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Transforming Kenya's addressing landscape: use case models approach to a responsive National Addressing System

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The rapid urbanization and population growth in Kenya highlight the need to revive the National Addressing System (NAS). This study aims to examine address systems across the globe, focusing on countries known for their efficient addressing infrastructures, such as the USA, UK, Japan, Switzerland, and Germany, and compare them to the currently used system in Kenya. Additionally, we critique the format proposed by NAS and use this knowledge to build conceptual models of a responsive NAS. Beyond conducting a simple survey of best practices, our objective is to extract the underlying principles and intricacies that lead to the success of these models. Drawing on this extensive global knowledge, our research aims to propose a detailed conceptual framework specifically designed to address the unique attributes and challenges that characterize Kenya's dynamic addressing landscape. By combining global insights with local needs, this paper advocates for a NAS that goes beyond traditional boundaries, aligning with international standards while promoting adaptability and resilience in response to the ever-changing urban fabric of Kenya.

KEYWORDS

National Addressing System, adaptability, GIS, urbanization, conceptual models, addressing infrastructure

1 Introduction

1.1 Background

The addressing landscape in Kenya is going through a significant transformation due to rapid urbanization, a high population growth rate, and smart technological innovations (Echendu and Okafor, 2021). From 1960 to 2022, Kenya's population increased from 8.12 million to 54.03 million people, showing a remarkable growth of 565.4 percent over 62 years. The largest annual increase occurred in 1982 at 3.94 percent, while the smallest increase was in 2015 at 0.32 percent. During the same period, the global population rose by 162.2 percent (WorldData.info, 2024). The average age in Kenya increased by 1.28 years, going from 18.72 to 20.00 years (median value) between 2012 and 2021. About 29 percent of the population lives in larger cities, contributing to the ongoing urbanization trend that is growing at a rate of 3.7 percent annually, potentially putting more strain on the addressing system resources (WorldData.info, 2024).

In navigating this transformative phase effectively, our research embarks on a holistic exploration of global address systems. Specifically, we draw inspiration from the conceptual models exemplified by successful nations such as the USA, UK, Japan, Switzerland, and Germany (Eccles and Kuipers, 2006; Dieke et al., 2013). These nations stand as beacons of success not just for their efficiency but also due to the intricate principles that underpin their

systems (Crew and Kleindorfer, 1992; Haitas, 2020; Otsetova, 2019). Our paper aspires to go beyond a surface-level examination; it seeks to unravel the subtle nuances and adaptability factors inherent in these models, discerning how they can be strategically employed to revolutionize Kenya's addressing paradigm.

However, Kenya's geographic richness is marked by a diverse array of village and district names, some replicated across different administrative units, reflecting the nation's cultural heritage (Edney, 2009). The impact of colonial rule persists in the form of imposed place names, contributing to ambiguity within the NAS and posing a substantial challenge for its development (Jones and Brown, 2015).

The main issue stems from the inherent ambiguity introduced by numerous similar toponyms (Johnson et al., 2018). Identical or nearly identical names, often imposed without consideration for local nuances, result in confusion. For instance, a development program intended for "Kaptembwa" in Kericho County may encounter challenges reaching its target community due to another "Kaptembwa" existing in Elgeyo Marakwet (Williams, 2013). This issue is not isolated; names like "Kampala" can refer to the capital city of Uganda or a town in Zambia, further complicating location identification and hindering targeted interventions (Derungs et al., 2013).

In addition to these challenges, the Korean address system has recently transitioned from an area-based address system to a street-based address system, implemented since 2014. The street-based address system, as highlighted by the Ministry of the Interior and Security of Korea, aims at enhancing the convenience of directions, enabling rapid response to emergencies, reducing logistics costs, and strengthening national competitiveness. This shift provides valuable insights and lessons for Kenya's evolving NAS.

As development programs face the challenge of addressing confusion, marginalized communities are increasingly isolated from essential services. The aggregation of data, which is crucial for making informed policy decisions, becomes pointless when statistics are muddled, and conclusions are distorted due to duplicated names (Clark and White, 2020). The fundamental principles of an effective NAS, namely precision and clarity, are compromised, leading to inefficiency, and hindering development (RISC, 2019).

