

Review Article

Comparative Analysis of Technology Development in Kenya, Estonia, and Mauritius: Pathways to Becoming a Digital Hub in East Africa

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Abstract

This paper conducts a comparative analysis of technology development in Kenya, Estonia, and Mauritius, focusing on how these countries have established themselves as leaders in the digital economy. It employs document analysis as the primary methodology, examining government reports, regulations, pieces of legislation, and case studies to identify best practices and strategies that Kenya can adopt to enhance its digital economy. The findings show that unlike Kenya and Mauritius, Estonia has made digital literacy compulsory for all citizens. It has also employed a citizen-oriented strategy in service delivery. By putting the needs of its citizens at the forefront of digital programs, the Estonian government has developed an efficient and user-friendly digital ecosystems and solutions. PPPs are also more valued in Estonia and Mauritius than in Kenya. As a matter of fact, in the former two countries, private industries build while governments acquire and do the implementation, something that is missing in Kenya. The findings also suggest that compared to Kenya and Mauritius, Estonia has invested heavily in digital literacy, accountable and transparent digital ecosystems, and cyber security. This approach encapsulates e-government's potential when implemented with robust, steadfast and clear commitment, infrastructure, citizen empowerment, and vision. Estonia views e-government as a vehicle for strengthening democracy and not just building technology; this is the foundation upon which its digital transformation is established. Kenya has made huge strides to make many of its public services accessible online. However, it still has room for improvement in terms of exploiting PPPs to explore collaborations with local and foreign entities.

Keywords

Digital Economy, Digital Policy, Technology, Development, Digital Ecosystems, Mauritius, Estonia, Kenya

1. Introduction

1.1. Background Information

Estonia's quest to becoming a trailblazer in digital governance worldwide was driven by a dedication to a *digital first* mentality since independence [27]. The government emphasized digital aspects in all governance dimensions, laying the

groundwork for a dynamic digital ecosystem and infrastructure. Key to its success is its e-ID system, which is similar to Kenya's proposed Maisha Card and ensures smooth access to e-government offerings via a unified digital ID program. Estonia also employs the *one only* doctrine that allows citizens to provide their information just once for different of-

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ferings [27]. This provision has also enabled the adoption of block chain technology, making the country's digital ecosystem more transparent and efficient. These formative measures illustrate the profundity of adopting a digital-based strategy for economic development. Kenya has a lot to learn from Estonia as it pursues digital transformation, including the importance of a PPP-driven digital ecosystem [26]. In Estonia, the public and private sectors have a strong synergy that fuels the digital economy by enabling collaboration and innovation. Kenya and Mauritius can leverage identical partnerships to cultivate enabling conditions for digital entrepreneurship and innovation. They can also exploit PPPs to boost knowledge sharing and technology exports [26]. Through PPPs, Kenya can improve data sharing, incorporate digital components in education delivery, and strengthen its government's architecture. Mauritius supports the formulation of custom solutions for its changing digital terrain by stressing co-development and customization. The author argues that one of the biggest challenges evident in the digital transformation journeys of Kenya and Mauritius is the demand for capable change management. Although technology creates opportunities, evolving traditional practices and worldviews pose major obstacles [26]. The governments of both countries have championed blueprints for digital development, emphasizing the significance of hierarchical leadership allied with elaborate retraining efforts to make their digital ecosystems more inclusive [25]. Overall, Kenya and Mauritius should focus on not just implementing novel innovations but also ensuring that all stakeholders migrate smoothly.

1.2. Problem Statement

In terms of sophistication, Estonia and Mauritius' digital ecosystems are ahead of Kenya's. In Kenya, priorities can drastically change because of the prevailing political atmosphere or the weather, such as when a natural disaster that demands urgent government intervention and drains much-needed financial resources, occurs [24]. Unlike Kenyans, where trust anchored in familiarity is usually needed before making progress, Estonians are accustomed to seeking services and undertaking tasks digitally. In terms of population, Kenya has close to 60 million citizens to serve while the combined populations of Estonia and Mauritius are less than 4 million [23]. This puts Kenya under more social and financial pressure to make e-government available to all its citizens. The ICT sectors of Estonia and Mauritius also employ more citizens as a proportion of their populations, than Kenya's. Estonia and Mauritius boast enabling regulatory climates that promote investment and innovation in their digital sectors. Efficient and explicit regulations in both countries enable the proliferation of digital enterprises [24]. In Kenya, it is common to see policies being formulated by people outside the ICT industry, something that impedes the advancement of the digital ecosystem by creating conflict between the needs and

policies of the sector. Compared to Estonia and Mauritius, Kenya is more corrupt [22]. Rampant corruption, moral bankruptcy, and integrity issues have undermined Kenya's digital transformation agenda. Estonia and Mauritius enjoy strong accountability and governance systems that have protected their digital ecosystems from being exploited for selfish gain. In Kenya, the greed of politicians and public servants has stunted innovation by blocking ideas and encouraging bribery in every stage where government support is needed [22].

1.3. Research Gap and Significance

Despite the growing recognition of technology as a catalyst for economic development in Africa, there remains a limited comparative understanding of how countries at different levels of development and with distinct institutional contexts have successfully built robust digital ecosystems. Specifically, while Kenya has shown promising strides in mobile banking and fintech, there is a paucity of comprehensive analyses that compare its digital development trajectory with that of established digital economies like Estonia and Mauritius. Existing studies often focus on individual country case studies without sufficiently exploring transferable lessons or adaptive strategies. This research addresses this gap by systematically comparing the technological ecosystems of Kenya, Estonia, and Mauritius, thereby uncovering contextual factors, policy frameworks, and innovation practices that can inform Kenya's strategic pathway. The significance of this study lies in its potential to provide policymakers, entrepreneurs, and development agencies with targeted insights and evidence-based recommendations to accelerate Kenya's evolution into a regional technology hub. Moreover, it contributes to the broader discourse on digital transformation in developing economies, highlighting how contextual adaptation of successful models can foster sustainable economic growth.

