Methodical recommendations for designing a digital logistics network in Ethiopian agriculture

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ABSTRACT

INTRODUCTION. Technological advancement is an essential instrument in order to achieve economic expansion, higher production, and social advancement. Ethiopia has a strategic digital agricultural plan and acknowledges the value of digital solutions throughout the value chains. However, there is a lack of a context-specific, organized framework for designing and implementing an integrated digital logistics network.

AIM. To offer systematic recommendations for establishing a digital logistics network tailored specifically for the agricultural sector in Ethiopia.

METHODS. The research employs a review of the literature on digital transformation in agricultural logistics, content analysis, and statistical techniques of trend analysis to achieve the aim of the study.

RESULTS. The study identified the benefits and possibilities of integrating digital technologies into agricultural logistics. The findings show that Ethiopia's digital coverage has improved steadily since the previous years, including internet users and mobile connections, despite infrastructural limitations. The research also offered concrete recommendations on how to establish a digital logistics network that is appropriate for Ethiopia's agricultural environment.

CONCLUSION. Digital logistics networks cannot be effectively established without methods that are structured, context-specific, and participatory. The country can have a robust digital logistics network through the expansion of core infrastructural foundations, stakeholder engagement, solution formulation that is specifically tailored to address needs, and enabling policies. For a more thorough analysis and improved generalization, field-level research may be taken into account in future studies.

KEYWORDS: agriculture, digital logistics, digital transformation, Ethiopia, methodical recommendations

Методические рекомендации по проектированию цифровой логистической сети в сельском хозяйстве Эфиопии

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АННОТАЦИЯ

ВВЕДЕНИЕ. Технологический прогресс является основой для достижения экономического роста, повышения производительности и социального прогресса. В Эфиопии принят стратегический план развития цифрового сельского хозяйства и признается ценность цифровых решений на всех этапах производственно-сбытовой цепочки. Однако отсутствует организованная система, адаптированная к конкретным условиям, для разработки и внедрения интегрированной цифровой логистической сети.

ЦЕЛЬ. Предложить систематические рекомендации по созданию цифровой логистической сети, специально адаптированной для сельскохозяйственного сектора Эфиопии.

МЕТОДЫ. В исследовании используется обзор литературы по цифровой трансформации в сельскохозяйственной логистике, контент-анализ и статистические методы анализа тенденций для достижения цели исследования.

РЕЗУЛЬТАТЫ. Исследование выявило преимущества и возможности интеграции цифровых технологий в сельскохозяйственную логистику. Результаты показывают, что, несмотря на инфраструктурные ограничения, цифровое покрытие в Эфиопии стабильно улучшается с предыдущих лет, включая количество интернет-пользователей и мобильных подключений. Исследование также предложило конкретные рекомендации по созданию цифровой логистической сети, подходящей для сельскохозяйственной среды Эфиопии.

ЗАКЛЮЧЕНИЕ. Цифровые логистические сети не могут быть эффективно созданы без методического обеспечения с учетом особенностей сетевого конфигурирования и интересов групп заинтересованных лиц. Эфиопия может сформировать надежную цифровую логистическую сеть за счет расширения основной инфраструктуры, привлечения заинтересованных сторон, разработки решений, специально адаптированных к потребностям, и проведения соответствующей политики. Для более глубокого анализа и систематизации в перспективе могут быть учтены результаты полевых исследований.

КЛЮЧЕВЫЕ СЛОВА: сельское хозяйство, цифровизированная логистика, цифровая трансформация, Эфиопия, методические рекомендации

INTRODUCTION

The development of digital technology is essential to rising nations' economic growth and ability to compete globally, mostly through the use of information and communication technologies. One of the main advantages of delivering public services via digital technology is the potential to reduce operating expenses. Furthermore, it can promote increased accountability, openness, and involvement while also improving the quality of services [1]. Agriculture forms the foundation of most of Ethiopia's economy and is also a significant driver of employment, GDP, and food security. Though it forms the foundation of the economy, the country continues to face logistical problems, including inadequate supply chains, broken infrastructure, and limited market awareness, all brought on by the slow adoption of digital technology. The Ethiopian Digital Agriculture Roadmap (DAR) aims to incorporate digital technologies that improve decision-making, efficiency, and productivity, all of which will eventually result in greater agricultural production and better farmer lives [2].

Ethiopia's strategy for digital transformation aims to offer digital services to the country's major industries, including manufacturing, tourism, and agriculture, leveraging its economic potential. It proposes cross-sectoral infrastructure, supporting systems, digital interaction, and the digital environment. Supporting systems include digital identity, electronic payments, and computer security; infrastructure comprises energy and connectivity. Financial support for the ICT industry, educated labour, and laws and regulations constitute Ethiopia's digital environment. Digital engagement covers e-commerce and e-governance [3]. Technologies, such as blockchain, facilitate fair trade certification, traceability, and better payment methods, while IoT helps farmers to monitor their crops. Though there have been a few improvements in ICT and infrastructure development over the last ten years [4], Ethiopia is still at the bottom of the rankings of ICT growth indicators. Ethiopia's manufacturing sector depends on the transportation and logistics subsector. Furthermore, this industry is vital for the agricultural sector and encourages more integration into global value chains.