This challenge extends beyond geographical inconvenience; it impedes progress in crucial sectors such as healthcare access and financial inclusion (Taylor, 2016). As Kenya aims to set up a NAS, addressing the issues arising from unconventional place names impacted by factors such as colonial place names are crucial (Jones et al., 2022). This necessitates a multi-layered approach, including standardized identifiers, contextualization with local knowledge, and community engagement (Taylor, 2016). Kenya can pave the way for an NAS that serves as a cornerstone for equitable and sustainable development (Clark and White, 2020). To achieve the above ambitious objectives, this paper aims to contribute to the development of responsive NAS by the following research objectives.

1.2 Research questions

i. What are the fundamental principles underlying successful conceptual models for addressing systems globally?
ii. How can we create a conceptual framework that effectively incorporates best practices from successful addressing models while considering Kenya's unique addressing context?
iii. What steps can be taken to promote the adoption of an internationally compliant NAS in Kenya, considering the specific challenges posed by urbanization?
iv. How can we actively contribute to designing and implementing a NAS in Kenya that is both adaptable and scalable?

This research aspires to be a catalyst for change, merging the wisdom distilled from global successes with the pragmatic understanding of Kenya's unique context. Thus, we aim move towards a NAS that promises adaptability, efficiency, and global connectivity.

2 Literature review

2.1 Introduction

Addressing systems globally are evolving to meet 21st-century demands, with a particular emphasis on the postal and courier industry. The integration of technology and addressing infrastructure is transforming courier services, catering to real-time consumer expectations and efficiency. ISO/TC 211, specifically through the ISO 19160 project, plays a pivotal role in developing international standards to facilitate address interoperability. These standards aim to provide a common framework for representing, exchanging, and integrating address information globally.

Drawing on examples from the USA, UK, Japan, Korea, and Germany, the research integrates global best practices, emphasizing adaptability to Kenya's unique context. ISO/TC 211's efforts in the ISO 19160 project contribute to the establishment of standards that ensure interoperability across diverse addressing systems.

In South Africa, the South African Post Office (SAPO) carried out a rural addressing initiative by utilising GIS and satellite data to assign distinctive identifiers to more than 10 million rural residences. The project enhanced the accessibility and provision of postal and courier services, along with other public services including healthcare, education, and social welfare, to remote populations.

In Trinidad and Tobago, the government and the Trinidad and Tobago Postal Corporation (TTPOST) worked together to implement a new system for addressing and postal codes. This initiative included the naming and numbering of streets, the allocation of postal codes to specific geographic areas, and the establishment of a comprehensive national address database. The initiative improved the effectiveness and precision of postal and courier operations, while also enhancing the security and convenience for customers.

The Zambia Information and Communications Technology Authority (ZICTA) in Zambia created a plan for a national addressing and postcode project. The goal of this project was to construct a thorough and consistent address system, utilizing GIS and grid-based codes. The project was anticipated to enhance the efficiency and accessibility of postal and courier services, while also facilitating the growth of e-commerce, e-government, and e-health industries.

The addressing system serves to identify and pinpoint specific locations, structures, and individuals through standardized codes and nomenclature. It plays a vital role in facilitating numerous functions including public service provision, e-commerce transactions, emergency management, social engagements, and regional cohesion. Despite its importance, Kenya has grappled with the absence of a unified and consistent addressing framework for an extended period,

leading to issues like inefficiencies, ambiguity, and marginalized inclusion.

The landscape of addressing in Kenya is undergoing a paradigm shift, driven by the relentless forces of rapid urbanization, technological advancement, and burgeoning population growth. To navigate this transformative phase effectively, our research embarks on a holistic exploration of global address systems, specifically drawing inspiration from the conceptual models exemplified by the USA, UK, Japan, Switzerland, and Germany. These nations stand as beacons of success, not merely due to their efficiency but owing to the intricate principles that underpin their systems. The ambition of this paper extends beyond a surface-level examination; it aspires to unravel the subtle nuances and adaptability factors inherent in these models, discerning how they can be strategically employed to revolutionize Kenya's addressing paradigm.