1.4. Research Objectives

1. To examine the key factors that have contributed to the technological success of Estonia and Mauritius?
2. To explore how the technological ecosystems of Kenya, Estonia, and Mauritius differ, and what impact do these differences have on the development of technology sectors?
3. To discuss lessons Kenya can learn from the economic strategies employed by Estonia and Mauritius to facilitate its own transformation into a technology hub?
4. To identify specific policy recommendations can be made for Kenya to achieve significant advancements in its digital economy within the next five years?

1.5. Contribution to Literature

This research contributes to the existing body of knowledge on technology development in Africa by providing a detailed

comparative analysis of Kenya, Estonia, and Mauritius. It highlights lessons that Kenya can learn from the successes and challenges faced by these countries, offering practical, context-specific recommendations for policymakers. Additionally, it aims at enriching the discourse on leveraging digital technologies for economic transformation in developing countries, emphasizing the importance of adaptive policy-making and innovation ecosystems.

2. Literature Review

2.1. Theoretical Frameworks

The theoretical framework for this study is grounded in innovation systems theory, digital economy framework theory, human capital development theory, and agile policy development theory.

1. Innovation Systems Theory

Emphasizes the importance of networks of institutions, organizations, and individuals that contribute to the innovation process. It highlights how collaboration among various stakeholders, including academia, the private sector, and research institutions, can foster technological advancements and economic growth.

2. Digital Economy Framework

Focuses on the role of digital technologies in transforming traditional economic activities. It examines how the integration of digital tools can enhance productivity, create new markets, and improve service delivery. Key components include digital infrastructure, digital skills development, and the promotion of entrepreneurship.

3. Human Capital Development

Underscores the significance of investing in education and skills training to build a workforce capable of thriving in a technology-driven economy. A skilled labor force is essential for innovation and competitiveness in the global market.

4. Agile Policy Development

Emphasizes the need for rapid adaptation and responsiveness in policy-making to foster innovation. It advocates for small-scale, experimental policy initiatives that allow for quick feedback and adjustments based on real-world outcomes.

2.2. Kenya's Digital ID Journey

Kenya's third and latest attempt to roll out a digital ID system, known as Maisha Namba, is yet to be completed and is also likely to run into the same headwinds that nipped its predecessors in the bud. For example, so far, it has faced numerous legal complexities with multiple petitioners citing anxieties about the state's attempts to implement Maisha Namba in a way that safeguards, fulfills, and upholds human rights [2]. To this end, the primary concerns comprise compliance with data protection, legal foundations, data security, public participation, and inclusion, especially of minority,

marginalized, and rural populations. According to Amnesty International, the Directorate of Civil Registration Services (CRS), created through the Births and Deaths Registration Act, is the government bureau tasked with coordinating the country's birth and death records. Maisha Namba, once rolled out, will usher in radical reforms. For instance, the existing composite system of manual and electronic processes will be wholly digitized [2]. The novel digital system will issue a Unique Personal Identifier (UPI) to newborns, which will function as their ID number in their lifetime until their deaths need to be registered. The UPI, which is the Maisha Namba, is an identity network, comprises four interconnected components: Maisha Card, digital ID, the National Population Master Register, and Maisha Namba. Maisha Card usurps the physical ID and also features advanced security aspects like a microprocessor electronic chip. Digital ID is the virtual iteration of the physical ID. In other words, someone's digital ID will be connected to their Maisha Namba and employed to validate their identity in consuming different services [2]. Finally, the National Population Master Register is meant to amalgamate all current government repositories into one consolidated log that all citizens and foreigners will refer to.

2.3. Digital Infrastructure in Mauritius

The Mauritian government understands that high-quality telecommunications networks and infrastructure are critical to sustaining the ICT sector's development, making Internet access a fundamental citizens' right, creating an inclusive digital economy, and popularizing e-government services [21]. In this regard, it established a cybercity hosting eminent ICT/BPO firms in a hub linked to the global gateway via a high-speed passive optical network—fiber-to-the-business architecture. The country is also connected to global networks and information infrastructures through fiber optic undersea linkages [21]. Domestically, the information infrastructure encompasses a fiber optic cable network, and high-capacity digital microwave connections that form the backbone of the country's connectivity [20]. Leading residential and business centers are now linked through fiber-to-the-building networks. Mauritius was also the first sub-Saharan African economy to launch a countrywide fiber-to-the-home technology network; this further enhanced broadband access, especially domestic consumption [20].

2.4. Digital Literacy in Mauritius

Mauritius is noted to have re-engineered its e-government offerings to make them more citizen-friendly, thanks to a dynamic ICT culture promotion initiative [19]. It has performed commendably in ICT literacy outreach because of an elaborate approach in ensuring that it offers suitable literacy or proficiency initiatives and free ICT facilities across the country. Since 2006, the National Computer Board (NCB) has established the Universal ICT Education Program to train the

citizenry in computer proficiency [19].