Trade and logistics would become more efficient, and global trade flows would be better interconnected with the implementation of digital frontier procedures and an enhanced transportation network. Developing effective and successful transportation and mobility networks can also call for digital innovation. Among these are digital logistics systems that enable real-time gathering and analysis of traffic data to help develop multimodal transportation systems, smart traffic signals, automatic parking, and fare collection for public transit [5]. The architecture of digital logistics networks is essential to the economic development of any nation, as it facilitates online interaction between buyers and sellers [6]. Logistical operations are undergoing a significant transformation due to the emergence of new digital technologies [7]. Tracking and monitoring devices can deliver real-time data from the supply chain, facilitating digital transformation in the logistics and supply chain industry [8]. Digitalization is helping to increase the competitiveness of the global supply chain, particularly by improving trade transparency and efficiency [9]. Digital transformation has provided the logistics sector with a strategic tool that it may use to enhance its performance [10].

Though Ethiopia has a strategic digital agriculture plan and recognizes the significance of digital solutions throughout the value chain, there is a limited context-specific guideline for the design and execution of an integrated digital logistics network suited to the specific challenges and opportunities of Ethiopian agriculture. Existing initiatives generally aim at digital transformation, advisory services, or single traceability systems. Sequential systematic recommendations for the design of an entire digital logistics network, considering the diverse smallholder farmer context, infrastructural limitations, and literacy levels, have not been considered yet. Therefore, this study was devised to fill this gap.

The theoretical framework of this research lies in the intersection of system theory and the theory of digital transformation. Together, these ideas direct the incorporation of infrastructure, technical, and human components required for a resilient and inclusive logistics system. According to [11], system theory views complex entities as integrated wholes made of interconnected and interdependent parts. This hypothesis sees agricultural logistics as a sophisticated network of mutually reliant elements, including transportation, communication, data, and human actors that have to work together for efficiency and scalability. A systems perspective helps to find bottlenecks and gaps in Ethiopia, where agricultural supply chains are dispersed and infrastructure is weak. Logistics, infrastructural foundation, digital platforms, and human actors must be viewed as subsystems that interact dynamically.

Digital transformation theory [12] provides the foundations of understanding how digital technologies radically transform businesses, sectors, and communities. Driven by innovation, data, and connectivity, it goes beyond basic digitization to include a strategic, cultural, and operational change. In the Ethiopian setting, agriculture is a top industry for ICT integration and digital transformation to enhance the national plan for economic modernization. Digital transformation helps the notion that smallholder farmers must be able to make decisions in real time, be transparent, tractable, and have inclusive access via digital logistics networks [13].
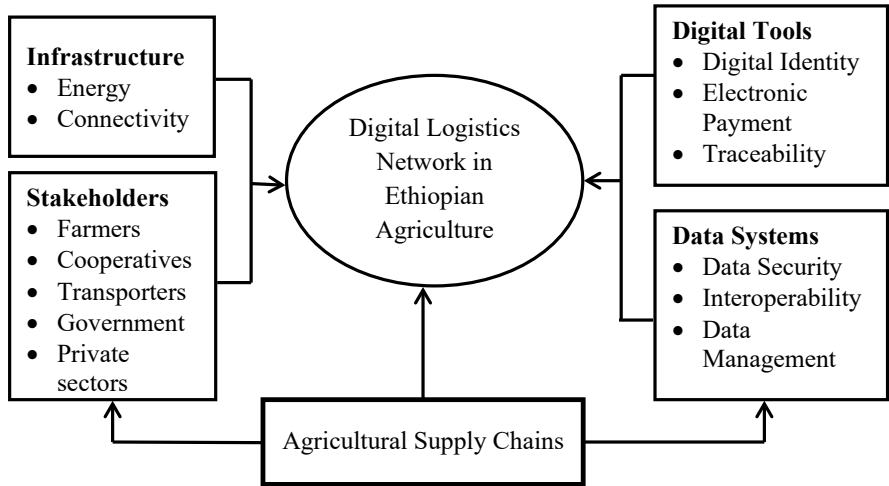
Figure 1
Conceptual framework of the study

Рисунок 1
Концептуальные рамки исследования

The conceptual basis of these theories rests on four important pillars, such as infrastructural foundation, stakeholder engagement, digital capability, and data systems, that are important for the establishment of a digital logistics network tailored to Ethiopian agriculture. Digital capability consists of digital literacy, device access, and institutional readiness. Stakeholder engagement provides inputs through reinforcement by farmers, cooperatives, private organizations, and government agencies for the development and upkeep of the network. Interoperability, analytics, and real-time monitoring, deemed essential for decision-making and transparency, are finally made possible through data systems. On the basis of this framework, this study aims to develop systematic guidelines for the formation of a digital logistics network tailored to the Ethiopian agricultural landscape.

