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DIGITAL TECHNOLOGIES IN PUBLIC ADMINISTRATION: A CASE STUDY OF ESTONIA'S E-GOVERNANCE FOR INCLUSIVE AND SUSTAINABLE DEVELOPMENT

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ABSTRACT

Introduction: In today's world, increasingly afflicted by inequality, climate change, and governance problems, the United Nations Sustainable Development Goals (UN SDGs) underscore the necessity of fostering inclusive and sustainable societies. Digital technologies provide a critical avenue for realizing these objectives and Estonia, a small Baltic nation, stands as an exemplary global example of this potential.

Methods: This qualitative case study uses a narrative approach to explore how the Estonian national government utilized digital technology to digitize public administration, including in the domains of education, taxation, and justice, with the aim of fostering inclusive and sustainable societies, drawing on peer-reviewed studies, government records, and industry reports. The study also underscores the nation's steadfast commitment to safeguarding privacy and cybersecurity, while also highlighting, scaling and sustainability challenges currently experienced by the nation.

Results and Discussion: The findings of the study indicate that Estonia's e-governance, facilitated by digital technologies and characterized by features such as e-voting, e-education, e-health, e-ID, e-residency, e-business tools, e-justice, and data embassy has enhanced public engagement, decreased operational expenses, and mitigated environmental effects. These results highlight how a government driven by digital technology is guiding the nation towards greater inclusivity and sustainability. Additionally, it emphasizes that inter-sectoral collaboration and strategic approaches to improve cyber resilience is crucial to the success of e-governance and ultimately to the establishment of inclusive and sustainable societies. The study concludes that Estonia's e-governance has helped establish inclusive and sustainable societies and furthered equitable and sustainable development in accordance with the United Nations Sustainable Development Goals, including SDG 9 (Industry, Innovation and Infrastructure), SDG 10 (Reduced Inequalities), and SDG 16 (Peace, Justice and Strong Institutions). It underscores equitable practices, strong inter-sectoral collaboration and strategic and proactive governance are crucial for enabling technology-driven public administration.

Originality and Value: Building inclusive and sustainable societies is increasingly significant, in today's world where governments are seeking governance frameworks that are transparent, effective, and people-oriented. This study offers policy makers and strategists of

other nations much-needed guidance on how digital technologies can be leveraged to improve public administration for building inclusive and sustainable societies.

Keywords: digital governance, inclusive development, public administration, sustainable development, strategic governance

INTRODUCTION

Estonia, a small Baltic nation with 1.3 million people, has established itself as a global frontrunner in utilizing innovation and technology to attain inclusive and sustainable development via e-governance. After gaining independence from the Soviet Union, Estonia lacked an administrative foundation and chose to establish a digital state from the ground up, prioritizing innovation and technology in its public sector administration to foster inclusive and sustainable growth. National e-governance system had the widespread use of e-public services like taxation, health, education, voting, and judicial process by the masses, thereby resulting in widespread cost reduction, empowering the masses, improving transparency, and removing bureaucratic inefficiency, thereby resulting in inclusive and sustainable growth (International Monetary Fund, 2018), (Espinosa & Pino, 2024)&(Duboise, 2023). Estonia's reform was founded on a clear vision and strong leadership, which brought innovation- and technology-based governance into reality. Its e-government model has become a reference point for nations seeking equitable and sustainable development through strategic technological action. Recognizing that technology-enabled public services are indispensable for national sovereignty and stability over the long term, Estonia opted for in-depth structural transformations rather than short-term digital quick fixes. In the past two decades, this strategic approach has led to the establishment of a fully digital society, in which the majority of public services, including voting, healthcare, and residency, are accessible online. Additionally, nearly all citizens interact with the government through a secure and encrypted digital identity system (Middlemiss, 2023)&(e-Estonia, n.d).

Figure 1 shows the timeline of a few e-public delivery services in the country. It reflects the nation's progress in applying innovation and technology to improve public administration and promote inclusive and sustainable development.

1994	•first draft of "Principles of Estonian Information Policy"
1996	•first e-Banking service
2001	•introduction of X-Road concept
2002	•e-ID and digital signature
2005	•e-Voting
2008	•e-Healthcare
2014	•e-Residency
2015	•world's first Data Embassy
2019	•national AI Strategy

Figure 1. Estonia e-government Timeline (Mechitov & Moshkovich, 2021)

Estonia's digital e-governance based on digital infrastructure is built on X-Road, an open-source data exchange platform that facilitates secure and seamless information exchange between public and private databases. It constitutes the foundation of the nation's e-governance framework, enabling efficient communication across diverse institutions while safeguarding data security and trust. Figure 2 and 3 show the interoperability of the system's components-digital applications, the X-Road data interchange layer, and digital identification-which ensures reliable, secure, and inclusive digital public services (Hardy, 2024)&(Espinosa & Pino, 2024). The nation's key public services such as e-health, e-tax, e-prescription, e-school, and internet voting operate on this shared infrastructure (Adeodato & Pournouri, 2020).