Mauritius' Legislative and Regulatory Framework

Since 1998, Mauritius has progressively reviewed its legislative framework and developed National Strategic Plans [19]. The current plan provides major policy direction to effectively complement the country's knowledge economy efforts and address the dynamic changes happening in the sector. It also aligns with the government's goals of transforming the country into a high-value economy while maintaining inclusiveness in its strategy at all times [19]. The current plan, which builds on earlier blueprints, has two core aims: to review initiatives proposed in the earlier ICT Strategic Plan and to make suggestions to ensure that the ICT industry becomes a centerpiece of the national economy and that the country stands out as a regional ICT center. The government has also further strengthened the regulatory system to satisfy global best practices by enacting multiple pieces of legislation, including the Copyright Act, the Electronic Transactions Act, the Data Protection Act, the Computer Misuse and Cybercrime Act, the Independent Broadcasting Act, the Postal Services Act, and the Information and Communication Technologies Act [19]. All these legal developments have augmented the ICT sector and positioned the country as a secure and safe destination for business process outsourcing (BPO) and ICT investments.

Cyber Security in Mauritius

Researchers advocate for a strong and elaborate cyber security blueprint as a central pillar in the trustworthiness of any country's ICT ecosystem and inspires the required confidence in all stakeholders [17]. To this end, Mauritius is one of the few countries in Africa with a National Computer Emergency Response Team, known as CERT-MU. CERT-MU has been managed by the NCB since 2008 and was formed on the basis of the National Information Security Strategy's recommendations [17]. CERT-MU's goal is to discharge support and information to its stakeholders to adopt proactive steps to minimize the perils of information security breaches.

Digital Access in Mauritius

Mauritius has also deregulated and implemented an open access strategy for its telecommunications sector [25]. This enables foreign telecommunications firms to venture into the market on the same level as local operators in relation to using standard telecommunications infrastructure. To further encourage competition in its ICT sector, the government has implemented an open access framework for the management of undersea cable landing ports [25]. It has also implored smaller local firms to enter the market and strives to prevent any one player from monopolizing the market.

Estonia's Digital Economy

Estonia's digital economy is rooted in the notion of a digital citizen with access to public and private services via a digital domain that guarantees the interoperability of decompartmentalized and diverse information systems [15]. This depends on concepts that run contrary to liberal economic thinking and adhere to the *hiding hand* principle. Two aspects

were influential: the welcoming by policymakers and politicians of bold visions and a risk-taking culture, and the development of numerous interconnected small networks to enable initial success and cultivate momentum. According to the Organization for Economic Co-operation and Development, these elements became symbiotically enforcing and facilitated rapid implementation of innovative remedies [18]. Overall, Estonia's digital economy was made possible by three core elements: convergence of various situational aspects, a series of common governance principles, and an assortment of innovative remedies [15].

3. Methodology

This study employed document analysis as the primary methodology. This approach involved a systematic and in-depth examination of government reports, case studies, and national legislations that shape technological development in Kenya, Estonia, and Mauritius. The comparative nature of this study enables a thorough understanding of the economic landscapes of Kenya, Estonia, and Mauritius, providing a solid foundation for the recommendations aimed at transforming Kenya into a technology and digital hub.

Suitability of the Methodology

Document analysis methodology is suitable for this research due to a number of reasons. First and foremost, it supports an in-depth examination of government reports, case studies, legislation, and regulatory frameworks that shape technological development and the digital economies in Kenya, Estonia, and Mauritius. Analyzing primary sources like government reports, case studies, legislation, and regulatory frameworks offers clarity on how digital economies and diverse technological policies interact within the international digital environment. Second, the comparative nature of the study suits document analysis since it allows for side-by-side comparison of digital economies and technological advancements in the three countries. Third, document analysis is a more efficient approach compared to other empirical methods like interviews and surveys because it does not require direct engagement with respondents [5]. Instead, it employs publicly available sources such as legislation, government reports, and regulations. This proves document analysis as a non-intrusive and cost-effective approach that is useful in comparative studies where large-scale field research may not be practicable. Finally, document analysis is an objective approach that provides reliable data for the research. Government reports, case studies, legislation, and regulatory frameworks are credible and authoritative sources. As such, their examination provides findings that are more accurate and are based on legal precedents and codified principles as opposed to subjective interpretations. This enhances the credibility and reliability of the research [5].

Selection Criteria for Documents

- 1). Relevance to technological development and digital economies: The research prioritized documents that

directly address technological advancement and digital economies

- 2). Coverage and scope
- 3). Authority and authenticity: The researcher only considered official documents
- 4). Diversity

Data Collection and Analysis

The researcher started by identifying data sources and extracting data from government reports, case studies, legislation, and regulatory frameworks. Second, the researcher then embarked on a systematic analysis of the content extracted. Using thematic coding, the researcher identified key concepts pertaining to technology and digital economies. Third, the researcher systematically compared the similarities and differences in technological development and digital economies between Kenya, Estonia, and Mauritius.

Limitations

Researchers associate document analysis with various limitations, including potential bias in sources, static nature of legal texts, limited access to some documents, and challenges related to contextual interpretation [5]. In the modern era, there exist powerful actors whose interests may not be a true reflection of reality. Therefore, some legal documents may only reflect the interests of such actors, thus resulting in biases in how technological and digital economic policies are framed and enforced. In addition, document analysis approach may hinder the comprehensiveness of the study as not all relevant legal texts such as governmental reports and case studies are publicly available and accessible [5].

