Decision Support Unit (DSU)

Rapid assessment:

Disruptive Technologies for Private Sector Development in the DRC

Marcus Jenal and Dr Shawn Cunningham

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Decision Support Unit (DSU)

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About the Decision Support Unit (DSU)

The DSU is a UK Department for International Development (DFID)-financed project implemented by Oxford Policy Management (OPM) in the Democratic Republic of Congo (DRC). It is designed as a support function to DFID's overall management of its Private Sector Development (PSD) programme. The DSU provides evidence and analysis aimed ultimately at improving the programme's overall impact of increasing incomes for the poor in the DRC. In addition, the DSU provides an external learning role targeting improved implementation practices of the broader development community working in the field of economic development.

As part of a broader assessment of the context in which the PSD programme operates in DRC, the annual *problematique* review, the DSU is mandated to provide short-term research support as one of its deliverables. The aim of the research activity is to support the PSD programme by conducting research on issues requiring more detailed investigation as identified through other workstreams, or requested by DFID DRC or the PSD programme component projects (currently ÉLAN, Essor, and the DSU), and agreed with DFID.

This study was developed by Marcus Jenal (DSU Learning and M4P Expert / Short-term Research Lead; Mesopartner) and Shawn Cunningham (Mesopartner). It has been further reviewed by Hamish Colquhoun (DSU Team Leader).

About Mesopartner

Mesopartner is a knowledge firm that specialises in economic development, competitiveness and innovation. Mesopartner's strategic intent is to be globally acknowledged as an innovator in economic development practice. Combining theory, practice and reflection, Mesopartner enables clients to explore options and support decision-making processes. Mesopartner collaborates with strategic partners to create knowledge on contextually sound economic development.

List of Abbreviations

DFAT	(Australian) Department for Foreign Affairs and Trade
DFID	(UK) Department for International Development
DRC	Democratic Republic of the Congo
FCAS	Fragile and Conflict Affected States
HEP	Hydro-electric power
I2I	Ideas to Impact programme
ICT	Information and Communication Technologies
IDS	Institute for Development Studies
IoT	Internet of Things
LDC	Least Developed Country
OPM	Oxford Policy Management
SADC	Southern African Development Community
SME	Small and Medium Enterprise
SPRU	Science Policy Research Unit (Sussex University)
STI	Science, technology and innovation
UNCTAD	United Nations Conference on Trade and Development
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene

1 Background

1.1 Rationale and objective of the study

Science, technology and innovation (STI) has gained prominence in the global development arena in recent years. Many of the Sustainable Development Goals (SDG) refer to the importance of technology development and STI as drivers of poverty reduction, clean energy, decent growth, sustainable cities and climate change action. In the Agenda 2030, Goal 9 explicitly states the importance of STI for infrastructure development, sustainable industrialisation and innovation. Additionally, SDG 17 on global partnership also emphasises the importance of enhancing international cooperation on access to technology, science, innovation and knowledge sharing.

In the Democratic Republic of the Congo (DRC), the use of new technologies[1] such as electronic documents and mobile money have shown initial signs of success for facilitating business registration, and improving access to finance, respectively. Based on this, the UK Department for International Development (DFID) DRC has expressed an interest in further supporting the development and adoption of technologies to enhance private sector development and inclusive economic growth in the DRC, as part of its private sector development programme.

Consequently, DFID DRC wishes to better understand the role it can play in supporting the adoption of new technologies to tackle the challenges faced by micro, small and medium enterprises operating at the provincial level in the DRC. Hence, building on both academic and practitioner-oriented literature as well as on DFID's existing work on technological development, this report provides a review of the potential role of technological change in supporting and enhancing private sector development in the DRC and other fragile and conflict affected states (FCAS).

The objective of the report is to shed light on what role technology might have in providing businesses in the DRC with opportunities for growth; how such technological change can be supported by DFID DRC; and how this would contribute to inclusive economic growth in the country.

1.2 The DRC context

In a captivating photographic narrative, *The Guardian* newspaper reported in 2015 how the small mountain town of Numbi in South Kivu received a mobile phone tower. In 2017, a follow up report showed how the new technology has benefitted the inhabitants of the town. In the report, Richard Nsengimana, the President of the Civil Society of the Haut Plateau region, says that phone reception has brought great benefits for business in the area. *"Now, [people] can communicate directly to find out when something is arriving … and with the internet, we can communicate with partners everywhere."* Besides benefits to local businesses, access to local healthcare provision has also improved, and people are now able to send and receive money via their phones. In addition, since the arrival of mobile phone reception in the area, security on the road has greatly improved, despite high levels of ongoing conflict in the region.

Other new technologies, like blockchain, promise to increase the transparency and accountability of both the public sector and also the private sector in the DRC. For example, Ford intends to use blockchain technology to *"clamp down on labour*

[1] Technologies are not *per se* disruptive—they might be in some contexts while not in others. Therefore, this study rather uses the term 'new technologies' to denote technologies that are new to the context.

exploitation in the cobalt mines of the Democratic Republic of Congo", as is reported in this article by *The Telegraph*.

Stories like these show what impact new technologies can have on communities in countries like the DRC. Yet the country has a long way to go until it can reap all the benefits offered by new technologies. Currently, most of the country still suffers from a very limited exposure to new technologies and the outside world. Some new technologies have not yet even arrived in the country, or have not been taken up, so many of the current technologies used are still rather basic. Key informants for this study tell of businesses in DFID's target provinces only using handwritten paper receipts, even for large transactions, and of motorbikes and wheelbarrows as desired investments for small traders to extend their business.

On the GSMA Mobile Connectivity Index[2], the DRC lies in the low to medium range with a score of 26.8, similar to Zambia, Mozambique or Malawi (2017 data). According to GSMA, mobile coverage reaches 44.58% penetration rate in the country, with just over 40% of the population covered by a 3G connection. The penetration rate is much lower than in the DRC's neighbouring countries of Zambia (78%), Rwanda (68%) or Uganda (68%).

Furthermore, physical infrastructure in the country is patchy. Many parts of the country are not connected to each other by major roads. Electricity supply is unreliable and sporadic: even many larger towns only receive a couple of hours of electricity per day.

Hence, while new technologies might promise some improvement for many people in the country, there are a number of other factors that need to change as well, including an improved physical infrastructure, improved governance and service provision in the public sector, and improved healthcare and education, for the country to be able to converge technologically with the developed world.

2 Introduction

2.1 Scope and research questions

The study looks at the effects of technological change and disruptive technologies and how they facilitate private sector development and inclusive economic growth in a broad and exploratory way. One area of particular interest to DFID DRC, although by no means the only one, is to look at how these technologies can be used to curb corruption, which is addressed in Section 4.2.3 of this report.

The primary role of the report is **NOT** to describe or recommend specific technologies, but to critically review empirical evidence on how supporting technological change has been used to facilitate inclusive economic growth. The findings of the study are intended to show clear relevance with regards to the situation in the DRC, and the recommendations of the study should be easily implementable as part of the forthcoming new iteration of DFID's private sector development programme.

The aim of the study is to address the following research questions:

1. What does the literature in the field of development cooperation say about technological change and the use of disruptive technologies in supporting private sector development?

[2] The Groupe Spéciale Mobile Association's index measures the performance of 163 countries against four key enablers of mobile internet connectivity—infrastructure, affordability, consumer readiness, and content and services.

2. In what circumstances has the support of technological change and the use of disruptive technologies achieved an improved business environment and enhanced private sector development?
3. What other factors beyond the technologies themselves need to be taken into account when aiming to promote technologies to enable or facilitate private sector development?

2.2 Some dilemmas in looking at disruptive technology and public service delivery

Technological change and the spread and adoption of new technologies is a complex process. Too often, development programmes have attempted to 'transplant' specific technologies from the developed world to the developing world with little success. There are even a few terms to specifically describe the (lack of) results of such programmes, such as 'white elephants'. What technology works and is adopted in a specific context strongly depends on the state and history of that context. What is seen as disruptive technology in one context is nothing more than incremental improvement in another.

The question is often how narrow or broad the focus should be. In other words, do we look at technology on the scale of a smart phone with a weather application, or do we look at data speeds and network coverage. Many modern technologies are deeply interwoven and require many complementary technologies to function. Furthermore, the successful use and development of technology by enterprises is dependent on an interconnected network of institutions including education, technological extension, and the wider framework conditions that incentivise innovation (or not). Understanding this wider system is crucial if one wants to support technological progress.

One consequence of this systemic view of technological change is that one also needs to be aware that there are some preconditions for technological change that should receive attention first, before technologies are looked at. These framework conditions shape the incentives that drive people to try and find new ways of doing things, and what they prioritise—including the adoption of new technologies. If the framework conditions, for example, incentivise people to ensure the safety of their assets rather than to invest in improving their productivity, investments in innovation and technological progress will be hampered.

For the present study, DFID DRC expressly does not want to look at specific technologies that can be transferred to the DRC context. Rather, the DFID team is interested in better understanding how technology can support its aim of developing the private sector in a challenging context. Hence, it is the aim of this study to take a wide perspective on technological change and how it happens in reality, rather than simply to present some case studies. Out of this 'naturalistic' view, the study develops some recommendations on how DFID DRC can support technological development.

2.3 Methodology

The study primarily relied on secondary literature combined with a small number of key informant interviews with experts on technological change and the use of disruptive technologies in developing countries. Key informant interviews were also used to get a better understanding of the reality at the provincial level in the DRC.

2.4 Overview of the paper

The study initially develops a conceptual understanding of technology, technological change, how technology spreads, and the importance of understanding technological capabilities and institutions. This is presented in Section 3.

