

Optimizing Electronic Voting System in Village Head Elections: Evaluation and Recommendations from Sleman Regency, Indonesia

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Abstract

INTRODUCTION: The rapid technological advancements of Industry 4.0 have influenced government politics, extending to the adoption of electronic voting in village head elections. In Sleman, e-voting was introduced in 2020, aiming for voting system efficiency and synchronization of population data, positioning the region as an e-voting pioneer in Indonesia. While e-voting offers efficiency and cost savings, it faces some problems.

OBJECTIVES: This study endeavors to comprehensively assess the implementation of the e-voting system in village head elections and provide recommendations for its optimization, with a specific focus on the context of Sleman Regency.

METHODS: This qualitative research encompasses data from 17 villages spread across 35 sub-districts within Sleman Regency. The study utilizes a comprehensive approach that includes secondary data analysis, incorporating literature, internet-based resources, scientific journals, books, regulations, and official documents. It further involves interviews with government officials at Sleman offices, officials at polling stations, and voters. Additionally, observational data is gathered to shed light on the intricate dynamics of e-voting.

RESULTS: The evaluation focused on four pivotal aspects of the e-voting system's success: public trust, public participation, technology, and adherence to election principles. The findings reveal improved dynamics in 2021 when compared to 2020. Public trust in the e-voting system has notably increased, aligning with the relatively successful implementation in the previous year. While community participation has reached a satisfactory level, it has yet to attain full community control, with interesting nuances observed, particularly in less 'advanced' villages where participation tends to be lower. In the realm of technology, the e-voting system excels in terms of security, hardware reliability, the comprehensiveness of application features, and user-friendliness.

CONCLUSION: The study underscores that the enhancement of e-voting systems presents an avenue to fortify democratic practices and electoral processes in Indonesia. Acknowledging imperfections in data collection systems and addressing participation disparities among villages should be prioritised. Furthermore, the study suggests that comprehensive future research is needed to evaluate the feasibility of extending e-voting systems to higher levels of government elections. This examination offers valuable insights into the evolution of e-voting in Indonesia and the prospects for its expansion in democratisation efforts.

Keywords: E-Voting, Village Head Election, Evaluation, Community Trust, Community Participation.

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1. Introduction

The rapid evolution of technology during the era of Industry 4.0 has exerted profound influence across various domains, with a noteworthy impact on government politics [1][2]. Beyond its transformative effects on the delivery of public services, achieved through the adept utilisation of diverse digital applications, the advancement of Information Technology (IT) has extended its purview to encompass the electoral process, commonly referred to as electronic voting (e-voting) [3] [4], [5]. E-voting applications have been introduced in village head elections, ostensibly offering cost-efficiency and expeditious vote tabulation. The implementation of such innovations remains a subject of contention, characterised by a discernible array of advantages and disadvantages [6] [7] [8].

Drawing upon previous research endeavours, including the investigations conducted by [3] [5] and [9], a consensus emerges, underscoring the heightened effectiveness of employing this method for the selection of village heads. Nonetheless, it is crucial to note that this policy innovation has engendered substantial resistance within the Sleman area of Yogyakarta Province. As reported by [10], the local populace harbours reservations concerning the suitability of e-voting as an alternative means of determining leadership. The rationale behind their resistance encompasses various concerns, ranging from apprehensions about technological manipulation to a perception that the prevailing regulatory framework lacks the requisite fortitude to address violations of e-voting. To delve further into the implementation of e-voting, the subsequent section will furnish a comparative analysis of its adoption and realisation, both at the global and local levels.

Estonia stands out as a frontrunner in technological advancements within public services and government politics, surpassing many other nations. This supremacy can be attributed to several factors, including the country's relatively small geographical size and population of just 1.3 million, which affords them the advantage of efficiently covering the entire territory with comprehensive and robust public infrastructure, including widespread internet connectivity. Commencing in 2005 through a local government pilot initiative, Estonia has effectively conducted e-voting, achieving noteworthy cost savings, with budgets roughly half that of traditional manual elections [11][12]. Despite being celebrated as the pinnacle of successful e-voting, characterised by principles of transparency and a high degree of accountability, Estonia's government policies have faced substantial criticism from diverse quarters. In 2016,

scholars from Oxford University specialising in computer science and network technologies asserted that the triumph of e-voting in Estonia primarily hinges on the foundation of trust and robust social networks rather than the sheer sophistication of the employed technology. Thus, the applicability of the Estonian model to a more densely populated country with lower levels of public trust remains a subject of debate [13][14][15]. Another comparative insight can be gleaned from India, a democratic nation with a population rivalling that of Indonesia. Several regions in India have long implemented e-voting as a method of electoral participation. However, this transition has been marred by incidents of malpractice and system abuse, which have cast doubts on the reliability of the e-voting system despite its widespread usage [16] [17][18].

To date, e-voting in Indonesia has primarily been implemented in regions with relatively small and sparsely populated local typologies. This approach is compounded by the fact that, as of January 2020, Indonesia's internet user penetration was only approximately 64%, primarily concentrated in larger urban areas with more robust network infrastructure. While these challenges persist, they have not deterred certain village government areas, such as Sleman district in Yogyakarta, from persisting with e-voting as their chosen method for conducting elections.

In this westernmost region of the Special Region of Yogyakarta, village head elections through e-voting commenced in 2020. Although it marked the inaugural instance of its implementation, the regional administration of Sleman regards the electronic village head election system as a prospective catalyst for substantial enhancement in efficiency. Justification for this outlook lies in the absence of invalidated or discarded physical ballots and the facilitation of precise synchronisation of population data. The local authorities expounded that adopting e-voting in village elections positions Sleman Regency as the pioneering jurisdiction within the Special Region of Yogyakarta to embrace this innovative form of electoral practice. The legal framework underpinning this initiative finds its basis in Decision Number 147/PPU-VII/2009, per the review request of Law Number 32 of 2004 concerning Regional Government *vis-à-vis* the 1945 Constitution. Additionally, Minister of Home Affairs Regulation Number 112 of 2014 governs the Election of Village Heads, stipulating in Article 49(1) that Village Head Elections will be conducted concurrently.