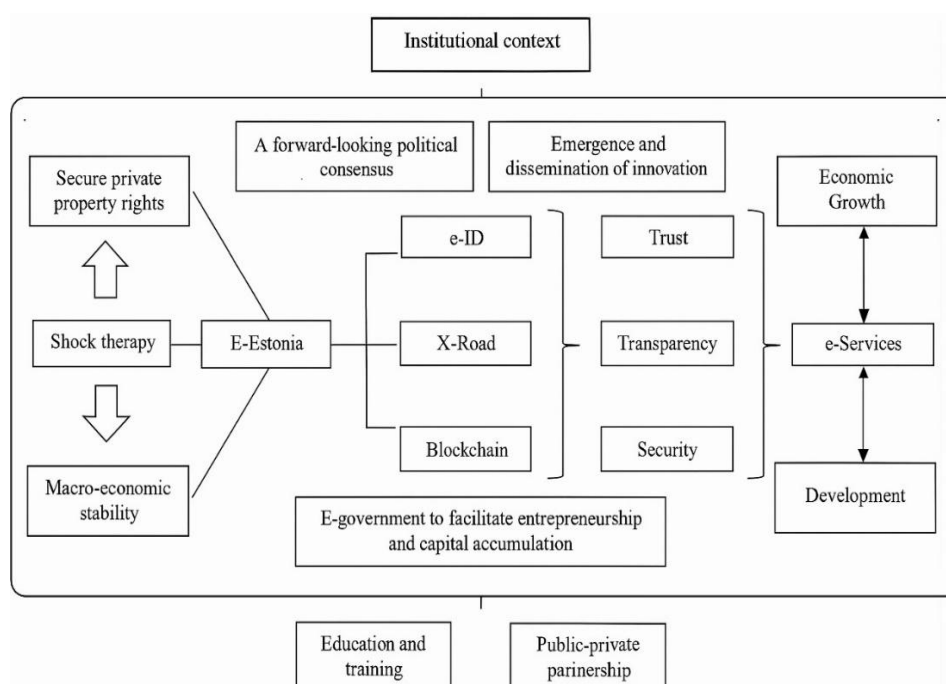
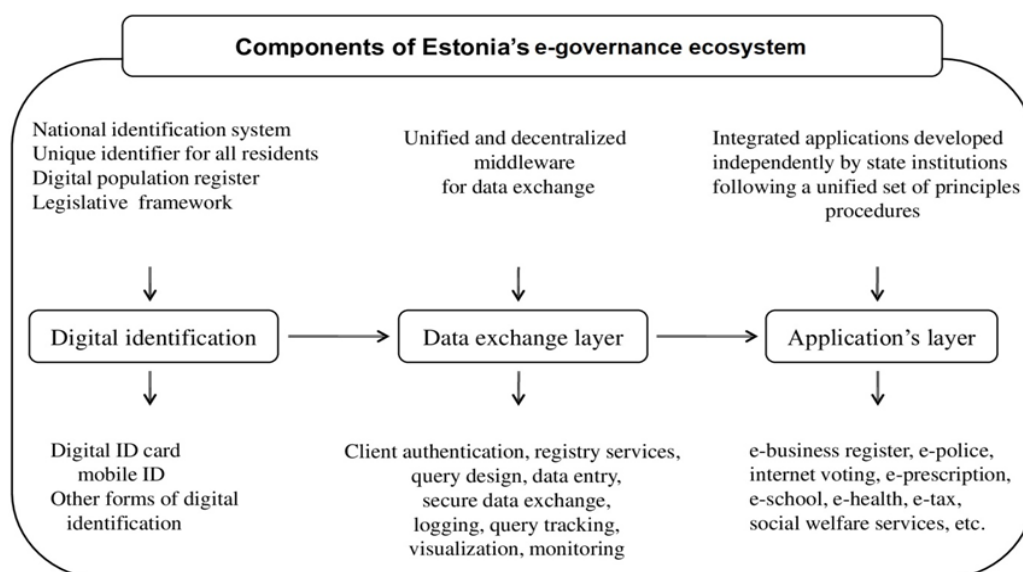


Figure 2. Institutional Foundations and Digital Infrastructure of E-Estonia as a Driver of Development (Espinosa & Pino, 2024)

Figure 3. Components of Estonia’s e-Governance Ecosystem
(Adeodato & Pournouri, 2020)



Estonia has transformed traditional public service processes into a seamless, interoperable system by connecting secure digital platforms with a decentralized and integrated data exchange infrastructure. This change not only digitalized services but also made them extremely efficient, paperless, transparent, and accessible to all so that no citizen feels left behind in the digital age. These technological integrations into the e-governance framework have ensured that public services are delivered in a manner that is accountable, accessible, inclusive, and resilient. This has facilitated social inclusion and equity, and it has established the foundation for a digital society that is both inclusive and sustainable.

Review of Literature and Methodology

Estonia's digital governance model is frequently cited in policy and academic discourse as a groundbreaking example of technology and innovation facilitating sustainable and inclusive societies. However, the majority of studies on the subject concentrated on specific aspects of e-governance, addressing single services. For example studies on Estonia frequently highlights single domains, such as e-education (Poldoja, 2020)&(Aru-Chabilan, 2020), e-health (Soares, Ferreira, & Veiga, 2023)& (Metsallik, Ross, Draheim, & Piho, 2018), e-residency (Tammpuu & Masso, 2018)&(Kimmo, Pappel, & Draheim, 2018), e-voting (Clarke & Martens, 2016)&(Agtsahkna, 2013), and smart mobility and transport (Kirejev, Gerstlberger, & Niine, 2024)&(Soe, 2020), highlighting the transformative role of digital solutions in their respective sectors. Few studies have examined its role in providing e-governance consultancies to foreign nations (OECD, 2021), (Remy & Barde, 2024)&(D4D HUB, 2025). Others have emphasized its function in reducing bureaucratic red tape, enhancing transparency, and improving public service delivery (Lember, Kattel, & Tõnurist, 2018), (Stephany, 2020)&(Espinoza & Pino, 2024).