MATERIALS AND METHODS

Ethiopia is a landlocked African nation that is developing fast and is highly known for having valuable natural resources and potential agricultural output. It is considered a regional development focus country, mechanization of agriculture, and facilitation of trade due to the location of the country and abundance of natural resources. The government is aiming to improve the logistics and agricultural sectors through integrating digital technologies. Upgrading and enlargement of the logistical infrastructure have received considerable national investment. However, infrastructure problems and poor digital advertising adoption continue to impede its logistics. In this investigation, we have developed systematic recommendations for designing digital logistics systems tailored to Ethiopian agriculture.

Literature review, content analysis, and statistical techniques of trend analysis were used for the data analysis to meet research objectives. The study critically analyses the literature surrounding digital transformation in agricultural logistics and its potential benefits for possible implementation in developing countries, such as Ethiopia. Trend analysis was used to compare the progress of digital infrastructural foundations, while the method of principal component analysis was implemented to create an index to show how the digital development of the country is progressing. Data used in this study were compiled from the ITU and World Bank Development Indicators, as well as published reports.

RESULTS AND DISCUSSION

Digital technologies are now the best way to cope with the growing demands of the modern world, particularly for digitalizing agricultural logistics operations. Most importantly, digitalization and, as a consequence, automation allow logistics businesses to build a robust working environment. Digital transformation in logistics is a disruptive process that takes place on an enterprise-wide level and requires a feasible digital transformation roadmap. A revolutionary and innovative influence within the logistics sector is revealed by research in the literature (Table 1) on digital transformation in the logistics sector. Because they facilitate automation, real-time data exchange, and more intelligent decision-making, digital technologies, specifically those of Logistics 4.0, are transforming the logistics process. Increased supply chain efficiency is an outcome of digital adoption supported by investment in infrastructure and the development of labour skills. Apart from improving logistical performance,

digital transformation turns business models around and promotes global competitiveness. Companies can improve services, respond to changing trends, and gain an edge over others because of digitalization. These effects point out the ways that logistics companies are required to be flexible, efficient, and competitive in a fast-changing world have to embrace digital transformation [7–10; 14].

The integration of cloud computing, blockchain, AI, and IoT has transformed logistics into real-time tracking, data-driven decision-making, and better supply chain coordination. Big Data in agricultural logistics can enhance operational efficiency, reduce cost and risk, and enhance transparency and flexibility of logistics operations. The Internet of Things makes farm product delivery streamlined, which does away with circulatory delays and improves overall logistics efficiency. Intelligent blockchain technologies may increase logistics revenue in agriculture. Breakthrough technologies such as additive manufacturing, exoskeletons, and collaborative robots as the main enablers of sustainable development in Logistics 4.0, with technological progress harmonized with environmental and social objectives. Digital innovation is not

only transforming logistics operations but also promoting innovation and sustainability for the whole industry [15–19]. Selected reviewed literature regarding digital logistics network and key contributions are presented in **Table 1**.

Digitalization of the agricultural supply chain has several advantages for industry development and optimized operation. It significantly enhances the evaluation of logistics strategy by the inclusion of new technologies and data-based decision-making. Digital technology improves agricultural supply chains to be resilient, transparent, and effective by means of optimization. Real-time sensor data gathering and GPS, for example, enable dynamic route planning and more effective inventory control. Blockchain lets stakeholders trace and securely distribute information. Artificial intelligence-powered predictive analysis aids in demand projection and optimal delivery schedule determination. Digital platforms and decision support systems also facilitate greater collaboration in the supply chain to enable more strategic analysis. Such innovations serve not only to improve efficiency but also promote sustainability objectives through minimizing energy and emissions [20].

