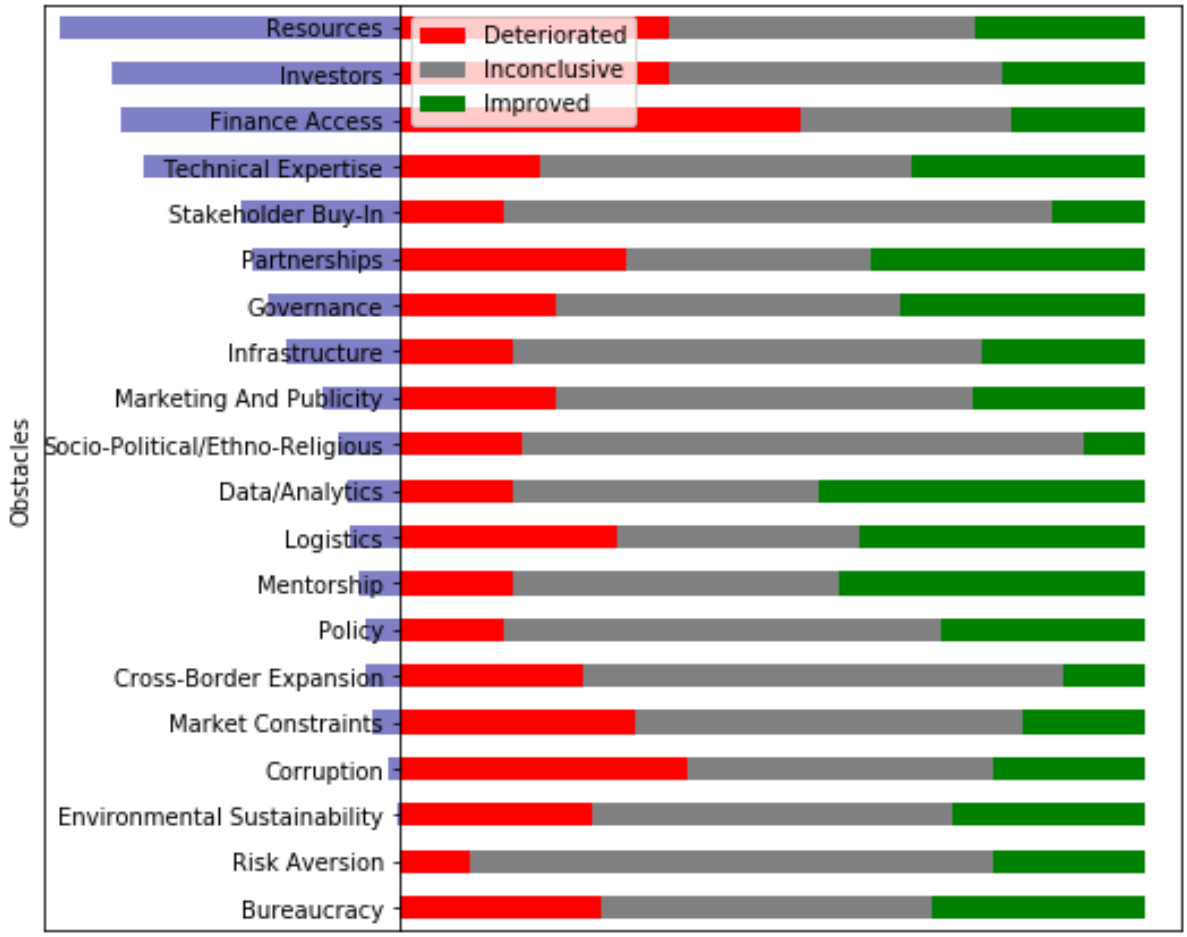
Appendix C: Changes to the African innovation ecosystem in the age of COVID-19-survey

A survey was performed in order to gauge the responses of various actors in the African innovation ecosystems. The data was collected in the time period between 2020-10-09 and 2020-10-25. The survey had five question areas on effects of the pandemic as follows:

Q1) The Effect of COVID-19 on the challenges facing the African innovation ecosystems.

The following figure indicates which obstacles in the African Innovation Ecosystems were exacerbated or alleviated during the pandemic response.

Figure 11: Deterioration and improvements of obstacles in the innovation ecosystems.