Addressing systems support the efficient and dependable transportation of postal and courier services worldwide. They facilitate the identification and precise location of clients, senders, and recipients, as well as the monitoring and tracing of mail items and parcels. Postal and courier businesses would encounter challenges in organizing, directing, and distributing their goods and services without addressing systems, leading to elevated expenses, delays, and mistakes (Brussel et al., 2019).

Nevertheless, several developing nations like Kenya lack sufficient and uniform addressing systems, particularly in emerging areas where address infrastructure faces difficulties due to urbanization, migration, and informal settlements. As per the Universal Postal Union (UPU), approximately 50% of the global population has access to a recognized address.[1] Consequently, a significant number of individuals are deprived of the advantages provided by postal and courier services, including e-commerce, financial accessibility, social security, and civic engagement.

To fill this need, the Universal Postal Union (UPU) and other relevant parties have been collaborating to create and enhance addressing systems in different nations, employing cutting-edge technologies and solutions. As an illustration, the UPU has initiated the "Addressing the World" campaign, with the objective of offering technical support and direction to member nations in developing and executing national addressing and postcode initiatives. Several solutions encompass geographic information systems (GIS), grid-based codes, and digital addressing platforms (Muketha, 2019). These solutions can assist postal and courier operators in improving their service quality, expanding their coverage, and increasing their competitiveness. Additionally, they can also simplify cross-border trade and promote cooperation.

Moreover, the impact of addressing systems on the postal and courier industry is profound. Technology and efficient addressing contribute to real-time tracking, ensuring customer satisfaction and enhancing overall service efficiency. The proposed Kenya's addressing models can benefit from these global practices, optimized further by adherence to ISO/TC 211 standards.

Addressing systems play a critical role in supporting small businesses, especially during challenging times like the COVID-19 pandemic. The importance of mobile phones and digital connectivity for small businesses is highlighted, emphasizing the need for adaptable and efficient addressing systems. ISO 19160 standards contribute to the resilience and compatibility of addressing systems, ensuring they remain effective in diverse economic landscapes.

As Kenya envisions a robust National Addressing System (NAS), the concept of a unified data market in Africa becomes paramount. Addressing systems form the foundational infrastructure for achieving this goal, enabling accurate data location, and contributing to the broader vision of a connected and data-driven Africa. ISO/TC 211's standards, particularly ISO 19160, provide the necessary guidelines for harmonizing addressing data on an international scale.

Research on Korea's address system has transitioned from the area-based to the street-based address system, prompting a comprehensive examination of street-based addressing. Notably, efforts have been directed towards enhancing the standardization of detailed addresses within Korea's street-based system (Choi et al., 2018). Additionally, investigations into geocoding methods and their limitations in relation to the address system have been conducted, with a focus on addressing existing constraints in area-based geocoding (Lee, 2009; Gatrell, 1989). The shift to street-based geocoding within the Korean system has spurred research aimed at evaluating and improving location accuracy (Roh, 2009). Furthermore, advancements in geocoding and reverse geocoding techniques have been achieved for 3-D addresses, leveraging the Korean street-based addressing system (Seok and Lee, 2016).

Training initiatives, especially those led by organizations like AFRALTI, are instrumental in the successful implementation of NAS. The phases of NAS implementation, including People, Technology, Operation, and User stages, need careful consideration to ensure a seamless and effective transition. ISO/TC 211's standards provide a solid foundation for training programs, guiding nations like Kenya through each phase of NAS development (Kalevi et al., 2010).

Future trends in postal and courier service delivery emphasize the shift toward a digital customer experience. Aligning services with the digital space and meeting the expectations of digital natives is crucial for Kenya's NAS to remain relevant and adaptive. ISO/TC 211 standards contribute to the forward-looking nature of addressing systems, ensuring they evolve alongside digital advancements.

For example, as Korea undergoes a transition from area-based to street-based addressing, the research landscape has evolved to address the challenges and opportunities presented by this shift. Efforts have been made to enhance the standardization of detailed addresses within the street-based system, ensuring precision and clarity (Choi et al., 2018). Concurrently, investigations into geocoding methods have sought to overcome limitations associated with the address system, with a particular emphasis on refining area-based geocoding techniques (Lee, 2009). The emergence of street-based geocoding has prompted research initiatives to assess and enhance location accuracy, a critical aspect in the evolving addressing paradigm (Roh, 2009). Moreover, developments in geocoding and reverse geocoding techniques for 3-D addresses signify a forward-looking approach to address system advancements in Korea (Seok and Lee, 2016).