A potential research gap in cybersecurity and data integrity within electronic voting systems can be identified. While the article evaluates the e-voting system's performance and user participation, it may not delve deeply into the vulnerabilities and potential threats such systems can face.

This research will explore the critical aspect of securing the e-voting infrastructure to ensure the confidentiality and integrity of the electoral process, as this is a pivotal concern in electronic voting systems worldwide. Addressing this gap would provide a more comprehensive understanding of the challenges and opportunities related to e-voting in the context of the Sleman Regency and contribute to the broader discourse on secure and efficient electronic voting systems.

This article aims to discuss two main points, namely: 1) To understand the implementation/organisation of e-voting for the Village Head Election in Sleman Regency and 2) To understand several important aspects in organising e-voting for village head elections in Sleman Regency (trust, participation, technology, and fulfilment of election principles) which support its success. Meanwhile, the target of this research is to develop lessons learned that can be studied by various stakeholders so that they can then improve innovative policies that encourage the holding of general elections that are based on free and fair principles (direct, public, free, secret, honest and fair). It is hoped that this research synthesis can be used as input for village, district and provincial governments to organise general elections better.

2. Literature Review

2.1 Principles and Implementation of General Elections in Indonesia

Numerous countries perceive elections as a fundamental instrument to bolster the underpinnings of popular sovereignty within governmental frameworks. In democratic governance, elections are a pivotal means to supplant authoritarian regimes, often prevalent in monarchical systems. The regular conduct of elections serves several vital purposes, encompassing the oversight of political leaders, the cultivation of commendable leadership attributes, and the stimulation of active civic engagement in the nation-building process [19][20].

The functions of general elections are technically multifaceted, including the determination of the composition of the government, facilitating a channel of feedback between the electorate and the government, quantifying the level of public support for the ruling authorities, the recruitment of political leaders, and the enhancement of the government's comprehension of the populace's aspirations. In Indonesia, a set of fundamental principles mandates adherence in elections, notably direct voting, universality, freedom, secrecy, integrity, and fairness. These cardinal principles play a pivotal role in safeguarding the effective execution of

elections, culminating in the election of competent leaders who command a high degree of legitimacy. The principles of integrity and fairness also confer an imperative duty upon election organisers, ensuring the equitable treatment of all election participants, encompassing voters and organisers alike.

2.2 Election Technology and E-Voting Concept

Electronic voting, commonly called e-voting, is one of several contemporary electoral technologies. This category of technologies encompasses at least four distinct definitions, each about the application of information technology within electoral processes. These definitions encompass the following: 1) Election technology, signifying the utilisation of information technology at various stages of elections, whether encompassing all phases or specific components thereof; 2) Voting technology, which entails the application of information technology at the voting phase, vote tabulation at polling stations, and the consolidation of votes [21][22][23]. 3) Electronic voting or e-voting explicitly denotes the integration of information technology at polling stations during the voting and tabulation stages. International IDEA offers a comprehensive definition, characterising e-voting as a system employing information technology for recording, casting, and counting votes during political elections. 4) Internet voting, which involves the use of Internet networks for organising elections, spanning from the casting of votes to their counting and consolidation [24][25]. These definitions collectively emphasise the pivotal role of information technology within the electoral process. According to these delineations, e-voting is a subset of electoral technology that primarily operates during vote recording, casting, and counting.

Electoral technology has found extensive application across various countries, tailored to their unique requirements. Presently, seven variants of electoral technology are discernible, comprising Direct Recording Electronic (DRE), Electronic Ballot Printer (EBP), E-Pens, OMR and OCR systems, Internet Voting, E-Recap, and Open Data systems [26][27][28]. These technologies have distinct advantages and shortcomings, encompassing aspects such as precision in vote scanning and computational demands. The introduction of technology in general elections primarily seeks to enhance efficiency and accuracy and expedite results; however, this technological integration sometimes confronts challenges in maintaining fidelity to fundamental electoral principles. Adopting technology in e-voting hinges on considerations encompassing swiftness in results,

precision, and cost-efficiency. Technology integration is also motivated to accommodate voters with special needs and those far from polling venues. The incorporation of technology may engender issues, including violations of electoral principles, particularly concerning the application of Direct Recording Electronic systems, which carry the potential for recording voter data [29][30].

2.3 Normative Principles and Application of E-Voting in Indonesia

A country's legal framework, whether it pertains to the constitution or electoral laws, necessitates careful examination to discern the extent to which it accommodates the regulation of electoral technology. Typically, the existing legal frameworks do not explicitly delineate or govern issues related to electoral technology. However, most legal frameworks associated with electoral processes encompass regulations that uphold the fundamental principles and values of democratic elections, such as direct voting, universality, freedom, secrecy, and integrity. Therefore, These fundamental principles serve as guiding principles for integrating technology into the electoral process. Incorporating technology must be aligned with and fortify these foundational principles and values of elections [27] [31].

In Indonesia, the constitution and the electoral legislation do not offer explicit directives on employing electoral technology. Nevertheless, it is noteworthy that Constitutional Court Decision No. 147/PUU-VII/2009 stipulates that Article 88 of Law 32/2004 concerning Regional Government is constitutionally conditional on Article 28 C, section (1) and (2) of the 1945 Constitution. In this context, the term "voting" within Article 88 of Law 32/2004 can encompass both conventional voting methods and the utilisation of electoral technology, as exemplified by e-voting. The application of electoral technology, including e-voting, must meet specific cumulative conditions: 1) It must not contradict the core principles of direct voting, universality, freedom, secrecy, integrity, and fairness; and 2) It should align with technological readiness, financial capabilities, human resources, software infrastructure, the preparedness of the local community, and other requisites deemed necessary for its successful implementation.

The implementation of E-Voting for Village Head Elections in Sleman Regency is governed by Sleman Regency Regional Regulation 18/2019 concerning the second amendment to Sleman Regional Regulation 5/2015. Specifically, Article 5A of this regulation stipulates that "Simultaneous Village Head Elections shall be conducted

electronically." The explanatory section elaborates on electronic voting, denoting it as the conduct of village head elections utilising information technology and electronic devices. Moreover, Article 37, section (2) outlines how voting for the village head election occurs, indicating that it is accomplished through the electronic selection of a Village Head candidate's image. The corresponding elucidation further expounds that the electronic selection of a candidate's image for the Village Head position is a method that involves employing information technology and electronic equipment for the selection process.