Although these studies provide valuable insights, few present a cohesive perspective of Estonia's e-governance approach as an integrated system. This case study is one among those that aims to provide a comprehensive and holistic overview of core digital services and systems that make up Estonia's e-governance and illustrating how an integrated system of e-governance functions in practice within a national framework. Looking into Estonia's experience as a pioneering example of how technology and innovation can transform public administration to build inclusive and sustainable societies is increasingly significant, in today's world where governments are seeking governance frameworks that are transparent, effective, and people-oriented. This study endeavors to answer the following question: How has Estonia leveraged innovation and technology in developing a digitally empowered state that supports inclusive and sustainable national development. In an effort to examine this question, the case study employs narrative approach drawing insights from peer-reviewed studies, government reports and industry publications to examine Estonia's technology- and innovation-driven initiatives, particularly its core digital services and systems, that have enabled the government to achieve transparent, efficient, and citizen-centric digital governance. The following section of the study explores major government-led initiatives within Estonia's e-governance system. Its digital transformation is being presented not only as a technological accomplishment, but also as a model of how technology and innovation that are aligned with development objectives can modernize governance and inspire global replication. The study also emphasizes that Estonia's digital strategy is profoundly rooted in cyber security and data protection.

Estonia's Digital Model for Inclusive and Sustainable Development

e-Voting: Safe, Accessible, and Sustainable

In 2005, Estonia implemented an e-voting system, becoming the inaugural nation to permit residents to vote online in national elections. The system was developed to improve voter turnout, accessibility, and efficiency in the electoral process, particularly among residents living abroad or in remote areas. Its goal was to make democratic participation more accessible, secure, and transparent (Election Universe, 2019). Voters can authenticate using a government-issued e-ID or Mobile-ID, and the technology protects anonymity by segregating identities from ballots prior to counting. Votes are encrypted, digitally signed, and sent via a secure network. To ensure security, a dedicated application needs to be downloaded just prior to each election. Voters can amend their votes numerous times during the voting period; only the final input is considered, providing protection against coercion (Eremia, Shivananjappa, & Creutzburg, 2025). Between 2005 and 2019, there has been a consistent increase in the number of e-voters (See Fig. 4) (Ehin, Solvak, Willemson, & Vinkel, 2022).

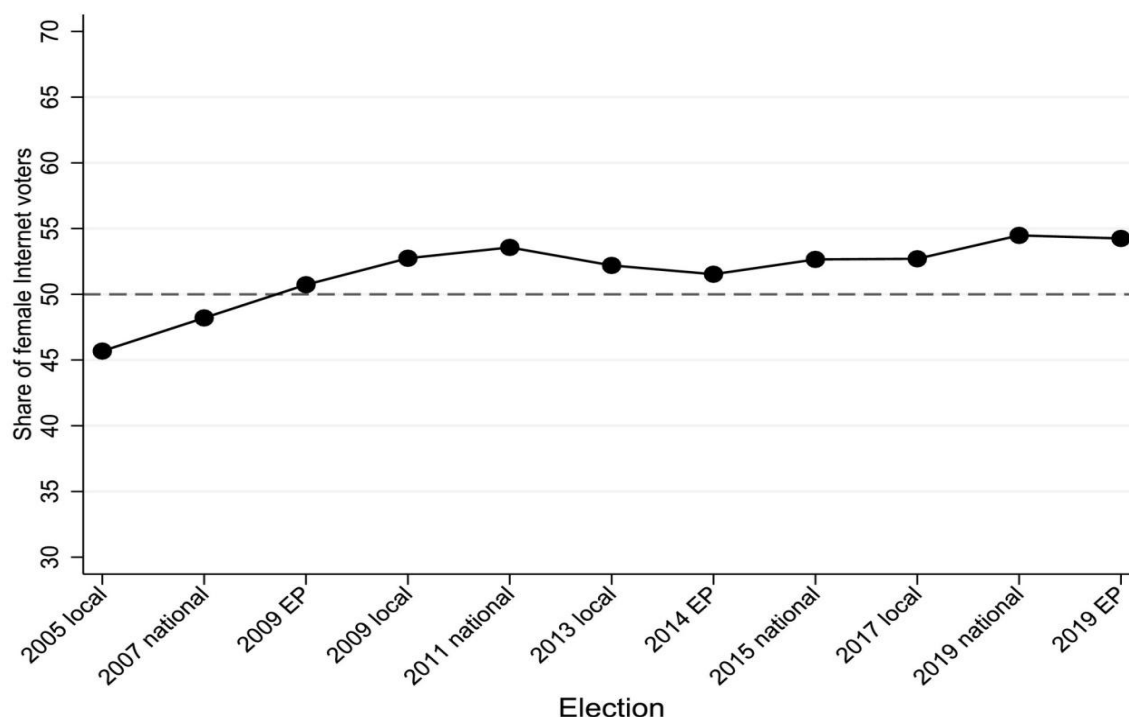


Figure 4. Trends in Internet Voting in National, Local, and European Elections (2005-2019) (Ehin, Solvak, Willemson, & Vinkel, 2022)

Its success lies in its robust digital base, robust auditability and data security focus, and blockchain validation. It replaced paper ballots, reduced administrative expenses, enhanced the accessibility of voters, and is an affordable, green, and transparent system. The Estonian electronic voting system is a shining example of how technology can facilitate democratic and effective governance, improve citizens' participation, and minimize the country's environmental footprint, thus attaining sustainable and inclusive development.

