DIGILOGIC

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Trend radar as a meta-study

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Abstract	In this document, which is Deliverable 2.4 of the DIGILOGIC project, a trend radar is presented. The trend radar has been formulated through multimethod research comprising multi-vocal literature review; semi-structured interviews; analysis of workshops with companies; and comparative analyses of start-ups participating in the DIGILOGIC mentoring programming. Findings from these different methods converge into three principal findings. Most importantly, it provides a first digital logistics trend radar that is focused on Africa. Second, it has importance beyond one continent by extending the scope of logistics trend radars from the societal and the technological to also encompass the biological. Third, it provides an example of how lack of published studies focused on a particular continent need not prevent the formulation of a trend radar for that continent.
Keywords	digital logistics, technological trends, societal trends, biological trends, challenges, solutions

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PU	Public, fully open, e.g., web	x
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CO	Confidential to DIGILOGIC project and Commission Services	

*** R:** Document, report (excluding the periodic and final reports)
DEM: Demonstrator, pilot, prototype, plan designs
DEC: Websites, patents filing, press & media actions, videos, etc.
OTHER: Software, technical diagram, etc.

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EXECUTIVE SUMMARY

Digital transformation can become a catalyst for economic growth and development. One area where this transformation has large potential is the logistics industry. Traditional supply chain processes are being revolutionized by digital technologies, leading to the emergence of digital logistics. In the past decades, research has increasingly dealt with the current developments, challenges, and trends within logistics on a global level. However, the results of global research are not directly applicable to the logistics industry in Africa. Thus, DIGILOGIC carried out multi-method research in order to develop a logistics trend radar that is specific to Africa. The systematic approach included the conduction of a literature review, the conduction of interviews with on-the-ground experts from the logistics industry in Africa, the analysis of company workshops from the DIGILOGIC project as well as the analysis of 12 start-ups that are taking part in the DIGILOGIC Challenges Programme. The identified trends were revealed by method of purposive sampling from the countries with which DIGILOGIC is actively engaged. This deliverable D2.4 provides an overview of background and objective; explanation of the multimethod research; description of participants; discussion of analyses findings; and presentation of the DIGILOGIC Trend Radar.

Overall, this deliverable provides three principal contributions. Firstly, it provides the first digital logistics trend radar with a specific focus on Africa. Secondly, it extends the scope of logistics trend radars beyond societal and technological aspects to also include biological factors. Lastly, it demonstrates that the lack of published studies on a particular continent need not hinder the formulation of a trend radar for that continent. A summary of the analyses results is shown below.

Societal Trends:

Today:	Long-Distance Communication
< 5 years:	Education on Digital/Technological Capabilities, E-Commerce, Tracking and Tracing Solutions, Complementary Structures, Non-Physical Payment Methods, Reduced Human Work at Borders, Intra-Continental Cooperation, Certification of Origin, Platform Economy, Digital Addresses
> 5 years:	Establishment of Collaboration Culture, Resilient Supply Chain, Sharing Economy

Technological Trends:

Today:	Global Navigation Satellite Systems, Wireless Infrastructure, Open Source Software, Mobile Phones and Networks
< 5 years:	(Big) Data Analytics, All-Terrain Vehicles, Hybrid Architectures, Artificial Intelligence, IoT, Automation, Electric Vehicles, Blockchain, Digital Map Services, Cloud
> 5 years:	EdTechs, Drones, Cybersecurity

Biological Trends:

Today:	Minimal Infrastructure
> 5 years:	Alternative Energy, Shared Earth

Overall, findings from analyses of expert interviews, company workshop participants, and start-ups in the DIGILOGIC mentoring programme indicate that implementation of digital technologies is not a top priority for logistics in Africa. Rather, new and old digital and physical technologies are being combined to obtain the best outcomes possible within the contexts for logistics in Africa. Existing challenges refer to the lack of infrastructure and climatic challenges as well as societal fragmentation across Africa, which persists from the continent's partition by Europeans. Accordingly, interview participants highlighted the need to address societal issues that hinder logistics in Africa. Companies in the workshops and start-ups in the mentoring programme provide insights into how logistics can be carried out in challenging contexts. In a world where uncertainties are introduced into global logistics unpredictably by extreme weather events and social conflicts, valuable insights for the future of European logistics could be gained from ongoing analyses of emerging logistics solutions in Africa.

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ABBREVIATIONS

AfCFTA	African Continental Free Trade Agreement
AI	Artificial Intelligence
ASCM	Association for Supply Chain Management
DIH	Digital Innovation Hub
DPMM	Delivery Process Maturity Model
DS	Digital standard
DSC	Digital supply chains
DSCM	Digital supply chain maturity model
FMCG	Fast-Moving Consumer Goods
GDP	Gross domestic product
GHSC	Global Health Supply Chain
GPS	Global positioning system
GRI	Global Reporting Initiative
IA	Innovation Action
ICT	Information and communication technology
IoT	Internet of Things
IT	Information Technology
IVR	Interactive voice response
IML	Fraunhofer Institute for Material Flow and Logistics
LPI	Logistics Performance Index
LSP	Logistics service providers
LTL	Less-than-truckload
NGO	Non-governmental organisation
NTB	Non-tariff barrier
SC	Supply Chain
SCOR	Supply Chain Operations Reference
SME	Small to medium enterprise
SMS	Short message service
USSD	Unstructured supplementary service data

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1 INTRODUCTION

This document is Deliverable (D) 2.4 of the DIGILOGIC project: Trend radar as a meta-study. In this section, background, objective, and document structure are presented.

1.1 BACKGROUND

As illustrated below in Figure 1 (A), Africa had widespread internal and external logistics networks before the arrival of European colonial powers (Oliver et al., 2001). However, as illustrated in Figure 1 (B), these were permanently fragmented by Europeans imposing countries and borders across Africa, splitting land masses, water bodies, and ethnic groups (Michalopoulos and Papaioannou, 2016). It entailed the forming of what have been described as "absurd geographies" (Jahateh, 2019) due to the imposition of alien borders that were drawn without the involvement of Africans. For example, according to a study published in The Geographical Journal, there are 14 landlocked countries in Africa, which is more than the rest of the world put together (Griffiths, 1986).

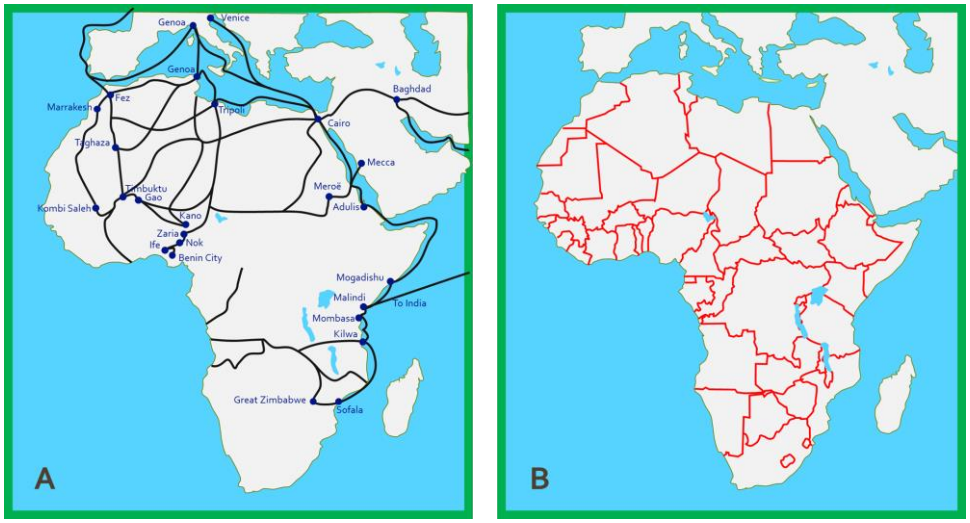

FIGURE 1: (A) AFRICAN INTERNAL AND EXTERNAL LOGISTICS NETWORKS FRAGMENTED BY (B) EUROPEAN IMPOSED BORDERS

In addition to imposing alien borders between African peoples and their established well-functioning trade networks, Europeans built physical infrastructure to serve their own purposes such as the removal of Africa's natural resources (Athow and Blanton, 2002). Thus, African's indigenous trade networks were fragmented by alien physical borders and logistics infrastructure. Although undoing the colonial imposition of alien borders and infrastructure on Africa is impossible, digitalization may introduce some opportunities to leapfrog over them. For example, digitalization can facilitate the exchange of logistics information across physical borders and improve the organization of transportation on existing physical infrastructure. Thus, despite concerns about what has been described as digital colonialism (Kwet, 2019), digital logistics could introduce new opportunities for prosperity growth in Africa. However, this is in the context of digital and physical infrastructure being constructed today in Africa by non-African countries for their own purposes (Antwi-Boateng, 2017; Gravett, 2020). Moreover, it is in the context of the complex legacy of geographical and cultural fragmentation in Africa caused by European powers over the past few hundreds of years (Michalopoulos and Papaioannou, 2016).

1.2 OBJECTIVE

The objective of the trend radar as stated in the DIGILOGIC Description of Action is to develop a publication assessing the most important digital technologies for smart logistics within a trend radar meta-study. Typically, a meta-study involves combining the results of many previous studies to obtain a comprehensive and balanced analysis of a topic that has already been studied widely. However, there are not enough published studies of digital logistics in Africa to provide the basis of a typical meta-study. Accordingly, the work reported in this

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deliverable and presented in the DIGILOGIC Trend Radar goes beyond typical meta-studies to include new primary research carried out by the DIGILOGIC consortium. This primary research adds to literature review, analyses of DIGILOGIC expert interviews, company workshops, and startups. Accordingly, the DIGILOGIC Trend Radar is not constrained by the lack of published studies of digital logistics in Africa. Rather, unlike typical meta-studies, it incorporates the latest developments in practical experience.

1.3 DOCUMENT STRUCTURE

The remainder of this document comprises eight further sections and four appendices. Next, in section 2, the research methodology is described. Then, in section 3, the literature review is reported. In section 4, details of expert interviews are provided. In section 5, details of company workshops are presented. In section 6, the startups are described. In section 7, findings from analyses of interviews, workshops, and startups are reported. In section 8, the DIGILOGIC Trend Radar is presented. It is compared and contrasted to previous trend radars. In the final section, conclusions are discussed.

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2 METHODOLOGY

As summarized in Figure 2, due to the low number of published studies concerned with digital logistics in Africa, the trend radar has been developed through a multimethod research process comprising a multi-vocal literature review; semi-structured interviews; analysis of workshops with companies; and comparative analysis of start-ups participating in the DIGILOGIC mentoring programme. The literature review encompassed global trends relevant to digital logistics and digital technologies in the logistics industry in Africa. In addition, primary findings were obtained through semi-structured interviews, which were carried out with on-the-ground experts from the logistics industry in Africa. Further primary findings were obtained from analyses of organizations participating in DIGILOGIC's Online Company Workshops, and from analyses of start-ups participating in DIGILOGIC's one-year programme of mentoring. The interviewees, the Company Workshop participants, and the start-ups provide a purposive sample. That is a small non-probability sample that has characteristics relevant to the objectives of the study (Campbell et al., 2020).

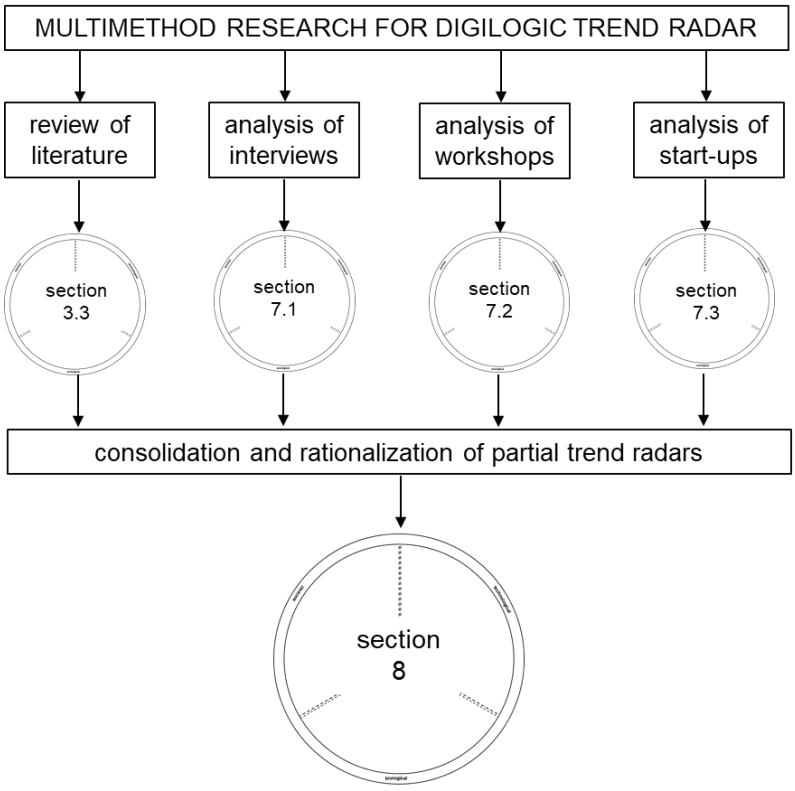

FIGURE 2: MULTIMETHOD RESEARCH FOR DIGILOGIC TREND RADAR

As summarized in Figure 2, four partial trend radars were formulated from each of review of literature (section 3.3), analysis of expert interviews (section 7.1), analysis of company workshops (section 7.2), and analysis of startups (section 7.3). The overall DIGILOGIC Trend Radar was formulated through consolidation and rationalization of the four partial trend radars (section 8). An overview of these five research activities is provided in the sub-sections below.

2.1 LITERATURE REVIEW

Throughout the development of the trend radar, a multi-vocal literature review was conducted. This type of review encompasses so called grey literature as well as formal scientific literature (Adams et al., 2017; Patton, 1991). Grey literature includes publicly available online information that may be produced by academia, businesses, communities, industries, governments, and/or NGOs, which is not necessarily peer reviewed and controlled by commercial publishers. Most of the literature referred to in the trend radar is formal scientific literature. However, grey literature is also relevant because technological advances can involve fast moving

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trends that are reported contemporaneously in online media, but much more slowly in formal scientific literature. For example, the TUB Logistic Navigator was used to gain insights on the current state of art of the logistics sector in Africa. The knowledge management platform synthesizes research on international logistics networks between Europe, China and Africa. Another yielding source is the transcontinental working project IDEA D4D Hub which focuses on an inclusive and sustainable digital transformation. In general, the literature focused on Sub-Saharan Africa is not very explicit. However, recent sources on challenges, opportunities and Africa's digital future do exist and have been reviewed for the purpose of this trend radar. The global trend radar, which is based to a large extent on the logistics trend radar 6.0 from DHL (Appendix D), serves as a basis for comparison.

2.2 EXPERT INTERVIEWS

As there are too few published studies concerning digital logistics in Africa for a typical meta-study, semi-structured interviews with experts from the logistics industry in Africa were conducted. All experts have either been or are still active in the logistics industry in Africa or have a direct relation to logistics in Africa. In total, 14 interviews between 30-60 minutes have been conducted. All interviews were held virtually through Microsoft Teams and Zoom and have been recorded and transcribed. Only one interview was replaced by written responses to the questions because the interviewee did not have the time to engage in a virtual interview. A semi-structured approach was chosen for the interviews including a mix of open and closed questions. This approach is specifically suitable in areas of research where the territory is largely unknown, and interviewers want to pursue certain leads or topics raised by the interviewees (Adams, 2015). In the context of the trend radar, this is especially important for the interviewers to focus and deepen on the insights and trends that were mentioned by the interviewees themselves without influencing their perception of trends through the addressing of logistics trends pre-dominant in Europe. The interview guide can be found in APPENDIX A.

Thereafter, the interviews were analysed by the inductive method of thematic content analysis. Following this approach, the interviews were scanned in order to avoid biases and develop an overarching impression of the data sets. Subsequently, the interviews were searched organically, looking for common patterns and themes between the interviews. This methodological approach was chosen on purpose as opposed to a deductive approach where interviews are analysed with a pre-determined framework. This ensures that no pre-conceived perception of logistics trends pre-dominant in Europe biased the analysis.

The recordings are edited into podcasts that are published on the library of the DIGILOGIC Community Platform. Furthermore, the key insights from the interviews are summarized in short articles of 1-2 pages, which are published as the "INSIGHTS Series" in the respective library on the DIGILOGIC Community Platform.

2.3 DIGILOGIC COMPANY WORKSHOPS

As part of Work Package 2, Fraunhofer IML conducted workshops with individual companies from the logistics industry in Africa. As set out in D2.3, the acquisition of companies was originally planned by conducting virtual Tech Talks (live webinars). During the Tech Talks that lasted about 60 minutes, experts from Fraunhofer IML introduced digital smart logistics technologies to the participants and shared relevant use cases from the African continent. Low participation in the Tech Talks indicated that the potential participants were not as interested as expected in specific digital technologies. Instead, knowledge on logistics processes and business models for advanced logistics service were of higher importance for the participants. Thus, the format was changed to an Open Consultation Hour. Entrepreneurs and innovators were able to register for and attend the Open Consultation Hour to ask questions that are related to logistics or the setting up of their business. Furthermore, they were offered to attend one-on-one company workshops with an expert from Fraunhofer IML to further work on solutions, broaden their horizon and leverage the technical expertise of the expert. Additionally, DIGILOGIC approached small-to-medium enterprises (SME), start-ups, and entrepreneurs through DIGILOGIC's African Digital Innovation Hubs, MEST and BongoHive. Also, contacts were made by project partner ENDEVA. To this end, a leaflet was developed (cf. Figure 3) that is used to approach the companies/entrepreneurs.

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FIGURE 3: DIGILOGIC'S LEAFLET TO APPROACH COMPANIES FOR THE COMPANY WORKSHOPS

On average, two workshops were conducted per company. The first one was focused on understanding the business model and the challenges the company is facing while the second workshop focused on the development of solutions or refining the business model. The discussions were performed online (via Zoom or Microsoft Teams) and used an online shared whiteboard solution licensed by Fraunhofer that is accessible via a web browser and hosted by a cloud provider (conceptboard.com). Access is restricted to the respective companies/entrepreneurs. The shared whiteboards can be used simultaneously by all participants (mentor and mentees) as well as prior to and after a workshop. Results can be exported as a PDF document by the participants.

Based on the experience with the first company consultation with MEGATRON a set of templates was created to structure the discussion, document discussion results and follow-up activities. The methodology is further explained, and the templates shown in APPENDIX B.

2.4 DIGILOGIC START-UPS

DIGILOGIC is carrying out a one-year mentoring support programme for 12 start-ups addressing challenges in digital logistics. In order to inform the development of the trend radar, the 12 start-ups' activities are analysed in terms of maturity models and fitness models. Maturity models are well-established in assessing the maturity of an organization's processes. For example, one maturity model has five maturity stages: basic digitalization, cross-department digitalization, horizontal and vertical digitalization, full digitalization, and optimized full digitalization (Asdecker and Felch, 2018). By contrast, fitness models are concerned with analyses of compatibility with the environment in which survival and growth are intended (Darwin, 1869; Gould, 1976; Odling-Smee et al., 2003; Spencer, 1864).

2.5 FORMULATION OF THE TREND RADAR

The DIGILOGIC Trend Radar is formulated through a step-by-step process of adding the trends identified through each of the four aspects of the multimethod research: literature review, expert interview responses analysis, company workshop analysis, and start-ups analysis. A partial trend radar is shown for each of these in the relevant section 3.3 and subsections of chapter 7 (Analyses). Subsequently, the complete DIGILOGIC Trend Radar is presented and discussed in section 8.

A trend radar is a diagram in the form of a radar screen. A trend radar can provide an overview of many different trends. A radar diagram can be divided into several segments, each of which includes the trends of a particular category. The DIGILOGIC Trend Radar and the partial radars are divided in the three dimensions societal trends, technological trends and biological trends. The former two dimensions are in accordance with other trend radars, as for example, the DHL trend radar (DHL, 2023). The third dimension biological trends was included in alignment with literature highlighting the increasing occurrence of trends related to green and

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sustainable supply chains (cf. chapter 3.1). Resulting from the multi-method approach, trends in all three dimensions occurred in the DIGILOGIC Trend Radar as shown in chapter 8.

The more realized a trend is, the closer it is to the center of the radar screen diagram (Blechschmidt, 2022). It has been argued that a trend radar can facilitate people connecting and exchanging views across functions and departments (Boe-Lillegraven and Monterde, 2015). Furthermore, it has been argued that a trend radar can inform decision-making, such as whether to “wait and see” or “act now” (Heinemann et al., 2019). Thus, the DIGILOGIC Trend Radar is divided into three circles indicating the time until widespread implementation. Trends in the inner circle represent trends that are currently being realized on a large scale and implementation scaling up fast in relation to the total addressable market. Trends located in the middle circle are likely to be implemented on a large scale in the next 5 years, whereas trends shown in the outer circle will take more than 5 years to reach large-scale implementation compared to their total addressable market.

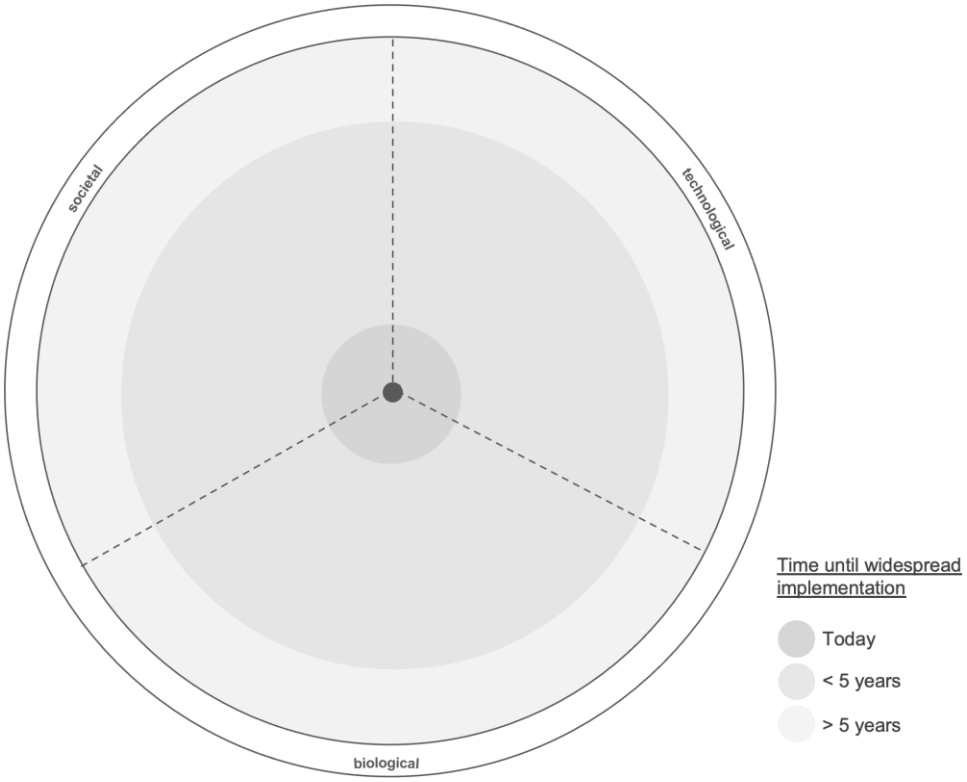

FIGURE 4: TREND RADAR TEMPLATE

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3 LITERATURE REVIEW

This section presents findings from a multi-vocal literature review, outlining current challenges, the state of art, and possible solutions and trends from academia and industry. First, the section reports findings from a review of global trends relevant to digital logistics. Next, it describes findings from a review of the current challenges pre-dominant in the logistics industry in Africa, followed by technological, societal and biological trends. Finally, it presents the contribution of the literature review to the DIGILOGIC Trend Radar.

3.1 GLOBAL TRENDS

Global logistics trend radars already incorporate social trends as well as technology trends (DHL, 2023), and the social relevance of trend radars may be increased by including contributions from online communities as well as expert groups (Zeng et al., 2019). The trend radar developed and provided by DHL on a bi-annual basis provides a comprehensive overview of the most recent and future trends in the global logistics industry. Hence, for this chapter, it was taken as the point of departure for global trends in the categories of social & business trends and technology trends.