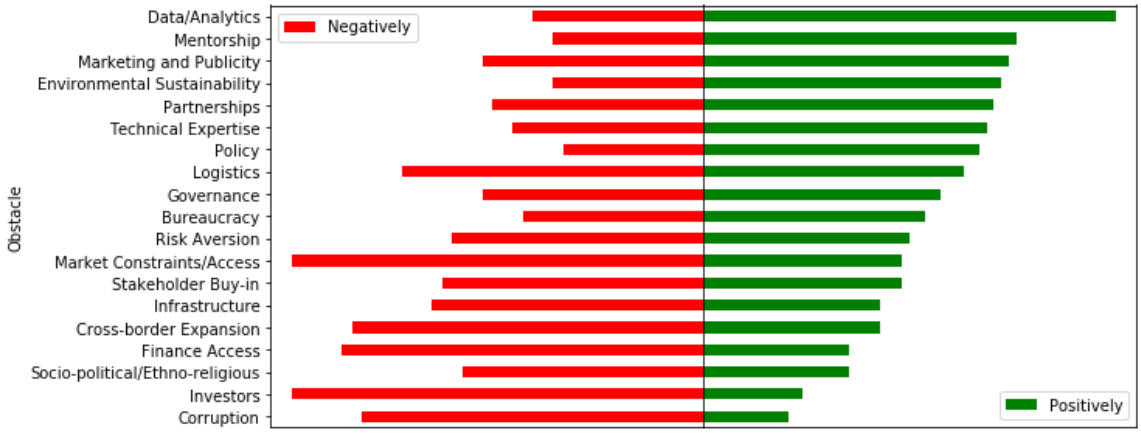


Source: Authors' own.

Q2) Virtualisation and the African Innovation Ecosystems.

The following figure describes the observations regarding the impact of virtualisation on the African innovation ecosystems.

Figure 12: The effect of virtualisation on obstacles in African innovation ecosystems.

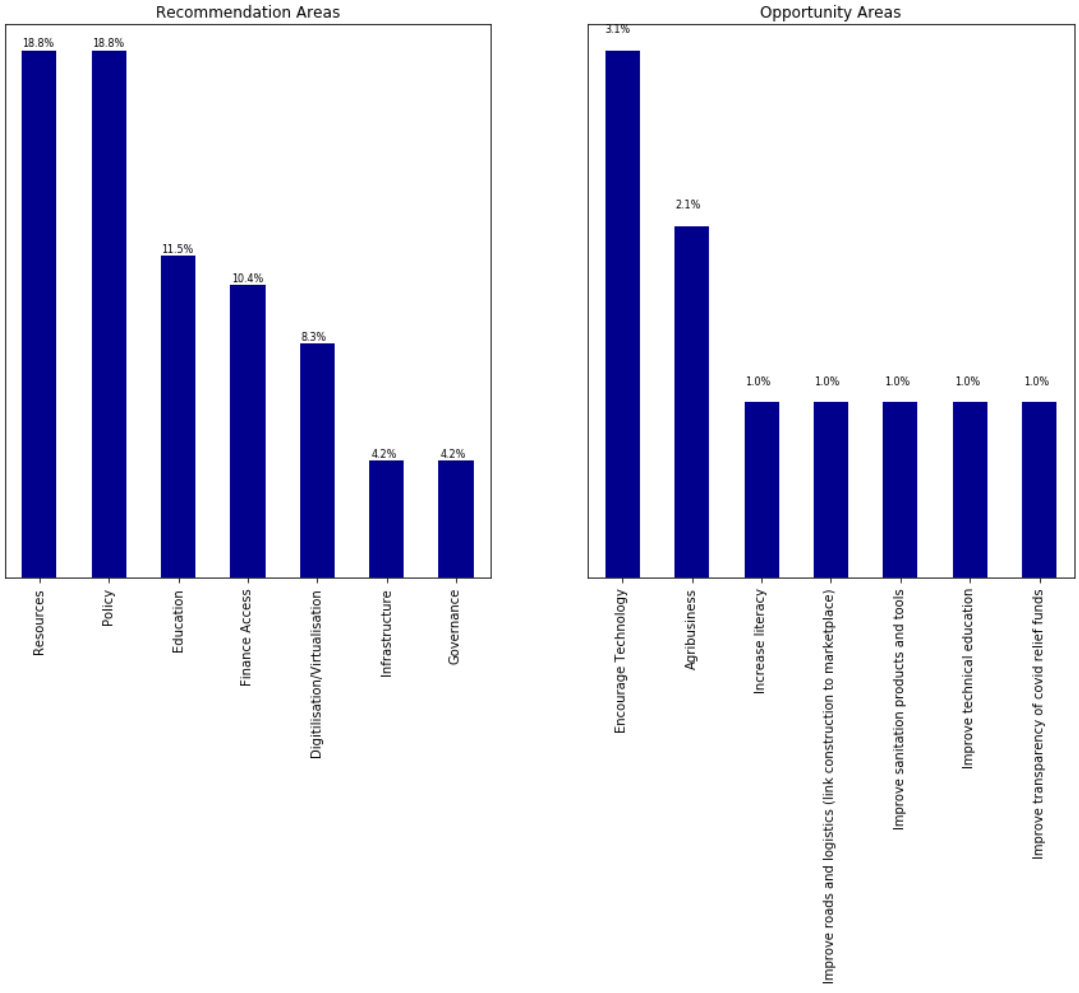


Source: Authors' own.