E-Health for All: Inclusive Digital Care

Estonia's Electronic Health Record System (EHR) is a strong example of how digital healthcare can be managed in a sustainable and inclusive way. It is founded on the robust X-Road infrastructure and was launched in 2008, subsequent to the construction of legal foundations in 2000 (The World Bank, 2022). It connects healthcare providers, government systems, and residents to a single, secure, real-time platform, with separate access points for each via a digital identity system. Individuals can review their medical history, medications, treatment bills, and healthcare provider or agency that accessed their information. Personal data control features enable patients to lock or unlock access, hence improving privacy and transparency. Patients can get prompt diagnoses, renew prescriptions, and emergency care from anywhere, eliminating travel, delays, ensuring better health outcomes (Metsallik, Ross, Draheim, & Piho, 2018). It guarantees equal access to healthcare services for urban and rural populations closing the digital divide to a significantly greater degree. For doctors, it gives immediate access to a patient's medical information like lab results, imaging, and case summaries. This allows for faster diagnosis, better provider coordination, and improved continuity of care. Other capabilities, such as prescription, referral, and sick leave certificates, help to streamline administrative duties and reduce the need for in-person visits. Government agencies use the system to track real-time epidemics, plan resources, and issue

digital health, birth, and death certificates (Steinmiller & Ross, 2024)&(e-Estonia, 2016), (e-estonia, 2020). In addition, genomic data is added to the EHR which helps support Estonia's transition to predictive and personalized medicine. Additionally, emergency responders can retrieve important information such as allergies and blood group immediately, which could help provide swift treatment. This digital ecosystem reduces bureaucracy, cut costs, eliminates paper waste, and improves service delivery at all levels. It streamlines operations, increases efficiency, and fosters accountability among patients, providers, and policymakers (Roppel, 2019)& (Election Universe, 2019). Estonia's e-Health approach through EHR exhibits a secure, inclusive, and sustainable digital health system. By bridging the urban-rural divide and improving public trust, it advances the broader goals of building an egalitarian and resilient model of e-governance for inclusive and sustainable development. Since its inception in 2008, Estonia's EHR system has expanded significantly, encompassing around 1.54 million individuals, managing nearly all prescriptions electronically, and facilitating over a million monthly enquiries from patients and healthcare providers (Metsallik, Ross, Draheim, & Piho, 2018).

Estonia's E-Education System: Sustainable E-Schools, Equal Access

Estonia has established itself as a global frontrunner in e-education, founded on the ideals of school autonomy, egalitarianism, and digital-first pedagogy. These pillars have enabled Estonia to attain quality, inclusivity, and future-oriented education via digitalization. Estonian digital education aims to enhance learning by fostering interactivity, creativity, and a student-centered approach, rather than relying solely on screen-based methods (Veldin, Mlekuž, Mägi, & Haugas, 2018). The roots of Estonia's digital education revolution date back to the 1990s when the Tiger Leap program was initiated in 1997. The ambitious initiative for putting technology in education involved ensuring that all the students, irrespective of their socioeconomic background, get access to high-quality education and learning. The program sponsored the installation of computers, internet connections, and digital skills training for educators in schools. By 2001, all Estonian schools had been equipped with internet facilities, marking a swift and successful step into the digital era (Aru-Chabilan, 2020). Additionally, the government improved internet infrastructure, offered digital equipment, and introduced digital literacy courses from an early age through ELLIS, a kindergarten portal, which enabled kindergarten parents to track the progress and activities of their child. In education, the installation of e-Kool, a school management platform, enabled communication between parents, students, and teachers-hence, transparency and participation. These technology tools support Estonia's comprehensive and lifelong digital education plan.

By 2015, Estonia had digitized its educational resources and launched extensive training courses to improve teachers' digital skills. Additionally, through Public-private partnerships a sustainable digital environment was developed Digital platforms such as Stuudium, Opiq, and Moodle were established to improve learning and instruction through interactive content, whilst ETIS and SAIS supported research, student admissions, and academic information management (Põldoja & Laanpere, 2020). Other Digital platforms like the Examination Information System (EIS) facilitate secure online examination with customizable tests that offer instant feedback of student performance. The integration of e-Schoolbag allowed students across all educational levels to easily access vital learning resources from various platforms, hence enhancing the learning process and reducing reliance on physical materials. Despite the prevalence of digital and cloud-based materials in educational settings, traditional literature and classroom activities remain esteemed, preserving balance. Initiatives such as ProgeTiger brought coding and robotics into early

childhood education, while Estonia's wider educational advancements extended to the integration of virtual reality, artificial intelligence, and customized digital textbooks within the curriculum. It proved beneficial when the COVID-19 pandemic struck, Estonia transitioned easily into virtual classes. The educational process proceeded as usual, with more than 90% of institutions employing digital diaries and e-solutions (Burkadze, 2022). In instances of device scarcity, educational institutions, local governments, and civil society organizations addressed the deficiency. For sharing its success with the world, Estonia established the Education Nation program, providing digital solutions, training, consulting, and study tours to help other countries develop digitally resilient education systems (PR Newswire, 2020). Through strategic investment, innovative approaches, and a steadfast commitment to students and teacher empowerment, Estonia has created a resilient digital education system that guarantees equitable access to learning, enhances educational outcomes, and promotes an inclusive and sustainable society.