However, in addition, logistics trend radars should encompass biological trends. This is necessary to include trends towards what is called green supply chain management (Sheu and Talley, 2011) or sustainable supply chain management (Bentahar and Benzidia, 2018). Furthermore, it is necessary to include the diverse range of logistics challenges and opportunities related to the environment (Abbasi and Nilsson, 2016; Zhang, 2020). For example, challenges and opportunities related to established issues such as reducing vehicle emissions (Van Woensel et al., 2002; Han et al., 2023), and to increasing priorities such as reducing loss of biodiversity (Green et al., 2019; Secco et al., 2022). Thus, this subchapter highlights the additional biological trends that were identified to be relevant for the global logistics industry in the upcoming years.

It is important to include a wide range of biological challenges and opportunities (Smith et al., 2020) in a trend radar for digital logistics. Not least, because biological variables can cause the expansion of digital logistics to lead to the global disruption of digital logistics. For example, the expansion of mining for raw materials that are essential for digital technologies (Buechler et al., 2020) and the expansion of physical logistics infrastructure can contribute to the loss of species habitats (Fernández-Llamazares et al., 2018; Sonter et al., 2018). Habitat loss can contribute to species migrations, which can contribute to the emergence of zoonotic diseases (Altizer et al., 2011; Mishra et al. 2021). Then, zoonotic diseases, such as Covid-19, can cause severe disruptions to global supply chains (Queiroz et al., 2022). Accordingly, the DIGILOGIC Trend Radar has three main categories: biological, societal, and technological. This biosocial-technical framing of digital logistics is congruent with the European Commission's preference for human development within planetary boundaries (European Commission, 2021), and recognizes the threats to biodiversity caused by the expansion of technologies that are claimed to be environmentally friendly (Sonter et al., 2020).

Biological topics for digital logistics include, for example, Covid-19 clearance protocols for truck drivers (Gachohi et al., 2020); addressing the negative environmental impacts of online shopping (Jaller and Pahwa, 2020); and increasing the sustainability of E-commerce packaging (Escursell et al., 2021). Other topics are reducing the negative environmental impacts of vehicle production (Koiwanit, 2018), including electric vehicle production (Xia and Li, 2022), cutting environmental costs from big data (Lucivero, 2020) and reducing the carbon footprint of Artificial Intelligence (AI) (Gibney, 2022). With regard to physical infrastructure, in addition to the need to reduce the multiple environmental impacts of road building (Praticò et al., 2020), there are trends such as the restoration of waterways to reduce risks of them drying out and or overflowing (Peters et al., 2021); and prevention of increased environmental harm from new shorter shipping routes (Lindstad et al., 2016). For all types of vehicles and infrastructure, there is growing recognition of the need to safeguard biodiversity (Narain et al., 2020), increase recycling (Asante et al., 2019; Rahman et al., 2020), and increase the use of biodegradable materials (Choi et al., 2023; Dalkiran, 2023). More broadly, important trends are increasing recognition of the need to manage environmental shocks (Davis et al., 2021) and climate change risks (Ghadge et al., 2020) in global supply chains. Figure 5 below shows a global trend radar for digital logistics. This is based on the most widely cited trend radar (DHL, 2023) with the addition of trends related to biological issues. In accordance with the preceding text, these are zoonotic disease protocols, recycling of digital infrastructure materials, recycling of physical infrastructure materials, climate change risk management, environmental shock risk management, low footprint big data, low energy AI, biodegradable vehicle materials, biodegradable infrastructure materials, biodegradable packaging, biodiversity safeguarding, optimized shipping routes, sustainable online shopping, waterway restoration, sustainable logistics, and green supply chain management.

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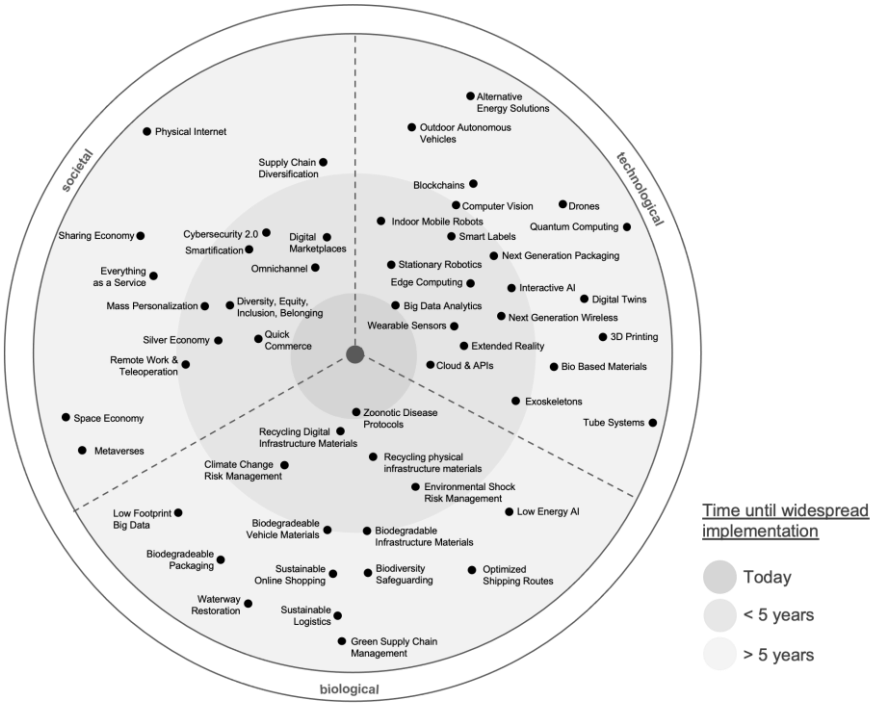

FIGURE 5: GLOBAL TREND RADAR BASED ON LITERATURE REVIEW (SOCIETAL AND TECHNOLOGICAL SEGMENTS BASED ON DHL 2023)

3.2 AFRICAN TRENDS

The movement of goods has a global impact by contributing to efficient supply chains as well as economic growth and logistics infrastructure around the world (Grater & Hoffman, 2021). Since the late 1980s supply chain topics appear on the academic agenda (El Baz et al., 2019). An intense debate continues to this day among academia and industry on the impact of global logistics and supply chain activities (Adewole, 2019). Nonetheless, the majority of research on supply chain management and logistics is conducted in Western and some emerging Asian countries (El Baz et al., 2019). The lack of research into logistics in Africa results in unavailability of data and broad knowledge on the topic (ibid.). Researchers and business analysts agree on economic growth in Africa and the continent emerging as a “strategic trading bloc” (Adewole, 2019). However, the significance of logistics infrastructure for efficient movement of goods and services only receives little attention (ibid.). This can contribute to slow economic growth although the trade within Africa and between Africa and the world has increased (ibid.). Academic research and the International Monetary Fund assign a significant role to trade logistics and supply chain activities in Africa due to its growing population, wealth and size of the consuming middle class and forecast “best opportunities for investors, businesses and logistics services providers” (ibid.). Along with that, research suggests the central role of digital technologies in transforming the way trade is conducted across borders (Kuteyi & Winkler, 2022; Grater & Hoffman, 2021).

With the emergence of industry 4.0 during the past decade, advanced technology implementation and usage have become essential in an increasingly competitive business environment (İyigün & Görçün, 2022). An increasing number of companies minimizes costs, increases efficiency and speed up their operations (Öztuna, 2022). Since logistics and supply chain management are the key to success in this context, Logistics 4.0 emerged (ibid.). "It is possible to define Logistics 4.0 as a new logistics system that is flexible, adaptable to market fluctuations, that lowers costs and supplies customer needs in the fastest and plentiful way“ (ibid.). Yet, technological advances such as big data, robotics, the Internet of Things (IoT) etc., “require time, talent, and investment” (Merkert & Hoberg, 2022). The following subchapter 3.2.1 highlights the current challenges dominating the logistics industry in Africa, followed by subchapter 3.2.2 focusing on societal, technological and biological trends.

3.2.1 Challenges

Although Sub-Saharan Africa seems to be on the move, different challenges remain in the public- and private sectors, inherently influencing the development of the logistics industry. In general, Grater and Hoffman (2021)

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identified the missing alignment of "motives, objectives and activities of public- and private-sector entities" as one of the biggest challenges when attaining supply chain efficiency. The government's role of strictly enforcing laws and the economic sector operating in favour of personal gain while circumventing the law stand side by side (ibid.). In addition, government officials play a major part in prevalent corruption, generating profits rather than enforcing legal activities (ibid.). The region-specific circumstances in the public- and private-sector make it difficult to achieve a stable economic environment, effective supply chain activities and the implementation of digital technologies which is elaborated in the following text.

Governance

Economists and policymakers increasingly recognize the importance of good governance and institutions for economic growth and development (Fayissa & Nsiah, 2013). Traditionally, countries in Sub-Saharan Africa experience "political instability, government ineffectiveness, the lack of rule of law, and serious problems of corruption" (ibid.). Investments are hindered by the political instability affecting future economic growth and creating a fragile socio-political environment (Dalyop, 2019). Nowadays, the political and regulatory environment is often described as unstable and inefficient, affecting whole economies in Sub-Saharan Africa (Kuyeti & Winkler, 2022). West and Central Africa are experiencing insecurity and militancy, especially in Nigeria, Cameroon and Mali, decreasing the attractiveness of investments and causing rising costs due to additional security needs (ibid.). In many parts of Sub-Saharan Africa, corruption and inconsistent policies and regulations affect customs procedures, transportation processes and infrastructure (ibid.). Reportedly, fund allocation processes among governments and organizations have been affected by corruption resulting in poorly maintained roads across the countries (ibid.). Disrupted supply chains can also be the product of cross-border restrictions, leading to very high lead times and costs (ibid.). In addition to that, Africa's digital divide, is often associated with its regulatory environment, to a large extent negatively impacting the continent's future (Joubert, 2021). Across Africa, the countries are at very different stages of digital development, making the regulation of data flows and information and communication technology (ICT) goods and services difficult (ibid.). This can be also traced back to differences in regulatory frameworks (ibid.). Joubert (2021) points out that one of the main challenges is government efforts to restrict or prevent information flows in order to manipulate competition (ibid.). This scenario is referred to as "Digital protectionism" (ibid.).

Trade

"Africa accounts for 16% of the world's population, but only for 2% of global trade" (ICA, n.d.), while intra-regional trade is significantly lower compared to other regions of the world (Kuteyi & Winkler, 2022). Kuteyi and Winkler (2022) highlight the two following reasons: the international export of only a few commodities (fuels, agricultural produce and mining products); and supply chain and logistics difficulties. The low trade activities and economic fragmentation can be ascribed to disruptive and inefficient supply chains (Kuteyi & Winkler, 2022; Oyedijo et al., 2021), generally due to high operation costs, poor infrastructure, and complex customs and administrative procedures (Grater & Hoffman, 2021). In terms of trade and supply chain activities, cross-border restrictions, excessive checkpoints, bottle-necked port operations and complex customs all add up to lead times and costs (ibid.). In fact, customs and border costs are 30% higher and the document processing takes up to 25% longer than the global average (ibid.). In turn, the goods are less globally competitive (ibid.) and import costs are higher (Kuteyi & Winkler, 2022). Another efficiency challenge for Africa are backloads (Kuteyi & Winkler, 2022). Since more products are imported than exported, vehicles have to return empty, which is an economic and environmental liability (McKinnon & Ge, 2006).

Infrastructure

An often-mentioned challenge for Africa is poor infrastructure in the energy, transport and ICT areas (Taisch et al., 2017). According to estimations, the lack of sufficient infrastructure reduced national economic growth by an estimated 2% in Sub-Saharan Africa (Luke & Walters, 2023). 80% of all freight is moved on the road although over 50% of the roads are still unpaved (Grater & Hoffman, 2021). The road networks are expensive yet poor in the inland (Kuteyi & Winkler, 2022; Oyedijo et al., 2021) which is traced back to a historical backlog of infrastructure (Grater & Hoffman, 2021). Heavy traffic, a high share of accidents and breakdowns affect lead-times and product delivery and result in economic losses (Oyedijo et al., 2021; Taisch et al., 2017). The transport infrastructure gap is also noticeable regarding rail networks and capacity (Kuteyi & Winkler, 2022), as well as maritime transport and air transport which are all weakly developed (Taisch et al., 2017).

The rudimentary developed logistics sector in many African countries is reflected by the Logistics Performance Index (LPI, see https://lpi.worldbank.org/international/global). The LPI is an international score created by the World Bank to assess the logistics performance on a country level. It has a score from 1 (worst

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performance) to 5 (best performance). African countries have a score between 2 and 3.4 whereas highly developed countries have a score of 4 or higher. Accordingly, many African countries therefore provide "less logistics friendly conditions" for logistics solutions that have been developed in the more benign environments of European countries. This is also reflected in the case of the Nigerian e-commerce company Jumia, which strives to become the Amazon.com of Africa. Besides its domestic market Jumia is especially present in northern Africa. Sustainable growth in sub-saharan countries has proven to be difficult due to the challenges of the respective logistics infrastructure. A simple imitation of business models that are successful in highly developed countries does not work (Peprah et al., 2022).

Technology

It has been opined that the logistics industry benefits from an increased use of digital (information) technology enhancing competitiveness, information flow, planning, control and transportation, especially since the adoption of Logistics 4.0 (Kuteyi & Winkler, 2022). Due to regional differences, the expansion of infrastructure varies across Sub-Saharan Africa, leading to an infrastructure gap (ibid.). Though the implementation of Information and communication technologies increased rapidly since the early 2000s (Taisch et al., 2017), the lack of infrastructure hampers the development and implementation of transportation and trade technologies (Kuteyi & Winkler, 2022). In terms of ICT assets, nowadays Africa grew to the second largest mobile phone market worldwide (ibid.). However, compared to regions with common needs and challenges the penetration rate of mobile phones is still among the lowest (ibid.). This also applies to internet access of individuals, ranging between 20% and 39% (ibid.).

Human Resources

Besides facing the challenge of providing access to the internet and digital technologies another key constraint is accessing workers with adequate (digital) skills (ibid.). Research indicates, that 65% of African CEOs believe skill shortage prevents them from innovating effectively and 54% believe they do not meet their growth targets due to inadequate skills (Luke & Walters, 2023). Luke and Walters (2023) also mention the impact of global skills shortage resulting in brain drain, which describes the emigration of relatively highly educated individuals (Docquier & Rapoport, 2016). Inadequate workforce affects the adoption of Logistics 4.0. It also affects the quality of the service provided due to inefficient time management and increased human error which in turn increases operational costs (ibid.).

Culture

There is a debate on the impact of culture on economic development with different approaches and theories around it (Kakonge, 2018). Luke and Walters (2023) suggest that "[…] cultural elements such as aesthetics, religious beliefs, social organisation, manners and customs and language can create distance between two trading countries" (Luke & Walters, 2023). The size of the continent contributes to a rich cultural diversity with different values and beliefs among society (Kakonge, 2018). Those cultural particularities can contribute positively to the development of the continent but also delay the progress (ibid.). However, adapting to local cultural specificities is a key aspect of organizational success (Tayo Tene et al., 2018). According to Kakonge (2018), declined sense of solidarity, lack of trust in the government, suspicion, especially in the area of business, and changed attitudes towards timekeeping in post-colonial Africa are some of the cultural attributes hindering progress.

3.2.2 Trends

The ITF (2021) predicts that continued economic development, especially after the Covid-19 pandemic, and the growing world population will lead to higher demand for transport in general. Total transport activity will more than double by 2050 compared to 2015 with a strong growth of freight activity, by 2.6 times, around the world (ibid.). However, as elaborated before, efficient trade activities and corresponding economic development are highly dependent on many different factors including supply chains, infrastructure, political environment, human resources and access to data and (information) technologies.

Societal Trends

The phenomenon of regional integration linked to free trade theory with the goal of increased welfare is not a new one (Butorina & Borko, 2022). In accordance with the approach of increased **Intra-Continental Cooperation**, the AfCFTA was launched in 2021 (Arreyndip, 2021). The AfCFTA is the largest free trade area in the world, bringing together 1.3 billion people and a US$3.4 trillion economic bloc (ibid.). A single market for commodities is established, allowing the free movement of capital and travellers aiming to attract long-term investment as

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well as creating a customs union on the African continent (Asongu et al., 2021). According to estimates by the World Bank, "[…] the AfCFTA could lift 30 million people out of extreme poverty and around 68 million people out of moderate poverty, with women benefiting more than men" (Everington, 2022). However, those predictions and tangible benefits are subject to a lot of work and strong political will (ibid.) in terms of significant policy reforms and trade facilitation measures (World Bank, 2020). In October 2022, the Guided Trade Initiative was launched as a pilot initiative to test the operational, institutional and legal framework of the AfCFTA with eight countries, namely Rwanda, Cameroun, Egypt, Ghana, Kenya, Mauritius, Tanzania and Tunisia (Rao, 2022). To date, the AfCFTA has introduced five different operational instruments on its journey to facilitate trade and digitalization, including different digital platforms and funds.

Long-Distance Communication through mobile connectivity in Sub-Saharan Africa plays an important role regarding economic and social challenges (GSMA, 2022). Africa remains one of the fastest growing mobile phone markets and in 2016 about 80% of Africans owned a mobile phone (Mourdoukoutas, 2017). A great number of people only has internet access via mobile phones (Vodafone, n.d.). According to Myovella et al. (2020), about 77% of the population had a mobile internet subscription in 2018. However, the digital divide remains a challenge facing the migration from 2G to 4G. Vodafone (n.d.) suggests four steps to reach a universal usage of 4G including lower costs for 4G enabled devices, investments in demand, e.g., investing in digital skills, tackling the gender- and rural/urban-gap and refarming the 2G spectrum. Digital information and advisory services can be used to inform workers in the industries to conduct business more effectively, e.g., in agriculture (Vodafone et al., 2021), examples of mobile phone communication are "[…] short message service (SMS), unstructured supplementary service data (USSD), and interactive voice response (IVR) either through a call centre or through agents from government extension services, NGOs, agribusinesses agents, financial service provider agents […]" (ibid.).

Another Societal trend is the growing **Platform Economy**, resulting from expanded internet access and improved financial inclusion, shaping Africa's digital economy across regions, economic sectors and industries (Johnson et al., 2020). In this report, Platform Economy refers to general value-adding interactions enabled by digital intermediaries. Among other things, the regulation of cross-border movement is a key factor in effective transportation (Grater & Hoffman, 2021). Research suggests that digital technologies, including digital trade facilitation can help Africa reduce trade costs and become more globally competitive (ibid.). According to the opinion of Grater and Hoffman (2021), Africa's many transport corridor problems can be tackled by integrating ICT and digital solutions, improving production times, the efficiency of supply chains and customer lead times. One of the key goals is to increase productivity for all stakeholders (ibid.). Reportedly, the latest developments in ICT have brought great change to (international) trade facilitation (Mbouwé, 2020). *Trade information portals* are one example of digital trade facilitation. These single source websites provide all regulatory information comprehensively, accurate and up-to-date, which can result in tangible trade benefits (World Bank, 2012). The information is provided by governments to traders in order to be able to comply with country-specific regulatory frameworks (ibid.). In order to facilitate a trade information portal, different steps and considerations have to be taken in terms of costs, infrastructure, design and engineering skills, data access, maintenance and legal framework (ibid.). One of the AfCFTA operational instruments is the African Trade Observatory, a trade information portal at the continental level (Mbouwé, 2020). The *single window*, by the World Bank referred to as "A Path to Paperless Trade" (World Bank, 2022), is another digital portal that supports the efficiency of border management and clearance processes (World Bank, 2013). Often times, many agencies are involved in cross-border trade processes, such as health, agriculture, police, immigration, etc. (ibid.). "National Single Window systems, […] allow traders to submit all import, export, and transit information required by regulatory agencies via a single electronic gateway […]" (ibid.). This approach is based on the logic of effective information sharing among all border agencies (ibid.). Reportedly, the system reduces the clearance time by 31 days, from 44 to 13, and compliance costs are reduced by an estimated 50% (Grater & Hoffman, 2021). Although the implementation of such systems is often underestimated (ibid.), African countries, namely Senegal, Tunisia, Congo or Cameroon, have proven their ability to do so (Mbouwé, 2020). Customs clearance is usually the last administrative step in cross-border trade (Mbouwé, 2020). Another example is the Non-Tariff Barriers (NTB) Reporting, Monitoring and Eliminating Mechanisms introduced by the AfCFTA (AfCFTA, n.d.a). This new digital platform enhances transparency by allowing trades to report NTBs when trading within Africa (ibid.). The goal is to reduce costs as well as boost and ease cross-border trade (ibid.). Meanwhile, logistics giants, such as DHL, also play an active role in embracing digitalisation in Sub-Saharan Africa (International Finance, 2019). In the past years, DHL launched two innovative mobile platforms, namely the Express Mobile App and the Africa DHL eShop, in several countries (DHL, 2019a; DHL, 2019b). The platforms target customers to track parcels (DHL, 2019a) as well as to purchase from and connect with global brands (DHL, 2019b). Johnson et al. (2020) identified an annual user growth of digital platforms which also facilitate transactions by 18% across all countries.

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As the world is moving towards connectedness, intelligent networks and smart devices are sustainably transforming trade and supply chain activities (ibid.). Research suggests that digital technologies, including digital trade facilitation can help Africa reduce trade costs and become more globally competitive (ibid.). The combination of digital and traditional trade facilitation reportedly could have the biggest impact on the African continent (ibid.). In order to improve the effectiveness of trade, a great deal of information is required (ibid.). A potential innovation to improve information processing is to reduce the amount of paperwork involved as goods go through customs. However, this has societal implications because it can reduce the number of formal and informal jobs at border customs. Automated customs could replace manual processing and is one of the most important tools for simplifying inter-regional trade (UNCTAD, 2011), and thus **Reduce Human Work at Borders**. Trade is facilitated more efficiently and sped up by "[…] normalizing forms and documents, standardizing data, and simplifying and computerizing customs clearance procedures […]" (ibid.). According to Mbouwé (2020), many African countries are still struggling to develop their own custom systems, though it's within their reach.

Another partly applied approach, which promotes coordinated and integrated facilitation of trade, is One-Stop Border Posts (Winston et al., 2016). As the name suggests, this concept allows goods, people and means of transport to only stop once when crossing borders (ibid.). Journey and clearance times are shortened by joint controls to minimize routine activities (ibid.). Besides faster crossing times, reduced logistics costs and improved security are other benefits of this approach (ibid.). An existing example is located at Chirundu between Zambia and Zimbabwe, with estimated cost savings of US$ 486m per year, it reduced border transit times of 4 hours for trucks from 2007 to 2012 (Grater & Hoffman, 2021).

Another important driver for positive growth in the African logistics industry is the increased popularity of **E-Commerce** (International Finance, 2019). Improved internet connectivity, the spread of mobile phone telephony and financial inclusion, on- and offline, all lead to the growth of E-commerce in Sub-Saharan Africa (Igue et al., 2020). With the emergence of ICT, E-commerce is arguably providing unique opportunities, especially for SMEs, to conduct their business digitally (Myovella et al., 2020). Reportedly, online payments and purchases increased by 240% from 2014 to 2017 (ibid.). However, Africa still lags behind with E-commerce (ibid.). Whereas domestic markets flourish, the access to international markets remains difficult (ibid.). The reasons are the ongoing digital divide and institutional difficulties (ibid.).