2.4 Research Framework

The research conducted, as expounded in the background, finds its intrinsic connection with the responsibilities vested in the Regency government concerning the oversight of village guidance and development, including organising village head elections. This responsibility is explicitly outlined in Law 23/2014 concerning Regional Government. Furthermore, village elections are intricately linked with the Constitutional Court (MK) Decree Number 42/PUU-XIX/2021, delineating the maximum term limit for village head positions. Consequently, this has noteworthy implications for the agenda of conducting Simultaneous Village Head Elections in Sleman Regency.

The success of implementing e-voting for village elections hinges on a multifaceted evaluation involving several vital aspects. Drawing from a substantial body of domestic and international literature, several pivotal facets are directly relevant to the successful execution of e-voting. These facets encompass, but are not limited to, the following: 1) Trust, 2) Community participation, 3) E-voting technology, and 4) Adherence to the principles governing elections. The accomplishment of e-voting for village elections is not solely contingent on adherence to meticulously planned procedural stages but on the discernible alignment with these four essential aspects. These aspects are systematically evaluated at each electronic village head election stage to ascertain their fulfillment.

3. Method

The research was conducted in various villages within Sleman Regency's jurisdiction in the Yogyakarta Special Region Province. The selection of research sites was determined through purposive sampling, aimed at procuring comprehensive insights into the specific procedures employed by each village in conducting village head elections using the e-voting system. The qualitative research

methodology is designed to facilitate a profound comprehension of the practices and processes involved in e-voting across multiple villages within Sleman Regency. The author employs both primary and secondary data sources. Primary data is collected through a structured process involving interviews with informants at various levels, ranging from the district administration to the polling stations in the villages where village elections are conducted. Meanwhile, secondary data is drawn from various scholarly sources, including literature, internet-based resources, scientific journals, books, tables, documents germane to the research topic, and other pertinent documents.

The informant pool for this research comprises Division Heads within the Sleman Community and Village Empowerment (PMK) Office, Division Heads within the Sleman Regional Financial and Asset Management (PKAD) Office, technical personnel from the PMK Service, and Heads of Voting Organizing Group (KPPS), who were chosen through the purposive sampling method. In addition, voter informants were selected using a Snowball Sampling approach. The research encompasses 17 villages spanning 35 sub-districts, with data from the Community Empowerment Service of Sleman for 2021. The data collection techniques adhere to established protocols for qualitative research. Both primary and secondary data acquisition methods rely on information gleaned from informants, sources, observational records, activity documentation, regional regulations, and literature resources. The predominant data collection techniques encompass interviews, observation, documentation, and Focus Group Discussions (FGD). Subsequently, the data undergoes technical validation and analysis by a sequential model involving data reduction, data presentation, data analysis, and conclusions. Data validity assessments are conducted using triangulation techniques to enhance the robustness and trustworthiness of the research findings.

4. Result and Discussion

4.1 Study and Planning Stage

The decision to employ e-voting for village head elections was officially articulated by the Sleman Regency Government in 2019. This declaration was formally conveyed by the Regent of Sleman, Sri Purnomo, during a press conference conducted in the Meeting Room of the Sleman Regent at the Regional Secretariat Office on Wednesday, August 5, 2019.

To realise the implementation of E-Voting for the 2019 Village Head Election, the Sleman Regency Government

entered into a memorandum of understanding (MoU) with the Agency for the Study and Application of Technology (BPPT) on Tuesday, July 7, 2019, in Jakarta. The MoU was jointly signed by the Regent of Sleman and the Head of BPPT, marking the preliminary phase of the collaborative endeavor. At that time, the Regent expressed the aspiration that E-Voting for village head elections would facilitate precise, transparent, efficient, and effective elections. In an official statement by the Sleman Regional Government, Regent Sri Purnomo remarked, "*Village elections employing E-Voting can be conducted using a simplified, secure method accessible to all. Our research has established that E-Voting can be successfully implemented in Sleman.*"

In the lead-up to the inaugural electronic village head election, the Sleman Regency Government also made provisions for potential challenges during the implementation phase. This pre-emptive strategy was formulated based on extensive research and collaboration with multiple stakeholders, including the Boyolali and Pemalang Regional Governments.

Sleman's Communication and Information Office (Diskominfo) elucidated that they conducted comparative studies in areas that had previously organised e-voting and engaged local educational institutions around Sleman to collaborate in developing the application for e-voting. This approach ensured that the election of village heads through the E-Voting system aligns with the principles of integrity and equitable participation, akin to manual village head selection processes. The Sleman Government allocated funds to implement e-voting, encompassing expenses for technical personnel, equipment procurement, and other associated costs. The financial implications of the COVID-19 pandemic in early 2020 led to budgetary adjustments, prompting the Sleman government to undertake proactive measures to secure the project's continuity. Consequently, the Sleman Regency Government initiated preliminary planning and conducted comprehensive studies in collaboration with various stakeholders, including BPPT and regional governments that had previously introduced e-voting systems, notably the Boyolali and Banyuasin Regency Governments.

The initial endeavour to conduct electronic village head elections incurred substantial financial investments and experienced an escalated budgetary demand after the COVID-19 outbreak. The Sleman Regency Government found it necessary to allocate additional resources to ensure the continued implementation of E-Voting while adhering to health protocols. This supplementary expenditure encompassed hand washing stations, hand sanitisers, personal protective equipment, and other necessary measures. Before the outbreak, technical personnel involved

in the project were predominantly drawn from Information Technology students residing in Sleman, representing academic institutions such as Gadjah Mada University (UGM), Indonesian Islamic University (UII), Muhammadiyah University of Yogyakarta (UMY), among others. Nevertheless, the pandemic compelled many of these students to return to their hometowns, rendering them unable to contribute to the E-Voting implementation. Consequently, the organising committee was compelled to reallocate funds to facilitate the training of alternative technical personnel.