Table 1

Results from selected literature on digital transformation in logistics

Таблица 1

Научный вклад авторов по отобранным источникам литературы на тему цифровой трансформации в логистике

Author	Contributions
Albrecht et al. [7]	Studied leveraging digital technologies in Logistics 4.0 and found that digital technologies are transforming logistics processes on a large scale, despite a lack of systematic understanding among organizations regarding the opportunities digital technologies afford for logistics processes.
Helo and Thai [8]	Conducted a study on digital transformation (DT) utilizing smart connected and tracing devices under logistics 4.0. They suggested the potential application domains for logistics 4.0, such as intermodal tracking of shipments for operations control, container asset management, and process step and authenticity certification.
Constantin et al. [9]	They discovered that the efficiency of the supply chain is improved by combining the adoption of DT, workforce development, and infrastructure investment.
Sahan [10]	Evaluated the effect of digital transformation on logistics performance and found that DT is shifting established business practices and improving logistics performance to realize competitiveness in global supply chains.
Kalinina [14]	Integration of DT in logistics enables businesses to enhance processes and adapt to new approaches, while improving the quality of services provided to customers, and also gaining benefits in the market.
Kurniadi [15]	DT in the transportation and logistics industry is investigated, and the result revealed that the adoption of IoT, AI, blockchain, and cloud computing technologies has led to real-time tracking, data-driven decision-making and improved supply chain integration.
Dupal' et al. [16]	Researched contemporary trends in the logistics of agricultural enterprises. They concluded that the transfer of Big Data in agriculture will lead to better decisions, resulting in higher operational efficiency, cost reduction, risk reduction, flexibility, and clarity of logistic processes.
Ai and Zhang [17]	Analyzed the intelligent logistics distribution path of agricultural products under an IoT environment. The results show that the efficient use of IoT technology resolves the issue of lagging agricultural product information.
Zheng and Zhou [18]	According to their research, at least 40% of the additional revenue could be generated by the logistics sector of the agricultural industry, which is based on smart blockchain technology.
Ferraro et al. [19]	Additive manufacturing, exoskeletons, and collaborative robots are the technologies that best support the sustainable development objectives of Logistics 4.0.

Source: results from review analysis.

Источник: результаты обзора.

Digitalization of agricultural logistics also enables connectivity and transparency by the utilization of sophisticated digital technologies for data interchange, collaboration, and openness in the supply chain. Connectivity is enabled by the use of IoT devices, cloud networks, and mobile apps to enable real-time communication among stakeholders. Applications enable coordination of activity at distant places without a time lag and enabling responsiveness. Blockchain provides transaction history for traceability and accountability along the supply chain. It is particularly valuable in generating a source of origin, tracking quality specifications, and ensuring regulatory compliance. Digitalization of agri-products distribution assists in rural development and sustainability based on enhanced connectivity and data-enabled open practices. Digital twins and analytics platforms enable farming stakeholders to manage complicated chains of logistics and make substantial savings through simulation and optimization [20–22]. The advantages of integrating digital transformations in the logistics of agriculture from the literature are summarized in **Figure 2**.

Despite Ethiopia's large population and domestic market, few organizations offer e-commerce services in the country [23]. This situation is mainly attributed to the underdeveloped financial and logistics sectors, the lack of a national addressing system, and the low adoption of internet services, which are further complicated by unreliable connectivity. However, as part of a digital strategy, the government is setting up an East Africa Hub to get the country ready

for e-commerce [13]. Implementation of computerized information systems and their application in the agriculture industry is paramount to boost productivity. However, infrastructural constraints are the issues behind the underdevelopment of digital skills and internet penetration in Ethiopia. The low digital literacy rate constrains the expansion of ICT-based agricultural extension and consulting services. The majority of farmers have limited technical capacity to adopt digital services and products [24].

Figure 3 shows the trend of internet penetration in Ethiopia from 2010 to 2023. The graph shows a gradual increasing trend of the use of the internet by individuals expressed as a percentage of the population. The year 2010 had minimal internet penetration, with less than 1% of the population connected to the internet, due to the evidence of restricted infrastructure and coverage. There was gradual growth in the subsequent years, advancing by 7.7% by the year 2014. Nonetheless, 2015 was the turning year as usage improved to approximately 13.9%. This increase is likely correlated with major surges in mobile coverage growth, smartphone penetration, and governmental efforts at going digital. Growth since 2016 has been relatively flat in percentage form at 16.7% by 2021. This indicates further improvement in digital understanding and connectivity, especially in cities. With an internet usage of 19.4% by 2022, there is a noticeable increase in the degree of connection throughout the country. The result also shows, nevertheless, that most of the population is offline, indicating that there are still challenges with mass digital inclusion.
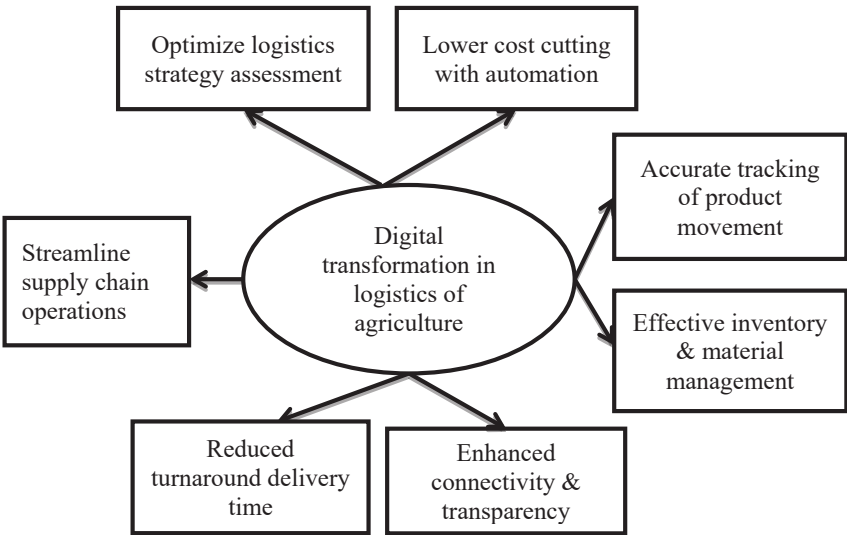