The fact that many people in developing countries are unbanked (ibid.) also remains a hindering factor for E-commerce. However, with increased mobile phone access there can be **Non-Physical Payment Methods**, which could increase financial inclusion. Reportedly, "Digital finance has the potential to boost the annual GDP of emerging economies by US$3.7T by 2025" (Vodafone et al., 2021). Regarding the logistics industry, the development of mobile payment solutions at a regional level can help to reduce transaction costs, since trading, taxes, fees and charges have to be paid to different administrators (Mbouwé, 2020). When handling international payments, the money is transferred through several banks from buyer to seller, leading to increased transaction costs (ibid.). Nowadays, different initiatives working on the development of regional payment exist (ibid.). Examples are SADC Payment Integration System and EAC Payment and Settlement Systems Integration Project (ibid.). Even more recent at the continental level: The Pan-African Payment and Settlement System within the framework of the AFCFTA, building a centralised financial market infrastructure which enables the secure flow of money across borders (ibid.). The most successful business cases, boosting financial inclusion especially in rural areas, are Safaricom and M-Pesa (Vodafone et al., 2021). Meanwhile, M-Pesa serves over 51 million customers enabling money transfer with a mobile phone as well as payments and microfinancing (ibid.).

The education sector is being changed by the so called fourth industrial revolution with new technological advancements (World Economic Forum, 2023) and challenges by the COVID-19 pandemic (UNICEF, 2021). Many of today's generation have access to digital technology from the moment they are born, however, all children are not equally prepared for a digital future (Mhlanga, 2022). In the African Union, many children remain excluded from access to technical education due to divides in internet access, mobile phone access and basic digital literacy (UNICEF, 2021). The World Economic Forum (2023) describes one of the transformations of learning content as follows: "Accessible and inclusive learning from a system where learning is confined to those with access to a school building to one in which everyone has access". The COVID-19 pandemic has shown different solutions to remote education from "[…] paper-based take-home learning material to broadcast media lessons, mainly using TV, radio and digital platforms, with both online and offline capabilities" (UNICEF, 2021). These technical and non-technical advances need to be further developed for more resilient and sustainable remote learning (ibid.).

According to the World Economic Forum (n.d.), 1.1 billion jobs will be radically transformed by technology in the next decade. It has been argued that the Fourth Industrial Revolution will be accompanied by a **Reskilling Revolution**, which could create demand for millions of new jobs but could have the potential to widen inequality across the globe (ibid.). The current and future labour market are disrupted by pandemic and

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technological influences as well as the green transition (ibid.). A major challenge faced by organizations is the skill gap among employees, particularly in the field of emerging technologies, such as AI, machine learning, deep learning, big data and analytics, blockchain, cloud computing and networking (Kuteyi & Winkler, 2022; Digital Transformation Center Rwanda & Gesellschaft für internationale Zusammenarbeit, 2022). Estimations suggest that half of the global labour force might need reskilling by 2025 (World Economic Forum, n.d.). In a case study from Rwanda < 60% of the respondents indicated a lack of skills regarding IoT, which accounts for innovative shopping systems, infrastructure management and transportation systems for E-commerce (Digital Transformation Center Rwanda & Gesellschaft für internationale Zusammenarbeit, 2022). About 40% chose a lack of skills regarding Cyber Security, another important field area for ICT professionals (ibid.).

Moreover, a trend which is usually facilitated by digital platforms is the **Sharing Economy**. This relatively new phenomenon has emerged first in the Western world and now globally during the last decade (Novikova, 2021). According to DHL (2023), "[t]he trend of Sharing Economy refers to an ecosystem in which users (businesses and consumers) temporarily share, rent, or borrow assets or services instead of buying and owning them". This is most common in the hospitality, automobile, finance and education industries (Novikova, 202.). Popular examples are Airbnb, Uber and Coursera (ibid.). Though these platforms have emerged on the African continent and e-hailing platforms are among the most prevalent types of transactional platforms (Dunn et al., 2019), the trend has not been realized yet in the logistics industry.

Technological Trends

Though Africa has a relatively slow technological uptake and has lagged during past industrial revolutions (Ndung'u & Signé, 2020), researchers agree that the continent has a large digital potential (Jansen van Rensburg et al., 2021). The African logistics market has witnessed rapid innovation, especially in the last two years (International Finance, 2019).

The increased use of **mobile phones** and expansion of **mobile networks** in recent years leads to increased data generation and, thus, an expected rise in data use (Logistic Update Africa, 2016). Supply Chains produce large quantities of high-volume data (Ashcroft, 2021). It has been argued that optimising, analysing and learning from data, offers the opportunity "[…] to manage supply chain functions, […] forecast demand, increase accuracy, better understand buying cycles, estimate future warehouse capacity, and solve complex operational challenges" (ibid.). Therefore, big data analytics and AI can be understood to be an essential and necessary tool for shaping the future of supply chain 4.0 (Awan et al., 2021).

It has been argued that **Big Data** holds major opportunities when applied to supply chains in terms of sustainable technology and mobile-enabled data collection models at the business level (Logistic Update Africa, 2016). Supposedly, it can create a first-mover advantage (ibid.). However, big challenges go along with it as data protection and privacy remain underdeveloped in Africa (ibid.). Moreover, to effectively collect, manage and analyse data, investments in the capacity of national statistic offices would be needed (ibid.).

Industry experts also assign **Artificial Intelligence** an important role in shaping socio-economic activities (Arakpogun et al., 2021) and expanding Africa's competitiveness (Candelon et al., 2021). It has been argued that by mimicking human intelligence, AI can enable machines to facilitate human jobs, create greater efficiency and drive economic growth activities (Arakpogun et al., 2021). Areas of interest include access to affordable health care, inclusiveness of financial services, long-term food security and streamlining government operations (Hao, 2019). At the same time, experts argue that the increasing use of AI can have a negative impact, especially on developing countries (ibid.). These countries host a significant number of jobs that can be replaced by automation (ibid.). Multinational firms such as IBM Research, Google, Microsoft and Amazon have already invested and opened AI Labs across the continent (ibid.). African initiatives such as Deep Learning Indaba and Zindi are bringing together African data scientists and AI experts (ibid.).

Another technology which is increasingly implemented on the African continent and the world is **Blockchain** (Smart Africa & GIZ, 2020). Common areas of use include digital payment infrastructure, public spending and governance, tracing agricultural goods along supply chains and trade facilitation (ibid.). Simplified, Smart Africa and GIZ (2020) describe Blockchain as follows: "Blockchain technology describes a new way of data handling. […] A blockchain is an append only list of transactions which are stored in blocks and secured through cryptography. A decentralised peer-to-peer network of computers is processing, verifying and validating all entries". Smart Africa and GIZ (2020) offer a quite detailed strategic plan for the implementation of blockchain activity in Africa. The approach considers developing a pan-African blockchain strategy, seeking a pan-African harmonisation of data protection, deciding about policy options according to the goals of individual countries and the African community, developing a pan-African concept for token classification, supporting research and education and pushing for interoperability and harmonised standards (ibid.).

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Also, it has been argued that a significant role in solving bottlenecks and improving cost, quality and efficiency can be assigned to the **IoT** (Mbaye, 2022). Ndubuaku and Okereafor (2015) refer to IoT as "[…] the use of intelligently connected devices and systems to harness data gathered by embedded sensors and actuators in machines and other physical objects". Basically, IoT collects data, aggregates them into a network, processes it and stores it, impacting energy efficiency, security, health, education and many other areas (ibid.). The Wazihup platform, first launched in 2016 in cooperation with the EU, is an open innovation platform for the IoT and big data in Sub-Saharan Africa (European Commission, 2022). Within the Horizon2020 project, key societal challenges are tackled by collaborative problem solving (ibid.). Another joint project is the Wazihub, a follow-up project which creates an open hub for IoT and big data (ibid.).

In addition, it has been opined that **Cloud** Computing can play an important role in the Sub-Saharan economy across industries (Dahiru et al., 2014; Kshetri, 2013). The National Institute of Standards and Technology defines Cloud Computing as follows: "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell & Grance, 2011). According to Dahiru et al. (2014) SMEs can be primary beneficiaries of this technology offering the opportunity to enter local and international markets and to improve their competitiveness. Cloud Computing is a fast-growing technology in Africa (Mosweu et al., 2019), however, the lack of technical, legal and cognitive infrastructure hinders the successful adoption process of SMEs (Adane, 2018) and varies across the continent (Mosweu et al., 2019). The adoption of a strategy which meets the specific needs of Cloud Computing is required for successful implementation (Adane, 2018). Further recommendations include skill training, adequate legislation, an assessment of cloud services providers prior to the adoption, the inclusion of a records management clause in cloud service contracts and information deposition (Mosweu et al., 2019).

Kuteyi and Winkler (2022) recognize leapfrogging potential of the African continent regarding the infrastructure and expected to bypass the traditional intermediate infrastructure stages of other developed nations and take advantage of new digital infrastructure and data governance systems. Opportunities in the field of supply chain activities are seen in several types of services with relatively low physical infrastructure needed (ibid.). One example can be broadband technology. Academic literature suggests broadband technologies play a key role in the economic development and prosperity of developing countries (Hasbi & Dubus, 2020). A study shows, that "[…] expanding mobile broadband penetration in Africa by 10% would increase GDP per capita by 2.5%" (Vodafone, n.d.). So far (academic) literature on wireless broadband is limited and mostly focused on mobile phone adoption and use (Hasbi & Dubus, 2020).

In recent years, cybercrimes increased globally with Africa registering one of the highest rates (Bada et al., 2019). Cybercrimes affect the continent's social, economic and strategic growth with high financial damage amounting to billions of dollars (ibid., Mwangi et al., 2022). Challenges are perceived in three main areas: "[…] personal data protection, violation of intellectual property and security risk" (Mwangi et al., 2022). One major problem is the poor awareness of cyber security needs among the population (Bada et al., 2019). Research suggests that investments in **Cybersecurity** awareness campaigns could reduce cyber-related risks by 45% to 70% (ibid.). Policy recommendations include the approach "one continent, one law", increasing regional cooperation, picking up best practices, e.g., from the European Union's General Data Privacy Regulations Guide, or implementing the topic of cybersecurity in curricula to sharpen skills (Mwangi et al., 2022).

Another example of logistics technologies needing relatively new physical infrastructure are **Drones**. The African lack of adequate transportation and supply chain infrastructure affects the last-mile, especially in rural areas. In the field of health care where supply chain efficiency and effectiveness in terms of accurate and timely supply in emergency situations is vital, drones can solve most problems (Anim-Yeboah et al., 2022). In cooperation with the drone manufacturer Wingcopter and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), DHL has started a pilot project in Tanzania which focuses on drone technology for medical deliveries (GIZ, 2018). However, as of now drone delivery is limited to one item per trip and charging and battery capacity is finite, drones cannot replace conventional delivery models yet (Anim-Yeboah et al., 2022). Moreover, academic literature and research are still needed, especially with a focus on parcel delivery (ibid.).

The education system has changed significantly in recent years, with rapid innovation during the COVID-19 pandemic (Mhlanga, 2022). In particular, teaching and learning delivery modes have been affected leading to education-enabling technologies, so called **EdTechs** (Ochieng et al., 2023). "[…] Primary applications include the digitalization of textbooks and other instructional materials as well as new IT gadgets" (Mhlanga, 2022). More recent teaching tools may be based on IoT or AI, supporting the experience and performance of learners and teachers, management of the school buildings and transport systems and sustained distance learning (Mhalanga, 2022; Zeeshan et al., 2022). Other examples of digital technologies include educational digital platforms, mobile

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applications and augmented reality applications to educate and provide guidance for the population (Kuteyi & Winkler, 2022). Recommendations from the Digital Transformation Center Rwanda and Gesellschaft für internationale Zusammenarbeit (2022) are improving teaching materials in existing curricula in schools and institutions for higher education, cross-disciplinary teaching and learning, creating a reskilling fund and establishing a future skills research hub especially targeting women and girls. African Blockchain Institute, Digital Opportunity Trust and Coursera are some examples of existing education initiatives across Africa (ibid.).

Academic literature concerned with the topics of future employment and labour markets often mentions **Automation** as a technological advancement, meanwhile also with a focus on developing countries (Gaus & Hoxtell, 2019). Currently, there are different drivers and inhibitors of Automation in Sub-Saharan Africa in terms of social, regulatory, economic, infrastructural and capital factors. (ibid.). Gaus and Hoxtell (2019) predict an unequal spread of Automation across industries. Strongly affected will be high-wage manufacturing and high-wage service economy impacting the African middle-class (ibid.). Workers in agriculture and the informal economy will be less affected in the short to medium term (ibid.). "Finally, and largely beyond the control of African policymakers, firms that have off-shored production to Africa withdraw some or all operations, given that Automation allows companies to restore and produce closer to their domestic markets at lower costs" (ibid.).

Biological Trends

It has been recognized for some years that supply chains that take materials from Africa for consumption purposes in the EU threaten biodiversity in Africa (Moran and Kanemoto, 2017). In order to reduce threats to African biodiversity, a "**Shared Earth**" policy is being advocated for supply chains, which "combines conservation with livelihoods, local cultures and local institutions to generate local solutions that meet people's needs at the same time securing biodiversity and its benefits into the future" (Obura and Treyer, 2022). A major priority for Africa is to address the negative environmental health impacts arising from the mining of rare earth metals, which are essential to the production of digital devices and digital infrastructure (Olapido et al., 2023).

Furthermore, digital logistics depends upon the supply of electricity that is necessary for the operation of digital devices and digital infrastructure. However, "Sub-Saharan Africa is the region with the highest energy poverty rates, especially with respect to electricity" (Alves, 2019). So far, access to the national power grid, especially for rural areas remains scarce because of high costs and slow adoption (Adenle, 2020). Thus, the rising demand due to a growing population represents a significant challenge to sustainable economic growth (ibid.). Part of the solution is replacing fossil fuels and traditional biomass with **Alternative Energy** (ibid.), "[…] based on wind, geothermal and solar energy technologies" (Alves, 2019). In general, Sub-Saharan Africa has a great potential to take advantage of renewable energy sources (Alves, 2019) with regional differences, as Eastern and Northern Africa have the greatest potential and Central Africa has the least (Adenle, 2020). Concentrating on solar power, South Africa has the greatest potential (ibid.). Solar power has several advantages such as being the most abundant energy resource, rapidly decreasing costs as well as a low carbon footprint and minimal environmental hazard (ibid.). To exploit renewable energy sources, challenges of sociocultural, economic, environmental and technical nature need to be tackled (Alves, 2019). Currently, most solar power projects in Africa are initiated by donors (ibid.). A study shows that the implementation of solar power technologies requires "[…] an integrated policy approach to leapfrog the technologies […]" and drastic measures in the financing, market development and development programs (ibid.).

3.3 CONTRIBUTIONS TO DIGILOGIC TREND RADAR

Figure 6 below provides an overview of logistics trends in Africa as revealed by the literature review. As with the global trend radar, the trends are classified as societal, technological and biological. Societal trends identified are Sharing Economy, Intra-Continental Cooperation, Platform Economy, Reduced Human Work at Borders, Non-Physical Payment Methods, E-Commerce, Reskilling Revolution, and Long-Distance Communication. Technological trends identified are EdTechs, Blockchain, Drones, Cloud, Cybersecurity, Automation, Artificial Intelligence, IoT, Big Data, Mobile Phones and Networks. Biological trends identified are Shared Earth and Alternative Energy.

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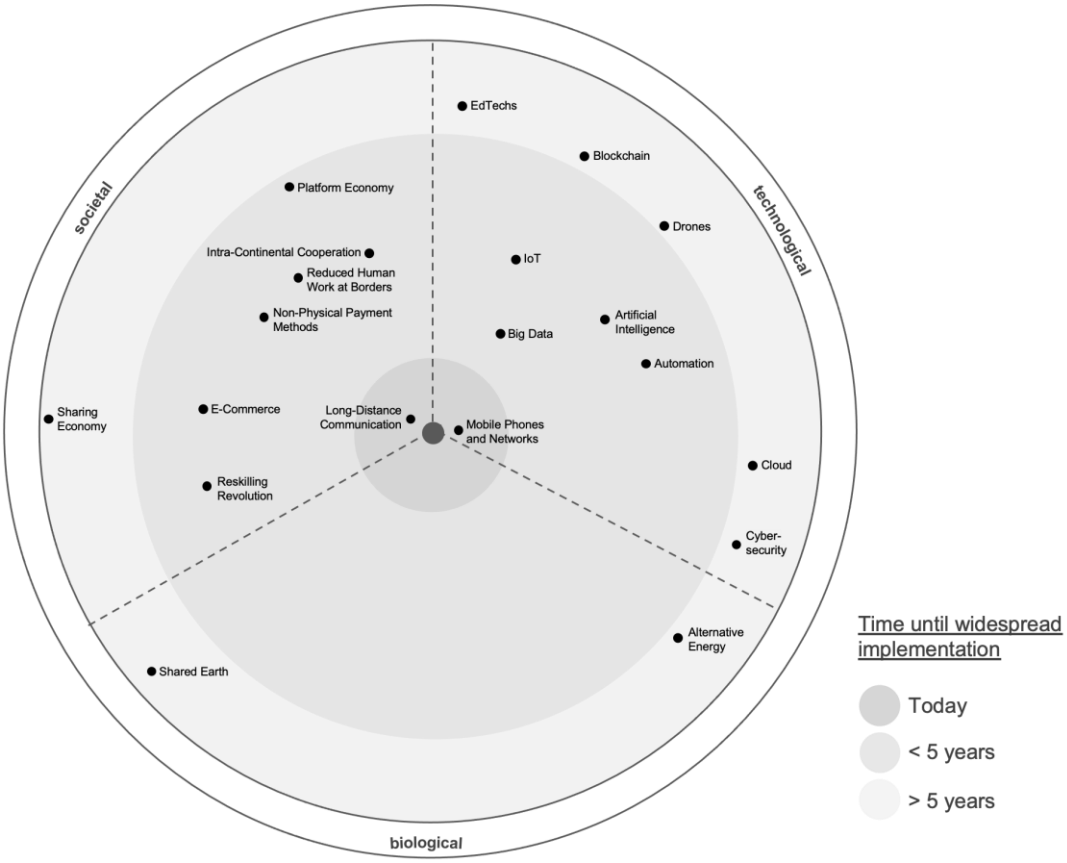

FIGURE 6: CONTRIBUTIONS FROM LITERATURE REVIEW (AFRICA) TO DIGILOGIC TREND RADAR

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4 DESCRIPTION OF EXPERT INTERVIEWS

First in this section, an overview is given of the interviews conducted. Then, the profile of each participant is described in more detail.

4.1 OVERVIEW OF INTERVIEWS

An overview of the interviews conducted for the trend radar is provided in Table 1 below. In total, 14 interviews were conducted virtually between January 2022 and June 2023.

TABLE 1: CONDUCTED SEMI-STRUCTURED EXPERT INTERVIEWS (AS OF 2ND JUNE 2023)

Int. No.	Date of the Interview	Name of the interviewee	Position	Company
01	06.01.2022	David Coleman	Founder and CEO	COLE Collective
02	21.01.2022	Sesinam Dagadu	CEO	SnooCODE
03	10.03.2022	Fabio Scala*	Founder & Director	Further Africa
04	29.03.2022	Juha Kunnas Kjell Andersson	Head of Product Chairman Partner Zambia & Zimbabwe	Vakava Technologies Ltd. Oy Vakaava Africa Ltd. Vakaava Africa Ltd.
05	19.05.2022	Stacy Nyathi	Chief Business Developer	Thumeza, Inc.
06	23.05.2022	Natacha Mugeni	Rwanda MD & Director of Health Operations	Kasha Global, Inc.
07	22.11.2022	Chinedu Hardy Nwadike Chinedu Princewill Dike	Communications Officer Supply Chain Officer	ColdHubs Ltd.
08	09.02.2023	Chuka Alumona	Gulf, GEMs, Levant SNO Leader & AMA-W Physical Distribution Leader	Procter & Gamble
09	28.02.2023	Angelica Coll	Research Assistant	Technical University of Berlin
10	20.03.2023	Lyndsey Duff	Chief of Staff	Amitruck
11	13.04.2023	Ahmed Agyapong Henry Kofi Mensah	Associate professors	KNUST School of Business
12	23.05.2023	Stephen Muraga	Founder & CEO	Nyamula Logistics
13	25.05.2023	Kwaku Tabiri	CEO	Swoove
14	01.06.2023	Vikas Kumar	CEO	Mercury Express Logistics & Tigmoo Group

*Note: This interview has been conducted via e-mail.

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4.2 INTERVIEWEE PROFILES

4.2.1 Sesinam Dagadu – SnooCODE

Sesinam Dagadu, born in Accra, Ghana, is a University of Warwick Engineering graduate. The qualified systems engineer who is referred to as an "accidental entrepreneur" founded the pioneering app SnooCode in 2011. For the first time, 8.7 million Ghanaians are able to access critical services with the digital addressing system allowing them to navigate even if there is no internet connection. In 2017, Dagadu won the Entrepreneurial Award at the Study UK Alumni Awards from the British Council in Ghana. The Award honours positive change and outstanding achievements in communities, industries and countries by international Alumni of a UK higher education. With his expertise in Logistics and Mobility Systems Engineering as well as being an entrepreneur in Africa, Dagadu knows the peculiarities of Ghana and other countries of the continent. Sesinam is member of the advisory board of the pan-EU-Africa network DIGILOGIC.

4.2.2 David Coleman – COLE Collective

David Coleman graduated in different subjects from universities in the UK and the Netherlands and gained work experience in various organizations in the fields of information management, marketing and entrepreneurship. As he realized the lack of mentoring in Ghana and too few people passing on their experience and business expertise, Coleman founded the Council of Local Experts (COLE) in 2018. COLE Collective is a Pan-African business support community providing mentoring, networking and peer-learning opportunities for local experts and entrepreneurs. David is member of the advisory board of the pan-EU-Africa network DIGILOGIC.

4.2.3 Fabio Scala – Further Africa

Fabio Scala is a founding member and director of Mozambique's National Investment and Development Bank (BNI), where he is responsible for the departments of sustainability, commercials and marketing. Before taking up the position at BNI, he served at a UK based family office with a focus on natural resources and logistics investment in Mozambique, Zimbabwe and Zambia for five years. In 2019 Scala founded Further Markets, a London based digital media holding company. Moreover, he is involved as a board advisor at Uhusiano Capital, a boutique, financial advisory firm specialized on impact investment with an African focus and member of the advisory board of the pan-EU-Africa network DIGILOGIC.

4.2.4 Juha Kunnas – Vakava Technologies Ltd. & Kjell Andersson – Tech Embedded

Juha Kunnas is an ICT professional that has been working in the field of cold chain logistics for the last 6-7 years. From 2017-2021 he had the role of the Chief Commercial Officer at Vakava Technologies Ltd and was Chairman of its subsidiary VAKAVA Africa Ltd. In the context of the latter, Juha ensured the provision of an uninterrupted cold chain from first to last mile logistics, especially for perishable food. Recently, Juha co-founded the company WICOAR Technologies Oy and works as a principal consultant at CSIT identity and access management. Juha is member of the advisory board of the pan-EU-Africa network DIGILOGIC.

Kjell Andersson is the CEO and founder of Tech Embedded Ltd, a company that provides smart mobile cooling solutions, solutions for environmentally friendly industrial water purification as well as solutions to produce clean and safe drinking water across Africa. Kjell is an experienced Sales Manager with a demonstrated history of working in the information technology and services industry.

4.2.5 Stacy Nyathi – Thumeza

Stacy Nyathi holds a Bachelor of Science Honors Degree in Journalism and Media Studies from the National University of Science & Technology, Zimbabwe. Over time she gained experience in strategic communications/public relations, filmmaking, community development, reporting and writing and social media management. In 2021, Nyathi started working as a Business Developer for Thumeza, a fintech company, headquartered in Johannesburg, providing data powered financing for the logistics sector in Africa. Due to her position at Thumeza, she has unique insights in the logistics sector, with a special dedication towards small scale transporters and an understanding for the challenges they face.

4.2.6 Natacha Mugeni – Kasha

Natacha Mugeni is a clinical psychologist and public health promoter, having experience in managing and leading various projects in the international development sector. Currently Mugeni is working for Kasha Global, Inc. as the Director of Health Operations. Kasha, located in Kenia and Rwanda, is the leading platform for Last Mile

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Access to Health in East Africa, as they sell and deliver pharmaceutical products, household goods and consumer health products directly to consumers, resellers, pharmacies and health facilities. By maintaining a country-wide distribution network, Mugeni has gained experience in the field of last mile logistics and the logistics sector overall.