Section 4 then presents and discusses the current evidence and experiences of using technology in development. This includes a view on the use of new and globally disruptive technologies (so-called 'frontier technologies') and how they are used to overcome development challenges, as well as examples of initiatives that use less cutting-edge technologies in development. The section also presents an evidence review to answer the research question of whether and in what circumstances technological change leads to growth and poverty reduction; it furthermore examines challenges with technology transfer; and presents a supplemental approach that focuses on strengthening the local innovation system, rather than the promotion of specific technologies. Finally, the section also discusses experiences that show how to make technological innovation more inclusive.

Section 5 then presents conclusions and recommendations for DFID DRC.

3 A conceptual understanding of technology and technological change

This section provides a conceptual foundation that unpacks how technology can be defined, and how technology evolves and spreads in an economic system. The section also provides a theoretical perspective on the role of institutions in the technological change process. This will provide the conceptual basis for later assessment of real-world experiences and cases of using technology for development.

3.1 A broader meaning of technology

Technology can be understood in many different ways. In everyday English, it often means a gadget or artefact, or know-how, or a broader group of ways of doing things. In contrast to this colloquial understanding, Arthur (2009) highlights the importance of a broader understanding in which technology is seen as a means to harness natural phenomena and arrange processes to produce something or achieve a specific purpose.

To substantiate this broader understanding of technology, Arthur (2009:28) provides three different definitions of technology:

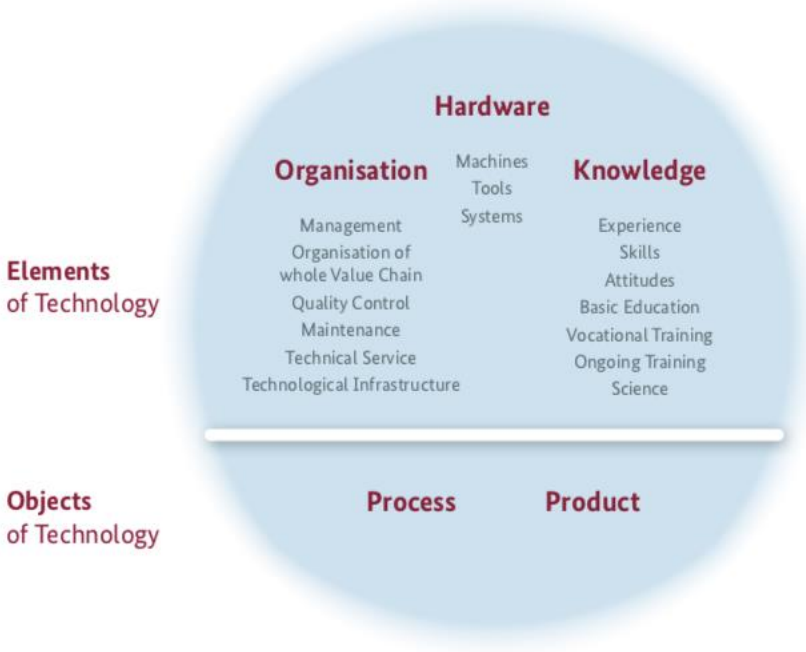
- The most basic definition is that technology (in a singular sense) is a means to fulfil a human purpose. For some technologies this purpose may be explicit, for others it may be vague. As a means, a technology may be a method, process or device. A technology does something, it executes a purpose. It could be simple (a roller bearing) or complicated (a wavelength division multiplexer). It could be material, like an engine, or nonmaterial, like a digital compression algorithm.
- A second definition is plural, technology as an assemblage of practices and components. This covers technologies such as electronics or biotechnology that are collections or toolboxes of individual technologies and practices. These assemblages can also be called bodies of technology.
- A third definition is technology as the entire collection of devices and engineering practices available to a culture.

These three definitions each outline a different category of technology. Each category of technology comes into being differently and evolves differently. Changes in the first category are relatively easy and fast, becoming progressively more difficult in the second and third categories. The third category is marked by a slow process of change. An example this third category would be how international air travel currently operates, or how we use a variety of technologies to communicate with family, friends, and business associates that are geographically distant.

In the economic development literature, there have also been long-standing discussions about a broader definition of technology, especially in the context of international technology transfer, technology adaptation in developing countries, and technological convergence. For example, Meyer-Stamer (1997:7–9) highlights four components of technology (illustrated in Figure 1):

1. Technical ***hardware***, i.e. a specific configuration of machines and equipment used to produce a good or to provide a service.
2. Know-how, i.e. scientific and technical ***knowledge***, including both formal qualifications and tacit knowledge.
3. ***Organisation***, i.e. managerial methods used to link hardware and know-how.
4. The ***product***, i.e. the good or service as an outcome of the production ***process***.

Figure 1: A broader definition of technology



Source: Meyer-Stamer (1997:7–9)

The three elements of technology (Organisation, Hardware, Knowledge) can be independent of the objects of technology (the process or the product). For instance, a particular arrangement of the elements could produce a great variety of products.

The broader definition of technology explains why technology cannot just be 'transferred' in a package form. Successful transfer depends not only on the hardware, but also on the recipient context, culture, and a range of other supporting factors, which differ vastly between countries, regions within countries, and even between different firms.

3.2 How technology changes

Absorption of new technologies, and further development of existing ones, are necessary to maintain economic development (Nelson, 2015). Technological change is an evolutionary process (Arthur, 2009; Beinhocker, 2006; Nelson and Winter, 1982). As is true in general for evolutionary processes, most technological change is

incremental, that is, each innovation constitutes a relatively small step built on the base of established practice (Nelson and Winter, 1982). Even though each step may be small, the cumulative economic consequences of change over many iterations may be huge.

Technology changes through a process of innovation, which is distinct from invention. Innovation means new to the context, while invention means new to the world. Innovation can occur at any level of a technology, or it can occur at the level of the process or business model that a given technology forms part of. To turn an invention into an innovation, a firm typically needs to combine several different types of knowledge, capabilities, skills, and resources from within the organisation and the external environment (Schumpeter, 1964/1911).

While many innovations can be linked to well-funded research programmes, funding is not a pre-condition for innovation. In fact, in some cases a lack of resources can stimulate people to innovate. However, innovation requires taking, or at least managing, risks. Therefore, firms with low capital or tied-up resources are generally less likely to innovate.

Firms usually innovate because they believe there is a commercial benefit to the effort and costs involved in innovating. Often increased competition, changes in market structure or market demand, or changes in technological performance also affect the innovation process. The willingness of an individual within a firm to tinker and explore is influenced in part by the organisational context of the innovator, but also by factors such as education, qualifications, meta-level factors such as social norms, personal characteristics (such as patience, inquisitiveness, or tolerance of failure), and the institutional environment. Other factors such as competitive pressure, problem pressure, or social and economic incentives also play a role. Locations with a more diverse economic and social make-up are more likely to be conducive to innovation, as actors interact with people with similar and different interests. The proximity of other actors, and the density of interactions make imitation, cross-pollination of ideas, learning from others, and the combination of different ideas into new products and services more viable (and less expensive).

An important form of innovation is through imitation—where ideas are copied from other contexts and then adapted or made to work in a new context. However, imitating is often not as straightforward as simply copying an idea from elsewhere. Every idea that is copied needs to be made to fit in a new context. Thus, each effort to introduce an innovation may have many knock-on effects, demanding innovations in the surrounding context, supplier networks, organisational structures, and so on.

Incremental technological changes generally favour incumbents because of their established organisational and technological capabilities. However, inertia in incumbents can also create a lock-in effect. Even if a new technology or concept could offer great benefits to an incumbent, the required change, restructuring, and rethinking of its business models could lead the incumbent to ignore certain developments, or not even recognise the need for change. When the incumbent is in the public sector, new innovations and technology could undermine their power and ability to extract rent. Hence, public officials, like business people, often have an incentive to protect what exists because they can control it.

Sometimes, however, new technologies become successful despite the resistance of the incumbents. These newly introduced technologies are disruptive, leading to radical change in the dominant technologies used. In these instances, innovations appear that depart dramatically from the norm of continuous incremental innovation that characterises product classes. These can be termed technological disruptions or discontinuities (Anderson and Tushman, 1990).

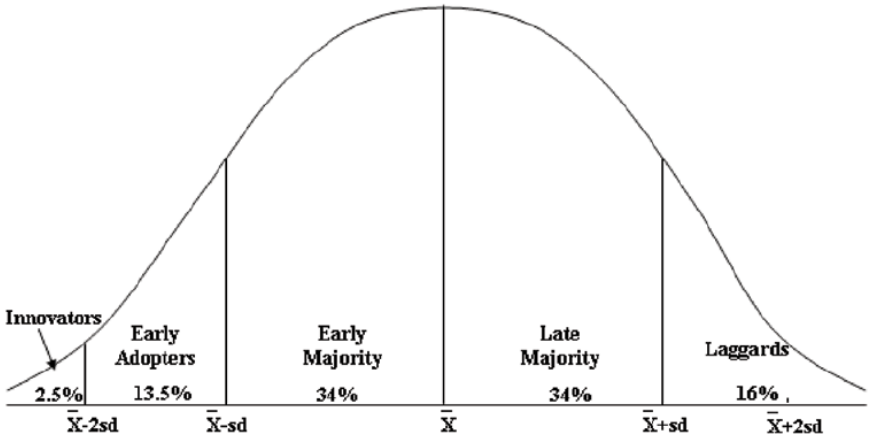
Because of the resistance of incumbents, new technologies are often pioneered by firms new to the industry they transform. These firms have had an opportunity, in a different industry or technological context, to develop their idea to a point where it surpasses the performance-cost curve of existing technologies in other sectors. The next section describes how innovations spread within an economy.