Figure 2

Successful digital transformation in the logistics of agriculture

Source: compiled from the Literature review.

Рисунок 2

Завершенная цифровая трансформация в логистике сельского хозяйства

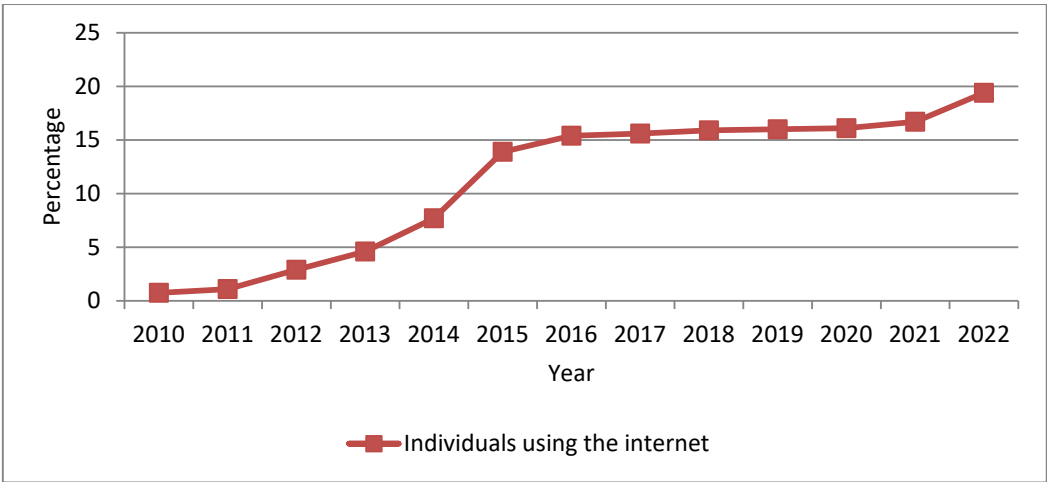Источник: разработано автором на основе литературного обзора.

Figure 3
Number of individuals using the internet (% of population)

Рисунок 3
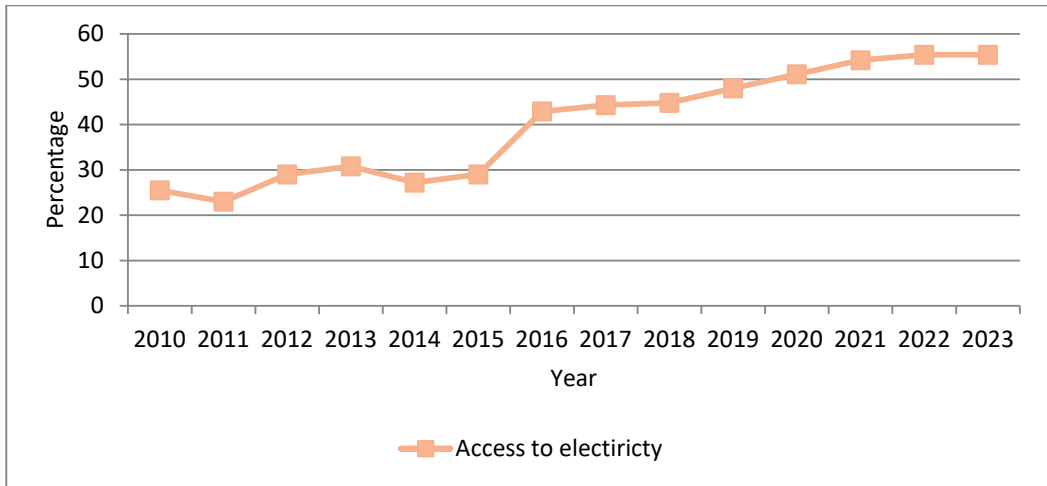**Число индивидуумов, использующих интернет (% от населения)**

Figure 4
Access to electricity (% of population)