Smart Mobility and Urban Innovation

Estonia's achievements in smart transport and urban innovation demonstrate the potential for innovation and digital technologies to transform governance systems. In 2011, Estonia implemented an Automated Border Queue Management System for freight carriers to improve the automation of freight management. This enabled driver to reserve slots and go into virtual queues, lowering average border crossing times from 60 hours to only 1.5 hours. This automation greatly enhanced export logistics, minimized traffic jams, and cut air and noise pollution-halves that ultimately spread to domestic ports and logistics centers (Sassiad, 2010). Following the trend, autonomous delivery robots created by Estonian startup, Starship Technologies, started service in Tallinn in 2017, revolutionizing last-mile logistics. These battery-powered, low-speed robots quickly became common in city streets, providing a cleaner and more efficient way to move goods such as food and other goods. In 2019, Estonia reaffirmed its commitment to urban innovation by opening the Twins Smart City Centre of Excellence (CoE) at Tallinn University of Technology, a €32 million initiative co-funded by the EU Horizon 2020 programme and the Estonian government. The CoE was assigned the responsibility of directing the nationwide smart urban renewal initiative through ten pilot projects from 2021-2027. These projects were designed to address regional-specific issues, including climate adaptation and digital mobility (Soe, 2017).

In 2021, the smart transport plans of Estonia received a boost when the first permission for an unmanned self-driving shuttle was granted to a local company, AuveTech. The first autonomous hydrogen car in the world, also manufactured in Estonia, was introduced subsequently. These innovations showcased Estonia's leadership in inter-linked and sustainable transport. Concurrently, Ridango, a public transportation technology company ceased paper tickets and made travelling very convenient by simultaneously introducing account-based ticketing and contactless payment. GPS-based arrival warnings and route guidance were also integrated into real-time public transport tracking apps such as Peatus which means that commuters are able to make more informed decisions, as well as to spend less time waiting. In order to enhance traffic flow, smart traffic lights were implemented at 45 junctions in Tallinn and programmed to prioritize public transport vehicles. These solutions reduced delays while improving overall fleet performance (e-Estonia, 2022). Estonia has also started creating Mobility as a Service (MaaS) services, aiming to consolidate various modes of transport into one digital platform (Kalda, Sell, & Kivimäe, 2024). In low-density rural areas, demand-responsive transport solutions were introduced to save on operation expenses and enhance accessibility.

In Tartu county, Estonia's urbanization featured smart pedestrian crossings, which enhanced pedestrian safety during low-visibility situations. To alert drivers in real time, the crossings were fitted with artificial intelligence motion sensors, LED indicators, and thermal sensors (Pashkevich, Krasilnikova, & Antov, 2016). Accompanying this are smart bus stops in Tallinn, which come equipped with solar panels, USB charging points, Wi-Fi, and real-time arrival displays, adding to sustainability and passenger experience. Accompanying this are smart bus stops in Tallinn, which come equipped with solar panels, USB charging points, Wi-Fi, and real-time arrival displays, adding to sustainability and passenger experience. Bikeeep's smartphone-enabled bike racks and e-scooter docks were installed to make secure, app-locked micro-mobility available, while Comodule's IoT-based solutions provided real-time management of e-bike and e-scooter fleets for operators. Heated sidewalks with sensors were piloted to prevent ice-related accidents and cut chemical use, while an online weather system using mobile and road sensors forecasted road conditions 48 hours in advance to support autonomous winter road maintenance (e-Estonia, n.d)&(Laast, 2024). By deploying solutions from AuveTech, Ridango, Bikeeep, Comodule, and Starship Technologies, Estonia has improved urban everyday life, demonstrating the potential of technology-driven mobility to improve public services while building an inclusive, environmentally resilient society.

e-Tax: Tech-Driven Tax for Inclusive Growth

Introduced in 2000 by Tax and Customs Board, the e-Tax system, transformed tax declaration with pre-filled forms, secure access, and rapid processing. It allowed Individuals and enterprises to file income tax, social tax, unemployment insurance, and pension fund contributions. Provision to file Individual income tax returns, customs declarations, and VAT and duty submissions were also offered (Kastik, 2019). The service is defined by speed and ease, with declarations processed in under three minutes and refunds issued within two weeks, encouraging mass adoption and ensuring a seamless experience. Due to these characteristics, e-Tax adoption increased from approximately 59% in 2004 to over 98% by 2019, with more than 98% of all tax declarations now submitted online (Williams, 2021). This tech-driven approach significantly reduced bureaucracy, eliminated the necessity for physical visits, and facilitated global accessibility. It enhanced Estonia's standing as a pioneer in leveraging innovation and technology to foster inclusive public services and supporting an efficient, sustainable, and citizen-centric governance style.

Banking Innovation: Borderless, Paperless, and People-Centric

Estonia was the first to implement e-Banking in the late 1990s. Currently, over 99% of financial transactions are conducted online through secure, user-friendly platforms that are accessible around the clock (e-estonia, n.d). Tuum and Wise, two prominent Estonian fintech businesses, were pioneers in the development of innovative financial products. Tuum's cloud-native, modular core banking system enables banking institutions to efficiently implement and manage a diverse array of digital banking products. Its flexible design enables quick product innovation, easy scaling, and fintech integration, helping banks upgrade legacy systems. Wise's mobile app allows customers to make fast and affordable international money transfers using live currency exchange rates, supported by a global network of local accounts. Customers are able to open accounts, handle finances, and make real-time transactions around the world without setting foot inside a branch (Martens, 2010). The secure e-banking infrastructure is augmented by the integration of e-ID and e-Residency cards, alongside digital authentication and facial recognition capabilities. The system addressed fundamental inefficiencies such as sluggish services and restricted banking hours.