4.2.7 Chinedu Hardy Nwadike & Dike Princewill Chinedu – Coldhubs

Dike Princewill Chinedu acquired his bachelor's degree in Statistics at IMO State University and his master's degree in Transport Management from Federal University of Technology, both located in IMO State Nigeria. He is a Supply Chain Specialist at ColdHubs Limited, an organization that provides solar powered cold storage to extend the shelf life of perishable food and reduce food waste with a focus on developing countries. His most recent project is concerned with post-harvest loss control. Princewill's areas of expertise include purchasing, supervision/training and re-training, seamless logistics and online tracking/GPS.

Chinedu Hardy Nwadike is a graduate of Industrial Chemistry from Madonna University Okija, Anambra State, Nigeria. With over a decade of experience in print, mass, corporate, and digital media, he is also the founder of OtownGist Media and Entertainment, one of the pioneering companies in the digital media sector in Imo State, Nigeria. Chinedu Hardy Nwadike joined ColdHubs Limited in 2021 as the head of ICT and Media and in early 2023 became the Information Technology System Manager where he oversees the implementation of digital solutions in the organization. He is also an author of three books as well as other articles published in print and digital media. He has earned awards and recognition as a leader, blogger, and media personnel.

4.2.8 Chuka Alumona – Procter & Gamble

Chuka Alumona obtained his bachelor's degree in electrical engineering at the University of Nigeria and his master's degree in Business Administration and Management at Obafemi Awolowo University. He gained hands-on experience at Procter & Gamble as a strategic business leader with 15 years of experience in Product Supply and Management roles. His fields of expertise include Manufacturing Operations, Supply Network Optimization, Supply Network Operations, Business Model Transformation, Distributor Operations and Organization Excellence amongst others with a focus on Sub-Saharan Africa. Chuka is member of the Advisory Board of the pan-EU-Africa network DIGILOGIC.

4.2.9 Angelica Coll – Technische Universität Berlin (TUB)

Angelica Coll completed her bachelor's and master's degree in industrial engineering at TU Berlin, where she also started her scientific career as a Graduate Research Associate in the Logistics Department, Institute of Technology and Management, in 2019. Additionally, she successfully completed a certification program by MITx in the field of Supply Chain Management. At TU Berlin, Coll is part of the project "IPLogE – Integration of Practice-oriented Logistics Education in Ethiopia" and teaches Applied Logistics Research. Angelica is member of the Advisory Board of the pan-EU-Africa network DIGILOGIC.

4.2.10 Lyndsey Duff – Amitruck

Lyndsey Duff completed her bachelor's degree in politics in Johannesburg, South Africa, and holds a master's degree in international relations from the London School of Economics and Political Science. Afterwards she worked in different research positions for the Institute of Global Dialogue, the House of Commons and independently. She gained working experience as the Head of Operations at the South African Chamber of Commerce, as an Inward Investment Officer at the Department of Trade and Industry for the Republic of South Africa and at What3words, a system which encodes geographic coordinates. In 2022, Duff started off as the Head of Strategic Partnerships at Amitruck, where she has become, most recently, the Chief of Staff. Amitruck is a digital logistics marketplace in East Africa, connecting clients and transporters to cut out expensive middlemen. With her expertise in market strategy and business development she has a unique insight into logistics and supply chain in East and Southern Africa.

4.2.11 Ahmed Agyapong & Henry Kofi Mensah – Kwame Nkrumah University of Science and Technology

Prof. Ahmed Agyapong holds a PhD in Strategic Management from Kwame Nkrumah University of Science and Technology (KNUST) and is associate professor at the same institution. His research is focused on entrepreneurship, strategic management, green supply chain and sustainability. Currently he is Co-Investigator of Affordable Sustainability for Logistics Network in Ghana (ASONG) and a Research Coordinator of Digital Logistics in Ghana (DIGILOG), under the German Academic Exchange (DAAD). With his experience based on several managerial positions, memberships at business and management academies as well as distinctive

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knowledge in the field of science and technology, Agyapong has a great insight in Africa's economic sector. Ahmed is member of the Advisory Board of the pan-EU-Africa network DIGILOGIC.

Prof. Henry Kofi Mensah's areas of expertise are Human Capital and Sustainable Logistics and Supply Chain Management. He teaches and conducts research in Business Sustainability, Responsible Management and Small Business Strategy since more than ten years. Mensah is an associate professor of management currently coordinating the project "Affordable Sustainability for Logistics Network in Ghana" (ASONG), jointly implemented by the Chair of Logistics at the Technische Universität Berlin (TUB), Germany, and Kwame Nkrumah University of Science and Technology (KNUST) Kumasi, Ghana. The project aims to link academia and industry in the field of sustainable logistics management. Henry is member of the Advisory Board of the pan-EU-Africa network DIGILOGIC.

4.2.12 Kwaku Tabiri - Swoove

Kwaku Tabiri is the CEO of Swoove, a prominent logistics software company in Ghana. He is also the co-founder and CEO of Roots Digital Limited, specializing in PaaS solutions. With expertise as an engineer and full-stack developer, Kwaku holds a bachelor's degree in aerospace engineering from the Kwame Nkrumah University of Science and Technology (KNUST). Under his visionary leadership, Swoove has achieved remarkable success, solidifying its position as a leading force in logistics software. Kwaku's dedication to innovation drives both Swoove and Roots Digital Limited to excel in their respective fields.

4.2.13 Stephen Muraga – Nyamula Logistics

Stephen Muraga is a Zimbabwean logistics expert who is a highly accomplished individual and the driving force behind Nyamula Logistics, a digital platform that connects cargo owners and transporters to drive a more efficient logistics ecosystem in Southern Africa. As the Founder and CEO of Nyamula, and together with his team, he is establishing the company as a prominent player in the logistics industry in Southern Africa. Since January 2023 he holds the position as managing director at the Zambia innovation hub Nyamuk Africa. Stephen's passion for logistics and his extensive experience in the field have been instrumental in Nyamula Logistics' success.

4.2.14 Vikas Kumar – Mercury Express Logistics & Tigmoo Group

Vikas Kumar is a dynamic professional with 19+ years of multinational experience in Strategy Planning, Sales & Marketing, Channel Management, Team Management, and Business Development. He currently holds the position of CEO at Mercury Express Logistics and Tigmoo Group. Vikas is known for his ability to drive business growth in new territories, implement effective sales and marketing strategies, and optimize resource productivity. With excellent communication and organizational skills, he has made influential contributions to the success of these companies.

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5 DESCRIPTION OF DIGILOGIC COMPANY WORKSHOPS

This section provides an overview of the company workshops conducted within Work Package 2 of DIGILOGIC. It includes an outline of the participating companies; describes their sphere of action and business model; their relation to the logistics industry as well as the current challenges they are facing. Furthermore, the support provided by Fraunhofer IML in the form of workshops is described in this section to shed light on the interplay of the companies and the local logistics innovation ecosystem. A summary is provided in Table 2 below.

TABLE 2: OVERVIEW OF CONDUCTED COMPANY WORKSHOPS (AS OF 5TH JUNE 2023)

Company	No. participants	Workshop Dates	Topics
MEGATRON	1	18.11.2022	• Business model development (services, processes, revenue model) for the distribution of fast-moving consumer goods (FMCG) to rural areas in Ghana
	1	28.11.2022	
	1	12.12.2022	
Merdeo Foods	1	12.12.2002	• Merdeo Foods is a Ghana-based B2B online marketplace connecting local farmers directly to restaurants and vendors • Business model development topics (processes and required technology) have been discussed
	5	25.11.2022	
	5	09.12.2022	
Mobility for Africa	5	13.04.2023	• Mobility for Africa, is a for-profit social enterprise, operational in Zimbabwe developing transport services for rural areas with e-tricycles • Discussion of network design topics
Nyamula	2	09.12.2022	• Nyamula Logistics Solutions Limited is a medium to long haul logistics and transportation business based in Lusaka, Zambia • Business model development topics (processes and required technology) have been discussed
	2	13.12.2022	
	2	05.12.2022	
ShapShap	3	18.04.2023	• ShapShap is a Nigerian logistics technology company developing innovative solutions for delivery companies. • Follow-up workshops are intended
ShaQ Express	1	08.02.2023	• ShaQ Express is a local E-commerce and courier company based in Ghana • Discussion of business models from comparable companies in Europe
Swoove	1	09.05.2023	• Swoove is a logistics service aggregator platform for offering high-quality delivery experiences for its customers • Follow-up workshops are intended
TheOceansMall	1	18.04.2023	• TheOceansMall provides services for fishers to sell their produce • Follow-up workshops are intended
Trober	1	10.02.2023	• Trober is a Ghanaian bus-hailing platform that connects commuters traveling the same route • Discussion on sustainable revenue models for Trober • Implementation & risk planning
	2	15.02.2023	
	1	27.02.2023	

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WeGoo	1	23.11.2022	• WeGoo is a delivery marketplace for local delivery companies and ecommerce • Specification of required expertise for consultancy • Business model development
	1	29.11.2022	
	1	17.01.2023	
YomYom	1	08.02.2023	• Transportation logistics for SMEs in Africa • Management of local drivers for YomYom • Letter to contact international LSP
	2	13.02.2023	
	2	22.02.2023	
	2	10.03.2023	
Zebra	1	09.12.2022	• Zebra is a logistics company executing parcel delivery in Ghana • Business model development

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6 DESCRIPTION OF DIGILOGIC START-UPS

As reported above, responses from interview participants indicate that new technologies are not always regarded as being of primary importance in improving the supply of goods. In this section, a review is provided of the digital logistics challenges that the twelve start-ups in the DIGILOGIC mentoring programme are addressing; their actions to address challenges; and the extent to which they use new digital and physical technologies.

Auto-Truck
Auto-Truck plans to address the high energy consumption and long durations in the transportation of goods by introducing electric vehicles such as its eco-cart, which it will produce locally to create local employment. In addition, Auto-Truck is developing new market offerings for the retro-fitting of fossil fuel vehicles with electric motors and batteries. Auto-Truck's operations are focused primarily on physical technologies, but digital technologies are important for the communication of information needed in their physical operations. In particular, they rely on digital technologies in the communication of training information to people who do not have previous experience in assembly of electric vehicles or retro-fitting electric motors and batteries to vehicles.

DeftPal
DeftPal aims to introduce a point-of-sale and inventory management platform that addresses the current lack of an all-inclusive platform service, allowing a seamless flow of data and information between suppliers, customers and transporters. The platform could also encompass life-cycle assessments of environmental impacts. DeftPal's operations are digital. They are using widely available web platform technologies and cloud services for the development and operation of their services.

Duniya
In order to address current supply problems, especially in rural areas, Duniya aims to introduce a web-based marketplace and app that allows village pharmacies to order medicines and medical supplies from their trusted local manufacturers and wholesalers. The target is that orders on the Duniya app are processed and delivered within 24 hours of confirmation of the order. Duniya's operations are digital and physical. In particular, Duniya's operations encompass a web-based marketplace and app, as well as physical delivery vehicles.

Farmisphere
In order to address current supply problems for fresh food, especially fish, Farmisphere is focused on improving fresh food logistics with its iSmart delivery cold box, which can be attached to delivery bikes and trunks of vehicles. Farmisphere's operations are primarily physical but digital technologies for online ordering and confirmation of delivery are important for enabling reliable deliveries.

InstaDriver
Due to current difficulties in finding competent drivers quickly, InstaDriver intends to set up a driver-employer marketplace that enables employers to hire competent and verified drivers in less than 10 minutes. InstaDriver's operations are digital through its software-as-a-service. Thus, their solution involves the consideration topics such as cybersecurity of third party e-wallet, data science to enable big data analytics, and GDPR.

Mwingi
Mwingi is focused on the problem that very remote areas far from paved road networks are underserved because there are no established supply chains. Mwingi's innovative business idea is the aggregation of demand for FMCGs in remote areas, such as cooking oil, flour, rice, sugar, etc. Mwingi's operations combine digital and physical technologies. In particular, an efficient digital point-of-sales system is essential for Mwingi to be able to have up-to-date information for its sales and stock. With regard to physical technologies, Mwingi uses conventional heavy trucks to make deliveries along paved and unpaved roads.

Radava
Radava aims to address the challenge that due to the lack of structured markets, smallholder farmers in sub-Saharan Africa fail to market their agriproducts and manage price risk effectively. For instance, the oversupply situation at the markets at the time of crop harvest forces millions of smallholder farmers to sell their produce at depressed prices. To address this challenge, Radava operates a commodity exchange model for the African market by depositing agricultural produce in physical warehouses and issuing an electronic receipt for the

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produce. The electronic receipt is the basis of three alternative trade options: sale of the produce; sale of the receipt to transfer ownership of the produce; use of the receipt as collateral for a loan.

Trotro.Live
Trotro.Live aims to address the current lack of information about TroTro[1] timetables and routes by introducing a trusted, fast and convenient on-demand transportation information service in Ghana. This is intended to be achieved through organizing data with the help of machine learning via a simple web app and mobile app for Android and IOS devices where users can download and access the database offline. Trotro.Live's operations are digital.

Trusty
Trusty is focused on applying blockchain to reduce the current challenge of information gaps between farmers and consumers. This involves improving the collection and traceability of information along the supply chain in total security, making the data collected accessible to all, and enhancing over time the contribution that each partner makes for the improvement of the supply chain. Trusty's operations are digital. In DIGILOGIC, Trusty is collaborating closely with Radava. They are working to combine Radava's warehousing system with Trusty's blockchain. Together, the two start-ups are exploring opportunities introduced in Kenya by the establishment of the Kenyan Warehouse Receipt Systems Act 8 of 2019 and the Warehouse Receipt System Regulations of 2021.

Vinmak
Vinmak aims to provide end-to-end solutions to smallholder farmers by creating access to inputs, such as seeds and fertilizer, mechanization services, agricultural extension information, credit and markets along the value chain for cowpea, maize, rice, soybeans, etc. Vinmak's operations are digital and physical. In particular, Vinmak has an online marketplace to coordinate the sales and deliveries of physical goods and services.

Wandonge
Wadonge is focused on reducing food losses for retail vendors of fresh produce. Wadonge aims to reduce the high food prices by reducing the 40 percent losses of perishable goods that are covered by increasing food prices. Wadonge's operations are digital and physical. Wadonge aims to address these problems with its Nitume Sokoni web platform and mobile app in conjunction with physical collection locations and delivery vehicles. Nitume Sokoni means to send to market in Swahili.

Yaaka
Digital logistics depends upon an electricity supply to power the many different types of electronic devices that are used in the digital management of physical deliveries. However, there are large areas of Africa where there is no electricity grid and no reliable alternative source of electricity. Yaaka aims to address the need for access to electricity along the value chains where there is no electricity supply. Yaaka intends to supply mobile charging stations, charged batteries, accessories, spare parts, and servicing for devices that are brought for charging. Yaaka's operations are primarily physical but digital technologies are important for processing orders. Moreover, Yaaka's operations are important for enabling the operation of the digital technologies of its customers.

Together, the 12 selected teams address many of the wide range of challenges in digital logistics from the local production of more efficient vehicles to the supply of information and energy throughout value networks that encompass urban areas and remote regions. Of these teams, only the operations of DeftPal, Trotro.Live and Trusty are entirely digital. However, the services that they offer are applied to the physical operations of other companies. The other nine start-ups' operations are digital and physical.

[1] TroTros are privately owned minibuses operating in Ghana and neighouring countries. They travel fixed routes, leaving the stations when filled to capacity but can also be boarded anywhere along the route.

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7 ANALYSES

In this section, analysis findings are presented from the semi-structured expert interviews, the company workshops and the DIGILOGIC Start-ups.

7.1 EXPERT INTERVIEWS

First in this subsection, findings from the expert interviews are described. Then, contributions to the DIGILOGIC Trend Radar from the interviews are presented.

7.1.1 Findings

According to the inductive thematic content analysis, common patterns and themes from the different expert interviews are identified and discussed. Trends within a certain industry usually cannot be identified and interpreted without putting them into context. In order to get a holistic view and understanding of the current state of the logistics industry in Africa, interviewees were asked to state and explain not only the current and future trends but also the challenges they see in the logistics industry. This important context helped to identify and evaluate the trends for the DIGILOGIC Trend Radar later on. The identified challenges are displayed in Table 3 below.

TABLE 3: OVERVIEW OF CHALLENGES FROM THE THEMATIC CONTENT ANALYSIS

Category	Common patterns of challenges
Governance	○ Lack of safety & security ○ Corruption ○ Lack of / inconsistent regulatory framework (e.g., technologies) ○ Global challenges (e.g., war in Ukraine)
Economy	○ Lack of available financing / funds ○ Working capital gap ○ High transfer rates for money transfers ○ Price instability
Trade	○ High dependency on manual labour ○ Missing resilience of SC ○ High bureaucracy in custom controls and inter-country trade ○ High import and export costs ○ Too many SC actors ○ Unavailability of materials and goods / long delivery times
Infrastructure	○ Lack of physical infrastructure / rural-urban-divide ○ Lack of digital infrastructure / digital divide
Culture	○ Lack of collaboration culture ○ Cultural diversity (e.g., language barriers, differences in values) ○ Resistance to change (e.g., digital innovations) ○ Lack of trust (e.g., in SC, E-commerce)
Human Resource	○ Lack of education on digital technologies / Inadequate skills ○ Workforce shortage
Biology	○ Climate change ○ Environmental pollution
Technology	○ Fast changing sector ○ Lack of digitalization processes

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The objective of the DIGILOGIC Trend Radar was the identification and evaluation of the most important digital technologies for smart logistics in Africa. However, throughout the project and the analyses, it became apparent that the logistics sector in Africa is quite complex and digital technologies cannot be reviewed independently of the social, economic and biological context they occur in. Accordingly, the trend radar has been expanded to include not only technological trends but also societal and biological trends. The following section highlights the main findings with respect to trends and discusses the results of the interviews.

Societal Trends

To find a viable path in the areas of working capital gap, infrastructure investments, lack of employees (e.g. truck driver shortage, especially in South Africa), pollution and renewable energy sources, Stacy Nyathi envisions the **Establishment of a Collaboration Culture** as a solution. Coll describes the national supply chain network as very segmented with many different actors leading to inefficient communication. Kunnas, Andersen and Duff confirm this observation. Duff says that too many middlemen involved potentially lead to control losses and costs driven up by 60%. However, Kunnas and Duff emphasize treating countries and regions across Africa differently. According to Duff and Coll, this is also based on the lack of information sharing among all parties. To accomplish this, Kunnas argues understanding the business environment is vital. He suggests sharing experiences, for example, by making use of local ambassadors and involving entrepreneurs, especially to acquire funding. Acknowledging different business cultures across Africa and understanding them helps building scalable solutions for the industry. Andersson also suggests collaborative work of governments, NGOs and other organisations to tackle corruption. Looking at the government level, Agyapong and Mensah demand to have a consistent strategy and joint policy framework, for example, by the Ministry of Agriculture and the Ministry of Transportation for the coordination of the distribution of agricultural goods across Ghana.

As a more general challenge, Coleman identifies the lack of written contracts as an influencing factor hampering the development of the logistics industry. “While written contracts are pretty standard in Europe, they are not in Africa. It is important to recognize the value of written contracts, which represents a commitment to that business from both sides”, he states. From his perspective, contracts have the capability of creating transparency and a basis for a trusted partnership. Currently, businesses are often not setting up written contracts because there is no retribution if a contract is breached. He hopes that more and more companies engage in the habit of establishing written contracts to foster an environment of transparent and trusted partnerships. With respect to the entrepreneurship scene, Coleman sees the risk that many people are not open enough to collaborate and cooperate with each other. This results partially also from the image that is transmitted about successful entrepreneurs in the press and media. Oftentimes, there is a large focus on the founder of a start-up who has successfully built and scaled up the company to success. Because of this narrative, Coleman states that many people in Africa don’t believe in the value of collaboration and sharing, thereby again hindering the establishment of partnerships that are essential for the scaling up of businesses.

In order to become (globally) competitive the pan-African logistics industry needs to be run smoothly, cost-effectively and efficiently (Coleman). Many interviewees mentioned the AfCFTA, established in 2018, hoping for a more logistics enabling environment in Africa. Alumona, Scala and Nyathi believe **Inter-Regional Collaboration** in trade will have a significant impact on the status-quo of the continent, especially on the logistics industry. Fabio Scala says the trade agreement is inevitable and concludes: “[…] Africa will finally do business with Africa”. Alumona predicts to see first benefits after only three years of implementation. As a part of this transformation, Alumona anticipates Africa becoming a net exporter over the next years. Nyathi opines that the AfCFTA will lead to an increased demand for truck drivers due to market growth. Key element of a more enabling environment arguably includes simplified custom procedures at borders. Coleman also hopes that the AfCFTA will dissolve barriers. According to him these barriers include a high load of bureaucracy which hinder the African logistics industry from scaling up. Alumona believes it is an enabler for the implementation of infrastructure, especially road and rail networks between countries but also within certain countries. Currently it is still challenging to travel across the continent. However, he says: “[…] this depends on the leadership of every country to boost it”. Coleman states: “The African Continental Free Trade Area is outstanding on paper, but companies need to feel there are solutions out there that will work for them”, and further “[f]irst and foremost, it’s important to note how diverse Africa is. It’s impossible to see same level of development across the continent. The Free Trade Agreement is important and it would be amazing to be able to feel the impact of that. If trade is fluid and all the systems actually work, that alone would change so much on the continent”. This also corresponds with Muraga’s and Tabiri’s opinion on the AfCFTA who think it is going to create a lot of opportunities, however, the implementation leaves some room for improvement.

Looking at digital platforms, Duff and Nyathi point to a digital divide across Africa. Working with pen and paper is still a common way to conduct business. Duff says: “Everything is still so incredibly manual […].

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Documents are still scrawled on a piece of paper and need a human signature". Moreover, Coll criticises regulatory frameworks, especially in Ethiopia but also in Rwanda and Kenya. She describes it as very "traditional" and remarks that "[the government has] not really implemented the policies that help companies into the implementation of digital platforms". In this context, Coll mentions the introduction of the single window system as a positive advancement of the digital platform trend (c.f. chapter 3.2.2).

Alumona predicts a huge expansion of **E-Commerce** across the continent. This can also bring new opportunities, for example, in terms of data collection and utilization. "So, I felt with the digital capability going up, this will improve significantly where we will have a lot of data on consumption, a lot of data on consumer behavior, a lot of data that will give you insight that you can project" (Chuka Alumona). This trend was also confirmed by Tabiri who states that more and more E-commerce companies are entering the Ghanaian market in recent years. However, there remain some challenges. Alumona and Mugeni experience a lack of trust with E-commerce platforms. Customers are used to be able to see the product before buying it. With Kasha Inc., Mugeni says, people are unfamiliar with this trend and are used to buying their products from brick-and-mortar stores. Kasha Inc. discovered the agent model to enhance the trust. Kasha's agent model encompasses the involvement of local women who are trusted by their community and support the companies' customers as agents in order to explain the functioning and benefits of using their online shop. Moreover, Alumona mentions too long delivery times and accessing rural areas as a challenge for E-commerce.

Another important aspect, for example, in terms of competitiveness but also in the context of E-commerce is the **Resilience of Supply Chain**. Alumona says the focus should sometimes be more on reliability than costs. "[…] [S]ometimes things that are reliable can be a little bit more expensive". Especially during the pandemic, the awareness for resilience increased. When designing supply chains, Alumona suggests to prior think about back up/alternative routes, instant changes that could happen, possibilities of using roads, ports or airways, etc. In addition to that, Coll recognizes transparency as vital for increased reliability. In terms of competitiveness of the African logistics industry, Kunnas and Andersson opine that the implementation of new technologies often comes with more difficulties since delivery lead times of technology are too long, spare parts are not available or also take a long time to deliver. An influencing factor for that are relatively high costs for customs and transportation from EU to Zambia, which leads to companies importing goods through other African countries, thereby again increasing delivery time and bureaucracy (Kunnas & Andersson). Kwaku Tabiri states that one reason for the slow growth of the logistics sector is the lack of manufacturing companies in Ghana and Coll further argues that in Eastern Africa the trend goes further in the direction of increasingly hosting value-adding processes in the supply chain inside the country and localizing the production. From Tabiri's perspective there might also be a higher focus of certain countries on specific industries, as for example, Ghana and Ivory Coast on Agriculture, Nigeria on production and fertilizer and Kenya on Technology development.