Kenya's geographic landscape, marked by a variety of village and district names, introduces challenges to the current addressing system. The legacy of colonial rule and similar toponyms create ambiguity within the NAS, impacting efficiency, transparency, and trust. Addressing these challenges is imperative for the success of Kenya's

1 Addressing—Universal Postal Union. https://www.upu.int/en/Universal-Postal-Union/Activities/Physical-Services/Addressing.

NAS. ISO/TC 211 standards provide a benchmark for addressing these issues, ensuring Kenya's NAS aligns with global best practices.

Proposed addressing models for Kenya draw inspiration from global exemplars, presenting strengths such as scalability, ease of implementation, and adaptability to Kenya's unique geography. These models aim to address the current challenges and set the stage for a responsive and effective NAS, adhering to ISO/TC 211 standards for international interoperability.

A comparative analysis of addressing systems globally, evaluating their applicability to Kenya, is crucial. Understanding the strengths and weaknesses of different models informs the development of Kenya's NAS, ensuring it aligns with international best practices while addressing local nuances. ISO/TC 211 standards provide a common ground for evaluation, enabling nations to assess and adopt addressing systems that harmonize with global standards.

2.2 Summary of the four phases of NAS proposed in the NAS policy

The NAS implementation has been set in four across four distinct phases, Phase 1: People Stage, Phase2: Technology Stage, Phase 3: Operation Stage, and Phase 4: User Stage.

The National Addressing System (NAS) implementation is structured across four distinct phases, representing a holistic approach to address various facets of the initiative.

In the initial phase, often referred to as the People Stage, the focus lies on laying the groundwork for the NAS project. This involves project definition, preparation, and the establishment of a National Project Management framework. Activities within this phase encompass stakeholder identification, the creation of a National Communication Numbering and Addressing Plan (NCNAP), and the formulation of addressing laws, standards, guidelines, and financial models.

The subsequent phase, known as the Technology Stage, is instrumental in identifying and developing the necessary technology, digital tools, and staff skills required for NAS implementation. Pilot projects are conducted during this stage to test and refine technology and tools, ensuring their readiness for broader application.

Building upon the outcomes of the earlier phases, the Operation Stage marks the actual implementation of the NAS. This involves putting into action the strategies, technologies, and tools developed in the preceding stages, setting the stage for the operationalization of the addressing system.

The final phase, termed the User Stage, focuses on managing the user ecosystem within the established NAS infrastructure. This includes addressing user concerns, ensuring smooth interactions, and optimizing overall user experiences with the implemented addressing system.

In the implementation of the National Addressing System (NAS), careful attention to managing all four phases is crucial. The emphasis is especially placed on avoiding oversight of Phase 1 and Phase 2, as neglecting these foundational stages frequently results in project failures. This underscores the essential need for a thorough and sequential approach to NAS implementation to ensure the successful achievement of its intended objectives.

The future trajectory of postal and courier service delivery hinges on a digital customer experience. Digital natives express a preference for digital space, emphasizing the intrinsic link between national development, commerce, and the digital environment. Postal and courier services are positioned as foundational elements in this digital future, underlining the need for alignment with the digital space to ensure continued relevance and excellence.

This literature review amalgamates insights from various dimensions of addressing system evolution, setting the stage for a nuanced understanding of the multifaceted impact of addressing systems on economic growth and digital innovation.

2.3 Current addressing system in Kenya

Kenya's current addressing system involves a combination of the recipient's name, street address, city or town, and P.O. Box for mail delivery, especially in urban areas (Table 1). While it has served its purpose, challenges arise due to the rapidly developing new cities and towns and increasing populations.

The proposed address system for Kenya, based on the criteria from the National Addressing Framework, is designed to reflect the nation's rich history, culture, natural heritage, and values through a structured approach to naming streets, roads, and public buildings. This system incorporates names from historical figures and events, African flora and fauna, geographical features, cultural artifacts, and heroes both past and present. While this framework has several strengths, it also presents certain limitations when compared to some of the world's best address systems.