4. Findings

4.1. Stakeholder Engagement

Estonia's e-government program has been strongly backed by external academics, IT professionals, local stakeholders, and the private sector since the early stages of its development, including the decision-making phase [14]. Academic experts sat in the government committee called the Informatics Council, which is now known as the e-Estonia Council. In the early 1990s, the government also exchanged ideas with and participated in workshops and conferences organized by the IT bureaus of Finnish and Swedish governments on IT in public administration. Private sector stakeholders, particularly from the telecommunications and banking industries, helped craft the digital ID (e-ID) program and served on the Look@World alliance and the Tiger's Leap initiative [14]. Local stakeholders included the office of the Prime Minister and the Department of State Information Systems (RISO). Members of the Information System Authority (RIA) also directly contributed to the initial policymaking processes [14]. In 2001, the government rolled out Today I Decide [Täna Otsustan Mina] (TOM), an online tool allowing the public to provide input to policy documents and proposals.

4.2. Political Commitment

The government, and the political class at large, is openly committed to the country's digital agenda because it was at the heart of most of the governing parties' visions of developing a modern and more efficient government [13]. In addition, political commitment was necessary because a digital agenda was a primary goal of the European Union (EU), which the country wished to become a member of from the early 1990s. It eventually joined the EU in 2004. In the 1990s, political parties and politicians were the foremost proponents of e-government; these entities also happened to be the most radical when it came to carrying out economic reforms [12]. They included the Pro Patria Union and the Estonian Reform Party. Right-wing parties and politicians backed the formative initiatives of the IT community because such programs aligned with their aspirations of establishing an efficient and minimal government. It is argued that over time, the notion that e-government should supersede an avenue or back-end tool for service delivery has become increasingly entrenched in the political and IT domains [11]. Bipartisan political backing for the digital agenda did not waver from the early 1990s to the early 2000s, despite a high attrition rate in government and the collapse of coalitions, because the goal of joining the North Atlantic Treaty Organization (NATO) and the EU was also bipartisan [14].

4.3. Public Confidence

Estonians are notably confident in the government's digital agenda [12]. This is evidenced by the widespread adoption of the e-ID and other e-government services. Statistics from the Ministry of Economic Affairs and Communications show that 76 percent of businesspeople and 67 percent of common folk are satisfied with e-government services [14]. At the same time, 80 percent of Estonians believed that e-government had made it easier to access public services such as filing tax returns to the Estonia Tax and Customs Board (EMTA) [14].

4.4. Clear Objectives

In 1998, when Estonia embarked on its e-government initiative, the objectives were ambiguous. For instance, the 1998 strategy blueprint, the Principles of Estonian Information Policy, lacked clear, measurable objectives [13]. However, they have become clearer over time, especially after the government prioritized the development of e-government offerings. Since then, four clear objectives have been formulated:

1. Implementation of e-government in all public services, alongside training and sensitization measures for the entire society [13].
2. Maintaining the diffusion of ICT use at not less than the EU's average measure, thus ensuring the overall socio-economic efficiency of Estonia.
3. Boosting the IT sector's export capacity [13].
4. Contribute to the attainment of more jobs, better welfare

and higher growth by cultivating an environment enabling the development and use of ICT solutions.

4.5. Strength of Evidence

The Estonia's e-government program used evidence from identical projects abroad, including counsel from scholars and industry experts, and pilot studies during policymaking [11]. When drafting the 1998 charter, Principles of Estonian Information Policy, the government borrowed from similar initiatives and policies in the US and the EU. For instance, it drew inspiration from the EU's Bangemann Report on Europe and the Global Information Society (1994), the Clinton administration's Information Infrastructure Task Force (1994), and the European Commission's White Paper on Growth, Competitiveness, and Employment of 1993 [11].

When it comes to pilot studies employed as evidence, a good example is the Tiger's Leap initiative for educational development [14]. After starting as a pilot investigation for education in the mother tongue, which was covered in the national budget, it evolved into a standalone project and is now primarily talked about in that regard. Government officials also sourced input from external academic IT professionals who contributed to the drafting of the original strategy paper on the country's information policy [14]. The external professionals advised Estonian policymakers using prevailing research and their experience.

1. Feasibility

Feasibility for actualizing e-government was encouraging because the government enacted relevant legislative policies early and obtained funding from the EU and public-private partnerships (PPPs). Some of the earliest legislative pieces passed to reinforce e-government comprised the Digital Signatures Act (2000), the Personal Data Protection Act (1996), the Electronic Communications Act (2004), the Public Information Act (2000), and the Population Register Act (2000) [12]. Altogether, these regulations encompass security, application development, and data protection issues in e-governance. In relation to financial viability, the government apportioned a modest ICT budget unlike other countries [12]. However, it collaborated with the private sector to safeguard the fiscal viability of specific elements of the initiative. Lastly, the country was well positioned in terms of human resources and technical expertise while implementing its digital agenda. For example, from the 1960s it had consistently supported its Cybernetics Institute – which concentrated on computer programming [12]. When the Soviet science program collapsed, younger researchers were compelled to launch their own startups. At the same time, resources were unlocked to develop new economic sectors. Scholars contend that as an emerging and complex sector, IT shared a lot with the budding market economy [13].

2. Management

Estonia's structure and style of managing its digital economy is more ad hoc and informal compared to that of

neighbors like Finland [14]. However, its close-knit, interpersonal networks give it an advantage over other countries. The management system is three-tiered: a common coordinating component, a decompartmentalized component in each government bureau, and partnerships or auxiliary agencies rooted in public-private networks [14]. Public-private networks enable development of the applications and services needed by the information society, where all stakeholders benefit mutually. The State Infocommunication Foundation, which discharges communication-based services for state agencies, is an example. Another example is the RIA, which designs shared information systems in the government and coordinates the e-government framework [14].