3.3 How innovations spread

Rogers (2003:7) describes the diffusion of innovations as "*a special type of communication in which the messages are about a new idea*". Two of the concepts that Rogers developed, and that he is mostly cited for, are the bell curve of diffusion of innovations and the attributes that determine the rate of diffusion.

To understand the bell curve of innovation (Figure 2), the process of diffusion must first be explained. According to Rogers (2003:14), diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system.

Figure 2: Rogers' bell curve of innovation with adopter categorisation



Source: Rogers (2003:281)

The actors that form sections of the bell curve can be categorised as:

- innovators, who adopt an idea because it is new;
- early adopters, who adopt an innovation because they can perceive a benefit;
- early majority, who adopt because they perceive a clear productivity gain;
- late majority, who join when there is lots of help, support, and guidance, and;
- laggards, who join because they have to, or because the use of the innovation has become a new social norm.

The so-called Rogers' Five Factors of Innovation are attributes of innovation, as perceived by individuals, and help to explain the rates of adoption.

Rogers' research has had a huge impact in the field of technology and innovation transfer, as well as in the domain of sociotechnical change. What Rogers did not discuss much is the role of social institutions in the dissemination of innovations and ideas. However, Rogers acknowledged that education institutions play a critical role in the choices they make in terms of what is included in the curriculum (they play an important selection role). Other scholars have taken up the question of the role of institutions, as discussed in the next section.

3.4 The role of institutional support for technological evolution

Enabling technological evolution in an economy requires a whole range of actors to play their part. From individuals and informal networks, to large and small firms, all play a role. A wide range of social institutions, both formal (for example a cluster development organisation) and informal (the trust networks between members of the clusters) also play an important role. Nelson (2015) refers to these social institutions as social technologies and he argues that they co-evolve with physical technologies to enable economic development. These social institutions range from central banks to a diverse range of firms, but importantly include other forms of organisation, such as scientific and technological societies, universities, government agencies, and even capital markets. Nelson emphasises that "*when a potentially new technology emerges, new institutions often are needed to develop it, and invest in and operate effectively the economic practices based on it*" (2015:13). However, **there is no single set of institutions and policies that are effective for all technologies and industries. Policies and interventions need to be adaptive and flexible to navigate the unpredictability of technological change.**

These institutions and institutional change processes are the focus of the discipline of **innovation systems**. Christopher Freeman was one of the early scholars who laid strong foundations for the study of innovation systems. Freeman (1987:1) defines an innovation system as "*the network of institutions in the public and private sectors whose activities and interactions initiate, import and diffuse new technologies*." Lundvall (1992:10) argues that the "*structure of production*" and the "*institutional set-up*" are the two most important dimensions that jointly define an innovation system.

The innovation system approach spells out quite explicitly the importance of the systemic patterns of interaction between the various components of inventions, research, technical change, learning, and innovation (Freeman and Soete, 2009; Soete, Verspagen and Ter Weel, 2009). Thus, acquiring an understanding of the interplay between knowledge application and absorption, and different kinds of innovation and learning by doing as an interactive process, is critical.

In a recent handbook that deals with innovation systems in development, to which many of the leading scholars of innovation systems contributed, the editors proposed a revised definition of innovation systems that encapsulates more than 20 years of development of the field: *"The national innovation system is an open, evolving and complex system that encompasses relationships within and between organisations, institutions and socio-economic structures, which determine the rate and direction of innovation and competence building emanating from the process of science-based and experience-based learning"* (Lundvall, Joseph, Chaminade and Vang, 2009).

In a paper commissioned by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Kraemer-Mbula (2011:4) describes innovation systems as the landscape in which capabilities inside a country or a territory can emerge. Her definition emphasises the importance of the development of tacit knowledge and the informal ways in which it emerges. She emphasises that it is the context that matters, as does the "*ecology of organisations*" and the interaction patterns between public and private actors. Thus, the innovation system approach does not just look for the existence of institutions and policies, and R&D expenditure, because this does not tell whether knowledge and applied knowledge for and with the private sector is developed in a creative and innovative way. Instead, it analyses the type and learning-oriented quality of interlinkages between certain business clusters, associations, NGOs, unions, universities, R&D institutions, and political and policy structures. Accordingly, promoting innovation systems requires far more differentiated policies; a highly sophisticated understanding of policy interactions and network-driven requirements on

the parts of ministries and support institutions; a much deeper understanding of market demands; and related joint technology-push and demand-pull cooperation relations between private and public sector representatives.

The United Nations Conference on Trade and Development (UNCTAD) (2014:23) succinctly summarises the discussion on innovation systems: "*An innovation system is the key to capturing tacit knowledge because it is developed over time through practice and interactions in environments specific to a particular technology. The effectiveness of* [a National Innovation System] *will, therefore, be largely defined by how it incentivises and supports such learning interactions*."

The level of functioning of an innovation system is termed the **technological capability** of a region or nation. In a seminal work, Lall (1992) emphasised three aspects of national technological capability:

- the ability to mobilise the necessary (financial) resources and use them efficiently;
- skills, including not only general education but also specialised managerial and technical competence; and
- "national technological effort", which he associated with measures such as R&D, patents and technical personnel.

Technological capability can be described as "*the ability to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies*" (Kim, 1997:4). Fagerberg and Srholec (2017) stress the importance of the ability to combine different types of knowledge related to, for example, finance, logistics, products, markets, production, and so forth.

Hillebrand, Messner and Meyer-Stamer (1994) argue that technological capability is built on four pillars:

- The skill of producers in imitating and innovating at product, process, and business model levels. This is largely dependent on pressure to compete, as well as pressure to collaborate with each other.
- The economic, political, administrative, and legal framework conditions determine whether there are incentives to develop technological capability. In the past, it was often not recognised that these incentives were lacking in many developing countries.
- Direct support by technology-oriented state institutions or specific types of knowledge-intensive service companies, which depends on the existing level of development, the competition situation, and the characteristics of a technology branch in the given country. These organisations disseminate technical and expert knowledge between different actors, knowledge domains, and industries, and play a crucial role in the use and application of tacit and explicit knowledge.
- Indirect support by the public and private educational systems—in addition to a sound basic education, it is important that technical training of a suitable quantity and quality is available at secondary school level and also in the universities. The private sector often plays a role in short-term training aimed at particular technology applications. Overall, the education sector must be able to identify and respond to changes in the application, development, and use of technology in society.

The close interaction between these four pillars effectively creates technological capability. Thus, technological capability differs between countries and even within countries because the context and the dynamics of interaction differ. A single firm may,

in the short-to-medium term, manage to get a sophisticated product into the market on their own. However, to sustain its position, it will sooner or later need to tap into the education system, the knowledge networks of intermediaries and technology experts, or into supplier networks. It is not enough to have a handful of companies that are able to innovate, explore new technological applications, or combine different fields of specialisation in one enterprise successfully.

4 Using technology in development

The previous section was conceptual and captured what is said in the academic literature. This section focuses on arguments for and experiences of using technology for development, and the challenges that come with it. In selecting these examples and arguments we had to choose from a wide range of literature and case studies that are often hard to apply in the specific context of the DRC, as the cases and experiences often come from more developed countries and not least-developed countries (LDCs) or FCAS. The topics we chose to include here provide what we believe to be some guidance to DFID how it can promote the uptake of certain technology clusters or how it can strengthen the technological capability of the DRC.

4.1 Frontier technologies to tackle development challenges

The world is in a phase of rapid technological change, often termed the fourth industrial revolution. According to Schwab (2017), the fourth industrial revolution is characterised by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries. According to the World Economic Forum (WEF, 2017), the fourth industrial revolution is bringing about the development of new techniques and business models which will fundamentally transform production processes, government decisions, industry, and society at large.

While discussion of the wider consequences of these global changes on developing economies lies outside the scope of this report,[3] the fourth industrial revolution and its technologies strongly influence the discussion on which technologies are deemed relevant for development: new technologies such as Artificial Intelligence, additive manufacturing (3D printing), or blockchain take a centre stage nowadays.

The opportunities are obvious. Inspired by rapid technological change on a global level, new and disruptive technologies are seen by many as a means to overcome so far intractable development challenges. According to Sir Tim Berners-Lee, the designer of the World Wide Web, these technologies "*could well carry the seeds of transformative change of tomorrow*" (Ramalingam *et al*., 2016:5). Also the DFID Digital Strategy 2018 to 2020 shares this optimism: "*Digital technologies offer an unprecedented opportunity to revolutionise the global development system, change lives, transform entire economies, stimulate growth and, ultimately, end reliance on aid.*"

A 2016 report by the Institute for Development Studies (IDS) describes ten 'Frontier Technologies',[4] which have "*potential to positively contribute to development and humanitarian efforts*" (Ramalingam *et al.*, 2016:15). While the report explicitly mentions that technology transfer initiatives have received considerable and sustained criticism,

[3] This discussion has been extensively covered by other work, for example by the Pathways for Prosperity Commission reports: Gollin (2018), Malherbe (2018), Rodrik (2018), Salam *et al*. (2018a), Salam *et al*. (2018b).

[4] The report uses the Organisation for Economic Co-operation and Development's (OECD) definition of frontier technologies as "those 'that will reshape industry and communications and provide urgently needed solutions to global challenges like climate change' and 'have the potential to displace existing processes'" (Ramalingam *et al.*, 2016:16).