One of the primary strengths of this address system lies in its cultural and historical relevance. By using names that resonate with Kenyan heritage, it fosters a sense of national pride and community identity. The inclusion of names in Swahili and local languages enhances cultural preservation and recognition of Kenya's linguistic diversity. Additionally, by honoring freedom fighters, modern heroes, and significant cultural elements, the system promotes national values and ethos.

Despite these strengths, the proposed system does not comprehensively address certain practical aspects that are critical in modern addressing frameworks, particularly those used in developed countries. For instance, the system does not explicitly address the unique challenges of addressing in rural and urban developments. Urban areas often require a more granular and systematic approach to accommodate high-density living, while rural areas need adaptable solutions for scattered and remote locations. Successful systems, such as the UK's postcode system or Japan's block numbering, offer precise and scalable solutions suitable for both urban and rural contexts.

TABLE 1 Kenya's current system includes recipient names, street addresses, cities or towns, and P.O. Boxes, which face challenges with rapid urban development and population growth.

Urban address example	Rural address example
Innocent Ngare	Isaac Kipkemoi
123 Nakuru Road	456 Farmhouse
Kaptembwa	Kapkatet Village
Nakuru	Kericho
P.O. Box 56789-00100	KENYA
KENYA	

Another limitation is the lack of integration with modern technological solutions that facilitate navigation and service delivery. Systems like What3words and Google's Plus Codes provide geocoding solutions that allow for precise location identification using simple alphanumeric codes or three-word combinations, enhancing usability in digital platforms and GPS systems. The proposed Kenyan system lacks this level of technological integration, which could hinder its effectiveness in an increasingly digital world.

Moreover, world-class address systems prioritize standardization and consistency to ensure clarity and reduce ambiguity. The proposed Kenyan system, while culturally rich, may lead to inconsistencies due to the subjective nature of selecting names based on cultural and historical significance. This can complicate data management and logistical operations, particularly for postal services and emergency responders.

Additionally, as urbanization increases and new developments arise, the address system must be scalable to accommodate growth. The proposed system may face challenges in maintaining consistency and relevance as new streets and buildings require naming. A more systematic approach, such as grid-based or numerical systems used in cities like New York or Tokyo, could offer better scalability and ease of expansion.

While the proposed address system for Kenya has commendable intentions and cultural significance, it falls short in addressing practical considerations crucial for modern address systems. By learning from the strengths of globally recognized systems, such as incorporating geocoding technology, ensuring standardization, and accommodating both urban and rural areas, Kenya can develop a more robust and effective addressing framework. Balancing cultural heritage with practical functionality will be key to creating an address system that not only honors the past but also meets the needs of the present and future.

3 Methodology

3.1 Case study analysis

To conduct our case study analysis, we took a systematic approach to selecting countries. We focused on reviewing the addressing systems of five best practice countries, as recognized by the Universal Postal Union (UPU) 2019 report. These countries are the USA, UK, Japan, Korea, and Germany (Postleitzahl—PLZ). We chose these countries because they have well-established addressing systems and are known for their efficient mail delivery. Additionally, we included Kenya's NASK Concept to compare it with the addressing system of a developing country as well as testing our recommendations against the findings from a pre-existing study conducted in Kiambu, Thika, and Machakos towns in Kenya. This study, part of a World Bank—Kenya Government program, assessed the effectiveness of a GIS-based physical addressing system (Muketha, 2019). This selection allowed us to understand the underlying principles of these countries' addressing systems and identify the key factors contributing to their success.

The NASK project on the other hand reviewed the addressing systems of the USA, UK, Japan, Korea, and Germany, identified by the UPU as exemplifying best practices in addressing standards. These countries were chosen for their advanced systems and innovative approaches to address challenges like those faced by Kenya in developing its addressing system.