Before the inaugural E-Voting for village head elections in December 2020, notable opposition to the plan surfaced. This resistance materialised before the actual execution of e-voting. It was particularly evident in the Sleman village head association's stance, as reported by the Central Java Post on August 2, 2019. The motives behind this resistance were suspected to be rooted in the interests of incumbent village heads, who might no longer be able to employ their resources to influence the outcomes of upcoming village elections.

4.2 Procurement Stage

The Regency Government conducted an open auction for all equipment to facilitate E-Voting for the Village Head Election. This auction process was managed through Electronic Procurement Services, which constitute information technology management services designed to streamline the procurement of goods and services. Goods/Services Procurement Work Units (UKPBJ) at the Ministries/Agencies/Regional level, lacking their Electronic Procurement Service, could utilise the Electronic Procurement Service facility nearest their location to execute electronic procurement. Beyond assisting UKPBJ in electronic procurement, the Electronic Procurement Service also encompasses registering goods and service providers domiciled within the respective Electronic Procurement Service area.

Electronic procurement of goods and services offers a range of benefits, including heightened transparency and accountability, increased market accessibility, stimulation of healthy business competition, enhanced procurement process efficiency, support for monitoring and audit procedures, and the provision of real-time information access to advance the ideals of clean and effective governance in the procurement of government goods and services. The legal foundation for establishing Electronic Procurement Services can be traced to Article 73 of Law 16/2018, governing government procurement of goods and services, with its operational and technical provisions specified in the Government Procurement Policy Institute (LKPP) Regulation 14/2018 on

Electronic Procurement Services. Electronic Procurement Services must adhere to the stipulations outlined in Law 11/2008 on Electronic Information and Transactions while providing an electronic Goods/Services Procurement service system.

The Electronic Procurement System encompasses several services, including tenders with operational and technical provisions governed by LKPP Regulation 9/2018 delineating E-Tendering Procedures. Additionally, LKPP offers the Electronic Catalog (e-Catalogue) facility, an electronic information system cataloguing various government goods and services, complete with listings, types, technical specifications, and prices from different government goods and service providers. It also includes features like online auditing (e-Audit) and guidelines for procuring goods and services through electronic catalogues (e-Purchasing). The procurement process for technology-related equipment appears to have proceeded smoothly. No public protests during the equipment auction for e-voting in village elections were reported in the mass media in 2019. Similarly, in 2021, there were no reports of public protests or concerns raised by independent institutions regarding procuring core or ancillary equipment for the implementation of e-voting in village elections in Sleman Regency, scheduled for 2021. Notably, the acquired e-voting tools are reusable for multiple village elections, rendering this approach more cost-effective, efficient, accurate, and expeditious for conducting village elections in the medium and long term.

4.3 E-Voting Application/Implementation Stage

On October 31, 2021, simultaneous elections were conducted in 33 villages in 15 sub-districts. Initially, the project had been planned to encompass the electronic election of village heads in 35 villages across 17 sub-districts. However, the decision rendered by the Constitutional Court during the campaign period, encapsulated in Decree Number 42/PUU-XIX/2021, which imposed a three-term limit on village heads, influenced the candidacies of several village head candidates in Sleman's village elections. The ineligibility of incumbents to seek re-election led to the annulment of the elections in two of the initially designated 35 villages scheduled for the year. The affected villages were identified as Selomartani and Sumberarum. Aji Wulantara, the Assistant Regional Secretary for Law, Government, and People's Welfare in Sleman, expounded that village elections necessitate the participation of a minimum of two candidates as stipulated by regulations. If one candidate withdraws, leaving only one in the race, the election cannot proceed and

is rescheduled for the subsequent period. Meanwhile, elections in the remaining five villages were conducted as planned, and the two villages for which the election had been cancelled were included in the election schedule 2023.

The sudden policy alteration instigated by the Constitutional Court caught the Sleman Regional Government unprepared, even though subsequent efforts were made to disseminate information. However, this response occurred after candidates had invested substantial financial resources in their campaigns. This generated frustration among aspiring village heads, who were compelled to withdraw from the election, representing a notable vulnerability in this process stage.

Despite the initial mixed reception concerning residents' trust and the Constitutional Court's decision, the execution of

village elections across 15 sub-districts unfolded seamlessly. The technical challenges encountered in prior elections were less frequent, with some areas still relying on manual processes, such as verification and registration, which invariably consumed more time.

To ensure the electorates' familiarity with the election process, the Sleman Government disseminated several informative videos through various social media platforms, including WhatsApp and YouTube. Each Polling Station conducted simulations to illustrate the e-voting system's operational procedure, albeit exclusively for citizen representatives, to mitigate the overcrowding risk. On the day of the implementation, eligible voters were required to adhere to the following voting procedures:

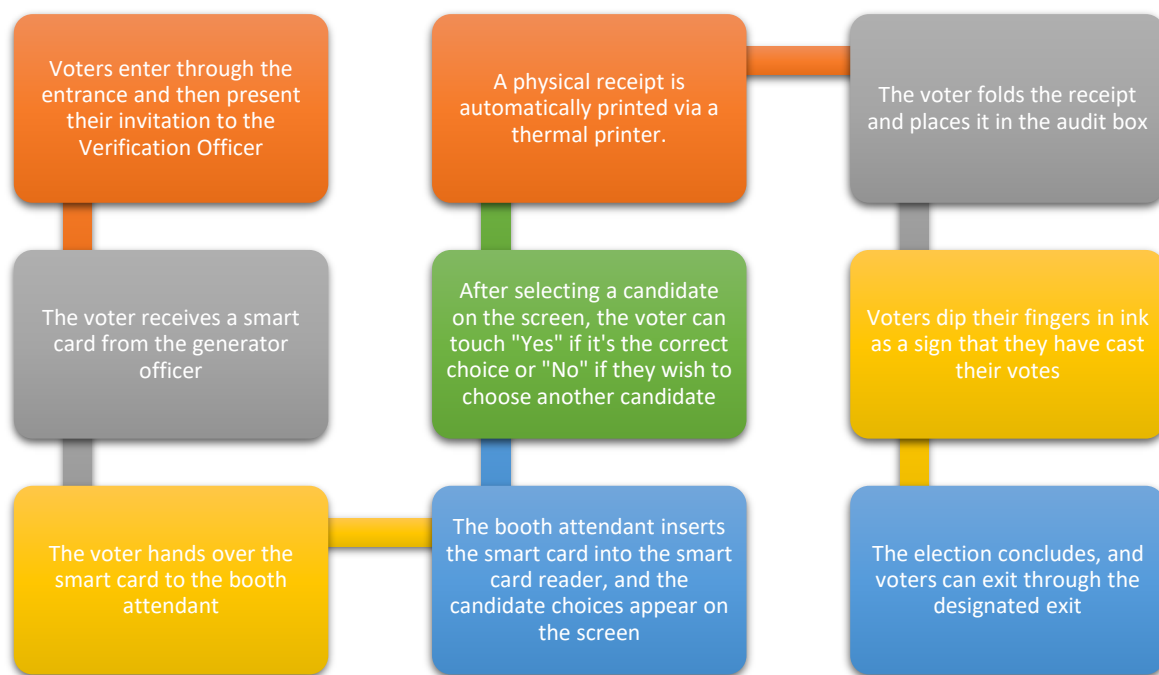


Figure 1. Electronic Village Head Election Flow
 Source: Sleman Regional Government official website/Sleman PMK Service (2021)

In Figure 1, the process of voters casting their ballots is illustrated. The initial step involves the voter entering through the entrance and presenting an invitation to the verification officer. Subsequently, the voter receives a smart card from the generator officer and hands it to the booth attendant. The booth attendant inserts the smart card into the intelligent card reader, enabling the display of candidate choices on the screen. Voters make their candidate selections using the touch screen, confirming their choice with "Yes" for correctness or "No" if they wish to opt for an alternative

candidate. The system automatically generates physical evidence as a receipt through a thermal printer. The voter folds the receipt and deposits it in the audit box, marking their participation by dipping their fingers in ink. The election concludes, and voters exit through the designated exit.

Interestingly, a high level of voter interest is observed, particularly in rural areas. Even during socialisation in various villages within Minggir District, the polling station's committee reported heightened enthusiasm among residents, especially older people, who had not previously encountered

such a voting system. However, this heightened enthusiasm has led to a situation where recommended health protocols are not consistently adhered to by voters. Although there is a strict implementation of health protocols based on the

observations made by the research team, specific gaps in their implementation persist. The detailed observations of health protocol implementation at polling stations distributed across 15 sub-districts in Sleman are provided in Table 1.

Table 1. Observation Results of Polling Places in Sleman Regency

No.	Aspect	Observation Results
1.	Health protocol	<ul style="list-style-type: none"> The committee has supplied hand washing stations and plastic gloves to protect voters. Overcrowding at several polling stations is challenging to mitigate, especially in the initial days, as the limited space does not effectively accommodate the heightened enthusiasm of residents. Some residents remain at the polling stations to await the final results rather than immediately returning home, contributing to crowded conditions.
2.	Device	<ul style="list-style-type: none"> The majority devices function correctly; however, a few cases result in technical delays, such as smart cards that fail to become operational. In certain polling stations instances, the device necessitates refreshing when the number of voters surpasses the allocated quota.
3.	Polling station conditions	The public enthusiasm increased. However, in some polling stations, vote interest decreased due to cloudy or rainy weather conditions.

Source: Primary Data Processed

In implementing e-voting, special assistance and guidance are extended to elderly voters, those with limited understanding, and disabled individuals who may encounter difficulties in casting their votes independently. Moreover, for individuals unable to cast their votes at the regular polling station, mobile polling station units are deployed to provide an opportunity for those who cannot attend the polling stations for various reasons, as specified in the regulations.

Although the vote count is automatically recorded at each polling station, each village's final vote accumulation is still manually conducted. The decision to manually calculate the vote recapitulation from the polling station to the overall village level aligned with the community's preferences. This decision was subsequently adopted as policy by the Sleman Regency Regional Government. Consequently, the e-recap application was deactivated and integrated initially into the e-voting tool developed by BPPT. However, it's noteworthy that even with the e-recap deactivated, electronic vote counting continues using the village election e-voting technology device through the e-count application. This streamlined approach ensures that vote counting at each polling station is efficiently completed immediately after voting concludes, significantly reducing the typically lengthy vote-counting process, which often spans several hours.

The calculation of the total valid votes and votes for each candidate is carried out by the village election e-voting machine or device, offering precision and speed that

surpasses human manual counting [27][31]. This highlights the effectiveness, speed, accuracy, and relative cost-efficiency of e-voting technology tools for village elections. It's important to underscore that this method is highly efficient and cost-effective, considering that the equipment is procured once and can be utilised multiple times.

4.4 Post-E-Voting Stage

Following the completion of the electronic village head elections, the subsequent phase involves the tabulation of votes. Electronic devices automatically execute this vote-counting process at each polling station once all eligible voters have exercised their voting rights. Nonetheless, the computed results were disseminated through various platforms such as WhatsApp groups, local community forums, and committee channels. These results were then collated manually to obtain the final aggregate results. This procedure, however, extended the time required for the entire process, indicating that the overarching system still lacks a comprehensive emphasis on effectiveness and efficiency in its technological components.

The delay in the tabulation process led to lingering crowds at the polling stations, causing impatience among residents and creating new congregations. In certain villages, reports surfaced of many residents failing to wear masks and maintain physical distancing, heightening concerns regarding

the potential transmission of the virus. On the front of security, the situation remained relatively stable. Field observations conducted by the research team revealed the absence of physical altercations among supporters. As a polling station committee member underscored, "...the e-voting elections conducted across 33 sub-districts in Sleman Regency have delivered swift, accurate, and transparent results. Thus far, there have been no disturbances. Stay safe!..."

In light of the details above, it can be affirmed that the security objectives envisioned by the Regional Government for implementing e-voting in Village Head Elections in Sleman Regency have been duly met. However, on a contrasting note, enforcing health protocols remains a pending area requiring future enhancements, particularly if the pandemic persists. While e-voting and its security execution have been executed effectively, the aspect of health protocol implementation necessitates evaluation and amelioration. It is worth noting that, as of the researchers' presence in Sleman, no post-e-voting assessments have been conducted, and consequently, no evaluation report has been generated.