3. Measurement

Initially, the government's strategic policy framework on digital transformation lacked measurable goals; as such, it was impossible to monitor or measure progress [11]. Nevertheless, the current strategy paper has been condensed further and includes pointers on how to measure progress. The government also collaborates with the University of Tartu to examine the impact of e-government, based on government records [11]. Estonia's public agencies collect data from the e-ID program, X-Road, different survey data on technology usage, and online voting. In 2015, the University of Tartu created a research center, the Centre for IT Impact Studies (CITIS), to collaborate with the government to utilize this vast data and assess the social, economic and political effects of e-government, model its next iterations, and develop information prototypes and streams to help the government formulate better forecasts that can augment future decisions and policymaking [11].

4. Alignment

The government and the private sector, especially the banking segment, were closely aligned while Estonia was undergoing digital transformation [11]. This is evidenced by the numerous productive collaborations and ongoing partnerships like X-Road, Look@World, Tiger's Leap, and the e-ID project. This relationship was positive because banks gained as much as the state in advancing the digital agenda. For example, banks could identify their clients securely on the internet rather than face-to-face, significantly minimizing the need for physical branches [11]. On the other hand, the government gained financially and via accumulated expertise.

4.6. Differences in the Technological Ecosystems of Kenya, Estonia, and Mauritius

1. Digital Identities

Mauritius and Estonia have robust digital identity systems, both of which are integral to the success of their digital economies. In Mauritius, the Mobil ID is a core component of the Digital Mauritius 2030 framework, which intends to transform the country into a digitally-oriented economy by strengthening, modernizing, and expanding public services, digital infrastructure, and 5G networks [9]. The framework

also emphasizes the development of digital skills to facilitate the nation's transformation into a tech-based, knowledge-oriented economy. By promoting innovation and enhancing access to public service, Digital Mauritius 2030 plans to develop a more secure, efficient, and transparent habitat for businesses and citizens [9]. Senior government officials have reaffirmed the government's commitment to ensuring Mauritius remains at the vanguard of technological advancement while enforcing sustainable data protection policies.

The Estonia's digital ID system, commonly known as e-ID, is vibrant and anchors all digital programs in the country [8]. Most importantly, it has been and remains critical to the country's hugely successful digital ecosystem. Kenya has recorded significant milestones in its quest to ensure that most public services are accessible online [16]. Estonia, on the other hand, started by issuing e-IDs for all citizens and making it the centerpiece of all its e-government functions. Citizens use e-IDs and their ecosystems for routine transactions such as shopping, marriage registration (e-marriage), which allows couples to marry by filing marriage applications online through the e-population database, paying utilities, accessing health data and signing contracts, among other daily undertakings [8].

Amnesty International report of 2024 indicated that the Kenyan government had repeatedly failed in its attempts to introduce a digital ID card [2]. In 2005, the government's efforts to roll out a third generation digital ID, which was programmed as an electronic ID, proved futile. In 2018, the government tried again to launch a third generation digital ID via a project known as Huduma Namba. Huduma Namba was designed as an overarching identifier that would be employed to access public services digitally [2]. Although it failed, the initiative opened the door to the establishment of the National Identity Integrated Management System (NIIMS).

NIIMS is a unified repository envisioned to centralize all government data in one ID system [2]. In 2019, the Kenyan High Court nullified Huduma Namba after civil society organizations filed multiple constitutional suits challenging it. At first, in *Nubian Rights Forum v. Attorney General & 2 Others* (2019), the courts directed the government to continue implementing NIIMS, but only upon enforcing an elaborate data protection policy [2]. In the same ruling, the courts emphasized data protection concerns, asserting that data collection for Huduma Namba was illegal since a Data Protection Impact Assessment (DPIA) was not conducted earlier. In the subsequent case, *Republic v Joe Mucheru, Cabinet Secretary Ministry of Information Communication and Technology and others ex parte Katiba Institute and Yash Pal Ghai*, the court found the launch of Huduma Namba illegal [2]. It also found the government at fault for continuing to implement the Huduma Namba project without adequate public participation and sufficient data protection policies. Amnesty International contends that in 2022, the government tried, for the third time, to introduce a third generation digital ID called Maisha

Namba [2].

2. Interoperability

The digital ecosystems characterizing Mauritius' and Estonia's digital economies are more interoperable compared to Kenya's. For instance, when a patient visits a hospital in Kenya for the first time, their details are captured. When the same patient visits another hospital a week later, again for the first time, their details will still be captured [16]. This cumbersome process is avoided in Estonia (X-Road) and Mauritius, where interoperability allows customers' details to be collected once [10]. When the same customer visits a different facility or institution, they can use their data because the systems are interconnected and can exchange data. This considerably enhances efficiency. In Estonia, the level of interoperability is so high that all services, including divorce filings, are done online; this represents a new milestone in citizen-oriented governance and positions the country as a world leader in e-government [9]. Estonia's interoperable systems allow citizens to take with them and access public services everywhere.

Researchers assert that whether inking government documents from Africa or voting on a train in the US, Estonians do not feel delinked as citizens, regardless of their current locations in the world [8]. Estonia has shown that through interoperability, it is possible to avoid the bureaucracy that Kenya and Mauritius accept as avoidable. The government is also dedicated to blazing the trail in creating an even more interconnected digital future [8]. In Kenya, interoperability is only apparent in a few of the 5,000 e-government offerings made available through the e-citizen platform, which are connected through cashless payment systems. These include passport processing, paying for public services, registration of birth, visa applications, and searching for company data [16]. Mauritius has tried to use its digital ID to facilitate interoperability, but it is also playing catchup to Estonia.