Q3) Practice Changes

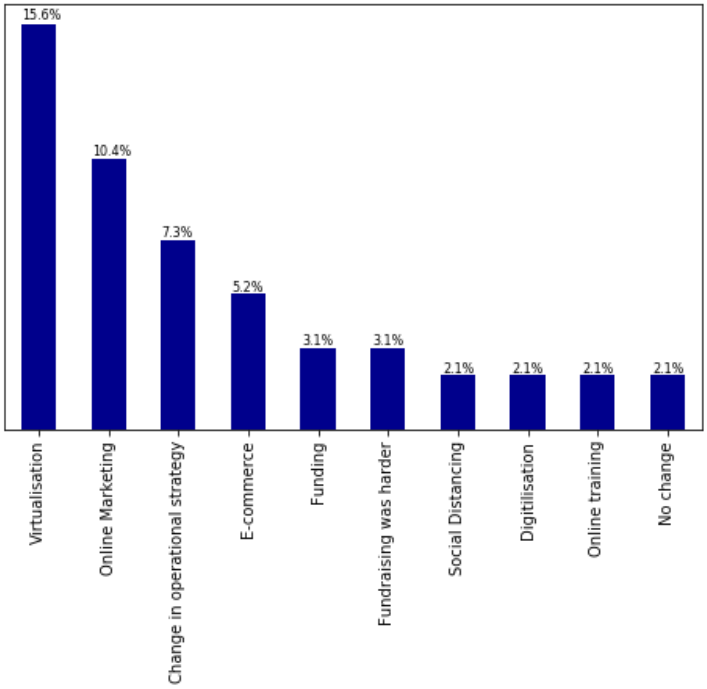
The following figure describes the observations regarding practices and policy on the African innovation ecosystems.

Figure 13: Recommendation and opportunity areas.



Source: Authors' own.

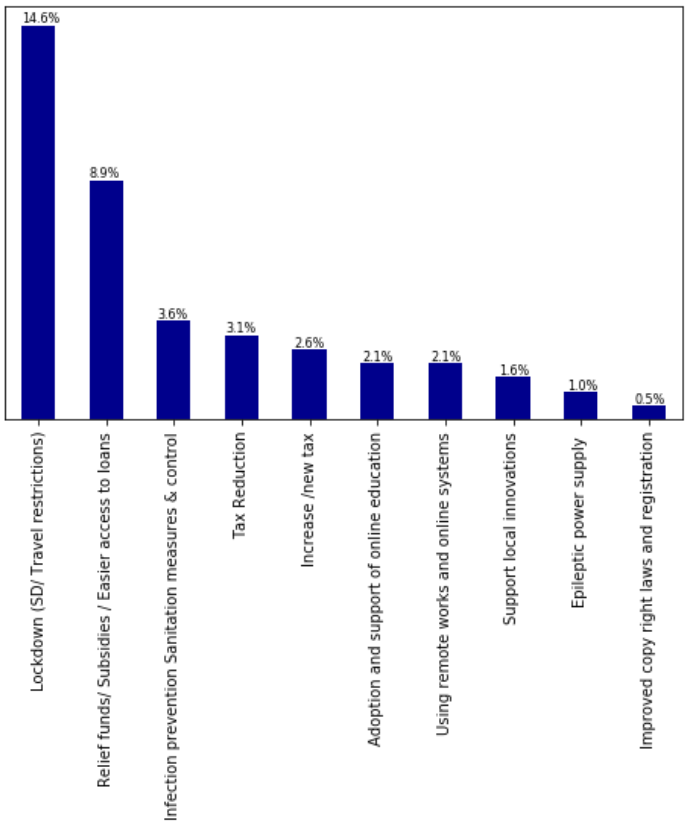
Figure 14: Identified practice changes during the COVID-19 pandemic.



Source: Authors' own.

Q4) Policy changes.

Figure 15: Identified policy changes during the COVID-19 pandemic.