4.5 Discussion

This subchapter delineates the pivotal factors that underpin the successful implementation of e-voting in the Sleman Regency, with a keen focus on the four crucial aspects articulated within the conceptual framework and operationalisation of concepts in this research. These four fundamental aspects encompass: 1) Public Trust, 2) Community Participation, 3) E-Voting Technology, and 4) Compliance with Election Principles. An amalgamation of circumstances within these dimensions significantly contributes to the overall efficacy of e-voting for Village Head Elections. Each aspect will be expounded upon in the subsequent paragraphs.

4.5.1 Public Trust in Village Head Elections

An essential endeavour to gauge the e-voting system's feasibility involves examining the extent of public trust. Trust is paramount in mitigating resistance to this innovative electoral technology despite being a non-technical facet. Therefore, several nuanced dimensions warrant analysis in evaluating voters' trust regarding the e-voting system's implementation during the concurrent village head elections held in Sleman Regency in 2021. These dimensions encompass the trust vested in the regulatory framework and governance of e-voting procedures for village head elections,

alongside the trust instilled in the e-voting devices employed in the context of village head elections.

The implementation of e-voting for the 2021 simultaneous village elections in Sleman Regency is the second such endeavour following the initial introduction in 2020. A paramount concern for voters revolves around the regulations and management of e-voting, encompassing the regional government's legal foundation and technical directives. Public trust in the processes and administration of e-voting assumes paramount in ensuring its successful execution. The regional government has instituted various regulatory measures, including Regional Regulations about the Procedures for Election and Dismissal of Village Heads. These regulations have undergone multiple revisions, culminating in the most recent iteration, Regional Regulation 18/2019. This revision stipulates the legal framework for e-voting, with Article 5A explicitly addressing the electronic conduct of village head elections.

Additionally, technical regulations, such as the Regent's Decree concerning Health Protocols during Electronic Village Head Elections amidst the COVID-19 pandemic and the Regent's Regulation delineating the Procedures for Electronic Village Head Elections, have been introduced. The technical team has also formulated comprehensive guidelines, subsequently sanctioned by the Technology Assessment and Application Agency (BPPT). Public trust hinges on the efficacy of the government formulating and executing the e-voting system. Notably, the regional government embarked on a comparative study during the system's inception, drawing insights from regions that had previously implemented e-voting. This comparative analysis also garnered support from the Local House of Representatives (DPRD) members.

The meticulous preparation of legal instruments and technical guidelines is paramount in augmenting public trust. The intensity of socialisation efforts equally bears weight in determining the level of public trust. This trust trajectory evolved from initial scepticism before implementation to growing confidence following the 2020 village elections, during which incumbent candidates were defeated. However, the challenges faced in 2021 were compounded by the imperative of conducting e-voting safely amid the lingering COVID-19 pandemic. Interviews with organisers and voters revealed that the extent of socialisation remained somewhat deficient, primarily due to restrictions on physical gatherings prompted by the ongoing pandemic. A considerable portion of the populace remains relatively unfamiliar with the intricacies of the e-voting system, mainly due to its divergence from traditional election methods. In response to this issue, the local government's official YouTube channel

has disseminated several e-voting simulation videos to enhance public understanding.

Trust from voters in the e-voting system is notably reflected in the high voter turnout, which reached an impressive 80.29%. This substantial participation rate underscores the growing confidence among voters in the effectiveness and integrity of the e-voting process. Such a significant turnout indicates that voters are increasingly willing to embrace this modern approach to elections, reflecting a positive shift in trust toward the system. This level of participation also signifies that voters are not only accepting the e-voting method but actively engaging with it, contributing to its successful implementation. The increased voter turnout is a testament to the system's credibility, and the trust voters place in the rules and governance of e-voting in village head elections.

The aspect of public trust in e-voting systems also necessitates careful consideration, particularly in the context of adhering to established regulations and the effective management of e-voting procedures. Despite the precedent set by previous implementations in Sleman, 2021 witnessed renewed local government endeavours to instil confidence in voters, prompted mainly by technical complications encountered in the initial phase of e-voting. These complications encompassed issues such as machine failures, primarily stemming from an inability to manage a voter count exceeding 200, and concerns surrounding the sufficiency of voting booth heights, thereby casting shadows over the confidentiality of the electoral process. Furthermore, lingering apprehensions among voters revolved around the overall security of the e-voting system. The regional government has diligently sought to rectify these vulnerabilities within the e-voting apparatus in response to these concerns. Al Adib Burochmad, the Head of the Subdistrict Apparatus Section at the PMK Office, affirmed that an independent institution had conducted rigorous testing of these devices. These technical aspects' intricacies remain beyond the community's purview but are entrusted to competent educational institutions.

The performance of these systems and devices can generate public scepticism concerning the methodologies underpinning their functionality. Agung Endarta, the Head of the District Institutional and Apparatus Development Division of the Investment and Licensing Office, noted that pre-socialization and pre-implementation reservations had been expressed regarding the potential for e-voting to exhibit biases favouring specific candidates. Such misgivings are alleviated as the public attains a more comprehensive understanding of the e-voting system, invariably culminating in heightened trust levels. Interviews conducted with voters reveal a spectrum of viewpoints. While some segments of the

populace remain sceptical, perturbed by the spectre of potential manipulation, others place their faith in the outcomes of university-conducted tests. To bolster trust, witnesses were allowed to acquaint themselves with the application before voting, thereby solidifying their confidence in the results generated by the e-voting device. Public trust in e-voting systems for village elections exhibits variance before implementation; however, following implementation, this trust is more likely to ascend, driven by the belief that the system operates autonomously and remains insulated from the internet or other external networks, rendering manipulative interventions decidedly intricate [32][33].

4.5.2 Community Participation in E-Voting for Village Head Elections

Community participation in implementing e-voting for village elections in Sleman Regency includes various forms of active participation. In this context, the community is involved in public consultation, conveying aspirations, socialising and discussing the e-voting system. The community also helped by providing polling places and donating food and drinks to voters. Community participation in e-voting for village elections in Sleman Regency shows a high level of involvement in local democratisation. The public utilise various forms of communication, such as print, electronic and social media, to obtain information and actively contributes to various stages of e-voting implementation. It can be seen that there is a strong understanding and enthusiasm for discussing and participating in technological changes in the village head election process. Additionally, variations in participation rates between villages suggest that several factors may influence levels of community engagement, including levels of digital literacy and attitudes towards innovation in electoral systems.