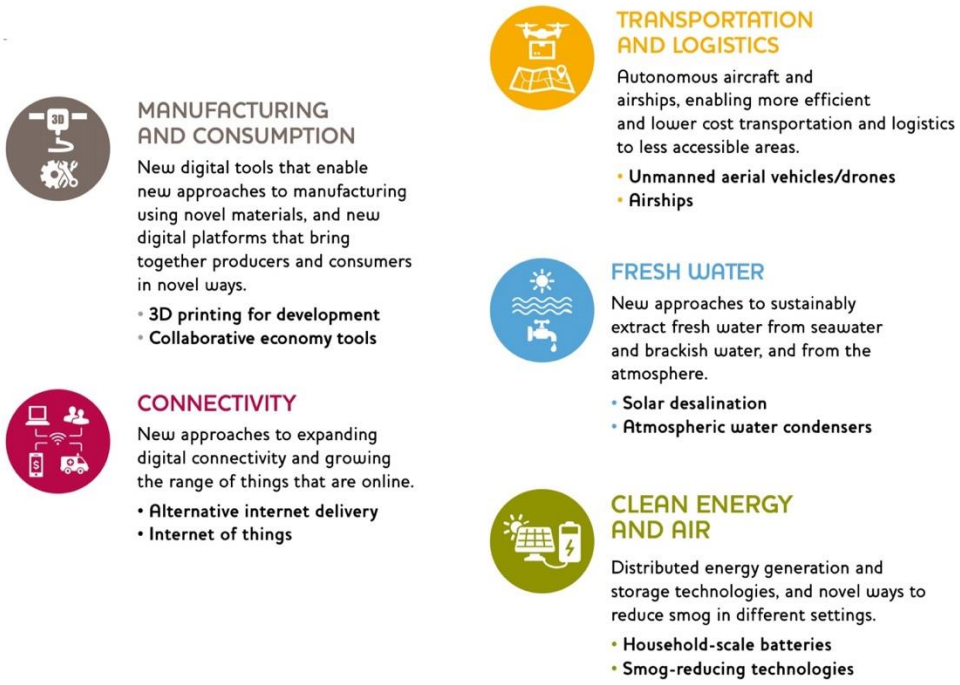
it suggests that this time it will be done differently, namely by designing the technologies with and for end users, being responsive to social, cultural, and political dynamics, and by taking an adaptive and iterative approach to innovation processes (Ramalingam *et al.*, 2016:14).

Ramalingam *et al.* (2016:18) suggest four pathways through which frontier technologies can contribute to social, economic, and political development gains:

- Driving innovations in business models, products, and processes that provide new goods and services to 'bottom of the pyramid' consumers.
- Providing means by which better use can be made of existing underutilised household and productive assets.
- Catalysing increases in demand, nationally and internationally, which create new industries and markets, leading to macro and microeconomic growth.
- Changing demand for labour and capital, leading to direct job creation and transformation of the workforce.

The ten frontier technologies suggested by the report are presented in Figure 3, organised in five technology groups.

Figure 3: Five areas of frontier technologies



Source: Ramalingam *et al.* (2016)

In a similar way, a report by the Pathways for Prosperity Commission looks at the potential impact of seven emerging technologies on low- and middle-income countries (Strukelj, Fenech and Buston, 2018). The technologies include:

- Artificial Intelligence;
- the Internet of Things (IoT);
- Augmented Reality and Virtual Reality;
- drone technology;
- blockchain and other distributed ledger technologies;
- quantum computing; and
- brain-computer interfaces.

While it is interesting to read about the potential of these technologies for developing countries, the challenges for the adoption of these technologies that are discerned by the authors sometimes feel quasi-insurmountable, if one understands the speed of change in developing countries. They often require fairly fundamental changes on political and policy levels and in formal and informal institutions that govern economic processes. For example, the use of Artificial Intelligence requires the provision of an "*open and secure data environment*" for which "*Policymakers will need to create clear legal guidelines on data ownership, transfer and usage*" including data protection and privacy laws (Strukelj *et al.*, 2018:13).

Knowing the situation in many developing countries, including the DRC, this shift would not only require policymakers to be willing to create, implement, and enforce these policies, but more crucially it would require a fundamental increase in trust by citizens and businesses in the government agencies who regulate the use of their data, and in politicians and the rule of law in general.

Many development agencies have started to promote new and emerging technologies to overcome development challenges. The International Finance Corporation (IFC), for example, states on their website that "*New technology and disruption can be positive forces for sustainable development. The latest analyses highlight how emerging markets have yet to fully take advantage of the opportunities that new technologies offer to increase development, growth and productivity. IFC seeks to foster innovations in emerging markets as well as eliminating obstacles to using and to the adoption of promising new technologies.*" The page lists a large number of reports on how new technologies can support investment in developing countries, dominated by technologies like blockchain.

In the next sections, the report will showcase a number of examples of initiatives promoting technology for development—starting with frontier technologies, but also including general technologies for rural development as well as technologies to overcome corruption.

4.2 Examples of initiatives promoting technology for development

4.2.1 Frontier Technology Livestreaming

DFID has been funding a five-year Ideas to Impact (I2I) programme, which is an action-research programme designing, implementing, and testing innovation prizes, to induce innovative solutions to development challenges in the areas of Climate Change Adaptation, Energy Access, and Water, Sanitation and Hygiene (WASH). While the programme's priority is to share learning and produce robust evidence on the value and use of prizes in a development context, the projects that are funded through its prizes also provide interesting case studies on the use of technology for development.

Connected to the I2I programme is the Frontier Technology Livestreaming, which builds on the assessment of potential of frontier technologies in development by the IDS mentioned in the previous section (Ramalingam *et al.*, 2016). Frontier Technology Livestreaming is a three-year programme designed to help DFID apply frontier technologies to development challenges. Frontier Technology Livestreaming uses three mechanisms:

1. Providing seed funding to enable small-scale testing of new technologies via a pilot.
2. Matchmaking DFID advisers with technology entrepreneurs and innovators.
3. Coaching in lean impact methodologies.

The project has just concluded the selection of the fourth cohort of projects they will support, including projects such as a multipurpose drone platform for Malawi, e-commerce platforms serving remote businesses in Nigeria, and seasonal cold storage with a flexible-access model in Zambia. Earlier projects were clustered around drones, electric vehicles, and connectivity and development.

After the first two years, the initiative has identified six challenges in promoting frontier technologies in developing countries:

1. Regulatory barriers: a non-favourable regulatory environment: non-existent, not keeping pace with technological change, difficult and costly to engage, and so on.
2. Supply chain infrastructure: supply chain infrastructure insufficient to support the technology operating at scale.
3. Skills infrastructure and ecosystem: a shortage of technical skills for local installation and maintenance of technology, or a lack of local ecosystem to develop and sustain the technology.
4. Fitting into existing systems: the technology is not a fit for existing planning, decision making, execution, or implementation systems in the country or domain area.
5. Sustainability post-pilot stage: the technology use case is not sustainable post-pilot stage, either through donor funding, private investment, government take up, or commercial revenue.
6. Awareness building: end user (person or organisation) is not aware of the technology or its benefits.

Most of these lessons point towards the need for a more systemic approach to technological change, supplementing the introduction of specific innovations so the latter can have a more sustainable impact. This confirms the need for a co-evolving institutional environment described in Section 3.4.

4.2.2 Technologies for rural development

An internet search on examples of successful initiatives to promote technology for rural development results in a long list of self-proclaimed successes or of technologies that are proclaimed to be inherently beneficial for developing countries. An example of the latter is an inventory of scalable agricultural technologies published in 2013 by the United States Agency for International Development's (USAID) online hub for agriculture, food security, and development, AGRILINKS.

As the aim of this report is not to recommend specific technologies *per se* while still providing some ideas on how technologies can be promoted to support development, we have selected a few organisations that, according to our experience and assessment, implement carefully designed technology dissemination projects that take a systemic view on technological change. This is far from being a complete list, but is intended to show some exemplary cases.

iDE has adopted an approach that does not just transfer technologies like agricultural machinery or drip-irrigation systems to farmers in developing countries, but also works towards the creation of markets and the commercialisation of these technologies. The goal is to establish distribution and maintenance networks, including training, as well as viable funding and business models. The organisation has also experimented with setting up new social enterprises that engage in bottom of the pyramid markets and introduce new technologies. An example is iDEal Technologías in Nicaragua, which distributes micro-irrigation equipment and techniques. In the iDEal case study, Julian Wolfson, the Chief Executive of iDE Europe states that "*iDE's experience taught us that, while the right technology is useful, the real success in addressing poverty was*

to identify and create sustainable markets that connected producers, equipment manufacturers, and produce buyers."

In contrast to iDE, which introduces new technologies like irrigation systems into a context, Mercy Corps attempts to use the increasing reach of new technologies like mobile phones to improve the functioning of agricultural market systems, by working on interactions and relationships between market actors to establish new viable pro-poor business models. For example, the Agri-Fin Mobile programme works with partners to build sustainable models in Uganda, Zimbabwe, and Indonesia, where farm and crop management tools and financial services are bundled in affordable, unified platforms on mobile phone channels to promote mass uptake commercially. Mercy Corps also commissioned a study that examined demand and supply factors affecting mobile application mediums for the provision of agricultural rural advisory and financial services in Uganda. The study also considers how policy changes impact adoption, especially with regards to taxation on mobile money and social media.

In the DRC, the DFID PSD development project ÉLAN RDC has taken similar approaches to both iDE and Mercy Corps. In the case of its renewable energy intervention, it built a market, including a distributing network and funding models, for newly introduced technologies like solar lamps. In the case of branchless banking and mobile money, it built on an emerging new technology (mobile internet) to develop new services for its target population.