3. Data Privacy and Security

Estonia and Mauritius boast more robust data security measures compared to Kenya. As they collect and analyze more data, the two countries instill trust in their digital ecosystems. In Kenya, the office of the data protection commissioner has heavily borrowed laws from the EU's General Data Protection Regulation (GDPR), which does not consider local issues, contexts, and factors [7].

4. Infrastructure

Kenya has achieved progress in increasing broadband connectivity [10]. However, it has a long way to go before it can compete favorably with Estonia in this regard. Massive gaps in internet connectivity still remain, especially in rural areas, yet affordable and reliable internet connectivity is critical to the success of digital services. For instance, the Kenyan government committed to giving every pupil a tablet, yet electricity is an outstanding problem in some parts of the country [7]. The tablets must therefore be taken to the closest towns with electricity to be charged before being returned to pupils. Kenya's infrastructural challenges hinder its digital

ecosystem from achieving global competitiveness [7]. In Mauritius, the government has optimized tax policies and fast-tracked expansion of internet connectivity to increase internet access. Estonia has gone a step further by promoting PPPs as gateway to digital equality and universal internet access [10]. Kenya is also intensifying efforts to support enterprises lacking necessary digital infrastructure, minimize operational costs, and provide affordable gadgets to build a streamlined digital ecosystem. Estonia, by comparison, is farther ahead in this regard because it has aligned technological developments with infrastructure advancements, thus taking its digital evolution journey to lofty heights. In Kenya, there is a mismatch between infrastructure and curriculum; for instance, while the former is underdeveloped, the latter denotes a digital first economy [7]. Mauritius has made substantial investments in digital infrastructure; this has made expanded internet connectivity and vibrant cyber security the cornerstones of its digital transformation.

5. Commercial Viability

In terms of commercial visibility and viability, Estonia is way ahead of both Mauritius and Kenya. The common argument is that its vibrant digital ecosystem has, in the last four decades, yielded ten (10) unicorn companies and over 1500 startups, including household names like Bolt and Skype [8]. Estonia is therefore best placed to share its expertise in growing startups with Kenya and Mauritius. Estonia also organizes events that provide avenues for countries and experts to share knowledge.

6. Human Capital and Expertise

Estonia is famous for its expertise in digital governance; in this regard, it is a reference point for Kenya and Mauritius. While Kenya's population is relatively young, the levels of digital literacy vary across the country [7]. As such, the government should invest more in digital education to develop a digitally competent citizenry. Estonia has emphasized digital education and literacy, such as by incorporating digital skills into its syllabus. Consequently, the country has created a citizenry that is digitally inclined and can adjust to the changing technological terrain [10].

7. Technological Vibrancy

Estonia has digitized 99% of all public services and is widely considered to be the most digitized economy in the world [4]. Kenya, on the other hand, is one of Africa's most highly advanced economies and East Africa's economic hub. The country keeps growing, courtesy of a carefully selected assortment of sustainable development goals (SDGs). The Kenyan government's emphasis on digitalization and congruence in its education policies has been the fuel for its long-term objectives of achieving lasting, systemic transformation and supporting poverty eradication [7]. Mauritius' startup environment, e-governance, and financial technology are one of the most competitive on the African continent, so much so that Kenya would do well to model some of its digital transformation pillars on the successes of Mauritius. In contrast, Estonia is globally celebrated for its successful startup

ecosystem, innovative solutions, and vibrant digital infrastructure [6].

4.7. Lessons for Kenya from the Economic Strategies Employed by Estonia and Mauritius

The biggest and most important lesson Kenya can learn from the economic approaches used by Estonia and Mauritius to enable its own evolution into a technology hub revolves around self-regulation and liberalization of its markets and economy. For instance, Estonia's evolution from a centralized, Soviet-style economy to a liberal democracy and free-market capitalism is nothing short of awe-inspiring [4]. Most importantly, Estonia's economic transformation features three pillars from which Kenya can extract valuable lessons: economic prosperity, a significant reduction in socioeconomic equality, and digital overhaul of the public sector. In the 1930s, the economic structure and ethnic makeup of Estonia's society were such that 88 percent of residents were native Estonians [1]. During World War Two, this grew to 97 percent following large-scale emigration. In the following decades, this pattern reversed as the Soviet government encouraged people, primarily native Ukrainians and Russians, to relocate to Estonia [4]. By 1989, ethnic Estonians comprised 62 percent of the population. In fact, in the north-east of the country, the proportion reduced to just 13 percent by 1989 – from a high of 65 per cent in 1934. These demographic changes were linked to accelerated industrialization, especially in the north-east part of the country [4].

Industrialization boosted a long-standing heightened need for labor. The government responded by planning more investment in resource-heavy mining and heavy industry. Amidst anxieties over a new influx of immigrants, this move was instrumental in stimulating the popular agitation for independence in the 1980s, which centered on environmental conservation matters [6]. The combination of ethnic conflicts with industrialization inspired the government to overlook the upgrade of the economy it inherited from the USSR; this was despite Estonia being one of the Soviet Union's most technologically and economically advanced republics. Instead of an upgrade, the government looked to ICT as a nascent, all-encompassing technology to solve its predicament, especially given the abundance of R&D expertise in the industry. It is opined that for this reason, digitalization came to represent [6] Estonia and its privileged class's aspirations. It also explains why up to now, ethnic Estonians dominate the ranks of the *digital elite*.