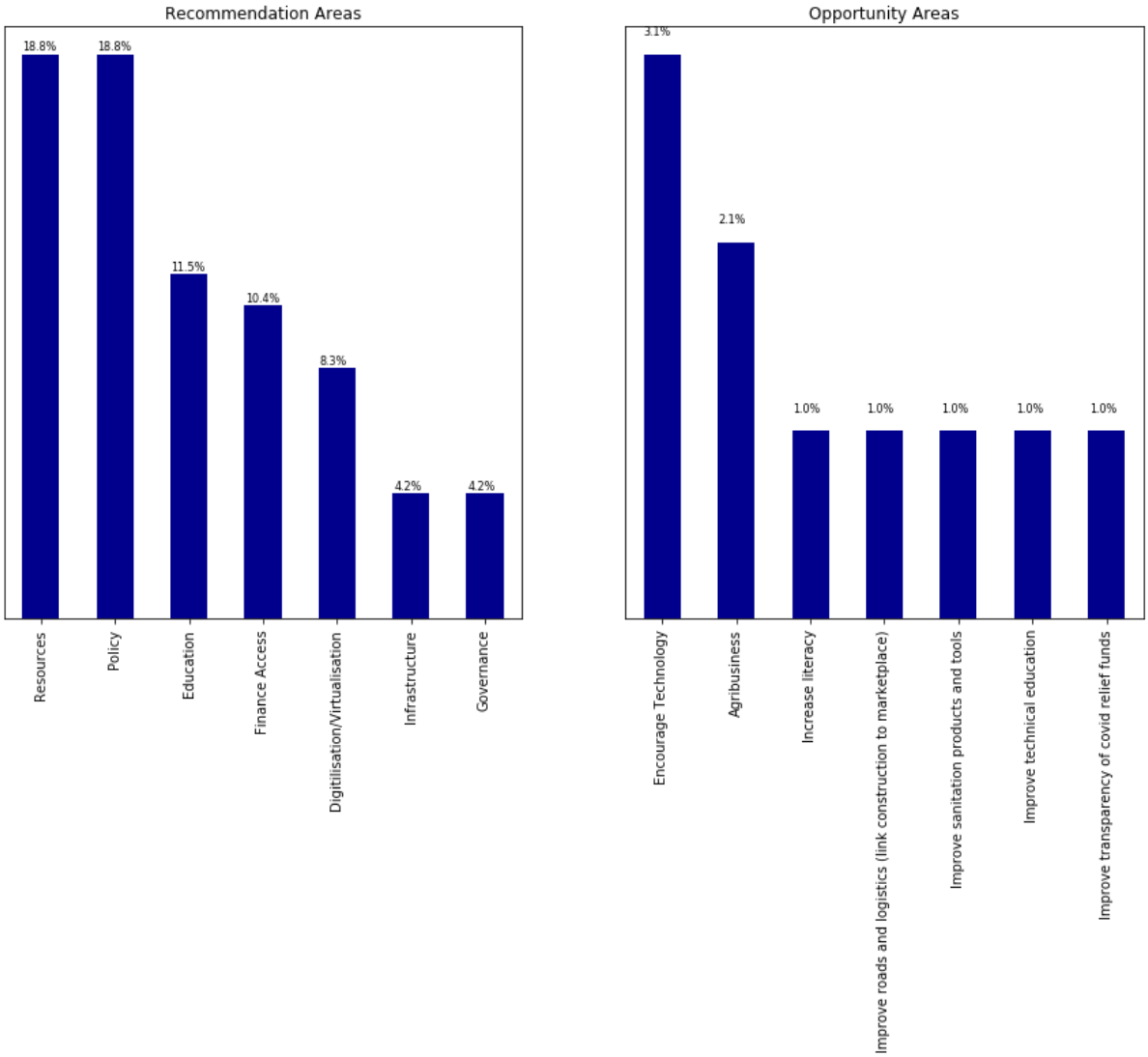


Source: Authors' own.

Q5) Recommendations and opportunity areas.

The following figure describes the recommendations and opportunity area of the impact of COVID-19 on the opportunity area.

Figure 16: Recommendations and opportunity areas.



Source: Authors' own.

DSI/NRF/Newton Fund Trilateral Chair in
Transformative Innovation, the 4IR and
Sustainable Development (UJ-TRCTI)
JBS Park, 69 Kingsway Ave, Auckland Park
Johannesburg, 2092

General enquiries:

Telephone: 011 559 1792
E-mail: nabilanm@uj.ac.za
Website: www.uj.ac.za