In general, good examples of organisations promoting technology for development stand out because when they transfer a technology, they do not focus on the technology in a narrow way. They pay careful attention to building local capacity to support, promote, and even further develop the technology and complementary capabilities. Not only do they implement the technology transfer and capability building at multiple levels, but also from multiple perspectives. For instance, attention is paid to policymakers and regulations, technology extension, capacity building, and further research (both technical and more socio-political), while at the same time raising awareness, demonstrating the technology, and strengthening suppliers.

Textbox 1: Examples form DFID's Digital Strategy 2018 to 2020

The following examples of technology programmes have been taken from DFID's Digital Strategy 2018 to 2020.

- Technology-Enabled Girl Ambassadors in Nigeria are being trained to become qualified mobile social researchers. They are using mobile technology to collect accurate, rapid insights into girls' lives, particularly in hard to reach communities.
- Project iMlango delivers e-learning programmes to girls in rural and remote Kenyan primary schools, who otherwise struggle to get access to education, through high-speed satellite broadband connectivity, provision of tailored online educational content, and electronic attendance monitoring.
- The Girl Generation Project is using social media to galvanise action to end FGM, driving social and behavioural change across Africa.
- Sehat Kahani is a health solution that provides female healthcare professionals with the tools to work remotely, such as video conferencing, transmission of still images, e-health patient portals, remote monitoring of vital signs, and continuing medical education. It is funded by DFID through SPRING

4.2.3 Technologies to fight corruption

DFID DRC has expressed an explicit desire to better understand how technology can be used to fight corruption. Transparency International finds that increasing transparency is the surest way of guarding against corruption. The organisation promotes increasing trust in the people and institutions on which our futures depend. According to Transparency International, "*transparency is about shedding light on rules, plans, processes and actions. It is knowing why, how, what, and how much. Transparency ensures that public officials, civil servants, managers, board members and businesspeople act visibly and understandably, and report on their activities.*"

Consequently, most initiatives using digital technology to fight corruption are focusing on improving transparency. In preparation for a 'hackathon' that brought together corruption activists and technology, Transparency International has collected 35 'problem statements'. Most of them describe the need for secure and anonymous online platforms on which citizens can report problems, or how information and communication technologies (ICT) can be used to make it easier for people to monitor their leaders. Transparency International has put together a web page that showcases a number of tools some of its country chapters have developed to fight corruption. Most of the tools listed are tools for citizens to report corruption. A similar reporting platform to those shown in the Transparency International list is ipaidabribe.com, which allows citizens in India to report cases of corruption.

Textbox 2: How to choose appropriate technologies for transparency and accountability initiatives

IDS, together with 'the engine room', funded through the DFID-supported 'Making All Voices Count' programme, developed recommendations on how to choose appropriate technology tools for transparency and accountability initiatives. The study is based on empirical research done in South Africa and Kenya. It presents a framework for improving tool choices. Based on this research, the online assistant 'Alidade' was developed for choosing and developing tools to support transparency and accountability.

The framework walks the user through four steps of choosing the appropriate technology: understand your needs, understand your tech, try it out!, and get help if you need it. In the online tool Alidade, this was further refined into six rules for choosing tech:

1. Research the people, the problem, and the tech. Do at least some research in three areas: the overall problem where you think the tool could help; what your intended users want and need; what technology options are available.
2. Think twice before you build. Look for existing tools that can do what you need. Building a completely new tool is complex and risky.
3. Get a second opinion. Someone else has probably tried a similar approach before you. Find them, and ask for advice.
4. Always take it for a test drive. Try out at least one tool, with the people you want to use it, before choosing. Trialling highlights problems at the start. It also raises questions you never knew you had.
5. Plan for failure. You will not get it right first time. Budget and plan to make regular adjustments to the tool throughout the project.
6. Reflect on what you are doing. Keep thinking about what is and is not working. Apply what you learn to your organisation's work, and share with other organisations.

These general rules are highly applicable to the DRC context as part of the design of disruptive technology intervention.

Source: de Lanerolle, Walker and Kinney (2016)

In 2017, the French Ministry of Europe and Foreign Affairs, Transparency International, the French Operator in Media Cooperation, and Liberté Living-Lab ran a Digital Award for Transparency. The award aimed at strengthening and promoting existing initiatives that promote good governance through three categories: Open Data, Citizen Engagement, and Anti-corruption Tools. In the latter category, one of the winners was again a tool for helping citizens in Madagascar to report incidences of corruption (Tsycoolkoly), while the other winner was aiming at raising awareness by providing useful information in order to fight corruption in Senegal (P.A.S.C.O).

Transparency International has also analysed the potential of blockchain technology to fight corruption. According to the report, blockchain technology "*has emerged as one of the most disruptive digital innovations in recent years.*" The report finds that "*Blockchain technology provides huge potential for more transparent, more accountable and efficient ways of storing government data and administering transactions. Yet, there are many challenges to overcome before the technology can be scaled. Legal frameworks need reform to regulate digital currency markets and to harness the full potential of blockchain technology*."

In a 2017 position paper, the G20 countries recognised Open Data as an important approach to improve transparency and accountability—and fight corruption. In a separate report, Transparency International also makes the case for using open data to strengthen anti-corruption efforts.

Making All Voices Count was a programme partly funded by DFID that supported the development and spread of innovative approaches to fostering accountable, responsive governance—many of them using tools and platforms based on mobile phone and digital technologies. It ran from June 2013 to November 2017. The programme website still provides a number of very insightful publications with collected lessons and principles-based learning from the 178 grants the programme issued.

Textbox 3: Applying technologies to broader, systemic governance challenges

"*Questioning an oversimplified vision of accountability problems as information problems brings into view not only a different vision of governance, but other roles that technologies can play in improving it. A different way of looking at governance is as an arena of contestation, in which government actors interact with each other and with non-government actors—both organised collectives and relatively unorganised citizens—in struggles over the distribution of public resources and over the very meaning of 'the public good'.*

Seen through this lens, unaccountable and unresponsive governance problems are deeper, more complex and more intractable than information asymmetry. They relate to systemic weaknesses in performance, corruption, malpractice, systematic discrimination against certain population groups, or the alienation of people by those who govern them. Information is but one factor among many that need to be addressed: the various actors and their behaviours, attitudes and capacities; their relationships with each other; the dynamics and processes in which they engage each other; and the key sites of opportunity for seeding changes in governance processes and outcomes.

Whatever the capacity available, some government actors may lack the political will to address these problems. Resolving them involves not applying technical fixes but

engaging with, contesting, and disrupting power relations. ***Technologies may help in this endeavour, insofar as they can contribute to building the 'critical mass' needed for citizens to push effectively for change in the face of opposition or inertia. But to be effective, tech-enabled pathways to change need to intersect with and complement non-tech or offline ways of reforming governance."***

Source: McGee, Edwards, Anderson, Hudson and Feruglio (2018:12-13), emphasis added.

4.3 The effects of (digital) technology on economic growth and prosperity

There is no doubt that bringing new technologies to developing countries can have a massive effect on the people in these countries, as, for example, the case of M-Pesa clearly shows. Equally, there is little doubt that general technological advancement is needed in order for an economy to develop. Indeed, Bresnahan and Trajtenberg (1995:83) emphasise that "*Economists have known for a long time that technical change is the single most important force driving the secular process of growth.*" In a similar vein, Fagerberg (2013) identified three factors affecting differential growth rates across countries: innovation, imitation, and other efforts related to the commercial exploitation of technology as driving forces of growth.

However, it is important to keep in mind that technologies cannot simply be copied and pasted from one context into the other. New technologies require a number of interconnected functions to adapt or be developed in the first place in order to function in a new context. A deeper assessment of the adoption of new technologies in developing countries finds that the transfer of new technologies is not as easy and effortless as promoted by many technology aficionados, because technological diffusion, adoption, adaptation, and innovation are embedded in political, institutional, and social structures (see Section 3.4). Salam *et al.* (2018a) for example argue that understanding pathways of and barriers to technological adoption and diffusion in developing countries is crucial. These pathways may vary from country to country depending on its specific context and history. Specifically, they state that "***there is a problem with the focus on frontier technologies, such as automation, AI and additive technologies, when non-frontier technologies are also highly important to many developing countries****. But, most fundamentally, the predictions and the debates they have spawned, take a deterministic view of technology in which effects are inevitable consequences of intrinsic features of technology and an abstract characterisation of jobs. Such a view fails to reflect that* ***the adoption (or not) of technology is not only constrained by technological feasibility, but by a range of other structures—political, institutional and social—in which it is embedded***" (Salam *et al.*, 2018a:13-14, emphasis added).

If we look at the evidence on the pathways by which digital technologies contribute to growth and poverty reduction, there is still a lot of ambiguity. Specifically, the link between the adoption of specific technologies and growth seems much less obvious than promoted by many. An IDS Evidence Report from 2016 reviews the evidence on the impact of digital technology[5] on economic growth and productivity (Hernandez *et al*., 2016). The authors conclude that "*although economic growth and digital technologies tend to have strong correlations, no one has yet resolved causality.* (…) [Given the current evidence,] *it is possible to argue that the economic impacts of the internet are caused by a third variable; that the economic impacts lead to internet*

[5] The authors of this report contend that, "due to its ubiquity and diversity, it is impossible to capture the impact of digital technology as a whole on economic growth. Instead, the term 'digital technology' is typically used interchangeably with 'ICT Investment' and different sets of ICTs such as computers, the internet or mobile phones." (p. 6)

adoption at the same time that internet adoption leads to economic impacts, and that it is economic growth that causes internet adoption rather than vice versa" (Hernandez *et al.*, 2016:10).