As an ethnically diverse country that is also striving to become economically and technologically competitive, not just in Africa but worldwide, Kenya can use Estonia's experience to formulate clear, specific, and sustainable techno-economic strategies [1]. Initially, *crazy* concepts were integral to Estonia's economic policy. For instance, it implemented a comparatively distinct currency committee to

administer its currency, and a fixed income tax rate – both of these measures were unique in the developed and developing worlds [4]. After independence, the first Prime Minister adopted drastically neoliberal economic policies inspired by Margaret Thatcher and Milton Friedman. The success of these policies gained global recognition and encouraged the government to double down on its radically liberal economic strategies [4]. As a consequence, the international community came to view Estonia as the eminent successful and radical reformer, as well as the chief proponent of Adam Smith's much-vaunted *invisible hand*-inspired economic strategies which are based on the assumption that free markets offer the most favorable economic outcomes [4].

The adoption of economic policies in Estonia was derived from the *invisible hand* depended on the enthusiasm of inexperienced politicians, whose naivety partially explained their boldness [1]. Kenyan policymakers can use this phenomenon, which is well-explained by Albert Hirschman as the *hiding hand*, to take on economic challenges without worrying about the inherent risks. This can lead to spontaneous success and ingenuity. According to Hirschman, the hiding hand functions via ignorance of ignorance, not knowing what is impossible and what is not, and doing the impossible by venturing into uncharted territories [6].

In the Kenyan context, this can spawn visionary economic strategies that are inspired by charismatic and transformational leadership, constant rejuvenation of networks and leadership, and close-knit networks. Economic prosperity and social equality are two sides of one coin [1]. In this regard, Kenya can adopt a neoliberal economic policy strategy to open its markets and enable globalization to manifest in its economy, creating win-win and win-lose situations for investors and local entrepreneurs. Kenya should also be inspired by Mauritius' successful marriage of its economic and digital transformation agendas [1]. To this end, it is especially interesting how the Mauritian government pursued digital evolution within an exceptionally liberal policy environment. Like Estonia, Mauritius has implemented the popular hidden hand principle or its variations to liberalize its economy rapidly and use the gains to finance its digital transformation agenda [1]. Kenya can use the two countries' experiences to learn how to straddle both horses successfully and move closer to becoming a free and digitally competent economy.

4.8. Policy Recommendations for Kenya to Achieve Significant Advancements in Its Digital Economy

- 1). Support the formulation and enforcement of national, regional, continental and global digital economic policies to boost supply and demand and support scaling up of digital programs to counter technological and economic obstacles bedeviling the country.
- 2). Formulate and enforce sectorial and national digital policies.

- 3). Formulate and implement cyberspace legislations and policies.
- 4). Formulate and implement data privacy and protection regulations and policies in line with relevant protocols such as the Malaba Convention.
- 5). Formulate regulation to facilitate seamless exchange of non-personal data.
- 6). Implement a capacity building initiative to support Kenyan regulators, policymakers, and other government representatives.
- 7). Formulate policies consistent with a holistic and human-centered strategy that considers local situations and cross-cutting matters pertaining to all policy formulation and implementation phases.
- 8). Pay special attention to minority, rural and marginalized groups such as persons with disabilities, women, and rural populations by creating a forum for dialogue and social cohesion that includes the needs and aspirations of these demographics.
- 9). Support online diversity to enable full inclusion.
- 10). Formulate and implement policies for maximum exploitation of limited critical resources like IP addresses and spectrum.

5. Discussions

In Kenya, key sectors like education, healthcare, and agriculture have benefitted from their digital transformation journeys. For instance, the healthcare sector has gained significantly from digital integration, which has allowed data sharing to be streamlined among hospitals; this has supported seamless partnerships and enhanced patient care and clinical outcomes [7]. The education sector has become more inclusive and equitable, thanks to the infusion of digital tools that have leveled the playing field for all schools and learners across the country while improving the effectiveness of teachers. Agriculture, which is a key economic sector, has exploited digital solutions to expand its international markets and increase profitability and productivity for producers. It is argued that the small and medium-sized enterprises (SMEs) segment is also thriving on the back of increased market access for small local enterprises and higher online accessibility and visibility [7].

Estonia inherited obsolete industrial infrastructure and a widespread aversion to industrialization after the disintegration of the Soviet Union. However, it was also left with a wealth of research and development (R&D) expertise in ICT via research institutes [10]. As funding for these institutes ran out in the early 1990s, many experts formed private outfits such as joint ventures (JVs) with Scandinavian telecommunications firms and other corporations. Geographical proximity to Scandinavia, which had one of the most advanced telecommunications industries in the world, allowed Estonia to open up policymaking activities – through JVs and counsel – and markets – via regulations and privatization – to Nordic

partners [8]. In return, it accumulated valuable investment and know-how.

Estonia's tiny population (1.3 million) and size, with about a third of residents concentrated in the capital city, Tallinn, enabled dynamic networks to take root rapidly and gain long-term political backing because of the minimal investment required to develop the corresponding infrastructure [1]. Government bureaus and ministries were directly responsible for their respective data, ICT policies, and investments. Additionally, the government decentralized departmental ICT policies, guidance, coordination, negotiation of ICT investment strategies, crafting of vital design principles, and information architecture. In the 1990s these roles were performed by the Prime Minister's office [1]. Today, however, they are handled by the Ministry of Economic Affairs and Communications.

The government also intentionally emphasized public-private networks instead of private organizations. The e-government terrain includes various organizations and cross-institutional networks, which are occasionally officially referred to as the Cyber Unit of the Estonian Defense League [6].

Estonia's e-government is distinguished by the fact that it lacks a legacy principle [3]. In this regard, public digital systems do not employ technological remedies older than 13 years. Second, the government favors building infrastructure from the ground up, especially in the formative phases, instead of acquiring *off-the-shelf* solutions from ICT vendors. Third, the government follows a once-only principle, whereby citizens and businesses must provide information to government agencies just once and data is accessible across public agencies via X-Road, the data sharing highway [3]. Fourth, the e-government system employs the security and interoperability doctrine. Instead of developing shared information systems and databases, the government prioritizes secure interoperability of e-government data infrastructure.