Two interviewees predict the establishment of a **Sharing Economy** as a trend. Lyndsey Duff says: "I do not think the future of logistics is businesses owning their own fleets". She works for Amitruck, a third-party logistics company which does not own any vehicles in contrast to traditional logistic businesses. Chuka Alumona agrees with that. He mentions 'Uberisation' which is a cloud-based system matching demand and supply. This business model suits transportation as well as warehousing operations. Customers can check for suppliers, choose the one which best suits the demand and book the service.

An important part of smart logistics are **Non-Physical Payment Methods**. Lyndsey Duff identifies the challenge of "[…] being hamstrung by things like exchange controls, which are still a really difficult feature of many African economies". She mentions fintech businesses and start-ups working on the ability to move money around flexibly, securely and without delay. This is currently not possible with traditional banking in Africa. Nyathi even goes further: "Many smaller operators still log their logistics business transactions using pen and paper, or they might not have a formal bank account with accompanying statements and records […]". In this situation funding is difficult to generate because credit worthiness cannot be verified. Reportedly, Kasha Inc. uses both, an online and offline payment model. On their website, USSD is used. Mugeni explains: "USSD means you can order our products just by clicking numbers. People are very familiar with the technology in Africa. It's free and you don't need the Internet or even credit on your phone to use it". Kunnas and Andersson also predict an increased use of mobile money and a decreased usage of cash in the future. According to them, a future trend are "smart integrated payment systems".

Besides structural challenges, the logistics sector often comes with indirect factors that prevent a smooth and fast implementation. According to Kunnas and Andersson, the lack of knowledge about the problem at hand on one side as well as the lack of knowledge about technology on the other side represent and issue. A large share of the population is not aware of the importance of an uninterrupted cold chain for preventing food loss and health issues and many do not have the knowledge or necessary skillset to value and use (digital) technologies. Based on Kunnas and Andersson's experience, companies should put a high focus on the

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Education on Digital/Technological Capabilities for their target group and share best practices in order to enhance their level of knowledge and capacity. Adding on to this, they mention that there is often a lack of trust and resistance to change that needs to be overcome by companies wanting to implement new technologies. The reason is that culturally trust is established through physically evaluating the quality of a product or the trustworthiness of a potential partner (Tabiri). To help meet these challenges, the Vakava team recruited young people from within an immediate community. These 'ambassadors' have the local knowledge and language skills to help shift opinion and encourage the changes that cold chain solutions inevitably require. "Everyone understands English but there are many local languages and that's why you need local guys on the ground if you want to succeed with the changes", Kunnas says. Most of the other interviewees agree on a lack of education with respect to digital technology skills among the population. Ahmed Agyapong believes there will be a revolution in the logistics industry where skilled workforce is crucial, especially in order to take advantage of digitalized logistics. Coll and Alumona agree that simply providing the tools is not sufficient. To tackle this challenge, Alumona demands education on digital capabilities starting in primary school. As an example measure, he names the necessity to provide laptops in public schools. On the one hand, the government needs to provide the infrastructure in terms of internet access and understand the value of a digital economy, on the other hand, the education systems play a vital role in teaching digital capabilities and supporting the growing industry.

Technological Trends

The majority of the interviewees agreed that logistics is one of the main drivers for economic development in African countries. For example, David Coleman states that if efficient, smooth and safe logistics can be assured across and between the countries, this will be a key enabler for the economic development of the African continent. However, Coleman states that there are certain challenges that prevent the logistics industry from enacting its facilitating role. One challenge that he mentions is the lack of safety and security for the transportation of goods. Companies are exposed to a high risk of robbery and hijacking in the transportation of their goods, especially across borders (e.g., Alumona, Kunnas and Andersson). Across the interviewees, there was consent that this often goes along with a lack of road infrastructure, especially in rural areas, and the existing infrastructure is often of poor quality and not maintained. On one hand, this increases the safety and security risk and on the other hand, makes it inherently difficult for companies to scale up their business beyond their original market (e.g., Coleman).

The majority of interviewees sees the responsibility for the provision and maintenance of infrastructure at the government level, however, they identify certain technological trends that contribute to solving or working around these challenges. Thus, companies can approach the security risk with the help of technology in the frame of the **IoT**. According to Ahmed Agyapong, collecting data through sensor technologies, conditions and processes can be tracked much more easily, creating transparency in the supply chain and transportation sector, as for example, with the tracing of trucks and goods in cases of hijacking. Vikas Kumar also predicts IoT and sensor technology, for example, for temperature control in cold chains, to become more relevant in the future. Currently, he identifies track & trace technologies as an important challenge. According to him, the next step would be to implement real-time track & trace. As an example, Fabio Scala reports that in a former South African company of his "some simple technology such as GPS tracking, and fuel consumption monitoring made an immediate impact on productivity". This also conforms to Angelica Coll's opinion on that topic, who sees a lot more transparency in the supply chains in the future through the tracking and tracing of products, especially in the agricultural sector and the monitoring of cold chains. In her opinion, these technologies will also provide progress in terms of security monitoring in the transportation and delivery of goods. Henry Kofi Mensah and Ahmed Agyapong also mention GPS in the context of lead time improvement: "One of the emerging technologies is using the GPS tracking devices to track the distances they travel". Reportedly, this enables companies to intervene and deal with occurring problems, reduce stops and, therefore, improve delivery times.

The implementation and use of sensor technologies along with the digitalization of processes enables the collection and processing of large amounts of data, which is another trend observed by the interviewees: **Big Data**. The collection and analysis of this data provides the basis for efficiency improvements in many areas along the supply chain (e.g., Alumona, Dagadu, Scala). Examples of this are the optimization of routes for delivery services as mentioned by Dagadu and Tabiri, the establishment of more reliable demand forecasting or the better management of inventory in warehousing as mentioned by Chuka Alumona. Kumar predicts that increased data analytics will have a positive impact on the carbon footprint. Angelica Coll states that predictive maintenance will also play a large role in the future, relying on the collection of data. A lot of work has been done with regard to making data available to authorities, the press and international bodies, but improvements are still to be made in order to foster the growth of the logistics industry (e.g., Dagadu).

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The basis for the collection of data is the Automation of processes. Many interviewees recognized that there is still a high dependency on manual labour in many African countries (e.g., Duff, Alumona). Lyndsey Duff describes the high amount of paper-based processes still prevailing in the industry and Tabiri describes how the delivery of packages requires several manual steps and interactions by the sender and receiver to reach its destination: "So if I am a student in Kenya trying to send something to Accra, I have to go to the bus station to give the package to the driver, give a phone number to the driver. When it gets to the other side, if my timing is right, I call the driver, ask if he's arrived, get my grandpa to pick up the package from the bus station or get a driver to pick it up. It's very complicated, right? Whereas in the West and in the East, it's as simple as putting a postage stamp on. It puts us in a box and it gets to your customer, right?". In Tabiri's opinion the issue is not anymore the access to certain services or products, but rather the inefficiency of the current processes (Tabiri). The challenge is tackled in recent years by several start-ups trying to digitize and automate the processes and connect the systems with each other. Chuka Alumona also identifies human errors as a challenge related to manual labor. He says: "If it is automated, the errors reduce quite a lot". Increased reliability directly influences the operation and, thus, competitiveness. Alumona observes that a lot of countries are now automating their port systems, reportedly, they make use of automated machines, for example, for loading containers. Further areas of process **Automation** are the end of line production and automized secondary packaging where initial steps have been taken, but it will take several years to create a significant impact across the countries (Alumona).

According to Henry Mensah, there is a large trend towards the digitalization of business models in logistics. Specifically, he refers to businesses moving online, such as the introduction of Online Takeaway by restaurants or the introduction of Uber in the transport sector in several countries. Chuka Alumona also observed this trend: "So that kind of **Cloud**-based operations we call the uberization in transportation. It is creating a lot of progress in that area and it's driving the cost down. You can see it in the normal consumer transportation all over the place taking over from the normal taxi operation that were there previously. You also now start having operation […] in warehousing […] [in] the same concept [as] Airbnb […]".

Looking into the future, David Coleman sees the potential for leapfrogging with the help of specific digital technologies, namely **Blockchain**: "Blockchain, the underlying technology for cryptocurrency, that is a public ledger of all transactions. The reason I bring it up is that Africans jumped straight into mobile technology before we'd even finished giving landlines out. And in that same way, cryptocurrency gives us an opportunity to leapfrog again. NFTs are another way to give intrinsic value to things that are unique. When mobiles came out and cost thousands of dollars, no one in Africa thought 'Oh, that's going to be ours in a few years' time,' but it was". According to Coleman there could even be potential for a common virtual currency for the whole continent. However, the requirement for any technology to be able to transform the economy, is that they need to be very user-friendly and simplified enabling the people to embrace and use it, he says.

Angelica Coll sees the potential for Blockchain in a different area of logistics, namely in the context of supply chain monitoring and management. With the recently implemented German Supply Chain Act she recognizes the opportunity for leapfrogging in the area of generating capacities for the implementation of Blockchain in African countries.

The implementation of such overarching technology trends often requires the set-up of a profound regulatory framework. In fact, Coleman, Dagadu, Coll and several other interviewees state that the lack of such policies or frameworks often accounts for the slow economic growth and the fostering of innovation. On the other hand, this also leaves room for opportunities and leapfrogging. For example, Dagadu states: "We are sort of at a crossroad when it comes to **Drones**. In Europe, I think policy has overtaken technology. But in Africa policy is still behind a little bit. So there is a small window of opportunity for innovations to happen in Africa". Dagadu and Coll further mention the example of the company Zipline which has been able to get high amounts of investment by first of all collecting a large amount of data on the safety of their technology by doing flights in Rwanda and Ghana. In Dagadu's opinion, this would not have been possible in Europe or the U.S. and provides them with a large competitive advantage. This complies with what Lyndsey Duff mentions: "Nowadays, the regulations and the regulatory environment in Africa have not caught up in terms of where we are and where we need to be for something like drone delivery". However, she sees interesting progress mentioning the example of Zipline. "With this innovation lifesaving medication can be delivered to people via drone, […] no need for road infrastructure […], which is really compelling".

With respect to transport logistics, Tabiri mentions that **Electric Vehicles** are heavily pushed by NGOs and the private sector, but in his opinion, this does not raise enough interest for the Ghanaian government to sustainably invest into, yet. However, he recognizes a trend towards Electric Vehicles in Kenya and other East African Countries, where governments are electrifying most of their supply fleets. However, he acknowledges that this on one hand requires a stable power grid and future improvements in the efficiency of such vehicles will help to reduce costs.

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Despite the identification of these technology trends, there is often a lack of ICT-Infrastructure and no secure energy supply network available in many African countries. Furthermore, the emergence of these technology trends is in most cases highly dependent on the penetration of reliable and consistent **Wireless Infrastructure**, which in turn is foreseen to be a large area of investment in Africa in the upcoming years (e.g., Alumona, Coleman).

Biological Trends

A common challenge mentioned by several interviewees is the lack of a reliable energy supply. According to Ahmed Agyapong and Henry Mensah, 80% of Ghanaians do have access to electricity right now, however, energy theft and illegal connection to the power lines is still an issue. The coverage in other African countries is often much lower. To tackle this issue, **Solar Energy Solutions** and renewable energy sources are good opportunities, especially for the target group of farmers in rural areas, for transportation and cooling of their products (Agyapong & Mensah). Fabio Scala also predicts an expansion of the market of African natural resources, especially energy. He also ascribes this to "[…] the current Western reality caused by events like BREXIT and the conflict in Ukraine". Kunnas and Andersson are both active in the cold chain sector of logistics. This area brings along a lot of challenges in the logistics space, however, it also provides the potential for current and future business opportunities. One of the largest challenges is the establishment of an uninterrupted cold chain in order to reduce post-harvest losses and enable the storing and transportation of perishable food, fruits and fish that would otherwise go to waste. For that, large amounts of energy are needed, while a steady and sufficient supply of energy in many countries in Africa is still not established. Kunnas and Andersson, therefore, agree that Solar Energy Solutions will play a larger role in the establishment of uninterrupted supply chains.

In terms of sustainability, Chuka Alumona believes that Africa will only scratch the surface, but that there is also a lot of potential across sectors. As an example of something that is already being implemented by P&G, he states the concept of zero manufacturing waste to landfill. Furthermore, Natacha Mugeni believes that more and more incentives will be provided for people to build with green materials, in the long run. Angelica Coll's opinion on the development of sustainability in the logistics sector is that in African countries, social sustainability is above ecological sustainability.

7.1.2 Contributions to DIGILOGIC Trend Radar

The expert interviews were conducted by DIGILOGIC in order to gain a qualitative perspective from on-the-ground experts on the logistics industry in Africa. By engaging in semi-structured qualitative interviews with a small purposive sample, challenges and trends were identified. Figure 7 below displays trends revealed by the expert interviews. Overall, the interviews conducted show that interviewees highlight the importance of solving the pre-dominant challenges and inefficiencies that are still dominating the logistics sector in Africa and put a focus on the importance of education about digital technologies in the population. They opine that without a foundation of an educated, digitally literate workforce, the implementation of new business models relying on smart digital technologies will not be successful.

According to the interviewees, the following trends have been identified: Sharing Economy, Resilient Supply Chain, Inter-Regional Collaboration, Platform Economy, Establishment of Collaboration Culture, Non-Physical Payment Methods, E-Commerce, Education on Digital/Technological Capabilities (Societal Trends), Blockchain, Drones, Big Data, Automation, IoT, Wireless Infrastructure, Cloud, Electric Vehicles (Technology Trends); Solar Energy Solutions (Biological Trends).

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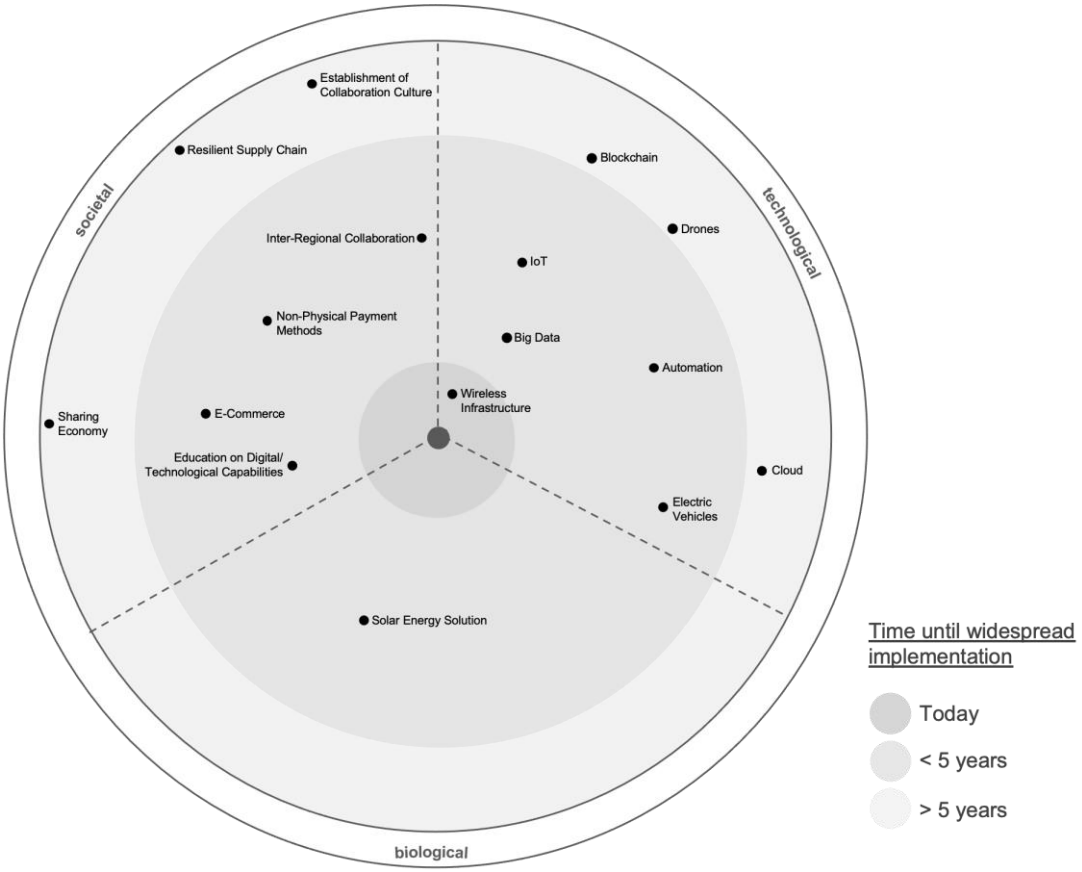

FIGURE 7: CONTRIBUTIONS FROM EXPERT INTERVIEWS TO DIGILOGIC TREND RADAR

7.2 COMPANY WORKSHOPS

In this subsection, activities of companies that engaged in the workshops within the DIGILOGIC Work Package 2 are analysed with respect to the challenges they are facing and solving operationally within the logistics industry.

7.2.1 Findings

As with the interviewees, participants in the company workshops also provide a small purposive sample. That is a small non-probability sample that has characteristics relevant to the objectives of the study (Campbell et al., 2020). The workshops can be categorized into two major dimensions. The first is the distinction between very new start-ups that have yet to define their business models and companies that have already defined their business models. For very new start-ups, workshops for definition of business model and revenue model can be their priority. This can include considering the pros and cons of operating/owning assets versus the application of brokering approaches; and identifying/specifying the service to be offered. By contrast, the workshop preferences of older companies can be different. In particular, companies that have defined business models can prefer workshops about specific tasks. Interestingly, their demand is more for workshops about traditional logistics topics and not so much for workshops about the application of new digital technologies. Most of the companies have already a sound base for applying digital solutions for E-Commerce. What is lacking is support in overcoming the deficit of the logistics sectors in African countries. Based on the workshops conducted so far, it can be said that the majority of companies are either active in the management of transport from rural areas to cities and ports; are fostering retail in rural areas or are providing mobility support within urban areas. Compared to Europe, a well-structured market for trucking companies is rarely existing and the demand is fulfilled mainly by individual truck owners. Furthermore, there are challenges in both urban and rural environments as listed below. Notably, door-to-door transport services – both for goods and people – are mostly non-existent or unreliable.

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- Urban-Area: lacking infrastructure (public transport, few roads, missing rail network for goods transports), power shortages (important for warehouse operations), high customer density.
- Countryside: poorly constructed roads (no tarmac), off-grid, highly distributed customers, produce manufacturers that struggle to transport their fresh produce (dairy products, fish) to the customers in the city, low population density and long transport distances.

Thus, it is apparent that business models and accompanying technologies that are successful in countries with a high LPI score require major adaptations to be successful in most African countries. Herein lies a significant opportunity for African SMEs and start-ups since they have in-depth knowledge of local situations. It is important to note that in both cases new African-specific approaches must be developed. Expertise in enabling technologies for E-Commerce platforms is already available at many companies consulted during the DIGILOGIC company workshops. However, mentoring on the topics listed below was requested:

- What processes (and resources) are required for transporting, warehousing and demand forecasting.
- How to design a goods distribution network
    - How many echelons are needed (hub-and-spoke, point-to-point, staged distribution)
    - Defining the locations of warehouses / distribution centres / cross docking centres / service stations
    - Required capacity for transporting, cross-docking, warehousing.
- Demand forecasting and inventory management.
- Order management.
- Management of service providers such as drivers of trucks or TroTros.
- Transport planning.
- Management of logistics contracts.
- Business relations with large international logistics service providers.

7.2.2 Contributions to DIGILOGIC Trend Radar

As brought by example, the structure of the transport sector is characterized by vehicle owners operating a single truck or bus, commonly known as “TroTro”, rather than freight forwarding companies found in countries with a higher LPI score. This makes the shipments of less-than-truckload (LTL) goods especially difficult, when there is no truck driver that is covering the entire distance. Shippers have thus to perform the tasks of transport routing and negotiating with different truck drivers. While this may represent an opportunity for leapfrogging in certain areas of technology, it also implies that there is a gap to be addressed with regards to the provision of the necessary services and infrastructure. Furthermore, it implicates that business models and accompanying technologies successful in countries with a high LPI score need major adaptations to be successful in most African countries (imitate but adapt).

The findings from the company workshops have provided insights on types of companies active in the logistics industry, their challenges and business models. Interestingly, many of the companies are active in developing **E-Commerce Platforms** (e.g. Merdeo Foods, ShaqExpress, WeGoo), which is consistent with the identified trend in the literature review and the expert interviews. In the workshops undertaken in WP2 with companies and entrepreneurs (see section 5) several logistical trends have been discussed. These trends are discussed in the following paragraphs.

Many African countries lack the road infrastructure in rural areas. Tarmac roads, bridges and ferries are often missing or not built for utilization by high-load capacity trucks. Consequently, the majority of companies rely on light-weight **All-Terrain Vehicles** for the transportation of goods and people. In addition, these rural areas lack networks of gas stations supplying petrol for trucks with combustion engines. Therefore, combustion engine operated trucks have to be equipped with large gas tanks which limits the freight transport capacity. Some start-ups such as MobilityForAfrica strive to overcome these challenges by constructing **Electric-Powered Vehicles** which can operate on gravel roads. These vehicles need a reasonable dense network of charging stations that generate electricity off-grid through local photovoltaic systems.

Another infrastructure related trend is the management of transport in countries that have insufficient address systems. In many sub-Saharan countries street names and house numbers are often missing – especially in rural areas. This of course makes the collection and/or delivery of goods highly dependent on the knowledge of truck drivers. Here the application of **Digital Addresses** (based on geocoordinates) in combination with **Global Navigation Satellite Systems** such as Galileo, NAVSTAR GPS, GLONASS or Beidu and the accompanying GNSS devices and **Digital Map Services** as being approached by MEGATRON can become a “game-changing” solution. With these available (GNSS, map services) and emerging (digital addresses) technologies it is possible

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to leap-frog over the time-consuming introduction of postcodes, street names, and house numbers which are dependent on the existence of the respective infrastructure.

In developed countries there is an established market for transport and warehousing services which are performed by logistics service providers (LSPs). If, for instance, a shipper wants to transport goods to a remote destination and there is no freight forwarder performing a transport to this destination then a LSP could offer a comprehensive service by performing the transport routing, the management (ordering, payment) of different truck drivers as well as the transport monitoring. The shipper is thus communicating with only one single company. Furthermore, this LSP can offer value added services such as customs management, payment services, or goods packaging. In many African countries such a market does not currently exist. However, recognizable effort is undertaken to establish such a business sector, a variety of technologies can be applied. **Freight Management Platforms** can be used as a communication means between shippers and/or LSP towards asset operators such as truck drivers or warehousing companies. This approach is for example pursued by the companies Nyamula and ShaQ Express. Low-cost **Tracking and Tracing Solutions** that can be easily installed at trucks and locations together with **Low-Bandwidth Communication** services are enablers for the monitoring of transport, as for example the business models of Swoove and Zebra show. Based on this, African entrepreneurs can develop value-added services such as **Blockchain-based Certification of Origin** and paper-less transport documents such as bill-of-lading or shipping documents for international carriage of goods by road (consignment note for international road freight transport, CMR). Here, African companies can build on **Open-Source Software** technologies, e.g., open-street map, or the solutions of initiatives such as the Open Logistics Foundation (https://openlogisticsfoundation.org/). This opportunity was discussed with companies such as WeGoo and YomYom.

A further emerging trend is the provision of **Cloud-Based Logistics Software** for tasks such as inventory management, forecasting, and transportation management). Start-ups such as ShapShap aim to build these systems to offer services for truck drivers, retailers, shippers, and consumers. The respective services are integrated into the above-mentioned e-commerce platforms. These platforms collect data both on customers/consumers as well as logistics service provider. Open-source-based **Data Analytics** Solutions can be applied to identify consumer demand patterns and monitor the performance of freight forwarders and warehouse operators. Another overlap with previous findings is the request for demand forecasting and inventory management, which in turn requires the collection of data.