In their report, Hernandez *et al.* (2016:10) put together a list of mechanisms that were identified by various papers and reports as having the potential to facilitate economic growth—particularly regarding ICT and the internet:

- Fostering inclusion through access to information; increasing efficiency and productivity through automation and coordination; increasing innovation through scale economies and cooperation; reducing barriers to newcomer firms
- Helping companies to reach economies of scale
- Fostering technology diffusion; improving decision-making quality for households and firms and resource allocation
- Reducing production costs and increasing demand and investment
- Increasing international trade; lowering transaction costs; improving quality and lowering the cost of offshoring functions, thus stimulating international trade
- Increasing information flows, innovation, financial capital access, entrepreneurship, and enhancing labour; increasing access to markets and giving rise to the micro-multinational (small and medium enterprises (SMEs) that can go global from day one)
- Reducing information asymmetries between buyers and sellers, and reducing the need for intermediaries
- Providing economic agents with empowering information and increasing firm efficiency and competitiveness
- Rejuvenating traditional sectors; 75% of the gains of the internet are captured by non-internet companies
- Overcoming infrastructure limitations through new platforms like M-Pesa.

The authors stress, however, that these mechanisms are assumed, rather than proven ways of supporting economic growth. A study by Molony, for example, contradicts tge assumption that information flow leads to increased trust when looking at the case of increasing information flows between farmers and traders: he finds that "*the ability to communicate using these new information and communication technologies (ICTs) does not significantly alter the trust relationship between the two groups (…) farmers, in effect, often have to accept the price they are told their crops are sold for – irrespective of the method of communication used to convey this message – because their buyers are also their creditors*" (Molony 2008, quoted in Salam *et al*., 2018a:23)

One of the major mechanisms by which new technologies are expected to lead to economic growth and convergence is through leapfrogging, i.e. the direct adoption of more recent technologies, missing out intermediate phases of technological evolution. A popular example is the adoption of mobile phone technology in developing countries without first adopting land-line technology. Digital technology in particular is seen as a promising target for leapfrogging by developing countries, as described in Section 4.1. There are, however, a number of prerequisites for leapfrogging to work, as expressed by Steinmueller (2001, quoted in Hernandez *et al.*, 2016:12):

- Absorptive capacities: the ability to produce or use ICTs is often acquired through tacit knowledge rather than manuals;
- Access to equipment and 'know-how' to make productive use of ICTs;
- Availability and linkages with other complementary technologies and sectors;
- Downstream integration capabilities: creation of internal markets, logistical capabilities and marketing capabilities to convince users of their utility, reliability, and value.

When assessing the evidence, Hernandez *et al.* (2016:12) find that "*there is no clear evidence that developing countries are disproportionately gaining from ICT investments or 'leapfrogging'* ".

Also with regards to the link between the adoption of digital technologies and poverty reduction, Hernandez *et al.* (2016:12) caution: "*At the macro level, correlations between ICT and economic growth often get conflated with correlations between economic growth and poverty reduction to argue that ICTs have a significant and positive impact on poverty reduction*". While there are studies that show a positive correlation between mobile coverage roll-out and poverty reduction, there is no clear indication as to causality—whether having access to mobile phones reduces poverty or whether reduced poverty levels allows people to start using mobile phones.

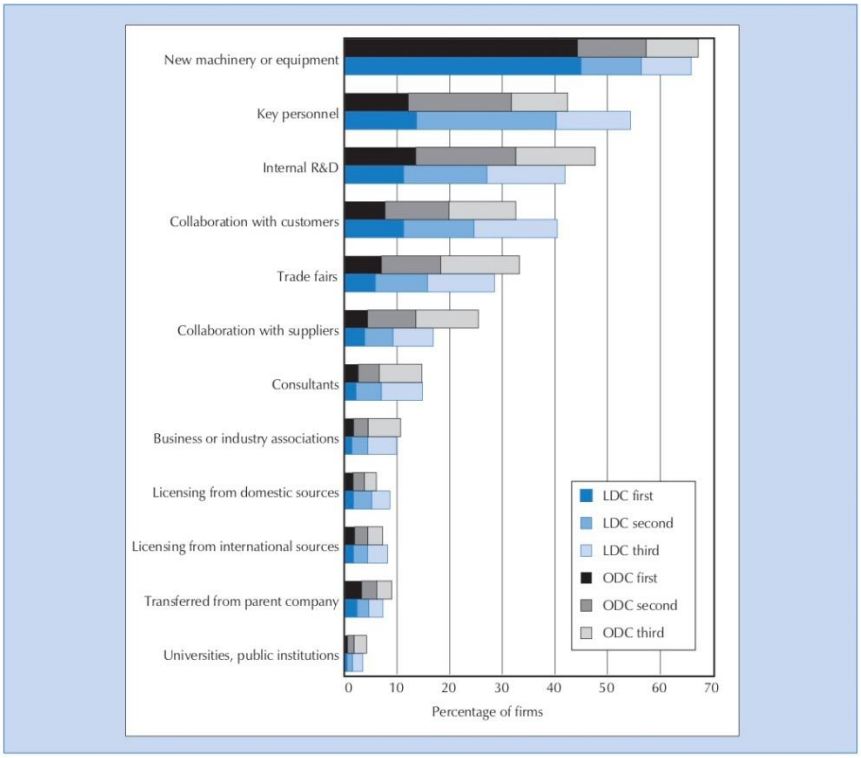
While the evidence about the pathways by which digital technology leads to growth and poverty reduction is ambiguous, empirical research shows how technologies are transferred to and adopted by developing countries, as described in the next section.

4.4 Sources of technological innovation in LDCs

This section summarises a review of how LDCs generally acquire new technologies (UNCTAD, 2007).

Figure 4 highlights the fact that both in LDCs and in other developing countries, the most important conduits for technology transfer are the acquisition of new machinery and equipment, the recruitment of specialised staff, internal R&D, interaction with customers and with suppliers, and trade fairs. More formal technology transfer channels like universities are ranked as least important.

Figure 4: The most important sources of technological innovation in LDCs



Source: UNCTAD (2007)

Remarkably, development assistance does not show up in the UNCTAD list as an important source of technological innovation. Yet it can still play a role in the technological development of these countries. The UNCTAD report introduced the

concept of 'knowledge aid', i.e. a type of development assistance that aims explicitly at strengthening the capacities and the knowledge base in LDCs to enable the adoption of new technologies.

The UNCTAD report also argues that instead of focusing on the capability to invent improved products and processes, the main focus should rather be on achieving catch-up with more technologically advanced countries. This does not imply that local innovation is not important, but that more attention should be paid to helping local stakeholders identify possible areas of local improvement based on what is happening elsewhere. Such processes can be stimulated through improving global connections through trade, participation in global technology fairs, or through fostering linkages between global suppliers and local business associations.

Absorption capacity plays a key role in understanding the use a country or its stakeholders can make of the knowledge that is available globally or locally, the knowledge that is embedded in a product or process, or the knowledge that is offered via services such as technical or consulting engineering or is made available as a result of R&D. Every effective technology transfer instance with a development objective hence needs to place much more emphasis on the absorptive capacities and tacit knowledge of the partner country's systems (Parente and Prescott, 1994).

'Knowledge Aid' and the improving of the absorptive capacity of LDCs to catch up with more developed countries is hence an important development intervention in its own right, as described in the next section.

4.5 Strengthening innovation systems to build technological capabilities

As the last section concluded, there is a need for a differentiated view on supporting new technologies and technological innovation in developing countries like the DRC. While the introduction of new technologies can have transformative effects, its success strongly depends on a deep understanding of the local and national context and the corresponding technological capabilities. An example of such a differentiated approach is the report commissioned by the innovationXchange of the Australian Department of Foreign Affairs and Trade (DFAT) (Institute of Development Studies and Caribou Digital, 2018). The report looks at the state of play of technological development in the Indo-Pacific region, and opportunities for Australian development assistance to support this development. Its recommendations are thereby mainly suggestions for interventions to strengthen technological capabilities rather than to transfer specific technologies. They include enhancing inclusive programming to enable women and marginalised groups to access new technologies; stimulating innovation in technologies that enable wider development, by championing the use of new technologies but also by strengthening the local innovation system; increasing efficiencies through catalytic investment in capacities such as improving digital literacy, skills development, and human capacity building; and supporting a free, open, and secure internet.

In Section 3.4 the concepts of technological capability and the strengthening of innovation systems were explained. Central to the innovation systems approach is the importance of the systemic patterns of interaction between the various elements in the economy that support innovation, such as the role, contribution, and responsiveness of the education system; the diversity, depth, and business-orientation of various technological institutions; and the competitiveness and innovation orientation of entrepreneurs. Thus, the interplay between knowledge application and absorption, as well as the different incentives and approaches to learning by doing and innovation are important.

While many people believe that innovation is driven by innovators and firms, innovation system research shows that innovation is more systemic: it is shaped by the prevailing innovation system. Entrepreneurs and individuals innovate because they have to; they are not only pressured by competitors, or by the availability of knowledge in the technological system, but also by increasingly demanding customers and the availability of or access to local or international equipment suppliers.

There are many factors in a country like the DRC that would make this difficult, yet critical. For instance, sophisticated or even aggregate demand could be poorly articulated, or sources of information, suppliers, or knowledgeable workers may be hard to identify. The lack of adequate market-supporting institutions to overcome various market failures and trust issues, coordination and search costs, may incentivise many to mainly trade in simpler goods and services, or the costs of coordinating any more difficult economic activities may be too high. Lastly, rent seeking in the public and private sectors may undermine the introduction and dissemination of innovations throughout the economy.