Secure digital identities significantly reduced financial fraud, and connected services were advantageous to businesses and private customers alike. By digitizing banking with e-ID integration, 24/7 online access, and mobile-first solutions, Estonia has enhanced financial services for rural communities, international citizens, and small enterprises, resulting in a more inclusive, accessible, and sustainable financial ecosystem.

e-Business Tools: Innovative, Transparent, and Efficient

Estonia's e-Business Register, launched by the Ministry of Justice, allows online registration of companies in a few minutes using an ID card, Mobile-ID, or e-Residency card. Since 2011, Estonian companies have mostly been registered online, reducing the traditional five-day registration time to hours. Companies can retrieve tax arrears, file annual reports, update company details, and carry out due diligence by reviewing factors such as ownership, obligations, and regulations. A pioneering feature of this system is the Visualized Business Register, which enhances transparency by graphically representing the legal and financial relationships among companies (Buyan-Arvijikh, 2020). It is connected to the European Business Register and associated official documents and can be accessed for a subscription fee. Users can query prohibitions of companies in real time and track updates. This technology enhances transparency and ensures compliance, and also help tackle unreported labor, significantly contributing to the creation of a more environmentally sustainable, egalitarian, and resilient corporate environment.

e-Residency: Connected Economy

Introduced in 2014, Estonia's e-Residency initiative provides a new virtual identity for non-residents. Administered by the Estonian Police and Border Guard, it enables global entrepreneurs to sign up and operate EU-based companies online. e-Residents are issued a digital ID with PIN codes for secure entry, legal digital signatures, and encryption. They are able to register a company within a day, run it remotely, open a bank account, access international payment systems such as PayPal, and file Estonian tax (Särav & Kerikmäe, 2016)&(Kotka & Alvarez del Castillo, 2016). There are more than 25,000 entrepreneurs who utilize e-residency, including digital nomads, freelancers, and contractors. The initiative links individuals to Estonia's secure digital environment, and the European Union single market. The processing, which lasts between three to four weeks, is paperless and efficient (Poleshchuk, 2016). e-Residency, Estonia's pioneering initiative based on digital infrastructure, expands opportunities for entrepreneurs, reduces barriers to entry, and attracts investment, thereby stimulating economic growth and promoting social equity and resilience.

e-ID: Privacy, Access, and Empowerment

Estonia's e-ID system was implemented in 2002 and is one of the world's most sophisticated and comprehensive national digital identity systems. This governmental document is much more than a mere identification card, incorporating 384-bit ECC public key encryption, facilitating secure digital verification for many services (Murphy, 2022). Estonians utilize their e-ID to digitally authenticate documents, participate in online voting, view medical records, file taxes, employ e-Prescriptions, log into financial services, and travel throughout the EU, as it serves as both a valid travel identification and a national health insurance card. The chip on the card contains encrypted personal information, facilitating authoritative digital identification verification (Rahe, Tzitzelkov, Decheva, Stăvărache,

&Tsonev, 2021). It offers remarkable efficiency, allowing citizens to skip standing in lines at government offices and reducing paper-based operations.

The e-ID is the cornerstone of Estonia's digital government concept, as it facilitates nearly 100% digital access to public services and establishes trust in digital transactions. For the authorities, e-ID facilitates effective provision of services, reduced expenses, increased transparency, and prevention of mistakes in record-keeping. For citizens, it provides convenience, access at all times of day and night, and better data protection. The privacy is preserved by secure access logs, which enable a person to view who has accessed his/her details and when. The e-ID system is at the core of Estonia's approach towards sustainability, saving paper, carbon emissions in physical travel and bureaucracy, and setting up a culture of digital independence. With a population of over 1.3 million citizens, virtually all Estonian adults use the e-ID (Felt & LaRivee, 2025). The widespread adoption of the e-ID has established it as a central feature of everyday life in Estonia, introducing efficiency, security, and accessibility, cutting bureaucracy, saving time and money, and facilitating inclusive access to the most important services in the long term in a sustainable manner.

Smart-ID: Paperless Identity for a Connected World

Smart-ID introduces unprecedented convenience to the people by providing 24/7 access to financial services, healthcare services, and government services from any location worldwide with an internet connection. Smart-ID's security architecture includes end-to-end encryption, a blockchain-based Keyless Signature Infrastructure (KSI) for authenticity verification, decentralized data storage, and an access-controlled data pool. The system achieves double-layer security by requiring a first Personal Identification Number (PIN) for access and a second Personal Identification Number (PIN2) for transaction verification. Customers retain ownership of their data and are adequately informed of its use in compliance with Estonia's Privacy by Design policy (Oruaas & Willemson, 2020). It eliminates the necessity for physical infrastructure and, hence, is very well-suited for business travelers and distant workers. It improves customer happiness, lowers operating expenses, and streamlines digital onboarding for enterprises and governmental entities. Smart ID is a crucial element of Estonia's digitalization and sustainability strategy. It enhances customer satisfaction, reduces operational costs, and facilitates digital onboarding for businesses and government. Smart ID is an essential component of Estonia's digitization and sustainability plan. By avoiding the use of paper, it reduces energy costs related to face-to-face services, and facilitates online transactions, it achieves a more efficient, green, and digitalized world. Smart-ID had over 730,000 customers in Estonia, over 1 million in Latvia, and approximately 1.6 million in Lithuania as of 2024, with growing cross-border interoperability among the Baltic countries (e-Estonia, n.d). Smart-ID showcases the capability of mobile-first solutions in fueling an eco-friendly, future-proof digital universe.