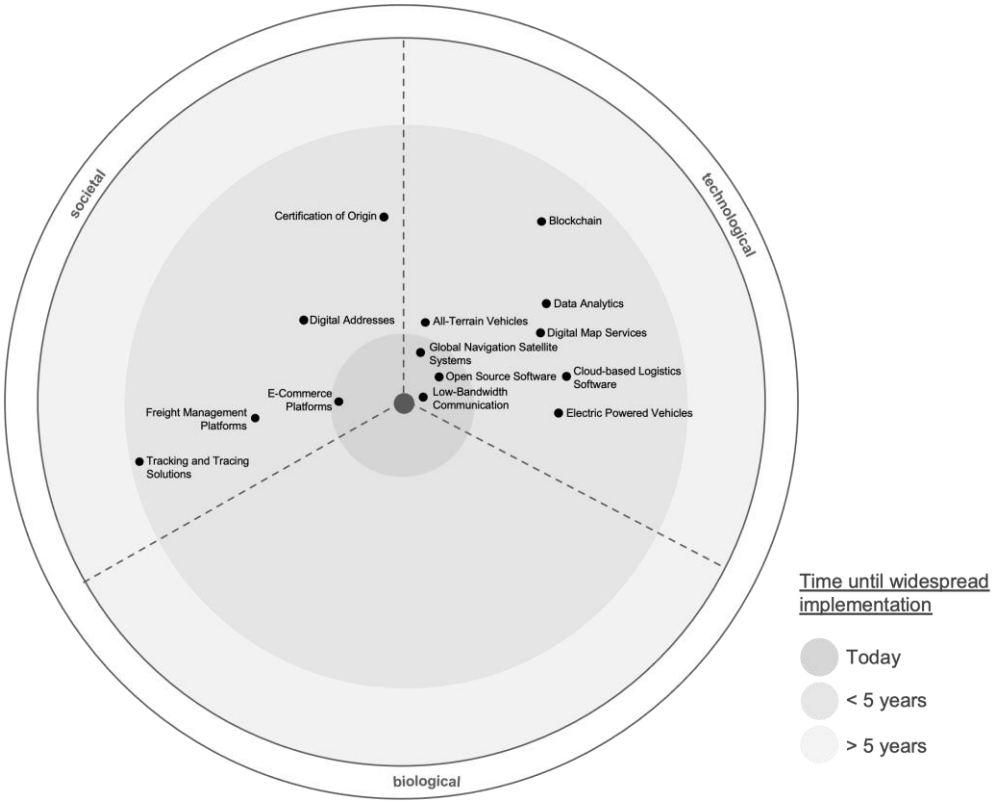

FIGURE 8: CONTRIBUTIONS FROM COMPANY WORKSHOPS TO DIGILOGIC TREND RADAR

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7.3 DIGILOGIC START-UPS

In this section, a detailed analysis is provided of interrelationships between digital and physical technologies in the start-ups' changing environments. Analysis is provided from the perspectives of maturity models and fitness models. Next, in sub-section 7.3.1, a description of one of the DIGILOGIC start-up's logistics operations is provided. That is the successful start-up Mwingi, which brings essential goods to rural East Africa. Then, in sub-section 7.3.2, Mwingi's operations are related to maturity models. Subsequently, in sub-section 7.3.3, Mwingi's operations are related to fitness models. Overall, it is explained that Mwingi's selective targeted applications of technologies are more compatible with fitness models than with maturity models that are predicated on assumptions that deployments of ever-increasing amounts of the latest technologies are preferable. Furthermore, it is explained that the biosocial-technical system operated by Mwingi is compatible with development within planetary boundaries, which is important for meeting Sustainable Development Goals and for meeting the objectives of Industry 5.0. In particular, rather than operating a technical system, Mwingi operates a highly sophisticated biosocial-technical system.

7.3.1 Example of Successful Digital Logistics Start-up

A diagrammatic summary of Mwingi's digital logistics operations is shown below in Figure 9. This shows that Mwingi is making its deliveries of heavy bulk quantities of cooking oil, flour, rice, sugar, etc., in regions without fully paved road networks. Hence, Mwingi deliveries are made with conventional heavy lorries, rather than with a wide range of newer vehicle technologies such as drones. Furthermore, Mwingi makes its deliveries to where there are few fuel supply stations close to its shops, and along routes that do not have comprehensive addressing systems such as named/numbered roads and buildings. However, Mwingi is able to make use of Internet coverage in rural areas provided by local Internet towers. It is this technology that enables Mwingi to gain up-to-date information about sales and stock. Nonetheless, deliveries depend at least as much on the human wayfinding skills of the lorry drivers as on Internet-enabled navigation technologies. Keeping the lorries moving towards their delivery destinations depends more on the ingenuity of drivers than on the availability of repair facilities such as garages. In addition, deliveries of goods and storage of goods depend more on traditional social structures involving there being one responsible person than on automated security systems. Mwingi does not invest in its own automated weather stations but makes extensive use of publicly available weather forecasts to inform its operational planning.

HIGH TECH SYSTEMS								
paved road network	multiple vehicle options	many fuel stations	complete addressing systems	reliable Internet access	digital navigation tech	vehicle repair centres	automated security systems	automated weather stations
	X			X				
X		X	X		X		X	X
						X		
natural ground conditions	pack animals	natural energy sources	natural landmarks	traditional communi-cation	human wayfinding skills	human ingenuity	traditional social structures	traditional climate responses
BIOSOCIAL SYSTEMS								

FIGURE 9: SUCCESSFUL DIGITAL LOGISTICS START-UP'S BIOSOCIAL-TECHNICAL SYSTEM

7.3.2 Maturity Models

Maturity models are related to, but different from, readiness assessments and roadmaps. Mittal and colleagues (2018a) have provided definitions, which are summarized here. Readiness assessments can be described as tools that are used to evaluate preparedness of conditions, attitudes, and resources, at all levels of a system, needed for achieving its goal(s). Roadmaps are plans that match short-term and long-term goals with specific technology solutions to help to meet those goals. Maturity models are models that can help organizations to reach a more sophisticated maturity level following a step-by-step continuous improvement process. In the opinion of Schumacher and colleagues (2016), the difference between readiness and maturity is that readiness assessment takes place before engaging in the maturing process. By contrast, maturity assessment aims to capture the as-it-is state during the maturing process.

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Maturity models have their origins in software engineering. For example, a capability maturity model was developed for assessing the ability of government contractors' processes to implement software projects (Humphrey, 1988). Subsequently, it has been argued that the concept of maturity can be used for descriptive, prescriptive and/or comparative purposes (Röglinger et al., 2012). It serves a descriptive purpose if applied for as-is assessments; a prescriptive purpose if used to establish a desirable path of development; and a comparative purpose if used for internal or external benchmarking (Asdecker and Felch, 2018). Apropos, it has been argued, maturity models can be adequate tools for the following: documenting the status quo; developing a corporate vision for process excellence and providing guidance on that development path; and comparing capabilities between business units and organizations (Asdecker and Felch, 2018).

Digital logistics takes place in the context of what has been described as Industry 4.0 (Garay-Rondero et al., 2020). For example, it has been argued that there is now Logistics 4.0, which enables the satisfaction of individualized customer demands using digital technologies (Winkelhaus and Grosse, 2022). More broadly, the 4.0 description of industry refers to applying digital-physical systems to industrial production in addition to technologies from what have been described as three earlier phases of industrialization: automation (3.0), assembly lines (2.0), and mechanization (1.0). Since the introduction of Industry 4.0 some ten years ago, numerous methods and tools have been proposed for the evaluation of Industry 4.0 readiness, the associated concept of smart manufacturing readiness, and related digital maturity (De Carolis et al., 2017; Schuh et al., 2017, 2020a, 2020b; Schumacher et al. 2016). As indicated by the technology-based numeric progression from Industry 1.0 to Industry 4.0, increasing industrialization and related logistics have been tied intrinsically to technological advances. Many reviews of existing Industry 4.0 methods and tools have been carried out (Mittal et al., 2018a; Felch et al., 2019; Hajoary, 2020; Walter et al., 2020; Flamini and Naldi 2022; Saari et al., 2022); with some authors focusing on small-and-medium size enterprises (Anderl et al., 2015; Brozzi et al., 2018; Mittal et al., 2018a; Mittal et al., 2018b; Rauch et al., 2020; Amaral and Pecas, 2021). Compared to many studies concerned with the digitalization of industrial logistics, there are few published studies that address the digitalization of rural logistics (Deichmann et al., 2016; Tim et al., 2021). Furthermore, there are comparatively few studies that have addressed the integration of urban and rural logistics. The few studies that are reported address related issues in theoretical engineering rather than in practical situations (Bai 2019, Gong 2019).

Overall, Industry 4.0 readiness and maturity tools reported in scientific journal papers are mostly focused on large manufacturing companies, manufacturing-related processes, digitalization of information flow and use of information technologies (IT). Often, logistics maturity is evaluated in intra-logistics or warehouse operations within structured and built environments. There are relatively few papers that are focused on the maturity assessment of digital logistics, smart logistics or Logistics 4.0 (Asdecker and Felch, 2018; Facchini et al., 2020; Weerabahu et al., 2022; Tubis and Grzybowska, 2022).

Asdecker and Felch (2018) have developed a Delivery Process Maturity Model (DPMM) 4.0. The work builds on reviewed six maturity models and the Supply Chain Operations Reference Model – Version 12.0, 2017 (SCOR). DPMM 4.0 consists of five maturity stages (basic digitization, cross-department digitization, horizontal and vertical digitization, full digitization, and optimized full digitization), which can be applied to three dimensions (order processing, warehousing and shipping) (Asdecker and Felch, 2018). Facchini and colleagues (2020) present the application of a maturity model for Logistics 4.0, focusing on the specific applications of Industry 4.0 in the area of logistics. The five maturity levels used are: ignoring, defining, adopting, managing and integrating. Their model was tested with two companies. Weerabahu and colleagues (2022) investigated the enablers and challenges of digital supply chains (DSCs) adoption by reviewing 64 publications. They introduce a digital supply chain maturity (DSCM) model. The developed model has four dimensions; Industry 4.0 technologies and resources; supply chain strategy and planning; people, skills and competencies, and supply chain dynamic capabilities. They propose the following four maturity levels: traditional supply chain; internal digital supply chain; extended internal digital supply chain; and digital supply chain ecosystem. They opine that this DSCM model can be used to guide practitioners in assessing maturity and developing implementation plans for successful digital supply chain adoption. Tubis and Grzybowska (2022) carried out a systematic analysis of 95 publications. Their focus was on Industry 4.0 application in production-related processes, particularly in the area of Logistics 4.0 and SME. Their literature review shows that most studies and developments focus on larger companies. They identified that Logistic 4.0 in SME publications typically focus on intra-logistic logistics and warehouse services. Furthermore, Tubis and Grzybowska (2022) draw attention to the lack of consideration of SME-specific digitalization challenges.

In addition to scientific papers, some associations are providing maturity or capability evaluation methods. For example, The Association for Supply Chain Management (ASCM) has recently published Digital Capability Model (DCM) for supply networks. The objective of the DCM is to provide the supply chain profession with a reference model to guide the development of digital supply networks. Each digital capability is mapped to

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relevant elements in the Supply Chain Operations Reference (SCOR) model framework. This compatibility enables immediate application without having to redo processes, metrics or practices in case the enterprise has adopted the SCOR framework. The latest version of the SCOR Digital Standard (DS) has been published 2022 and is openly available. The ASCM has also published Global Health Supply Chain (GHSC) Maturity Model, which can inform organizing and prioritizing changes to a healthcare supply chain. Also, GHSC is intended to help teams to plan and collaborate effectively with partner organizations in allocating resources and implementing sustainable changes. The latest SCOR model has environmental sustainability aspects included in performance metrics with GRI (Global Reporting Initiative) standardisation.

Maturity models assume that existing industrial infrastructure such as addressing systems, communication networks, energy supply, information technology, and road networks are available to support digitalization efforts. By contrast, the lack of industrial infrastructure and the effects of extreme weather and natural disasters, which can destroy industrial infrastructure, receive less consideration. However, there is increasing recognition that potential disruptions need to be evaluated during supply chain and logistics digitalization road mapping and during the later implementation planning phases (Katsaliaki et al., 2022).

Overall, environmental considerations are not well covered in Industry 4.0 maturity self-assessment tools or in logistics maturity models. For example, Eisner and colleagues (2022) state that there is a lack of self-assessment tools that integrate sustainability and digitalization perspectives. Furthermore, in a review carried out by Hein-Pensel and colleagues (2023), it is argued that Industry 4.0 maturity models are focused primarily on economic objectives of digitalization. By contrast, they opine that Industry 5.0 will bring social, human-centred and ecological, environmental sustainability objectives: as Industry 5.0 is intended to go beyond Industry 4.0 by aiming to provide prosperity within planetary boundaries (European Commission, 2021).

As summarized in Figure 10 below, Mwingi's successful survival and growth is not compatible with maturity models that are predicated on assumptions that deployments of ever-increasing amounts of the newest technologies are preferable. Within the conventions of maturity models, Mwingi operates amidst the constraints of digital and physical infrastructure that has a low level of maturity compared to many countries in Europe. Hence, the maturity of Mwingi's operations could be considered to be at a lower level of maturity than companies that operate in Europe. However, as explained in the next subsection, the sophisticated biosocial-technical system operated by Mwingi is more compatible with development within planetary boundaries, which is important for meeting the Sustainable Development Goals and the objectives of Industry 5.0.

"HIGH MATURITY" HIGH TECH SYSTEMS								
paved road network	multiple vehicle options	many fuel stations	complete addressing systems	reliable Internet access	digital navigation tech	vehicle repair centres	automated security systems	automated weather stations
	X			X				
X		X	X		X		X	X
						X		
natural ground conditions	pack animals	natural energy sources	natural landmarks	traditional communi-cation	human wayfinding skills	human ingenuity	traditional social structures	traditional climate responses
BIOSOCIAL SYSTEMS								

FIGURE 10: SUCCESSFUL DIGITAL LOGISTICS START-UP'S BIOSOCIAL-TECHNICAL SYSTEM NOT COMPATIBLE WITH MATURITY MODELS

7.3.3 Fitness models

The best-known fitness model is that of survival of the fittest, within which fittest refers to being best adaptation with the local environment (Darwin, 1869; Gould, 1976; Odling-Smee et al., 2003; Spencer, 1864). This section draws extensively upon papers that report translation of the latest natural science research concerned with the first principles of adaptive fitness into practical examples related to start-ups (Fox, 2021; Fox, 2022; Fox and Vahala, 2022).

There is survival of the fittest because the better the fit an agent has with its environment, the lower the information uncertainty the agent has about how to survive in that environment. As there is lower

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information uncertainty about how to survive, there is less physical disorder in the work done to survive. As there is less physical disorder, there is less energy lost in unproductive work. In other words, the better the fit with the environment, the lower the information-theoretic entropy, the lower the statistical mechanics entropy and the lower the thermodynamic entropy. Accordingly, because there is low entropy, there can be surplus energy available for survival and growth. For example, digital logistics start-ups have information certainty when they know what will motivate potential customers to buy from them. So, there can be physical order in the start-ups' work to acquire new customers. Consequently, their energy is used efficiently in productive work and much of the start-ups' energy is conserved for growth. In the daily operations of digital logistics start-ups, there is information certainty when drivers have correct location information for a delivery, and there is physical order because they can drive directly to the delivery locations. Thus, the drivers' and vehicles' energy are conserved because they are used efficiently in productive work (Fox, 2022; Fox and Vahala, 2022; Kaila and Annila, 2008).

Interrelationships between information-theoretic entropy, statistical mechanics entropy and thermodynamic entropy at particular locations during specific times can be considered in terms of situated entropy. It is important that there are balances of situated entropy between agents and the environments in which they intend to survive and grow (Fox, 2022). Consider, for example, the different experiences of situated entropy that can arise from replacement of tropical forest with industrial infrastructure. As explained in Fox (2022), initially, the tropical forest experiences extreme physical disorder and information uncertainty when its trees are ripped up (Giovannetti et al., 2006; Rhodes, 2017). Hence, situated entropy is high for the forest. Conversely, people can experience low physical disorder and low information uncertainty when driving lorries on the newly constructed hard paved roadways. Hence, situated entropy is initially low for people. However, the underside of new roadways can soon crack because of ground heave due to heavy rains, and the forest can begin to grow back through the road. This can lead to people experiencing increased physical disorder and information uncertainty as they have to drive around wide cracks in the road. As the road deteriorates and the forest tries to regrow through the road cracks, there can be more balance between situated entropy experienced by people and situated entropy experienced by the environment compared to when the road was first built. Yet, it is not a positive balance because it is a balance in which neither thrives. Indeed, transportation problems are a major cause of post-harvest losses (Affognon et al., 2015; Swai et al., 2019).

As explained in Fox (2022), more energy could be expended to try to minimize peoples' situated entropy. This could involve more energy being expended in repeated repairs to roads. Alternatively, even more energy could be expended by destroying the whole forest to try to stop it from impinging on human activities. However, an imbalance between very low situated entropy for people and very high situated entropy for environments is also not positive. This is because systems characterized by very low entropy can be vulnerable to disturbances (Ulanowicz et al., 2009), and disturbances are inevitable including natural disturbances that can destroy well-constructed infrastructure very quickly (Boer et al., 2020; Patton et al., 2019; Puzyreva et al., 2022).

Hence, there needs to be synchronous flexibility in the ongoing development of ecological fitness between agents and their environments in what can be described as joint agent-environment systems. Iterations of learning and development between agents and environments can be represented as reciprocal oscillating interactions. However, human development of logistics infrastructure has involved human agents being less flexible than the environments in which logistics takes place. Initially, this can benefit people at the expense of the environment. Yet over time, it can come to be at the expense of people as well through circular causation. For example, over centuries, rivers have been engineered by people so as to change the environment in order to improve logistics. This has included floodplains being engineered to drain into rivers and rivers being straightened to better enable water-borne transportation. However, amidst extreme weather such interventions can leave waterways more vulnerable to both overflowing and to drying out. Either of which can cause severe disruption to global supply chains. This is evident when overflowing rivers destroy road infrastructure and when the drying out of rivers to impassibly shallow depths restricts the passage of water-bourne vessels. Accordingly, there needs to be a rethinking of centuries of human interventions that have changed the environment with the aim of improving logistics (Gemmer et al., 2008; Halbe et al., 2018; Peters et al., 2021).

Ideally, as explained with practical examples in Fox (2022), agents are dynamical living systems that survive through maintaining a near-to-equilibrium steady state in relation to environmental fluctuations. However, an agent can be stubborn in persisting with actions based on old policy even though the agent experiences observations that indicate continuing with the old policy is counterproductive. This can lead to the end of back-and-forth reciprocal exchanges of agent-environment learning and development, in which synchronous near-to equilibrium steady-states are sustained by both. Instead, agent and environment can form stable steady states that undermine the survival of both by leading to the loss of general oscillation synchrony between them (Fox, 2022).

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By contrast, sustainable general oscillation synchrony can be described in terms of rhythmogenesis. That is the generation of rhythms found in most of the coupled physical, chemical, and biological systems in which underlying coupling acts as a feedback factor (Arumugam et al., 2016). For example, sustainable agricultural practices need to involve people synchronizing with the environment's seasonal rhythms (Kreitzman et al., 2010). Although Mwingi's successful survival and growth is not compatible with maturity models, Mwingi's successful survival and growth is very compatible with fitness models encompassing rhythmogenesis. This is because, rather than being a stubborn agent that seeks to change the environment so there is zero entropy in its own operations, Mwingi is a flexible agent that adapts to the environment through continuous iterations. For example, Mwingi increases the volumes of its deliveries when the seasonal rhythms of nature are forecast to bring heavy rainfall. This enables shopkeepers to have larger stocks than usual as buffers for periods of heavy rain that can reduce the number and volume of deliveries that can be made for a few weeks. Thus, Mwingi does not set up an unsustainable imbalance between the very low situated entropy experienced by Mwingi and very high situated entropy experienced by environments. Accordingly, Mwingi's operations can be less vulnerable to disturbances, because of its synchronous coupling with the environments in which it seeks to survive and grow.

More broadly, Mwingi's operations are compatible with digital logistics involving combining digital technologies and physical technologies with the aim of improving logistics (Cichosz et al., 2020; Hofmann and Osterwalder, 2017). Furthermore, Mwingi's operations are consistent with arguments that digital logistics can introduce new opportunities for the launch of logistics start-ups (i et al., 2021), and can expand the range of positive consumer experiences (Burroughs and Burroughs, 2020). However, the example of Mwingi illustrates that digital logistics does not need to depend upon the deployments of ever-increasing amounts of the newest technologies. Moreover, as well as being compatible with Sustainable Development Goals, Mwingi's operations are compatible with Industry 5.0 which is intended to go beyond Industry 4.0 by aiming to provide prosperity within planetary boundaries (European Commission, 2021). Mwingi's fitness with the biosocial-technical environment in which it operates is related to its fitness in business markets in Table 4 below.

TABLE 4: MWINGI'S FITNESS WITH BIOSOCIAL-TECHNICAL ENVIRONMENT IN RELATION TO FITNESS WITH BUSINESS MARKET

Ecological variables (biosocial-technical)		**Fitness Components**				
		Efficient ICT	No. of Shops	Sales per Shop	Stock Control	Margin / Sale
Ground	Paved					
	Natural					
Vehicles	Mechanical vehicles					
	Pack animals					
Energy sources	Fuel stations					
	Natural					
Addressing	Digital system					
	Natural landmarks					
Communication	Reliable Internet					
	Traditional					
Location finding	Navigation tech					
	Wayfinding skills					
Repair resources	Repair centers					
	Human ingenuity					

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Security	Automated systems					
	Traditional society					
Weather	Automated stations					
	Traditional responses					

In particular, Table 4 shows business fitness components (Fox, 2021; Sahoo et al., 2010; Siepielski et al., 2011) for Mwingi in five columns as follows: efficient ICT; the number of shops; sales per shop; stock control, and margin per sale. An efficient digital point-of-sales system, enabled by Internet coverage in rural areas provided by local Internet towers, is essential for Mwingi to be able to have up-to-date information for its sales and stock. Mwingi needs to have enough shops to cover the overhead costs of operating its efficient ICT system. Also, sufficient sales per shop at an adequate profit margin are needed to cover the overhead costs of each shop. The green colouring in Table 4 indicates relationships between biosocial-technical fitness and business market fitness. For example, Mwingi's success in opening shops and achieving sufficient sales per shop at an adequate margin is based upon Mwingi operating in regions where there are no paved roads.

Figure 11 below shows Mwingi's fitness with its business market in relation to the perspectives of its customers. This shows that Mwingi having many shops enables its customers to have a Mwingi shop close by. Mwingi aims to have many sales per shop enabling customers to be able to go to the shop for many hours per day. Mwingi's focus on stock control enables customers to be able to buy what goods they need when they need them. From the customer perspective, Mwingi needs to offer affordable goods, and this influences Mwingi's structuring of margins per sale. Overall, Mwingi's efficient ICT system enables it to have shop-specific information, which enables it to stock for its customers the goods they need when they need them at affordable prices. In the type of modelling shown in Figure 11, Mwingi's five fitness components are shown as parameters. In particular, the five parameters upon which its business survival depends: i.e. its survival parameters (Fox, 2021; Fox and Vahala, 2022).