For a team to figure out where to start with a regional or sectoral innovation system, the technological capability framework (discussed in Section 3.4) can be applied by using the following six lines of inquiry:

1) The company level innovation and learning capability must be established. This includes paying attention to how and why companies innovate, collaborate, compete, and improve, in other words the firm-level factors affecting the performance of enterprises and the networks of customers and suppliers must be understood.
2) Attend to the macroeconomic, regulatory, political, and other framework conditions that shape the incentives of enterprises and institutions to develop technological capability and to be innovative.
3) Investigate the technological institutions that disseminate knowledge and support enterprises by providing knowledge-intensive business services and facilities.
4) Determine the role and responsiveness of all kind of education institutions, training providers and equipment suppliers in building the capacity of industries, employees, entrepreneurs and the society at large.
5) The patterns and dynamic of interaction and information exchange between the different elements in the system must be understood.
6) The poorly articulated needs or unmet demands that are not visibly pursued or communicated must be amplified.

Within Africa, there are several initiatives to promote innovation systems. For instance, the promotion of innovation systems is on the agenda of the Southern African Development Community (SADC), the Agenda 2030 as well as the African Union. In countries like South Africa, Botswana, Rwanda, Kenya and others, national systems of innovation approach are pursued. This is because the national innovation system can more easily be measured and compared with other countries: most attention is typically paid to the public sector, investments into R&D and post-graduate research, and participation in global research activities. There are research and academic networks that collaborate on multi and transdisciplinary research around innovation systems and technological capability development, often connecting African researchers and policy makers with European and global research networks.

However, the strong focus on the key role of the public sector, and the over-emphasis on the role of formal research and development, often does not translate to innovation in the broader economy. Not enough attention is paid to the dynamics of learning by doing, the broader technological capability in the country, to sub-national regions, or to building and strengthening public and private competence in innovating, solving

problems collectively, and the dynamics of interaction between potential problem solvers and problem owners.

4.6 Inclusive innovation

Making technological change more inclusive is one area where development assistance can play a major role. This was recognised, for example, by the report mentioned above for the Australian DFAT (Institute of Development Studies & Caribou Digital, 2018).

As part of his background paper for the Pathways for Prosperity Commission, Kaplinsky (2018) describes six cases where inclusive innovation has led to technological change that opened up opportunities to facilitate the transition to a more inclusive growth and development pathway. These cases are not specifically focused on PSD, yet they are still insightful as they apply the lens of inclusive innovation to technological change. This can, given DFID's focus on poverty reduction and reducing marginalisation, shed some light on how DIFD's PSD interventions in the DRC could become more inclusive.

Kaplinsky defines inclusive innovation as those innovations that *"contribute towards a more economically, socially and environmentally sustainable pathway in which the gains from growth are distributed more equitably than the currently dominant growth path"* (2018:2).

In the following, the key take-aways from the six case studies are briefly described:

The first case, on large-scale hydro-electric power (HEP), is something of an antithesis to inclusive innovation, and an example of how it should not be done. Large-scale HEP is a classic example of the mass production paradigm in which exclusion has become widespread. Kaplinsky argues that *"large-scale HEP reflects the co-evolution of concentrated economic and political power and results in exclusionary pathways"* (2018:46). However, technological advances in small-scale renewables such as solar and wind power are increasingly cost competitive and scalable, which provides the potential for supporting a new, decentralised, and more inclusive pattern of growth and development.

The second case looks at inclusive innovation in SMEs and SME clusters, in particularly those in the informal sector, which provide an important source of employment and income for marginalised populations. Kaplinsky argues that *"innovations in both process technologies and in organisation have a critical role to play here"* (2018:47). In the case study, he observes that there seems to be a beneficial link in the use of capital goods such as machinery imported from economies with similar endowments. He identifies two major hurdles for SMEs: first, that they are isolated and, second, the smallness of their markets and the impoverishment of their proximate customers. The first, he argues, can be overcome by collective action, while the second can be overcome by income growth, either through general growth or redistribution policies. As an additional factor he recommends assisting SMEs in penetrating new markets.

The third case study discusses distributed infrastructure, in particular mobile telephony. Here, the main case portrayed is the use of mobile money, enabled through mobile telephony. Kaplinsky regards M-Pesa as *"an exemplary story of how advances in ICT can serve to enhance economic and social inclusion in low-income economies"* (2018:48). He also presents it as a case that developed from the new 'heartland

technology'[6] of ICT. Furthermore, he argues that ICT, coupled together with renewable solar energy, has had a major inclusionary impact.

Healthcare in Cuba is used in the fourth case as an example to show innovation happening without the 'Schumpeterian motor' of competition.[7] The case study describes how Cuban healthcare was transformed into a distinctively inclusive system and how, in addition to this redesign of the public health system, development of advanced new pharmaceutical products based on biotechnology happened. *"The primary innovatory impulse in reaching these achievements was in the design and delivery of public healthcare … responding to the incidence of morbidity in Cuba, rather than to the pursuit of profit*" (Kaplinsky, 2018:48).

The fifth case study looks at transnational companies at the bottom of the pyramid. In particular, it looks at the case of Unilever in India, where the company used a combination of new product development and innovations in marketing to draw on the entrepreneurial energy of women in these low-income markets, which is seen as innovation in an inclusive process. However, Kaplinsky also notes that *"there is little evidence that marginalised populations have been actively involved in the design of inclusive innovations"* (2018:49) by transnational companies (2018:49).

The final case study describes the role of social movements and innovation in the urban wetlands in Bogota. The case study describes the positive contribution of social movements to the innovation of inclusive products and processes. This contribution is important because, as Kaplinsky notes, *"[w]hen the negative externalities in public goods are predominantly felt by marginalised populations, there is not just an underinvestment in innovation in these areas, but a bias in this underinvestment which leads to social and economic exclusion"* (2018:49). In particular, he mentions the importance of the involvement of user-communities in generating public awareness of the need for different paths of innovation. Kaplinsky furthermore contends that the case study *"also highlights how social movements can lead to the tailoring of innovation to meet the particular environmental characteristics of different locations"* (2018:50).

In conclusion, looking at social innovation points us towards supporting innovations and technological change that are more distributed, informal, frugal, and participatory, while at the same time building on the wave of the current sociotechnical paradigm driven by ICT.

5 Conclusion and recommendations—how to 'do technology development differently'

There are exciting new developments happening on a global level in terms of new technologies that have emerged over recent years. This massive technological shift will undoubtedly have consequences for developing countries' economies. The proponents of technology promotion say that the emerging new technologies, such as Artificial Intelligence or blockchain, will help us overcome development challenges we have not been able to tackle. Yet transferring such technologies to developing countries—and in particular to LDCs and FCAS—as a simple way to solve

[6] Kaplinsky uses the term 'heartland technology' to describe major families of technological change that are at the core of successive waves of techno-economic paradigms emerging as a result of disruptive innovation-led structural change. ICT is at the heart of the current paradigm, while frontier technologies such as artificial intelligence and the internet of things build the core technologies of the next paradigm, embodied in the fourth industrial revolution.

[7] "Competition erodes profitability and, to escape from competitive pressures, entrepreneurs innovate to create new products, production processes, forms of organisation and business strategies" (Kaplinsky 2018:58).

development challenges remains challenging. Technologies may have worked in some cases but have either failed after a while because the support environment was lacking or have remained isolated and have not increased the general capability of the recipient country actors to improve their technological capabilities in the long-term.

The evidence on how digital technology supports economic growth and poverty reduction is ambiguous. While there certainly is a correlation, the causal link has not been established. In other words, the available evidence does not allow us to conclude that digital technologies, like internet access or mobile telephony, have significantly contributed in their own right to economic growth or poverty reduction.

What we do know from empirical research are the general pathways through which developing countries are acquiring new technologies and upgrade their industries, as well as the institutional framework conditions that are needed for this—expressed as the technological capabilities of a region or country. Hence, a useful addition to promoting specific technologies is to improve technological capabilities in a region or country by strengthening its innovation system. Interventions to that avail need to be very context specific and remain flexible and adaptive (see Textbox 4).

This report is not questioning that technological development is important. Indeed, it supports the notion of the Addis Ababa Action Agenda, which was established to support the implementation of the 2030 Agenda for Sustainable Development, that: *"The creation, development and diffusion of new innovations and technologies and associated know-how, including the transfer of technology on mutually agreed terms, are powerful drivers of economic growth and sustainable development. "* (UN, 2015).

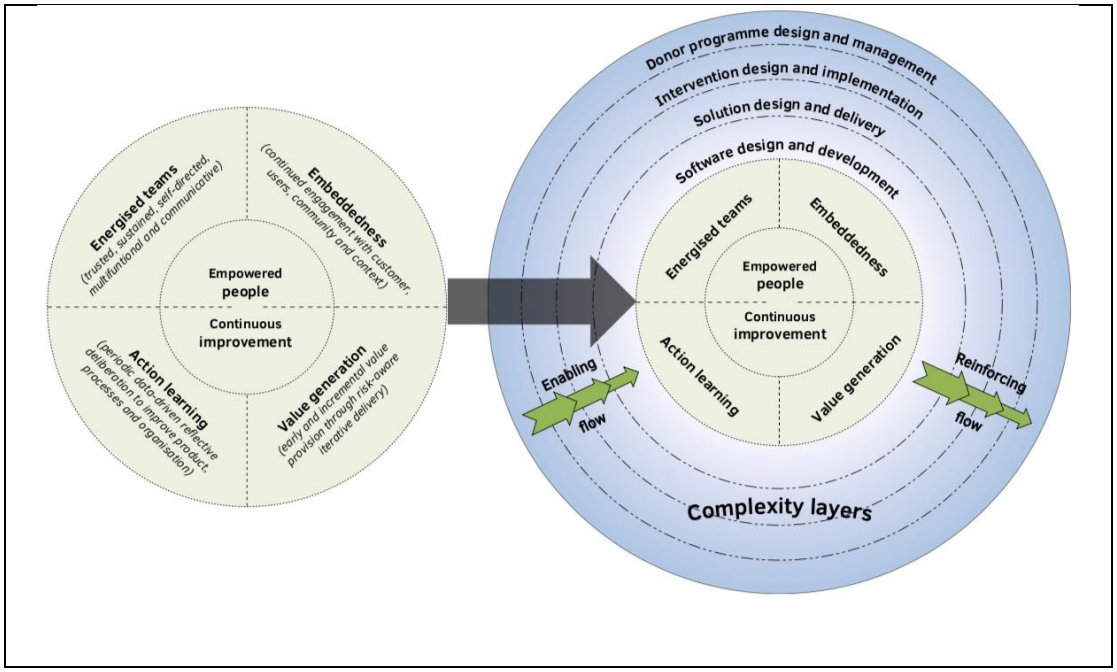
Rather, this report makes the case for moving from a sole focus on the transfer of specific technologies to solve development problems, to a more broad-based, systemic technological development focus involving various actors and institutions in developing countries. More concretely, it recommends the use of an innovation systems approach to strengthen the technological capabilities of developing countries like the DRC.