The level of participation is also reflected in the voter participation rate in the village head election elections, which reached an average of 80.29%. There are variations in participation rates across villages, with Wukirharjo village having the highest participation rate (92.83%), while Maguwoharjo village has the lowest participation rate (54.55%). Villages with an independent classification tend to have lower participation than villages with a developing and advanced classification. Community participation in implementing e-voting for village elections in Sleman Regency illustrates their strong involvement in the local democratisation process. People are not just passive voters but are active in various aspects of e-voting implementation.

One striking aspect is participation in public consultation and outreach. The community was involved in intensive discussions regarding the e-voting system, seeking a more profound understanding and discussing technological changes in the village head election process. This shows that the community in Sleman Regency is aware of the importance of their role in village head elections and is trying to be more involved in the process.

The theory that supports this level of participation is the political participation theory, which states that active participation of society in the political process is the primary key to a healthy democracy. The public can provide input, raise aspirations, and influence political decision-making through participation. In the context of e-voting for the village elections, the people of Sleman Regency have carried out this role well. Community participation in providing places for voting and donating food and drinks to voters also reflects the spirit of cooperation and concern for implementing elections. The community is actively involved in providing facilities and support to run e-voting efficiently; this reflects the importance of community participation in supporting the local democratisation system.

Political sociology theory also supports this phenomenon. This theory suggests that people active in local political affairs tend to have more robust and cohesive communities. Participation in various forms, such as socialisation and practical support for village head elections, strengthens social ties between residents, encourages collaboration in advancing common interests, and reflects the practice of political participation theory and political sociology in local democratisation. Communities who actively participate in various stages of elections, from technical understanding to practical support, make a valuable contribution to maintaining the quality and health of democracy at the regional level.

4.5.3 Technology in Implementing E-Voting for Village Head Elections

The successful implementation of e-voting in Sleman Regency is closely intertwined with its technological aspects, encompassing security, reliability, completeness, and convenience [34][35]. These technological facets are instrumental in fostering public trust and enhancing voter participation.

The security aspect assumes paramount importance and is assessed through various indicators: physical, personal, software, communications, and network security. The criteria for each of these security indicators are expounded below. Physical security encompasses safeguarding e-voting

equipment for use during the election, comprising laptops, PCs, generators, and accompanying accessories. Physical security is indispensable to preventing equipment damage and preempting interference by unauthorised parties [36][37]. The regulations governing the physical security of equipment have been codified in Sleman Regent Regulation 35/2021, about the Technical Guidelines for the Procedures of Electronic Village Head Elections and the Field Pocket Book published by the Sleman PMK Office. All equipment employed in the e-voting system for the 2020 village elections has been stored at the PMK Service. At the district level, the Main Technical Personnel (TTU) undertook preparatory measures to ensure the proper functioning of the electronic village head election equipment before relinquishing it to the District Level Election Committee. Subsequently, Field Technical Personnel (TTL) at the sub-district level accompanied the electronic transportation of village-head election equipment from the Sub-district Level Election Committee to the Voting Organizing Group (KPPS) or Mobile KPPS. The oversight of e-voting device distribution from sub-districts to polling stations is the responsibility of TTL, a task executed one day before the election.

The reliability of hardware is evaluated through various indicators, encompassing the reliability of voting equipment, computer equipment, and power supply. The majority of informants attested that no hardware-related issues were encountered. All equipment adheres to minimum specifications, with no instances of the damage attributed to unsupported systems or inoperative devices. The equipment conforms to the specifications established by the BPPT standards, and the devices employed were only one year old, having been used solely during the preliminary phase of e-voting in the 2020 village elections.

The software component integral to e-voting in village elections is a collection of lightweight programs requiring minimal storage space and robust processor performance. Computers with specifications dating back five years can effectively run the e-voting program or application for village elections. Given that computer procurement occurred recently in 2019, the reliability of the equipment remains unequivocal, effectively supporting the execution of the e-voting program during the village elections. The committee's notebook to verify voters against the permanent voter list can operate for 7-8 hours, necessitating an electrical network and power charger. The availability of power chargers and electricity networks is consistently assured during research activities, consequently vouchsafing the reliability of the computing system.

The e-voting system deployed in Sleman Regency for village elections encompasses a comprehensive suite of

software features supporting e-vote, e-count, and e-recap. Village elections in Sleman Regency utilise e-vote technology to prevent issues such as misplaced ballot papers, invalid votes stemming from double voting, or votes cast outside the designated candidate area. Voters are granted the option to cast a 'blank vote' if they do not support any of the listed candidates, with this alternative appearing as a small-sized icon at the bottom right. In addition to the e-vote feature, the village elections in Sleman Regency also integrate the e-count feature. The e-voting system incorporating the e-count feature generates an electronic audit trail as a printed voter's choice receipt. These electronic outcomes are appended to the records of village election results, constituting legal evidence. Significantly, the e-count feature operates in a standalone mode, devoid of connectivity to other computers, internet networks, or intranet networks [38][39][40].

The final feature encompasses e-recap, which facilitates the electronic tabulation of results. Nevertheless, for implementing e-voting in the Village Head Election in the Sleman Regency, the e-recap feature remains deactivated as a deliberate policy choice of Sleman Regency. This decision reflects the prevailing sentiment to abstain from leveraging the internet or other networks in the recap system due to perceived vulnerabilities susceptible to hacking.

The technological design of the e-voting system in Sleman Regency is intricately crafted to mitigate the likelihood of voters casting invalid ballots, a common occurrence in traditional paper-based voting systems. With the e-voting technology, the system effectively eliminates several traditional pitfalls. In conventional paper ballots, voters sometimes mistakenly mark outside the designated candidate area or select more than one candidate, leading to invalidated votes. The e-voting system introduces intuitive design elements such as precise touchscreen interfaces and clear indicators to address this challenge. These user-friendly features guide voters through the process, ensuring that votes are cast accurately and within the designated candidate area. The interactive design of the system not only minimises the margin for error but simplifies the voting experience for the electorate.