e-Justice: Justice for All, Powered by Technology

In the early 2000s, Estonia commenced the digitization of its legal system, and by 2008, court proceedings were conducted entirely online. The intention was to improve the access to justice, reduce the cost of litigation, and improve the transparency and efficiency of the process. The system is built around the e-File central information system, which integrates courts, police, prosecutors, and prisons. By inputting data into a database a single time and enabling access from any location, redundancy and latency are eradicated. The public e-File portal enables citizens to request and track civil, administrative, or criminal

cases over the Web. After a claim is submitted, it can be reviewed and filed remotely by judges with access to case files through the court information system. Judges make decisions electronically, and court clerks arrange hearings on the Internet. Hearings take place through the portal, and after the electronically signed decision, it appears in the official electronic state gazette (Vatsa & Chhaparwal, 2021)&(Ahmed, et al., 2021). Court backlogs were reduced, case durations were shortened, and increased access was ensured, especially for individuals residing in rural areas. Through the digitization of records and hearings, Estonia has established a more expedited, transparent, and accessible judicial system. The extensive implementation of e-Justice has optimized the judicial system in Estonia. It has improved accessibility and transparency, streamlined legal processes, and reduced procedural barriers. Technology, in turn, has facilitated equal access to legal redress and reduced reliance on resource-intensive traditional court procedures. Technology-driven e-justice serves as the cornerstone of Estonia's e-governance, exemplifying judicial reform that fosters sustainable and fair development via efficiency and accessibility.

Data Embassy: Estonia's Sustainable Digital Backup

Estonia launched the world's first Data Embassy-a cloud-based extension of its key state information systems-in LuxConnect's Tier IV-certified data center in Betzdorf, Luxembourg. The project started as a concept back in 2015 and materialized through the signing of an agreement with Luxembourg in 2017. The project commenced in 2018, involving collaboration between the Estonian government and prominent business sector entities such as Cybernetica, Dell EMC, Ericsson, OpenNode, and Telia. The response addressed a serious concern. Estonia's digital government infrastructure could put critical national information at risk during a crisis or attack. In the absence of physical backups, preserving uninterrupted digital continuity became essential for national security. The data embassy has successfully addressed data loss, geopolitical concerns, and digital security, establishing Estonia as a global leader in digital sovereignty and cloud governance. A bilateral agreement with Luxembourg, based on Vienna Convention on Diplomatic Relations (VCDR) principles, provides Estonia's Data Embassy with specific legal protections (Robinson, Kask, & Krimmer, 2019), (Rice, 2019)&(Kaljund, 2018). This ensures Estonia's digital sovereignty and security, even beyond its boundaries. The stored data is protected by KSI Blockchain technology, which provides resilience and traceability. The data embassy provides inclusivity and sustainability through ensuring long-term access to essential digital services to all citizens and reducing resource consumption by having essential infrastructure outside the country. It also stands as a model for other nations seeking safe and stable digital continuity arrangements.

Digitization is Estonia's top priority. The nation has established higher goals for itself by embracing the National Digital Agenda for 2030, which came into force in 2021. The current focus is on connecting services to life events and creating features that automatically suggest the next steps (The Organisation for Economic Co-operation and Development, 2020).

Estonia's e-governance initiatives have helped the government achieve various Sustainable Development Goals. They have enhanced public health and well-being (SDG 3), increased access to quality education for all citizens (SDG 4), and encouraged economic growth and entrepreneurship (SDG 8). In addition, such digital initiatives have encouraged innovation and increased resilient infrastructure (SDG 9), helped reduce social and economic disparities (SDG 10), and ensured more secure, sustainable urban areas (SDG 11). They have also enabled responsible resource consumption (SDG 12) and strengthened the development of responsible, transparent, and inclusive institutions (SDG 16).

Multi-Pronged Approach to Cybersecurity

Estonians have enjoyed easy access to a range of e-government services for many years. With society, business, and politics becoming increasingly interlinked online, issues of cybersecurity have emerged. In countering these challenges, Estonia has assiduously built its cyber resilience. The nation has increased the capacity of its National Cyber Security Centre, enabling it to better identify threats, coordinate responses, and improve cyber capacities across sectors, thereby enhancing readiness and accelerating response to incidents (Kohler, 2020). Further, the Cybertest platform was built to provide free cybersecurity training to public and commercial enterprises. This has assisted more than 15,000 individuals to enhance their cyber awareness and reaction capabilities (Estonian State Information Authority, 2024). Development of initiatives like the Open Cyber Range and the Cyber Defense Unit enhanced resilience by enabling SMEs and volunteers to work on national security efforts. It imposed security standards on 3,500 companies, contributing to the improvement of digital protection across sectors. It also introduced public awareness initiatives to inform citizens and enterprises about cyber threats and good digital behavior (State Information Systems Authority, 2024). All the ministries were tasked with securing their digital infrastructure, reflecting a decentralized but integrated cyber defense framework (Kaska, Rebane, & Vaks, 2021). Furthermore, Estonia has been enhancing its international action on cybersecurity matters, with a focus on securing the critical infrastructure as well as generating confidence in digital (European Union Agency for Cybersecurity, 2024). These multilateral projects reflect Estonia's longstanding efforts to cultivate a resilient digital environment that upholds public trust, promotes equitable growth, and equips the nation to confront potential future global cyberattacks.