Textbox 4: The need for being adaptive and flexible

IDS, funded through the 'Making All Voices Count' development fund, has recently published a report that looks at adaptive management in ICT for Development (ICT4D) and particularly in Technology for Transparency and Accountability (Tech4T&A) (Prieto-Martin, *et al.*, 2017). It features an extensive literature review on practices in adaptive management and adaptive programming. The main message of the report is that adaptive capacity is essential for the success of technological development initiatives. Building on this insight, the report specifies an analytical framework to specify technology development adaptiveness issues and systematically build them into new initiatives.

The authors also identify four core adaptive development practices as well as a conceptual framing that links vertical and grounded accountability in development initiatives with the various collaboration flows that sustain adaptiveness. The scope of this paper is too limited to detail any of these, but it is highly recommended that they are consulted when moving into the planning of technology interventions.

The figure below shows the four core adaptive practices across ICT4D complexity layers, as formulated by Prieto-Martin *et al.* (2017).



As seen in Section 4.2, there are examples of organisations that have managed to develop a carefully crafted approach to introduce or develop new technologies into developing countries to benefit small enterprises and farm-based businesses. These organisations take a systemic approach as they try to understand the factors that facilitate the adoption of a specific new technology and what they need to put into place so that the long-term use of the technology is ensured—such as distribution and maintenance networks. Yet the predominant number of such initiatives still focus on solving specific issues for small-scale enterprises or farmers.

In order to use technological development as a driving force for the whole of the DRC's growth, and to enable the DRC to significantly progress technologically as a whole, DFID needs to take a wider perspective and understand how actors in the DRC can be supported to find, evaluate, develop, adopt, and use technologies themselves. Currently, the DRC, like most developing countries, has neither the research capacity to develop new technologies and adequate STI systems, nor access to international networks to support the effective acquisition and adaptation of technologies. National STI systems in most developing countries are far from able to reinforce the capabilities that are required to catch up with technological progress. UNCTAD (2014:9–10) reports that while in some instances gaps have narrowed in the last 30 years (for instance in secondary school enrolment and total R&D expenditure relative to GDP), in other instances gaps have notoriously widened, particularly in scientific and technological output.

Hence, while carefully reviewing the opportunities for using technologies to support the private sector overcome certain hurdles or to fight corruption, building national and regional innovation systems to strengthen the technological capabilities of the DRC needs to move more into focus in DFID's efforts.

Furthermore, DFID should exercise care when selecting a specific technology or group of related technologies to introduce into the DRC without first understanding why this uptake has not occurred naturally; what technological capabilities are required to fully leverage, adapt and further deploy the technology; and which of these capabilities already exist or must first be developed. This would involve:

- considering the key attributes of technology diffusion and adoption, and

- targeting the technology in a way that would specifically lead to more inclusive innovation.

Building technological capability and strengthening the innovation system could include collaborating with research groups in the UK, such as Oxford Policy Management (OPM), Science Policy Research Unit at Sussex University (SPRU), Overseas Development Institute (ODI), Manchester University, etc. who have a track record in supporting innovation systems development.

As an LDC and a FCAS, the DRC is constrained by several persistent market and structural failures. Where appropriate, technologies that overcome market and government failures should be prioritised, such as:

- technologies that improve or substitute for a lack of basic physical infrastructure, such as electricity supply, basic education, clean water, or adequate healthcare;
- technologies that reduce high coordination costs, or that are unlikely to be adopted by the actors in the DRC on their own due to high coordination costs between different economic actors.

The evidence suggests that trade connections are important for natural technology transfer and the dissemination of ideas. DFID can use its regional presence and its supplier and technological bases to broker linkages by aggregating demand and brokering connections with global or regional equipment, knowledge, or solution providers. This can be done using instruments such as business linkages, access to trade fairs, trade linkages, licensing and brokering market access. Instead of only looking sub-nationally for scale, considering leveraging regional programmes/ organisations, such as the African Enterprise Challenge Fund for synergies.

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Annex 1 – Terms of Reference

Background and objective

Science, technology and innovation (STI) has gained prominence in the global development arena in recent years. Many of the Sustainable Development Goals (SDG) refer to the importance of technology development and STI as drivers of poverty reduction, clean energy, decent growth, sustainable cities and climate change action. In the Agenda 2030, Goal 9 explicitly states the importance of STI for infrastructure development, sustainable industrialisation and innovation. Additionally, Sustainable Development Goal 17 on global partnership also emphasises the importance of enhancing international cooperation on access to technology, science, innovation and knowledge sharing.

In the Democratic Republic of the Congo (DRC), the use of technologies like electronic documents and mobile money have worked well for facilitating business registration and improving access to finance, respectively. Based on this, DFID DRC has expressed an interest to further support the development and adoption of new and existing technologies to enhance private sector development and inclusive economic growth in the DRC as part of its private sector development programme.

Consequently, DFID DRC wishes to better understand the challenges faced by MSMEs operating at the provincial level (see Annex A) in the DRC with relation to technological change. Building on secondary literature as well as on DFID's existing work on technological development[8] this consultancy will include two discrete phases of analysis: in a first phase the consultancy will provide a detailed review of the potential role of technological change in supporting and enhancing private sector development in the DRC and other 'fragile and conflict affected states' (FCAS). In a second phase, the consultancy will, in collaboration with the also planned MSME Survey, collect primary data on MSMEs' technological and absorptive capabilities. Based on this data, the study will generate a better understanding of the situation of MSMEs in DFID's target provinces regarding the enterprises' potential to try, adopt or modify technologies.

The two-stage approach will be used as the basis for two separate but interlinked processes and analytical products. The first phase constitutes the main focus of this consultancy and will be carried out as an independent study. The second stage will be used to strengthen the findings of the first stage. This second phase is, however, contingent on DFID's approval and ultimate start date of MSME Survey.

Overall, the study will shed light on what role technology might have in providing businesses in the DRC with opportunities for growth, how such technological change can be supported by DFID DRC, and how this would contribute to inclusive economic growth in the country.

Recipient

The primary recipient of this consultancy will be DFID DRC. However, it is envisaged that through the dissemination of the findings, via appropriate technical and non-technical means, the results of this product will be disseminated, as a public good, to other bilateral, multilateral, private sector, and NGO actors; who work in the space of business environment reform and market development in the DRC.

[8] https://www.gov.uk/government/publications/dfid-digital-strategy-2018-to-2020-doing-development-in-a-digital-world/dfid-digital-strategy-2018-to-2020-doing-development-in-a-digital-world

Scope and research questions

In a **first phase**, the consultancy will look at the effects of technological change and disruptive technologies and how they facilitate private sector development and inclusive economic growth in a broad and exploratory way. One area of particular interest, although by no means the only one, will however be to look at how these technologies can be used to curb corruption.

The primary role of the consultancy and the resulting report should **NOT** be to describe specific technologies, but to critically review empirical evidence of how supporting technological change has been used to facilitate inclusive economic growth in FCAS. When describing specific examples of support for disruptive technologies in different contexts, the study will explain why these examples are relevant for the DRC and how the described successes could be replicated in the DRC context, particularly on the provincial level. This might require some differentiation of the type of support for technological change needed in different contexts that reflect the situations in the different provinces. In this way, the findings of the study should show clear relevance with regards to the situation in the DRC and the recommendations of the study should be easily implementable as part of the forthcoming new iteration of DFID's private sector development programme.

In this first phase, the study will look at the lessons learned by development initiatives supporting technological change and disruptive technologies to address the following research questions with a particular focus on FCAS:

4. What does the literature in the field of development cooperation say about technological change and the use of disruptive technologies in supporting private sector development?
5. In what circumstances has the support of technological change and the use of disruptive technologies achieved an improved business environment and enhanced private sector development?
6. What other factors beyond the technologies themselves need to be taken into account when aiming to promote technologies to enable or facilitate private sector development?

In a **second phase**, the consultants will collaborate with the planned MSME Survey in order to generate a better understanding of the situation of the MSMEs in the target provinces. This part of the study will attempt to answer the following additional research questions:

7. What are the sources of support that enable the surveyed MSMEs to adopt, use or modify new technologies?
8. What is the capability of the surveyed MSMEs to adopt, use or modify technologies to improve their business's competitiveness and contribute to inclusive economic growth?
9. What technologies have been tried, adopted or modified by the surveyed MSMEs?