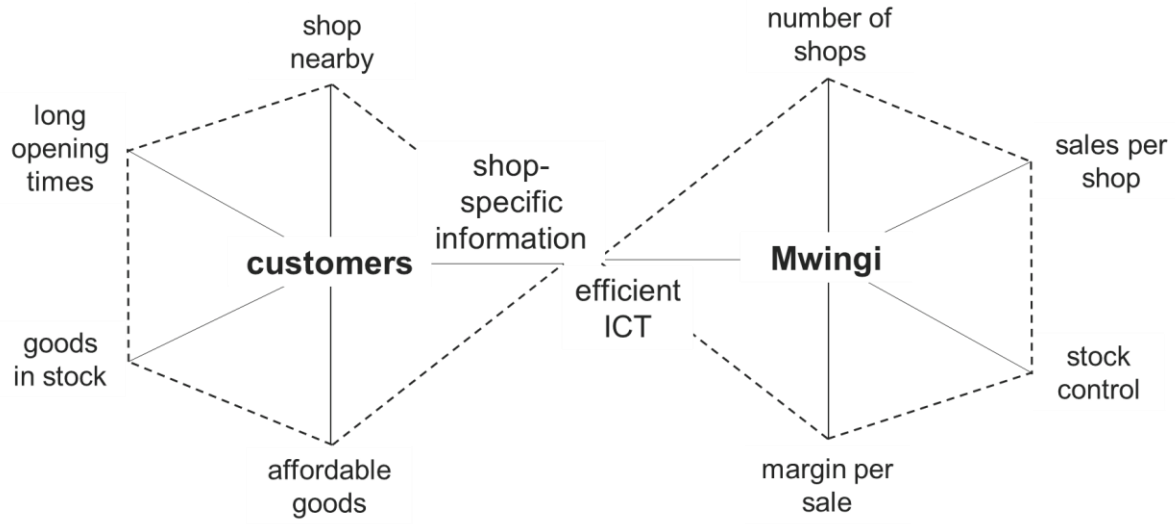

FIGURE 11: START-UP FITNESS WITH BUSINESS MARKET

Figure 11 above indicates relationships between biosocial-technical fitness and business market fitness in the environment in which Mwingi has begun its operations. However, as Mwingi grows it will need to operate in environments that have some different biosocial-technical characteristics, which Mwingi will need to adapt to in order to have fitness in those environments. This can be facilitated by Mwingi having a modular rather than unitary organizational structure (Lipson, 2007; Marfenin, 1997; Pineda-Krch and Poore, 2004; Wagner, 1995). Modularity is associated with clustering (Clune et al, 2013), and Mwingi's structure already includes the grouping of its shops into clusters. Fitness tables for the other start-ups are in Appendix C of this deliverable.

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7.3.4 Contributions to the DIGILOGIC Trend Radar

As with the interviewees and participants in the company workshops, the DIGILOGIC start-ups also provide a small purposive sample. That is a small non-probability sample that has characteristics relevant to the objectives of the study (Campbell et al., 2020). Figure 12 below displays trends revealed by findings from start-ups. With regard to the technological trends segment, start-ups are making selective targeted combinations of technologies, which can operate robustly in the biosocial contexts of their operations. For example, Mwingi combines relatively narrow bandwidth Internet with its point-of-sale system, which has been developed specifically for Mwingi to be compatible with the extent of Internet available. Another example is Radava using combinations of person-to-person, telephone, and Internet-enabled communication. Radava establishes contact with farmers through person-to-person communication via cooperative societies. Subsequently, Radava communicates with farmers via basic phones. Typically, farmers are sellers of agricultural produce. Radava manages transactions between farmers and sellers via its platform, which is Internet-enabled. Duniya also uses combinations of basic phones and Internet-enabled platforms to enable communications between supply-side and demand-side. Similarly, Vinmak combines the use of basic phones and its Internet-enabled web-based platform. Only about 30 percent of Vinmak customers have sufficient Internet access to be able to use its online platform directly. Accordingly, the majority of its customers communicate their orders by phone to Vinmak personnel who enter the order information into the Vinmak platform. These are examples of the start-ups setting-up robust hybrid technology architectures based on selectively targeted combinations of technologies. These architectures are hybrid in their combination of technologies with origins from different decades: none of which are the most recently introduced technologies. For example, Wadonge combines common navigation apps with two-wheeled vehicles driven by people to make deliveries: rather than, for example, self-navigating autonomous drones. The start-ups' selective targeted combinations of technologies are indicated in Figure 12 as **Hybrid Architectures**.

With regard to the societal trends segment, the start-ups are harnessing traditional human skills and social structures. For example, some of the start-ups' operations encompass urban areas that often have street names, but sometimes do not have building numbers (e.g., Farmisphere, InstaDriver). Other start-ups operate extensively in regions without road names, building numbers, and Internet connections (e.g., Vinmak, Yaaka). Although it can be possible in some cases to use offline GPS (e.g., Duniya), collections from (e.g., Wadonge) and deliveries to (e.g., Mwingi) such regions often rely on human wayfinding skills. Here, it is important to note that, rather than being an out-of-date practice, exercising human wayfinding skills is a socially sustainable practice. This is because reliance on GPS-enabled apps can reduce the human ability to navigate, and decreased human navigation skills correlate with dementia (Baron, 2021). Also, the security of goods being transported and stored by the start-ups is more dependent on traditional social structures than on the implementation of advanced automated security systems. Again, rather than this being an out-of-date practice, exercising trust in traditional social structures is a socially sustainable practice. This is because the application of surveillance technology can lead to personnel trying to avoid being watched and to personnel losing trust in their employers. It can also lead to workplace stress, job dissatisfaction, increased personnel turnover and, in some cases, retaliation (Stark et al., 2020). By contrast, as indicated in Figure 12, the start-ups deploy **Complementary Structures** to facilitate their operations. In particular, complementary structures that enable people to exercise personal agency through their skills and ingenuity. For example, the start-ups complement human knowledge of local weather patterns with publicly available weather forecast information from meteorological institutes in order to deal with changing climatic conditions.

With regard to the biological trends segment, the start-ups are operating with what can be described as **Minimal Infrastructure**. For example, rather than constructing fixed buildings in rural areas for the retrofitting of fossil fuel vehicles with electric motors and electric batteries, Auto-Truck is developing retrofitting services based on mobile retrofitting centres comprising trucks that carry necessary components, equipment, and personnel to wherever they are needed. More broadly, the start-ups' operations do not depend upon the construction of more physical infrastructure, such as road construction in rural areas. For example, Mwingi successfully delivers tonnes of products every week in regions that do not have paved roads. Similarly, much of Vinmak's and Yaaka's operations are in regions without paved roads. The start-ups use a variety of vehicles to make their deliveries on different types of ground conditions, load sizes, and distribution of customers. For example, Duniya can bring bulk loads of pharmaceuticals to rural areas in trucks. Then, divide that load into smaller quantities for delivery by three-wheeled or two-wheeled vehicles. Furthermore, the start-ups operate successfully with minimal Internet connectivity and cloud storage. Hence, start-ups are making contributions to sustainable logistics. Generally, start-ups are making good use of the ever-evolving virtual infrastructure of many different types of open-source software and related open-access online programming training courses.

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As shown in Figure 12 below, rather than providing a listing of individual technologies etc., analysis of the DIGILOGIC start-ups reveals three broad trends that encompass many possible combinations of digital and physical technologies. These broad trends, Hybrid Architectures, Complementary Structures, and Minimal Infrastructures are compatible with the Industry 5.0 goal of human development within planetary boundaries which is advocated by the European Commission.

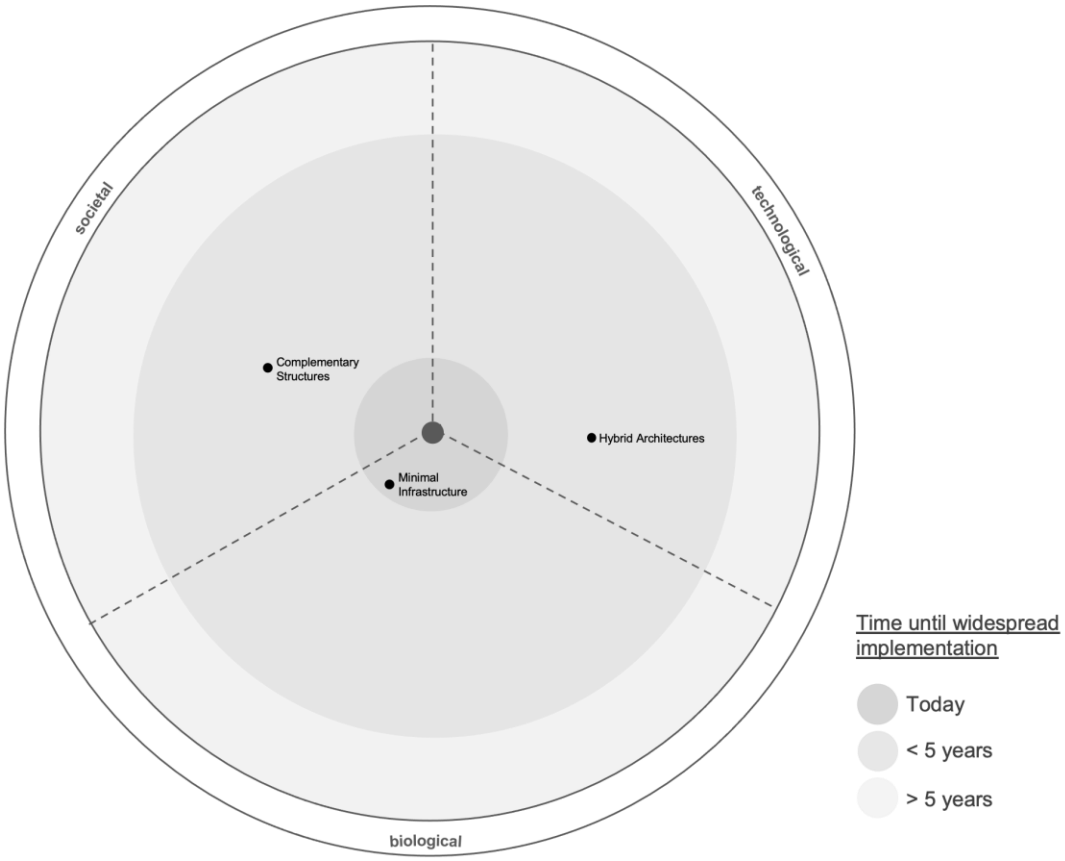

FIGURE 12: CONTRIBUTIONS FROM START-UP ANALYSES TO DIGILOGIC TREND RADAR

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8 DIGILOGIC TREND RADAR

In order to reach an overall trend radar that combines the findings from the literature review, expert interviews, company workshops and start-ups analyses, consolidation was done of the four partial trend radars presented in the preceding sections. As a first step, all trends identified in the four partial trend radars were brought together into one trend radar. As the analyses are qualitative, a trend is shown only once in the overall trend radar even if it appears in more than one of the preceding partial trend radars. Trends shown in this preliminary overall radar have been simplified by harmonizing trends that were expressed in slightly different terms into the partial trend radars. For example, in the trend radar resulting from the expert interviews, the trend of Inter-Regional Collaboration was identified as a societal trend while in the radar of the literature review the trend of Intra-Continental Cooperation appeared under the same section. Due to the fact that both trends are addressing the same objective and both trends are placed in a comparative time frame, the naming Intra-Continental Cooperation was kept as the title for the trend and defined to include Inter-Regional Collaboration. The same was done for the following trends: Reskilling Revolution (literature review) was integrated into Education on Digital/Technological Capabilities (expert interviews); Freight Management Platforms (company workshops) was integrated into Platform Economy (literature review); E-Commerce Platforms (company workshops) was integrated into E-Commerce (literature review, expert interviews); Cloud-based Logistics Software (company workshops) was integrated into Cloud (literature review, expert interviews); Electric Powered Vehicles (company workshops) was integrated into Electric Vehicles (expert interviews); Low-bandwidth Communication (company workshops) was integrated into Mobile Phones and Networks (literature review); Solar Energy Solutions (expert interviews) was integrated into Alternative Energy (literature review); Big Data (literature review, expert interviews) and Data Analytics (company workshops) were joined in the trend (Big) Data Analytics.

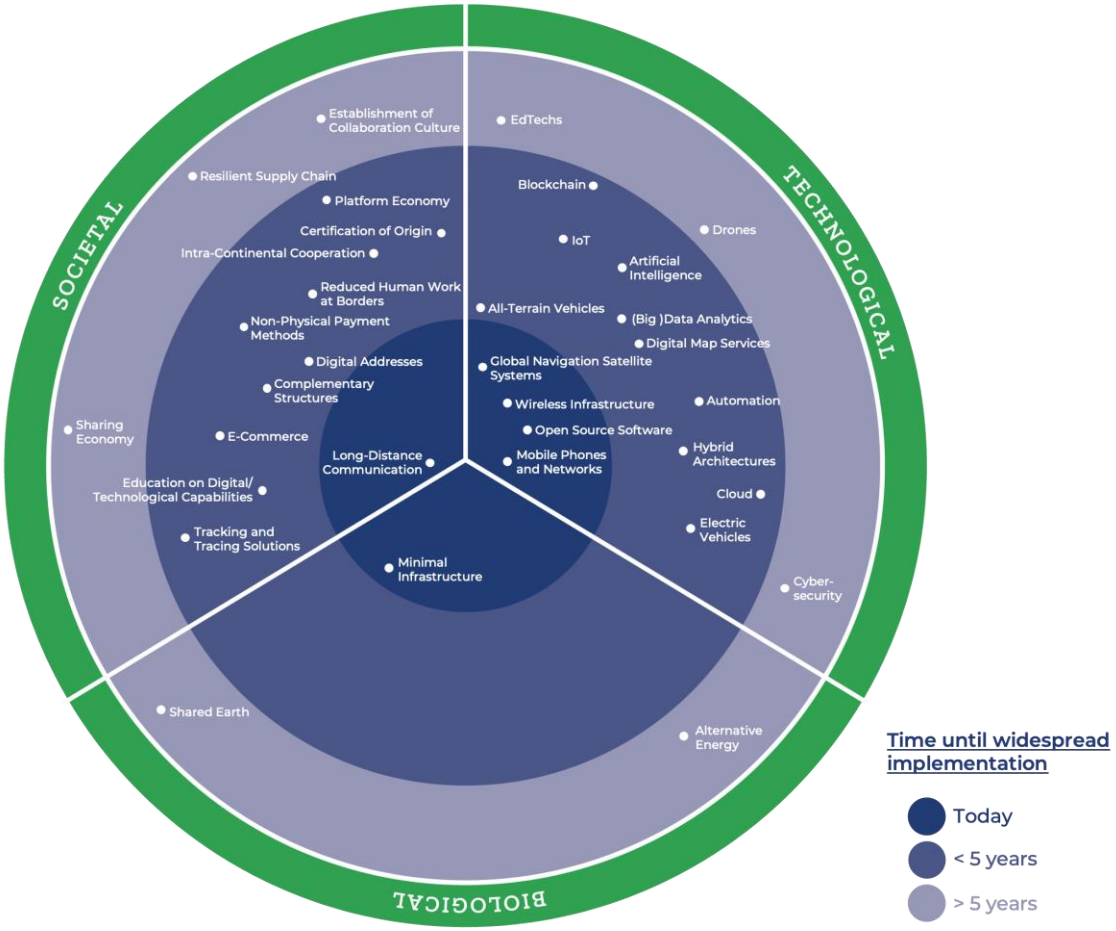

FIGURE 13: DIGILOGIC TREND RADAR

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As shown by Figure 13, the DIGILOGIC Trend Radar provides a visual summary of the trends listed below.

Societal Trends:

Today: Long-Distance Communication

< 5 years: Education on Digital/Technological Capabilities, E-Commerce, Tracking and Tracing Solutions, Complementary Structures, Non-Physical Payment Methods, Reduced Human Work at Borders, Intra-Continental Cooperation, Certification of Origin, Platform Economy, Digital Addresses

> 5 years: Establishment of Collaboration Culture, Resilient Supply Chain, Sharing Economy

Technological Trends:

Today: Global Navigation Satellite Systems, Wireless Infrastructure, Open Source Software, Mobile Phones and Networks

< 5 years: (Big) Data Analytics, All-Terrain Vehicles, Hybrid Architectures, Artificial Intelligence, IoT, Automation, Electric vehicles, Blockchain, Digital Map Services, Cloud

> 5 years: EdTechs, Drones, Cybersecurity

Biological Trends:

Today: Minimal Infrastructure

> 5 years: Alternative Energy, Shared Earth

Trends are positioned in segments (societal, technological, biological) and time rings (today, within five years, after five years). Time positions are based on time to full realization in practice. For example, Mobile Phones and Networks are in the technology segment in the Today-ring because they are already used extensively in practice throughout Africa. By contrast, drones are in the > 5-years-ring of the technology segment. This is because, although drones can already be implemented widely in practice, it will take many years for all of the potential implementations to be realized in practice. Other trends are in the < 5-years-ring of the technology segment. For example, IoT is entering African logistics through the sensors and actuators that are built into new commercial vehicles, but it will take several years for new commercial vehicles to replace older vehicles across Africa. Time to full implementation is also the basis for the positioning of trends in the other two segments: societal and biological. For example, Long-Distance Communication and Minimal Infrastructure are already in practice, while full Resilient Supply Chain and Shared Earth implementations will take years to be realized.

When comparing the DIGILOGIC Trend Radar (Figure 13) to the Global Logistics trend radar (Figure 5) major differences in recent and future trends are apparent. This supports the hypothesis that motivated the development of the DIGILOGIC Trend Radar: a trend radar established with a Western-centric perspective is not directly applicable to Africa.

In terms of Societal Trends, increasing intra-continental trade and cooperation, especially the recently agreed on AfCFTA, is a major development on the African continent. On a global scale, intra- and inter-continental trade agreements have been established for some time, e.g., the North American Free Trade Agreement (NAFTA) or the internal market of the EU. Since the AfCFTA is still in a pilot phase, development results are based on estimates and projections, but it is expected to be an enabling force and major driver of trend developments in logistics. One area that is specifically impacted by the AfCFTA already is the beginnings of customs automation at the borders and development of more sophisticated trading practices.

Compared to the global trend radar, the DIGILOGIC Trend Radar does not include so called 'next generation' trends such as digital marketplaces, everything as a service, mass personalization, quick commerce, remote work, smartification, and teleoperation. In addition to that, some trends such as diversity/equity/inclusion/belonging, metaverses, physical internet, silver economy, space economy, supply chain diversification have not been identified for the African agenda yet.

On the other hand, the global trend radar does not include all the trends shown in the DIGILOGIC Trend Radar. More specifically, only the trends Sharing Economy, Platform Economy and E-Commerce are common to both trend radars. For example, the societal trend Digital Addresses and the related technological trends Global Navigation Satellite Systems and Digital Map Services are specific to the local environment and pre-conditions going hand in hand with the lack of a traditional address system especially in rural areas in many African countries. Similarly, Reduced Human Work at Borders is directly related to the fact that the continent of Africa is divided into > 50 individual countries with their respective borders, which leads to high obstacles when it comes to the transportation of goods across the continent. For all countries, but especially for the 14 land-locked

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countries, their economic development depends on the smooth running of border processes for importing and exporting goods. Thus, those trends are not indicated as global trends.

With respect to technological trends, AI, Automation, Big Data, Blockchain, IoT, Cloud, Drones, EdTechs, and Cybersecurity were identified as major trends in Sub-Saharan Africa. Trends which could be identified in both radars are Blockchains and Drones. The trends that can be found in both radars may differ in their implementation and capabilities. These technologies may provide a good opportunity for leapfrogging by African countries. As explained by interviewee Sesinam Dagadu, a lack of policies and frameworks for drones, for example, did not hinder Zipline in gathering a large set of data to define and improve their process of operation. The impact of this trend on the logistics industry remains open to debate. In the global trend radar, big data analytics and cloud and API occur as soon to be realized trends. These trends are also assigned an important role in transforming different sectors in Africa. Most technological trends of the global trend radar could not be identified for Africa. This includes Exoskeletons, Tube systems, Bio-based Materials, 3D Printing, Wearable Sensors, Edge Computing, Stationary Robotics, Digital Twins, Next Generation Packaging, Smart Labels, Indoor Mobile Robots, Computer Vision, Quantum Computing, Outdoor Autonomous Vehicles and Alternative Energy Solutions.

The DIGILOGIC Trend Radar goes beyond the state-of-the-art by incorporating a biological trends segment. By contrast, the DHL 2023 trend radar (Appendix D) addresses biological topics only by situating three biological trends within its social & business trends segment: circularity, decarbonization, and environmental stewardship. As summarized in Figure 5, which provides a global perspective, there are many biological trends to be considered. Global biological logistics trends are sustainability of E-commerce and online shopping, including recycling, innovative products, e.g., Electric Vehicles, but also increased sustainability regarding data usage, e.g., concerning big data and AI. Other trends tackle climate change risks, protection of biodiversity and zoonotic diseases. However, these are absent from the DHL trend radar, and the biological segment is the sparsest segment of the DIGILOGIC Trend Radar. Nonetheless, as climate change becomes increasingly apparent and the European Commission advocates human development within planetary boundaries, it is imperative that attention is drawn to biological trends. In Africa, biological trends include policies advocated in the so-called Shared Earth and Alternative Energy supply. The Shared Earth policies are supposed to reduce threats to African biodiversity. Moreover, to tackle the infrastructure gap in terms of electricity supply, also regarding increased digital facilitation, alternative energy is part of the solution. Furthermore, many African countries are characterized by minimal provision and maintenance of road and rail infrastructure as well as wireless infrastructure, especially in rural areas. What is unique to the landscape of trends in Africa is coping with this minimal infrastructure. Due to the limited extent and basic conditions of physical infrastructure, many companies in Africa have grown to be excellent in coping with the prevailing conditions. Here, a relation to the trend All-Terrain Vehicles can also be seen. This is closely connected to the trend of Complementary Structures and the use of Hybrid Architectures which can also be seen as unique to the African logistics industry and fosters African sustainable logistics. Although only a small sample, this suggests that African logistics enterprises, both new start-ups and established companies, leapfrog over technology hype cycles. In hype cycle terminology (Fenn and Raskino, 2008), they are leapfrogging over the “peak of inflated expectations”, and the “trough of disillusionment” in order to go straight to the “slope of enlightenment” and the “plateau of productivity”. Despite this, the trends Wireless Infrastructure, Mobile Phones and Networks and Long-Distance Communications are important facilitators for improving inefficiencies in the logistics industry in Africa and build the basis for other trends that depend on access to the internet or mobile network, as for example, Non-Physical Payment Methods, Platform Economy, Blockchains etc.

Another difference between the trend radars is the level or depth of the trends displayed on the radar. As stated by DHL (2023), their radar is continuously developed and enriched with the feedback from customers and experts from the industry, leading to refocused, more specified or remodelled trends. In some cases, trends on the DIGILOGIC Trend Radar are identified as trend clusters (e.g., Artificial Intelligence and IoT) or focus areas (e.g., Automation) in the DHL trend radar. For example, the DIGILOGIC trend IoT is represented by the cluster IoT in the DHL radar including trends such as Smart Labels, Next Generation Packaging, Digital Twins, Wearable Sensors etc. Conclusively, it is difficult to compare the two radars solely based on the individual trends shown.

Overall, many trends identified in the DIGILOGIC Trend Radar are related to the diverse challenges many African countries are still encountering with respect to the provision of infrastructure, governmental policies and regulations, corruption, cultural differences and high dependency on manual labour.

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9 CONCLUSIONS

The DIGILOGIC Trend Radar offers three principal contributions. Most importantly, it provides a first digital logistics trend radar that is focused on Africa. Second, it has importance beyond one continent by extending the scope of logistics trend radars from the societal and the technological to also encompass the biological trends. Third, it provides an example of how lack of published studies focused on a particular continent need not prevent the formulation of a trend radar for that continent.

Over the past decade, Africa has witnessed a notable growth in digital technologies. One of the key factors driving the adoption of digital technologies in African logistics is the continent's increasing connectivity. Africa has experienced a continuous improvement in internet penetration, with the proliferation of mobile devices and the expansion of telecommunication infrastructure. This increased connectivity has opened up new opportunities for leveraging digital solutions in logistics. Mobile technology, in particular, has played a vital role in shaping the digital landscape of African logistics. With a growing proportion of the African population accessing the internet through mobile devices, logistics service providers have capitalized on this trend to offer innovative solutions. Mobile applications in combination with sensor technology are emerging, enabling real-time tracking and monitoring, more efficient communication between stakeholders, and streamlined documentation processes. These applications improve visibility, transparency, and overall efficiency in logistics operations.