Рисунок 4
Доступ к электрической энергии (% от населения)

Access to electricity is a basic type of infrastructure for the scalability of digital logistics in emerging regions. The energy supply in Ethiopia between 2010 and 2023 is shown clearly in **Figure 4**. The years from 2010 to 2015 exhibit a fairly erratic pattern with values ranging from around 23 to 31. This implies that electrification-related initiatives may have varied over these years owing either to policy changes, infrastructural difficulties, or subpar local execution. There is a dramatic rise in 2016, where access rises to about 42.9. The increase can be traced to the beginning of major national initiatives or international partnerships with the agenda of stepping up electrification. Since 2016, the line has up on a strong and linear trend up to a peak of around 55.4 in 2022. This is then maintained through to 2023, with the suggestion that Ethiopia has reached a new plateau in its process of electrification. The repeating highs of the last few years reinforce that the country has made significant strides towards stabilizing and growing its energy base, possibly to a larger segment of the populace. Early volatility followed by strong and steady improvement indicates growing attention to energy access, while rural areas need further government intervention.

Digital tools are becoming increasingly important for development initiatives nowadays. They let companies operate

more effectively, offer more individuals access to financial opportunities, and enhance the distribution of vital goods. Their influence extends over many spheres of government activity, logistics, and agricultural systems. A digital development index was created in this study using principal component analysis, using fixed broadband and landline access, internet penetration, and mobile subscription density as metrics. As seen in **Figure 5**, which illustrates systematic underperformance, the index was below zero until 2013. But starting in 2014, consistent development has been noted that might be related to ICT investments, legislative changes, or the increasing accessibility of mobile and internet services. Starting in 2015, the index consistently shows continuous improvement in digital development. The most apparent increase occurs in 2022, when the score hits its maximum, hence indicating a significant digital transformation jump possibly spurred through government-sponsored initiatives or better connectivity. Ethiopia's consistent but deliberate path toward digitalization is depicted in the graph overall; key inflection points could correspond to planned interventions or technical initiatives. However, the digital development is steady compared to population needs.

Recent statistics (**Table 2**) indicate that by the start of 2025, the proportion of people who own a mobile phone in the country was 63.8%. The price of mobile data was meant to be high then because of the country's new floating macroeconomic policy. However, the current overall price per gigabyte is reported to be USD 0.68, which has remained constant over the last year. The report shows that 47.7 apps were local language in 2025. Digital skill, on a scale of 1 (low) to 7 (high), was 3.75 in 2019. The country is doing well in digitalization, with expanding mobile coverage and stable data prices. But still, there are challenges in improving

digital skills and local-language content, which are critical for achieving higher and more inclusive digital integration.

Table 2
Recent statistics on some themes of digital infrastructure
Таблица 2
Последние статистические данные по некоторым аспектам цифровой инфраструктуры

Sub-theme	Score	Year
Cellular mobile connections (% of population)	63.80	2025
Average mobile data price per 1 GB (USD)	0.68	2025
Number of apps in the national language (quantity)	47.7	2019
Digital skill among population (ranking 1to 7; low to high)	3.75	2019

Source: https://datareportal.com/reports/digital-2025-ethiopia
Источник: https://datareportal.com/reports/digital-2025-ethiopia

The findings indicate that digital technologies are being increasingly adopted in Ethiopia with a gradual trend, even though many of the country's citizens remain offline. Infrastructural foundations are showing gradual progress as evidenced by the expansion of telecom services and energy supply. The Grand Ethiopian Renaissance Dam, which was just opened and is ready to be utilized, will increase the national energy supply significantly. Anecdotal evidence suggests that Ethiopian companies are lagging behind their international counterparts in terms of technical invention and digital skills, hence hurting overall productivity and the performance of daily business operations [25]. The Ethiopian government intends to map out current digital technologies in agriculture and potential opportunities to hasten a digitally-enabled agriculture transition, with an emphasis on the route to realize value from agriculture [26].
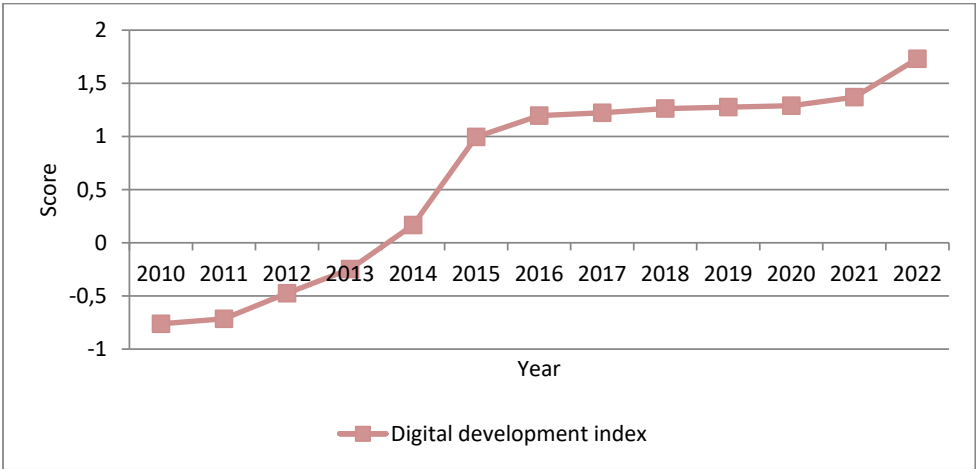