The methodology utilized the R wordcloud package in R for creating word clouds from PDFs. The research method involved a systematic literature review following the methodologies outlined by Junior and Godinho Filho (2010), de Camargo Fiorini and Jabbour (2017), de Camargo Fiorini et al. (2018) and Mariano et al. (2015). Articles were searched for in the database using specific keywords. The files retrieved from the search were then imported into R for analysis and mapping of the results. The list of articles was narrowed down by reviewing titles, abstracts, and keywords. A classification system was developed, and inclusion and exclusion criteria were defined. Three separate searches were conducted in the Scopus database (using article titles, abstracts, and keywords) and the Web of Science database (searching all fields) up until February 2023. The following search strings were used: "Structured Addressing" and "Addressing"; "Digital Integration" and "Addressing"; "Standardization" and "Addressing." The search did not specify the type of paper, but this was determined after the search based on the results and the inclusion and exclusion criteria. Articles published after February 2023 were not included.

The two search engines were used to enhance the comparison and verification process. The search files from these databases were imported into R, a software tool that generated word cloud maps and lists of keywords. The analysis of these maps and lists is presented in Figure 1 and Table 2. R is specifically designed for creating and visualizing word clouds based on uploaded PDF files.

3.2 Gap analysis

In this section, we systematically identify gaps and challenges within Kenya's current NAS using established models and scientific methods, incorporating insights from the literature review and case study analysis. Additionally, we evaluate the impact of toponymic ambiguity, colonial place names, and other pertinent challenges on the efficiency of Kenya's addressing paradigm.

To identify existing gaps and challenges in Kenya's NAS, the researchers employed Albert S. Humphrey's 5 Whys technique of SWOT analysis on the respective countries policies and published material. The study identified several gaps and challenges within Kenya's NAS. These encompass inconsistencies in address formats, inadequate coverage in rural and informal settlement areas, and difficulties in accessing accurate address information. Furthermore, issues related to toponymic ambiguity and colonial place names exacerbate the challenges, leading to confusion and inefficiencies in the addressing system.

The presence of ambiguous place names and colonial toponyms significantly hinders the efficiency of Kenya's addressing system. These challenges lead to errors in verifying addresses, delay the delivery of postal services, and impede emergency response efforts. Additionally, the lack of standardized address formats further complicates the situation, making it difficult for individuals and businesses to effectively use the addressing system.

To address these issues, we draw insights from established models and scientific methods, focusing on the transition of South Korea's

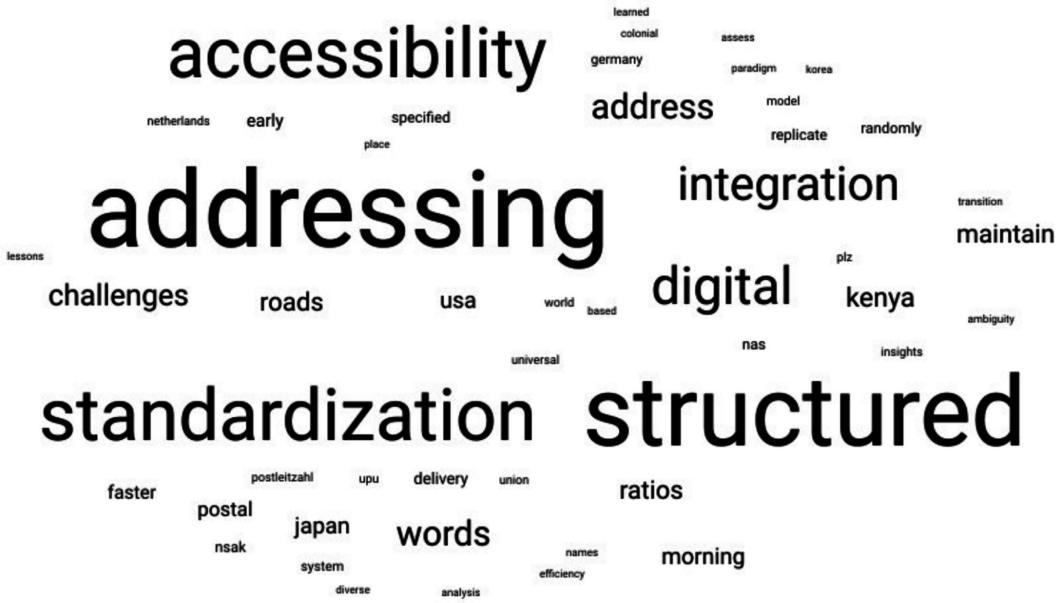

FIGURE 1
Word Cloud based on words that form theses for best practices in addressing systems in the 5 countries.