Another interesting development in African logistics is the utilization of big data and AI applications in devices to enhance decision-making and optimize operations. By leveraging data generated through digital platforms, logistics companies can gain insights into customer behaviour, demand patterns, and supply chain performance. These insights enable them to optimize routes, improve inventory management, and streamline processes, resulting in cost savings and improved customer satisfaction. A prominent use case in this context is the development and provision of platforms to match supply and demand for individual truck drivers for the transportation of goods. Furthermore, it is interesting to note that the implementation of drone technologies is tested and leveraged in several use cases in Africa, implying that there is a potential for leapfrogging in this area. Despite this, time until widespread implementation is still to be seen as > 5 years. Finally, it was observed that many entrepreneurs rely on hybrid architectures in the implementation of their business models, combining physical and digital technologies.

In addition, Africa has seen the rise of E-commerce platforms, which have created a demand for advanced digital logistics solutions. Online marketplaces have gained popularity, facilitating the trade of goods and services across borders. To meet the growing needs of E-commerce, logistics providers have embraced digital technologies to optimize last-mile delivery, warehouse management, and inventory tracking. This has led to the emergence of trends such as automated warehousing systems, addressing the unique challenges like inadequate transportation infrastructure and remote locations faced in African logistics.

Despite these advances, it is important to note that challenges still exist in the adoption of digital technologies in African logistics, such as limited access to reliable internet connectivity, especially in rural areas, and concerns related to data security and privacy need to be addressed to build trust in digital solutions. Additionally, findings from analyses of expert interviews, company workshop participants, and start-ups in the DIGILOGIC mentoring programme indicate that implementation of digital technologies is not a top priority for logistics in Africa. Rather, new and old digital and physical technologies are being combined to obtain the best outcomes possible within the contexts for logistics in Africa. Existing challenges refer to the lack of infrastructure and climatic challenges as well as societal fragmentation across Africa, which persists from the continent's partition by Europeans. Accordingly, interview participants highlighted the need to address societal issues that hinder logistics in Africa. Companies in the workshops and start-ups in the mentoring programme provide insights into how logistics can be carried out in challenging contexts. In a world where uncertainties are introduced into global logistics unpredictably by extreme weather events and social conflicts, valuable insights for the future of European logistics could be gained from ongoing analyses of emerging logistics solutions in Africa.

The DIGILOGIC Trend Radar has been formulated through multimethod research comprising multi-vocal literature review; semi-structured interviews; analysis of workshops with companies; and comparative analyses of start-ups participating in the DIGILOGIC mentoring programming. Findings from these different methods converge into one principal finding. That is, the primary trend is for selective targeted configurations of digital technologies with physical technologies in the context of the biosocial-technical environments in which companies' business markets are situated.

When reviewing these findings, it needs to be kept in mind that the sample does not cover the more than 50 countries of Africa. Rather, the identified trends were revealed by method of purposive sampling from the countries with which DIGILOGIC is actively engaged. Between the countries addressed, and even between regions within those countries, there can be large differences in the culture, economic and social development,

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pre-conditions etc. that may have a large effect on the challenges and trends in the respective logistics industry. Accordingly, the DIGILOGIC Trend Radar does not aim to display the current trend landscape throughout the whole of Africa. Rather, it provides an initial indication of trends across those African countries that DIGILOGIC is engaged with.

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APPENDIX

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APPENDIX A: SEMI-STRUCTURED INTERVIEW GUIDE

DIGILOGIC TREND RADAR – Semi-structured interview guide

1. **Introduction**
   - ⇒ Short Introduction from the interviewer
   - ⇒ What led you to work in logistics in the first place? What is your passion in the field?

2. **Focus on the past: Challenges in the field of digital logistics**
   (Problems you faced within logistics in recent years & possible solutions)

   Questions:
   - ⇒ What challenges/obstacles have you observed in the logistics industry in recent years?
   - ⇒ Which problems do you believe are worth tackling?
   - ⇒ Which solutions do you know of that are trying to solve the issues? – Have any of them been overcome by market providers and how?
   - ⇒ What technologies do you believe can help/could have helped to overcome these obstacles?

3. **Focus on the future (trends/ outlook)**
   (Challenges and opportunities, developments that will play a role for the industry in the near future etc.)

   Questions:
   - ⇒ What challenges do you see for logistics in Africa in the near future?
     - Do you see them as opportunities?
     - How are they going to be approached?
     - What is the role of technological developments in logistics in the upcoming years?
       - Which technologies do you believe will be essential? Why this technology?
       - What is the underlying trend?
       - Which impact do you believe it has on logistics?
   - ⇒ Which sector within logistics/part of the supply chain do you believe will be disrupted/changed?
   - ⇒ How would you reimagine logistics in Africa in 5-10 years?

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APPENDIX B: METHODOLOGY DIGILOGIC COMPANY WORKSHOPS

The first template used in a company consultation contains basic information on the company/project (see Figure 12).

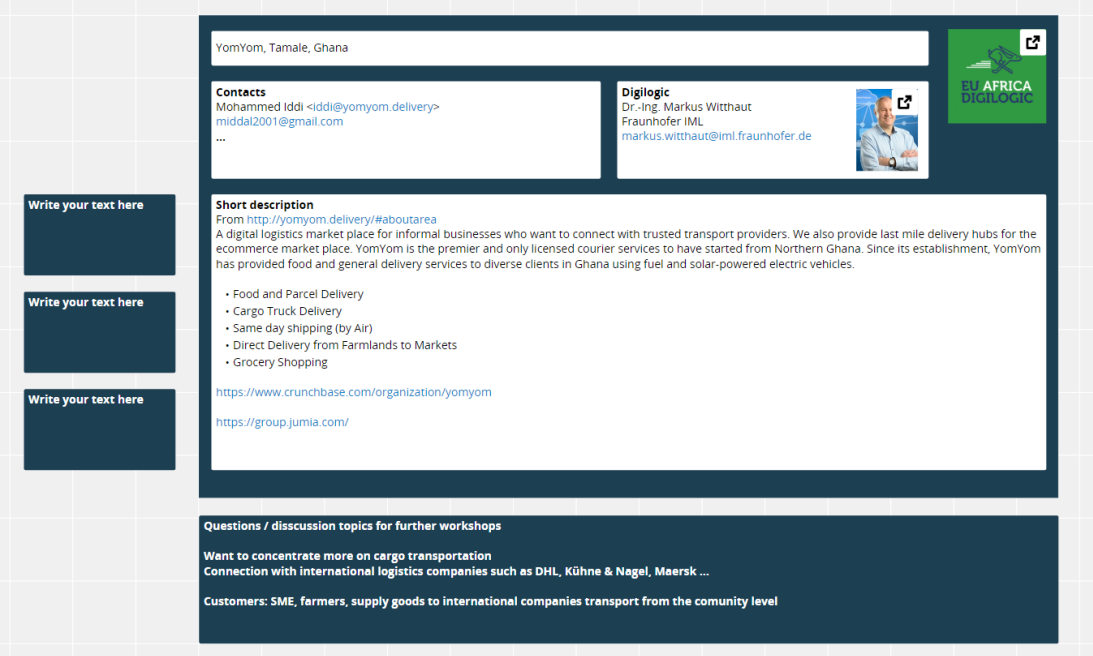

FIGURE A 1: EXAMPLE OF BASIC INFORMATION TEMPLATE FOR A COMPANY WORKSHOP

The discussion of business model topics was especially relevant for the workshops with start-ups. Therefore, we have applied a simple framework based on Osterwalder, Pigneur (2010), Business Model Generation (see figure A 2**Fehler! Verweisquelle konnte nicht gefunden werden.**).

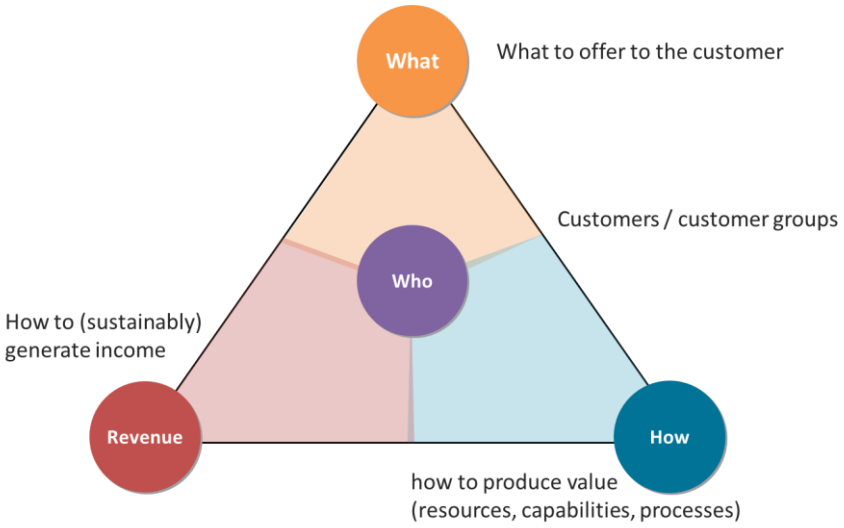

FIGURE A 2: THE FRAMEWORK TO STRUCTURE THE BUSINESS MODEL DISCUSSION

For each of these dimensions (Who, What, How and Revenue) we used a template containing further questions and virtual sticky notes to be used by the participants. An example is shown in figure A 3.

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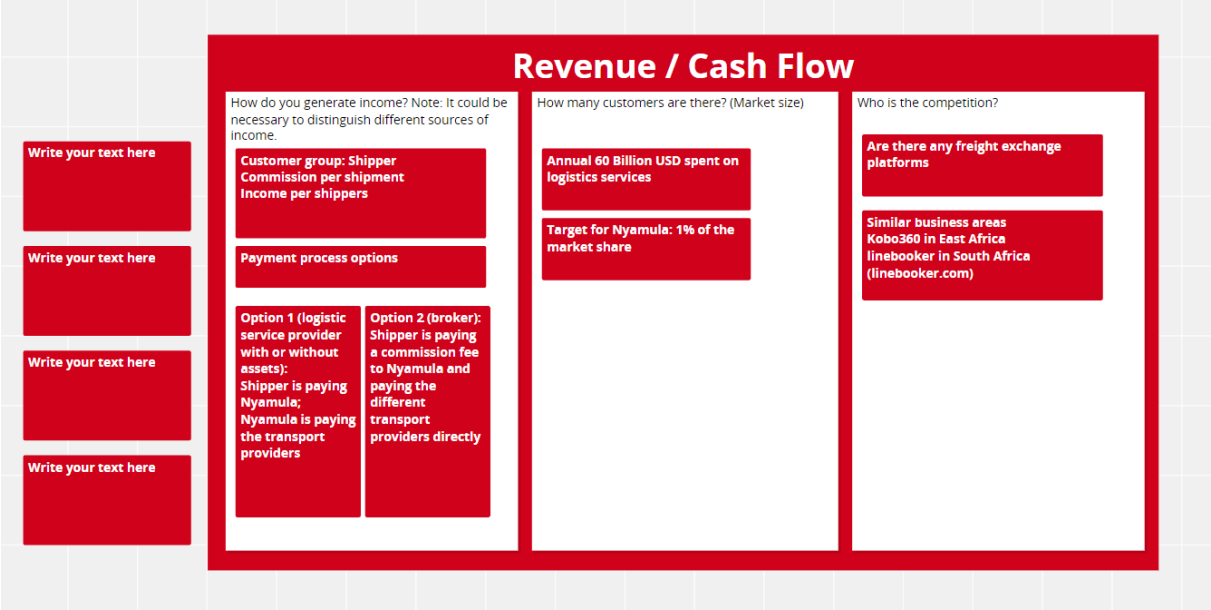

FIGURE A 3: EXAMPLE FOR THE REVENUE TEMPLATE

Another model used for the discussion is the supply chain management / logistics task model of Fraunhofer IML (see figure A 4). This was helpful to stress that smart logistics encompasses much more than the mere movement of goods.

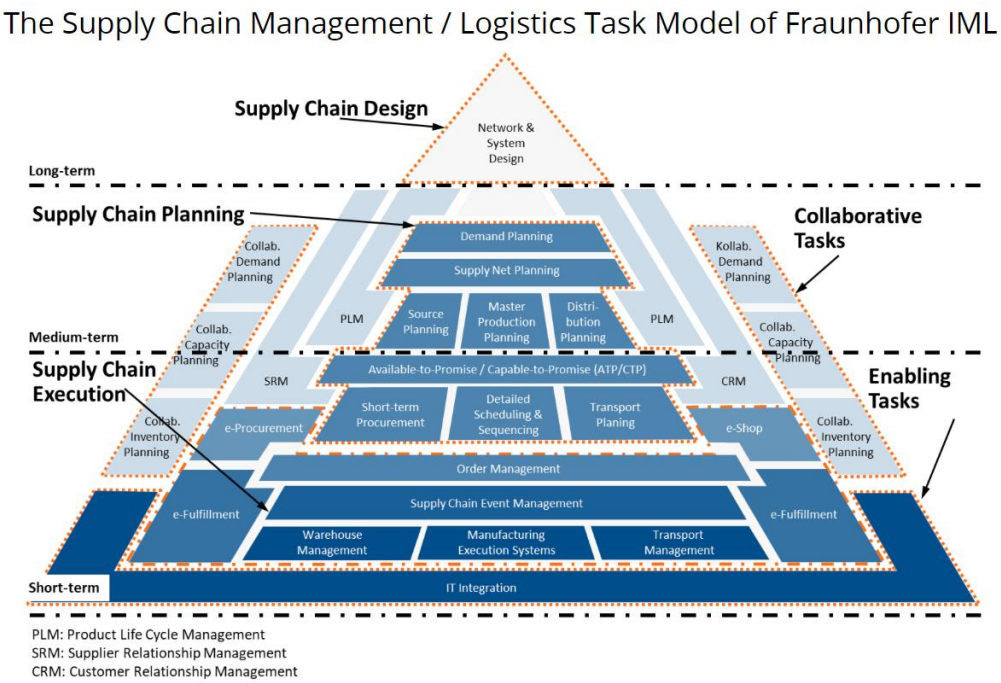

FIGURE A 4: THE TASK MODEL USED TO STRUCTURE DISCUSSIONS IN THE COMPANY WORKSHOPS

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APPENDIX C: START-UP FITNESS TABLES

The following tables display start-ups' fitness with the biosocial-technical environment in relation to fitness with business market.

TABLE A 1: AUTOTRUCK

Ecological variables (biosocial-technical)		**Fitness Components**				
		electric vehicle systems	component cost	retro-fit kit versatility	facilities access	life-cycle skills
Ground	Paved					
	Natural					
Vehicles	Mechanical vehicles					
	Pack animals					
Energy sources	Fuel stations					
	Natural					
Addressing	Digital system					
	Natural landmarks					
Communication	Reliable Internet					
	Traditional					
Location finding	Navigation tech					
	Wayfinding skills					
Repair resources	Repair centres					
	Human ingenuity					
Security	Automated systems					
	Traditional society					
Weather	Automated stations					
	Traditional responses					

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TABLE A 2: DEFTPAL

Ecological variables (biosocial-technical)		Fitness Components				
		efficient online and offline software	competent support personnel	financial licensing	number of customers	number of use options per customer
Ground	Paved					
	Natural					
Vehicles	Mechanical vehicles					
	Pack animals					
Energy sources	Fuel stations					
	Natural					
Addressing	Digital system					
	Natural landmarks					
Communication	Reliable Internet					
	Traditional					
Location finding	Navigation tech					
	Wayfinding skills					
Repair resources	Repair centres					
	Human ingenuity					
Security	Automated systems					
	Traditional society					
Weather	Automated stations					
	Traditional responses					

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TABLE A 3: DUNIYA

Ecological variables (biosocial-technical)		**Fitness Components**				
		wholesaler / retailer inventory tracking	web market place	delivery integrity	efficient delivery	commision agreements with wholesalers
Ground	Paved					
	Natural					
Vehicles	Mechanical vehicles					
	Pack animals					
Energy sources	Fuel stations					
	Natural					
Addressing	Digital system					
	Natural landmarks					
Communication	Reliable Internet					
	Traditional					
Location finding	Navigation tech					
	Wayfinding skills					
Repair resources	Repair centres					
	Human ingenuity					
Security	Automated systems					
	Traditional society					
Weather	Automated stations					
	Traditional responses					

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TABLE A 4: FARMISPHERE

Ecological variables (biosocial-technical)		Fitness Components				
		cold box internal temperature	reliable delivery	diverse customer base	diverse local supply	NAFDAC approvals
Ground	Paved					
	Natural					
Vehicles	Mechanical vehicles					
	Pack animals					
Energy sources	Fuel stations					
	Natural					
Addressing	Digital system					
	Natural landmarks					
Communication	Reliable Internet					
	Traditional					
Location finding	Navigation tech					
	Wayfinding skills					
Repair resources	Repair centers					
	Human ingenuity					
Security	Automated systems					
	Traditional society					
Weather	Automated stations					
	Traditional responses					

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TABLE A 5: INSTADRIVER

Ecological variables (biosocial-technical)		Fitness Components			
		demand-side marketing	sufficient qualified drivers	reliable software-as-a-service (SAAS)	cash flow
Ground	Paved	■	■		■
	Natural				
Vehicles	Mechanical vehicles	■	■	■	■
	Pack animals				
Energy sources	Fuel stations				■
	Natural				
Addressing	Digital system		■	■	■
	Natural landmarks				
Communication	Reliable Internet			■	■
	Traditional				
Location finding	Navigation tech			■	■
	Wayfinding skills				
Repair resources	Repair centers				■
	Human ingenuity				
Security	Automated systems				■
	Traditional society				
Weather	Automated stations				
					■
	Traditional responses				

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TABLE A 6: RADAVA-TRUSTY

Ecological variables (biosocial-technical)		**Fitness Components**				
		security	reduce counterparty risk	traceability	scalability	stakeholder integration
Ground	Paved				■	
						■
	Natural					
Vehicles	Mechanical vehicles				■	
	Pack animals					
Energy sources	Fuel stations				■	
	Natural					
Addressing	Digital system					
				■	■	■
	Natural landmarks					
Communication	Reliable Internet					
		■	■	■	■	■
	Traditional					
Location finding	Navigation tech			■	■	■
	Wayfinding skills					
Repair resources	Repair centers	■			■	
	Human ingenuity					
Security	Automated systems					
		■	■			
	Traditional society					
Weather	Automated stations					
					■	■
	Traditional responses					

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TABLE A 7: TROTRO.LIVE

Ecological variables (biosocial-technical)		Fitness Components				
		real-time communication for stakeholders	real-time data collection	real-time data processing	multi-channel platform	fixed and dynamic payment system
Ground	Paved					
	Natural					
Vehicles	Mechanical vehicles					
	Pack animals					
Energy sources	Fuel stations					
	Natural					
Addressing	Digital system					
	Natural landmarks					
Communication	Reliable Internet					
	Traditional					
Location finding	Navigation tech					
	Wayfinding skills					
Repair resources	Repair centers					
	Human ingenuity					
Security	Automated systems					
	Traditional society					
Weather	Automated stations					
	Traditional responses					

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TABLE A 8: VINMAK

Ecological variables (biosocial-technical)		Fitness Components / Survival Parameters				
		paying customers	disinter-mediation	ease of access to quality inputs	timely delivery of quality inputs	marketing platform
Ground	Paved					
	Natural					
Vehicles	Mechanical vehicles					
	Animals					
Energy sources	Fuel stations					
	Natural					
Addressing	Digital system					
	Natural landmarks					
Communication	Reliable Internet					
	Traditional					
Location finding	Navigation tech					
	Wayfinding skills					
Repair resources	Repair centres					
	Human ingenuity					
Security	Automated systems					
	Traditional society					
Weather	Automated stations					
	Traditional responses					

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TABLE A 9: WADONGE

Ecological variables (biosocial-technical)		Fitness Components				
		produce distribution points	online multimedia market place	clients per distribution point	produce handling systems	versatile transport-ation
Ground	Paved			■		■
		■				
	Natural					
Vehicles	Mechanical vehicles	■		■		■
	Pack animals					
Energy sources	Fuel stations	■		■		■
	Natural					
Addressing	Digital system					
				■		
	Natural landmarks					
Communication	Reliable Internet		■			
	Traditional					
Location finding	Navigation tech			■		
	Wayfinding skills					
Repair resources	Repair centers					■
	Human ingenuity					
Security	Automated systems					
		■				
	Traditional society					
Weather	Automated stations					
		■				
	Traditional responses					

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TABLE A 10: YAAKA

Ecological variables (biosocial-technical)		Fitness Components				
		power consumption monitoring	reliable components	component security	ERB approval	customer variety
Ground	Paved					
	Natural					
Vehicles	Mechanical vehicles					
	Pack animals					
Energy sources	Fuel stations					
	Natural					
Addressing	Digital system					
	Natural landmarks					
Communication	Reliable Internet					
	Traditional					
Location finding	Navigation tech					
	Wayfinding skills					
Repair resources	Repair centers					
	Human ingenuity					
Security	Automated systems					
	Traditional society					
Weather	Automated stations					
	Traditional responses					

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APPENDIX D: DHL TREND RADAR

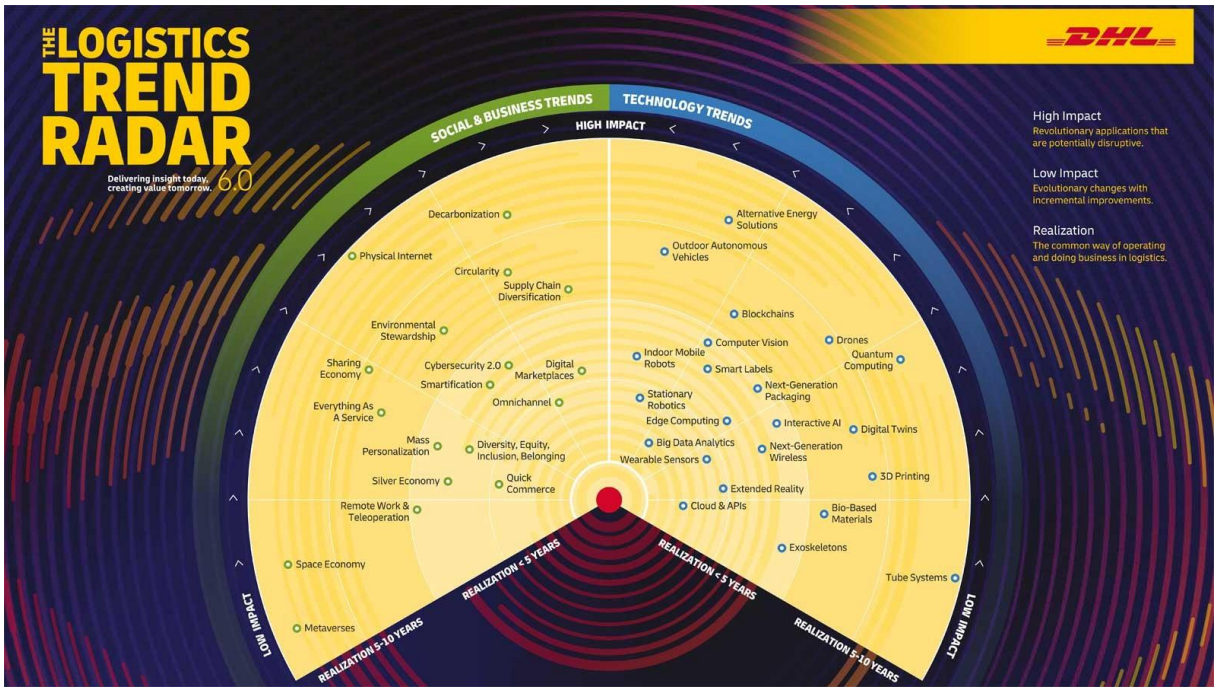

FIGURE A 5: DHL LOGISTICS TREND RADAR 6.0 (2023)

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