Altogether, the intersection of contextual factors, strategy, policy and an exceptionally motivated, relatively young, and talented labor force enabled the development of a public digital system that is undeniably world-class [9].

The Digital Mauritius 2030 master plan revolves around five short-, medium-, and long-term strategic components: ICT infrastructure and broadcasting, business/investment facilitation and e-Government, talent management, cyber security and cybercrime, and innovation and emerging technologies [10]. In the formative stages of its digital transformation, Mauritius realized that a cybercity and dependable broadband were inadequate, and that it needed to build a digital ecosystem consistent with its lofty aspirations. This process led to the formulation of the Digital Mauritius 2030 Strategic Plan explaining how the country will drive innovation, increase employment opportunities and expand government services to fuel economic development [1]. According to the plan, businesses, public services and citizens' routine lifestyles would all be anchored in the digital economy

[10]. Many governments formulate such frameworks, but Mauritius' is different because it works, thanks to the government's creation of centralized digital cornerstones to streamline banking, local enterprises adopting novel digital tools, and the leading university incorporating technology into more facets of learning.

6. Conclusions

This paper outlines a comprehensive approach to analyzing the technology development trajectories of Kenya, Estonia, and Mauritius. By focusing on lessons learned and contextual adaptations, this research aimed at providing actionable recommendations for Kenya to enhance its digital economy and position itself as a leading technology hub in East Africa within the next five years. Of the three economies studied, Estonia is the most digitally advanced. As a result, it is the reference point for both Kenya and Mauritius in terms of legal, regulatory, infrastructural, economic, and political development. In spite of their respective challenges, Kenya and Mauritius boast considerable potential for digital advancement. First, they can exploit mobile technology by leveraging their success in mobile payment solutions. They can also increase mobile-oriented services to other sectors of the economy such as agriculture, education and healthcare. Second, Kenya and Mauritius can invest in e-government and streamline public services via digital portals to improve transparency, accessibility, and efficiency. In Kenya, e-Citizen has been successful, but there are many improvements that can still be made to increase its efficiency and accessibility. Third, Kenya and Mauritius should look to Estonia for cues on how to cultivate enabling conditions for digital businesses and startups to stimulate employment creation and economic development. Startups, such as Sendy, Mobius and Copia, have collapsed or ceased operations in Kenya, thanks to liquidity problems. Fourth, Kenya has an opportunity to improve and expand its human capital by building a skilled labor force in facets like cyber security, software development, and data science that are critical to a successful digital ecosystem and economy. Kenya can also draw lessons from Tallinn, the capital city of Estonia which has become the global benchmark for e-government. Innovations like X-Road provide valuable insights on interoperability and collaboration that can be easily replicated in Kenya in a cost-effective and sustainable manner. Such insights can also inspire digital solutions that enable diverse Kenyan databases to 'talk' seamlessly and increase the efficiency of e-government.

7. Future Research

Kenya, Estonia, and Mauritius need to conduct further research on digital inequalities across various populations and government agencies and bureaus. Kenya, especially, should

explore how create a systems and whole government approach by adopting stronger and more official coordination mechanisms than it currently employs. To become a digital hub in East Africa, Kenya must investigate how to strengthen civic engagement. Finally, Kenya, Estonia and Mauritius should examine how to reduce reliance on decentralized and unofficial systems in building and maintaining their digital infrastructures.

Policy Implications and Recommendations

- 1). Establish coordinated legal, regulatory and policy frameworks.
- 2). Formulate and implement national, regional and continental regulations and guidelines.
- 3). Formulate guidelines and standards to facilitate digitalization.
- 4). Establish fundamental principles for collaboration between the government and the private sector.
- 5). Formulate a national digital infrastructure framework, taking into account the confluence of technologies.
- 6). Create internet infrastructure initiatives that enable national, regional and continental integration.
- 7). Create and facilitate internet exchange points (IXPs) and stakeholder backing for IXPs, eliminate entry barriers for IXPs, and promote a competitive traffic exchange and broadband interconnection climate.
- 8). Modernize current infrastructure, and harmonize and complement novel infrastructure initiatives with current infrastructures.
- 9). Make sure that all public agencies have at least two global linkages to guarantee and encourage competition.
- 10). Implement the Sectoral Working Group report of 2024, developed by the Ministry of Information Communication and Digital Economy.
- 11). Strengthen the Universal Service Advisory Council to ensure digital inclusion, by implementing the Sectoral Working Group report of 2024.

Abbreviations

BPO	Business Process Outsourcing
CERT-MU	Africa with a National Computer Emergency Response Team
CITIS	Centre for IT Impact Studies
CRS	Civil Registration Services
DPIA	Data Protection Impact Assessment
EMTA	Estonia Tax and Customs Board
EU	European Union
GDPR	General Data Protection Regulation
ICT	Information and Communication Technology
ID	Identification
IXPs	Internet Exchange Points
JVs	Joint Ventures
NATO	North Atlantic Treaty Organization
NCB	National Computer Board

NIIMS	National Identity Integrated Management System
PPPs	Public-Private Partnerships
R&D	Research and Development
RIA	Information System Authority
RISO	State Information Systems
SDGs	Sustainable Development Goals
SMEs	Small and Medium-sized Enterprises
TOM	Today I Decide [T ãna Otsustan Mina]
UPI	Unique Personal Identifier

Author Contributions

Amos William Omolo is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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