TABLE 2 Examples of residential, commercial, and public building addresses in Kenya.

Residential address	Commercial address	Public building address
Building Number: 23	Building Number: 15	Building Name: Wangari Maathai Convention Center
Street/Road Name: Simba Street	Street/Road Name: Uhuru Road	Street/Road Name: Tom Mboya Lane
Neighborhood: Nyayo Estate	Neighborhood: Central Business District (CBD)	Neighborhood: Upper Hill
Town/City: Nairobi	Town/City: Mombasa	Town/City: Nairobi
Postal Code: 00100	Postal Code: 80100	Postal Code: 00100
Country: Kenya	Country: Kenya	Country: Kenya

This table provides examples of residential, commercial, and public building addresses, including building numbers or names, street/road names, neighborhoods, towns/cities, postal codes, and the country.

address system from area-based to street-based. By analyzing the objectives, challenges, and lessons learned from this transition, we evaluate the applicability of these insights to Kenya's National Addressing System (NAS). Specifically, we aim to address challenges related to rapid urbanization and diverse place names in Kenya and explore how the lessons learned from Korea can inform improvements in Kenya's addressing system.

Based on the systematic gap analysis, we propose a responsive model for Kenya's National Addressing System (NAS) that prioritizes scalability, adaptability, and ease of implementation in various geographic and cultural contexts in Kenya. By incorporating standardization, digital integration, and stakeholder engagement, our proposed model aims to address identified gaps and challenges, ultimately enhancing the efficiency and effectiveness of Kenya's addressing paradigm.

To assess the addressing systems in the USA, UK, Japan, Korea, and Germany, we conducted a comparative analysis along with the concept of the National Addressing System of Kenya (NASK). It's important to note that stakeholders, including County Government officials, were introduced to the concept of NASK during a second buy-in workshop held in October 2016.

4 Results

4.1 Overview

The outcomes of the NASK project, focusing on the review and refinement of addressing systems in five best practice countries recognized by the Universal Postal Union (UPU): the USA, UK, Japan, Korea, and Germany (Postleitzahl—PLZ), alongside Kenya's NASK Concept. Through this review, we identified five key themes: Structured Addressing, Standardization, Digital Integration, Accessibility, and Challenges.

The frequency of the words from the results is given in Table 2. The analysis presented in Table 3 identified four preferred system-based characteristics: Structured Addressing, Standardization, Digital Integration, and Accessibility. These characteristics are prevalent in the addressing systems of the USA, UK, Japan, Korea, and Germany, which have been recognized by the Universal Postal Union (UPU) for their efficiency.

The structured addressing format employed in these countries offers a well-defined and consistent framework, which enhances operational efficiency in service delivery and navigation. By providing clear and systematic address components, structured addressing

TABLE 3 Frequency of words from analysis.

Word	Frequency
Address	84
Structured Addressing	68
Kenya	12
USA	32
UK	32
Digital Integration	28
Standardization	44
Accessibility	36
NAS	16

This table presents the frequency of key terms used in the study of addressing systems, reflecting the emphasis on various concepts and regions. The highlighted words show preferred system-based characteristics.

ensures that mail and services reach their intended destinations promptly and accurately (Laseinde and Mpofu, 2017).

Standardization plays a crucial role in guaranteeing uniformity and precision in addressing systems. The implementation of standardized formats leads to a decrease in errors and an overall improvement in address verification processes. This consistency is vital for both national and international mail delivery, as it simplifies the address validation process and reduces the likelihood of mis deliveries (Coetzee et al., 2011; Cooper and Coetzee, 2008).

Digital Integration is another key characteristic, with the incorporation of digital technologies such as GPS and online mapping services. This integration enhances address accuracy and accessibility, particularly in remote locations where traditional addressing methods might be inadequate. Digital tools enable real-time updates and easy access to address information, improving overall service delivery and user experience (Gann et al., 2011; Curl et al., 2011).

Finally, Accessibility ensures comprehensive address coverage and caters to the requirements of diverse populations and regions. Effective addressing systems must be inclusive, providing reliable address information for urban, suburban, and rural areas alike. This inclusivity is essential for equitable access to services and infrastructure, promoting social and economic development across different regions (Rahman, 2019).