Figure 5
Digital development index

Рисунок 5
Индекс цифрового развития

Adopting digital technology provides a respectable foundation for turning agricultural logistics into a productive, cost-effective, and life-improving industry for farmers. In addition to a variety of platforms and social networks that reduce transaction expenses and information asymmetry [27], a wide range of technologies and applications promise to improve efficiency and have a significant impact on trade logistics and the agriculture sector. **Table 2** presents non-technical overviews of several digital technologies that are now being utilized or tested for use in agricultural industries in general and the creation of digital logistics networks in particular.

Ethiopia developed a National ICT policy in 2017, aiming at promoting and facilitating extensive use of ICT in key sectors like agriculture. Its key strategy is to develop and implement computerized information systems and applications for agriculture,

an imperative driver of anticipated digital agriculture growth. Referring to the first route towards deriving value from agriculture, the government intends to map existing digital technologies in agriculture and opportunities in order to lead a digitally empowered agriculture revolution [26]. Within the framework of digital logistics of Ethiopian agriculture, the sector has introduced a number of digital solutions and services, including e-marketing, digital finance, real-time market data, and soil and product management systems. Digital Green's *FarmStack* platform offers advisory content on weather, soil, and market trends. Similarly, *Yerras Gebeya* facilitates livestock transactions using electronic payment systems. Mobile money services such as *M-birr* and *Telebirr* are also expanding financial inclusion because they enable payments for retail shopping and utilities. *Awesome Africa* is yet another platform that empowers farmers by offering permaculture training in local languages [26].

Table 2

Description of possible digital technologies in agricultural logistics

Таблица 2

Описание возможных цифровых технологий в сельском хозяйстве

Digital technologies and platforms	Descriptions
Electronic data interchange (EDI)	EDI is an automated tool that facilitates electronic data sharing between trading partners at every stage of the supply chain, starting with the initial supplier and continuing through several production and logistics processes. The receiver can complete the intended transactions through the inter-company computer-to-computer transmission of conventional commercial transactions in a standard format.
Platforms	Digital platforms can link individuals, groups, and resources to enhance company management efficiency and to facilitate the fundamental interactions between companies and customers. The rise of intermediary platforms that enable business dealings between suppliers and consumers is one of the most notable aspects of the digitalization of global trade.
Sensors	Sensors convert various physical attributes into digital data. Sensor centres represent the main benefits of increased visibility, efficiency, and cost savings. Reasonable costs are the cause of where real-time visibility, data-driven decision making, and streamlined operations along the supply chain lead. Sensor technology extends supply chain visibility by monitoring supplier performance.
Internet of Things (IoT)	IoT is transforming logistics operations by allowing real-time tracking and monitoring of shipments. Sensors in packages provide real-time feedback on location, temperature, and humidity. This provides timely and secure delivery of products and guarantees the prompt and secure delivery of goods. This technology can track shipments and cargo deliveries, as well as manage fleets and the technical health of vehicles.
Blockchain technology	Blockchain technology guarantees transparency and security in logistics transactions. Every transaction is recorded in a tamper-proof decentralized ledger. The origin and path of commodities may be tracked using this technology. In addition, it expedites the customs clearance process, which results in less delay. The site, timestamps, and documentation of each delivery are kept on file indefinitely. Customers track orders confidently while sensitive data remains secure through cryptography.
Artificial intelligence (AI)	AI algorithms process massive data streams to reveal powerful insights and can optimize logistics operations and delight customers. The technology reduces inefficiencies by taking into account a large number of factors and constantly learning. By improving decision-making in supply chain management and lowering risk and uncertainty in logistical activities, AI and machine learning contribute to enhanced decision-making.
Cloud computing	Cloud computing enables users to access computing resources in a flexible, on-demand manner. It offers the capacity for the data to be stored and aggregated to support big data analytics and enable data processing and decision-making, while IoT collects data and takes action based on specific rules. Both cloud computing and data analytics include improved machine learning applications, operating at a new level of AI.
Digital twins	Digital twins are sophisticated digital tools that can transform the logistics sector and its operations in general. They are virtual copies of physical objects, which are employed to simulate within virtual environments without interfering with ongoing business operations. This technology combines cloud computing, machine learning, AI, data analytics, and IoT to create simulated worlds.