4.5.4 Fulfillment of Election Principles in Implementing E-Voting for Village Head Elections

The implementation of e-voting for village elections in Sleman Regency strives to uphold election principles mirroring general elections, mainly focusing on two key facets: 1) the fulfilment of *langsung* (direct), *umum* (public),

bebas (free), and *rahasia* (confidential) principles (abbreviated as “luber”), and 2) adherence to the principles of *jujur* (honest) and *adil* (fair) (abbreviated as “jurdil”). While the former principles are germane to voters and organisers, the latter principles are applied to election organisers. The actualisation of these elements is delineated below:

Direct: During the village head elections across 15 sub-districts, most voters exercised their voting rights directly by physically attending polling stations and casting their votes via the dedicated booths. Nonetheless, some cases involved voters with disabilities or elderly individuals who had difficulty voting directly. In such instances, they were accompanied by relatives who assisted them in voting without compromising their votes' validity. The validation of voter eligibility is ascertained through an e-KTP (Residential Identity Card) reader, cross-referenced with the online permanent voters list (DPT). Eligible voters receive a V-token smartcard to generate an electronic ballot.

Public: To maximise citizen participation, the committee introduced a novel initiative by conducting home visits, known as the Mobile polling station, targeting residents who were registered as disabled or unwell, enabling them to cast their votes for their preferred village head. The mobile polling station assists residents facing physical challenges or residing far from their designated station. However, feedback from several Mobile polling station officers in Seyegan suggested that despite optimised implementation, certain obstacles persisted.

Free: The e-voting system must guarantee that each eligible citizen can choose without external pressure or coercion. Interviews with voters who visited polling stations spread across 15 sub-districts yielded an overall consensus that voting during the village head elections transpired devoid of coercion. Some village residents emphasised that the election process unfolded smoothly.

Confidential: E-voting is expected to ensure the secrecy of each voter's choice. During the village head election held a year prior, one of the evaluation points pertained to the scarcity of voting booths. This resulted in election officers facing challenges in discerning the candidates selected by voters. However, this condition did not necessarily incentivise technical officers (especially those stationed near the voting booths) to infringe on the secrecy of citizens' choices. The voting booths were heightened and enclosed in a proactive response to mitigate this risk in the current village head election. The committee and regional government implemented this strategic decision to safeguard the confidentiality aspect of the electronic village head election.

Honest: The fulfilment of the honesty aspect mandates a definite assurance that each voter is entitled to cast their vote

once in the election. The committee pursued the realisation of the honesty principle by establishing election Standard Operating Procedures (SOPs), disseminated verbally and through social media channels. To assess the actualisation of this factor, the research team conducted on-site observations at polling stations scattered across 33 villages. These observations revealed that voters within the booth could not cast multiple votes using a v-token smartcard, which becomes instantly invalidated after use. The system generates audit logs, verified during the vote tallying process after the election at a given polling station. The ultimate validation mechanism, essential for ensuring the honesty principle in this village head election, involves issuing a printed receipt each time a voter concludes their voting, offering a resource for manual calculations when required and requested by election participants.

Fair: Every voter partaking in an election is entitled to uniform treatment. In pursuit of justice, residents equipped with an e-KTP can legally engage in the election process at the designated polling station in their localities. Special accommodations such as braille boards and sound-based aids are provided to voters with disabilities. For situations where voters cannot physically attend polling stations, the e-voting committee has introduced the innovation of mobile polling stations. These mobile stations facilitate the collection of votes from residents facing obstacles in reaching the polling station, providing identical voting facilities. In cases where individuals do not possess an e-KTP, election organisers simplify the process by accepting proof of local residency as a valid form of identification. Several polling stations, such as the one in Condongcatur village, even offer extended timeframes to enable residents encountering administrative barriers to exercise their electoral rights [41][42].

5. Conclusion

Several critical factors that underpin the successful execution of e-voting for village elections, encompassing public trust, community engagement, technological proficiency, and adherence to electoral principles, have displayed notable improvements compared to the prior implementation of e-voting for village elections in 2020. In the case of public trust, which previously precipitated protests during the planning and exploratory phases, the successful implementation in 2020 resulted in a significant reduction in protests and increased public confidence in the system. In terms of community engagement, although it has not yet reached the stage of community control, it exhibited positive indicators with 80.29% voter turnout and 100% casting valid ballots. However, it is noteworthy that villages

with a higher degree of development tended to report lower participation rates.

The technological aspects of e-voting, spanning security measures, hardware reliability, application features, and user-friendliness, have demonstrated commendable performance. Security concerns are more closely linked to the manual data recording process rather than inherent vulnerabilities within the e-voting system. Furthermore, the compliance with electoral principles, encompassing "luber" (direct, general, free, and confidential) and "jurdil" (honest and fair), also exhibited robust performance, notwithstanding certain shortcomings associated with general and free principles, particularly about the collection of voter data.

One notable limitation of this study is the focus on a specific region, Sleman Regency, and its unique sociopolitical context. While the findings provide valuable insights into implementing e-voting in this area, they may not be directly generalisable to other regions or countries with different political, cultural, or technological landscapes. Additionally, the study primarily relies on data collected within a specific timeframe, and the rapidly evolving nature of technology may lead to changes in e-voting systems and practices.

A critical area for future research lies in assessing the feasibility and readiness for implementing e-voting systems in higher levels of elections, including at the regency/city, provincial, and national levels. While the current study has shed light on the experiences and dynamics of e-voting in village elections, scaling up this technology to more complex and larger-scale elections poses distinct challenges and considerations. Comprehensive research is required to explore the technical, logistical, legal, and societal aspects of introducing e-voting at higher levels of government. This would involve evaluating the capacity of existing infrastructure, the legal frameworks required to govern such elections, and the implications for inclusivity, security, and public trust on a broader scale. Such a study could provide valuable insights into the potential benefits and drawbacks of e-voting in diverse electoral contexts and help policymakers make informed decisions regarding its implementation in various tiers of government.

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