E-Governance Implementation Challenges

Estonia's effort to embed digitalization into its governance structure has been confronted with various challenges. One of them is the prevalent digital divide, especially between the older generations, who are least likely to have the digital skills. The skills gap has been a challenge to the mass take-up of digital government services (Leppiman, Riivits-Arkonsuo, & Pohjola, 2021). In addition, growing public interest in the security of children on the web and privacy of their information has caused other segments to be more reluctant to move into online environments (Estonian Safer Internet Centre, 2023). Lack of adequate awareness in the public regarding decision-making through AI, especially potential biases, black-boxing, and fairness, is another severe limitation. Thus, trust and satisfaction with online services have been lost among different segments of society. Estonia's strategic position within NATO's cyber coalition poses a threat of increased geopolitical and structural risks. Typically, potential threats from Russia give rise to serious vulnerabilities in the cyber system, including the risk of cyberattacks, internet shutdowns, and software failures. International digital connectivity also exposes ongoing issues, traditionally bedeviled by system compatibility issues that limit interoperability and detract from performance effectiveness (Laasme, 2012). From an economic perspective, small and medium-sized enterprises (SMEs) have been slow in embracing critical digital innovations, which remains the biggest impediment to general growth. Around 5.2% of Estonian companies use artificial intelligence, with 25.6% using data analytics, both rates lower than that of the European Union average. Digital competitiveness varies significantly across the private sector (Digital Strategy, 2024). To address these challenges, the Estonian government has unfolded a policy of managing risk that aims to balance technological progress with ethical conduct, good data protection legislations, and robust cybersecurity solutions. Despite such attempts, adopting

digital services in public administration still needs massive resources, and the economic sustainability of doing so for a small Baltic state with little financial resources is questionable.

DISCUSSION

Since the inception of e-governance initiatives, Estonia has strategically leveraged innovation and technology in public administration to improve the delivery of public services and to support its wider goal of fostering a more inclusive and sustainable society. It greatly expanded access to key public services through its pioneering e-governance framework, offering healthcare via the e-Health Portal with secure access to medical records and prescriptions, education through e-School that links parents, teachers, and students in real time, legal services through e-Justice that makes judicial processes more transparent and efficient, and democratic participation through e-voting that allows citizens to engage in elections conveniently and securely. Moreover, Estonia's e-Residency and Digital Nomad Visa take its digital governance global, promoting economic inclusion for foreign businesses. Early exposure to information technology, from primary school coding to national digital literacy initiatives, cultivated enduring digital resilience and adaptation among the workforce. Projects like the Data Embassy and blockchain-based data exchanges have redefined data sovereignty and national resilience. Sustainability is also top of mind in Estonia's approach—reduced use of paper, elimination of physical travel, and optimized performance of public services all reduce the carbon footprint and boost resource efficiency. The impact of these e-public service delivery is clearly evident: the citizens have benefited directly, services have been streamlined, and there has been increased use of digital platforms. This has enhanced societal engagement and sustainability, hence validating the value of governance through innovative and technology-driven initiatives. Estonia cannot sustain the performance of its e-governance without stronger cyber resilience, as it has made improving cyber resilience a top priority and adopted a multi-pronged approach to address these risks. Its successful digital implementations did not happen overnight. They were the result of decades of diligent effort, effective utilization of limited resources, and robust coordination between governmental institutions, technology innovators, and community organizations.

CONCLUSION

In the past two decades, Estonia has achieved significant progress in creating a more egalitarian and sustainable society. The findings of the study indicate that Estonia's e-public services are extensively trusted and utilized by its residents, which in turn has increased public participation, while also lowering costs and reducing environmental impact. These findings underscore how technology-driven government is steering the nation towards enhanced inclusivity and sustainability. It emphasizes that equitable practices, flexibility, strong inter-sectoral collaboration, proactive planning, and effective governance are crucial for enabling innovation- and technology-driven public administration to promote sustainable, inclusive, and future-ready societies. The nation's innovation- and technology-driven e-governance has furthered equitable development in accordance with the United Nations Sustainable Development Goals, including SDG 9 (Industry, Innovation and Infrastructure), SDG 10 (Reduced Inequalities), and SDG 16 (Peace, Justice and Strong Institutions). Estonia's example illustrates that when digital governance is founded on ethical principles and supported by robust institutions, it fosters openness, efficiency, and resilience, essential for attaining the SDGs. For countries seeking to transition to digital governance using innovation and technology, Estonia serves as a valuable example. The Estonian experience proves that success in building inclusive and sustainable societies does not depend on size or

wealth but on a definitive vision and a purposeful, inclusive approach to harness innovation and digital technology.

Limitations and Future Directions

This study relies on theoretical studies and secondary data sources such as peer-reviewed studies, government documents, and industry publications. Though this study offers an overview of how innovation and technology support e-governance for inclusive and sustainable development, it doesn't provide firsthand perspectives and comments by parties directly involved in the transformation process. It also does not adequately address criticisms or negative consequences related to Estonia's digital initiatives. The omission was intentional, because the main aim of the study is to showcase digital initiatives that could be applied elsewhere. There is ample opportunity for additional research on the subject. Future studies should aim to collect firsthand perspectives from policymakers, administrators, and citizens, and to conduct cross-country studies to analyze the scalability of Estonia's model. Studies on evaluating how digital initiatives maintain inclusiveness and sustainability over time would also be helpful.

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