Source: compiled from scientific literature.

Источник: составлено на основе научной литературы.

Though a widespread adoption of digital platforms is observed in Ethiopian agriculture, there are some bottlenecks to their complete utilization. Poor digital infrastructure is one of the major bottlenecks, primarily in rural regions where there is no internet connectivity and stable electricity, constraining the use of platforms such as *FarmStack* and *Awesome Africa* that are dependent on stable digital connectivity [13]. Furthermore, poor digital literacy among smallholder farmers is also deterring the use of such technology since they are unable to utilize mobile apps or comprehend digital advisory content. The second constraint is data governance; there exists no one-size-fits-all data sharing and privacy policy that would prevent integration and scalability of digital services. Financial constraints also affect sustainability because activities are dependent on donor money or pilot projects without long-term investment guarantees. Furthermore, fragmentation of platforms, each of which caters to different dimensions of agriculture but not in an interoperable context, prevents the development of a single digital ecosystem. Inclusivity is also lacking with pastoralists, women, and marginalized groups, not typically included because of language, culture, or access to devices. It will require collective efforts in infrastructure development, e-learning, policy reform, and accessibility design to bring e-agriculture as a change driver for farmers across the board in Ethiopia [24].

Despite the government's evident dedication to all of the existing initiatives, their long-term viability is contingent upon the ongoing development of infrastructure. Additional investment in digital foundations is necessary for long-term success. Through the gradual adoption of digital technologies, Ethiopia can have a sustainable digital logistics network. This study offers organized recommendations for creating a successful digital logistics network that takes into account Ethiopia's distinct agrarian environment.

1. Building core infrastructure for connectivity and transport: Expand broadband internet and mobile network coverage in rural areas; improve electricity access to support digital tools and mobile devices to enable real-time logistics tracking and communication. This stage also needs upgrading of rural roads and transport hubs to support efficient movement of goods, especially perishables.

2. Enhancing digital literacy of farmers through training: Organizing capacity building education for farmers using local languages and a culturally relevant approach to digitalization. Farmers value digital identity, which seeks to increase economic prospects and facilitate access to public and commercial sector services.

3. Developing integrated digital platforms: Building a centralized digital logistics hub that connects farmers, cooperatives, transporters, and buyers. At this stage, it is necessary to ensure interoperability with existing platforms like *FarmStack* and *Yerras Gebeya* to streamline operations from farm to market.

4. Enable real-time data sharing and market intelligence: This includes deploying IoT sensors and mobile apps for inventory and weather monitoring. Integrated market price data and demand forecasts are important to guide logistics decisions. The existing platforms can also be expanded to include logistics modules.

5. Designing inclusivity and last-mile delivery: Enhancing mobile money and e-payment systems such as *Telebirr* and *M-birr* to facilitate transactions across the supply chain. This stage includes ensuring the accessibility of platforms to marginalized groups, pastoralists, and women by providing subsidized devices or shared access points, such as digital kiosks.

6. Data protection and certification. The establishment of data protection laws and facilitative legislation is required to promote proper acceptance and long-term success of the system with international standards. The scalability and security of the system need to be considered at this stage.

7. Public-private partnership: There should be strong ties and cooperation with corporate sectors, such as government organizations and other concerned agencies, to share resources, exchange experts, and expedite the adoption of the system. Such collaboration can spur innovation and make the network more flexible in response to possible changes.

CONCLUSIONS

This research examined the current state of digital transformation in agricultural logistics and made systematic, methodical recommendations for the establishment of a digital logistics network for Ethiopian agriculture. This study stands out in the Ethiopian logistics scene because it is the first to develop methodical recommendations for sector-specific research. Digital logistics networks cannot be effectively established without methods that are structured, context-specific, and participatory. While the number of internet and cellular mobile connections is increasing, the evidence indicates that digital adoption is piling up gradually. However, poor digital literacy, scarcity of internet connection, and stable electricity, especially in rural areas, are among the challenges to the complete utilization of digital platforms in Ethiopian agriculture. The country can have a strong digital logistics system that raises productivity, expands market access, and encourages sustainable agricultural expansion by conducting systematic need appraisal, stakeholder engagement, infrastructure development, need-specific solution designing, and facilitative policies. Digital transformation of the logistics industry is a smart step towards improving the lives of farmers and the nation. The future study may consider a field-level investigation for a comprehensive analysis and better generalization.

Contributions:

Barykin S.E. – conceptualization, supervision, writing-review and editing.

Negeri M.A. – methodology, theoretical framework, and writing-original draft.

Korchagina E.V. – investigation, data curation, and writing-original draft (results and conclusions).

Voronova O.V. – data collection, visualization.

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