4.2 Challenges

Kenya faces significant challenges in its addressing systems, particularly in informal settlements due to the high and growing population. As of 2024, approximately 31.2% of Kenyans live in urban areas, with about 60% of this urban population residing in informal settlements (UN-Habitat, 2023). In rural areas, the addressing system is often less detailed. By 2030, it is projected that 50% of Kenyans will live in urban areas (World Bank, 2016), with a significant portion still residing in informal settlements unless substantial improvements are made.

These challenges are further exacerbated by factors such as toponymic ambiguity, colonial place names, and rural address coverage that were identified and resolved in the countries' systems.

The NASK project has accomplished significant milestones, including the Universal Postal Union (UPU) Certification of Kenya on S42 Addressing standards in April 2017. In September 2017, draft NASK standards and guiding frameworks were developed, providing the groundwork for the implementation of a standardized and efficient addressing system in Kenya.

Stakeholders, such as the Council of Governors, Independent Electoral and Boundaries Commission (IEBC), and the Postal Corporation of Kenya, actively participated in the NASK initiative as well as those stakeholders that were included in the study by Muketha (2019), which included social, cultural, and political stakeholders. Their involvement and support are crucial for the successful implementation and adoption of the NASK standards throughout Kenya.

4.3 Gap analysis results

The gap analysis results presented in Table 4 are based on the outcomes of the NASK project, which focused on the review and refinement of addressing systems in five best practice countries recognized by the Universal Postal Union (UPU): the USA, UK, Japan, Korea, and Germany (Postleitzahl—PLZ), alongside Kenya's NASK Concept. Through this review, we identified five key themes: Structured Addressing, Standardization, Digital Integration, Accessibility, and Challenges. The most important themes, as illustrated in Figure 1, are Structured Addressing, Standardization, Digital Integration, and Accessibility Challenges. The gap analysis results are presented in Table 4.

5 Proposed solutions

5.1 Responsive framework

Drawing inspiration from the best practices identified, propose a responsive framework for Kenya's National Addressing System. Consider the establishment of an immutable and secure NAS, as well as collaboration frameworks between national and county agencies.

5.2 Identified gaps in current addressing system in Kenya

Kenya's current addressing system involves a combination of the recipient's name, street address, city or town, and P.O. Box for mail delivery, especially in urban areas. While it has served its purpose, challenges arise due to the rapidly developing new cities and towns and increasing populations (Table 5).

5.3 Proposed hybrid models for address systems

Drawing inspiration from existing addressing systems worldwide, we propose a series of hybrid models to improve the accuracy and comprehensiveness of address components, especially in regions with complex addressing requirements. For instance,

TABLE 4 Gap Analysis Results for the Kenya's draft concept against the addressing systems in five best practice countries recognized by the Universal Postal Union (UPU): the USA, UK, Japan, Korea, and Germany (Postleitzahl—PLZ).

	USA	UK	Japan	Korea	Germany [The post code (Postleitzahl—PLZ)]	Kenya (NASK Concept)
Structured Addressing	Addresses typically consist of a street name, house number, city, state, and ZIP code. Accessed February 2024—https://worldpostalcode.com/united-states/	Addresses include a house number or name, street name, locality, town or city, postal code, and country. Accessed February 2024—https://ideal-postcodes.co.uk/guides/good-addressing-guidelines	Addresses may include block numbers, building names, and district names, contributing to complexity. Accessed February 2024—https://www.realestate-tokyo.com/living-in-tokyo/apan-info/apanese-address/	Addresses consist of building numbers, street names, neighborhoods, and postal codes. https://expatguidekorea.com/article/understanding-south-korean-addresses.html	Address components typically include street name, house number, postal code, and city. https://allaboutberlin.com/guides/addressing-a-letter-in-germany	Developing a structured format for addresses to improve consistency and ease of navigation, accommodating Kenya's diverse geographic and cultural settings
Standardization	Highly standardized system with strict guidelines for address formatting and postal code allocation	Well-established system of address standardization managed by the Royal Mail, ensuring consistency and accuracy	Precise address formats contribute to high levels of accuracy and efficiency	Standardized addressing system managed by Swiss Post, ensuring consistency across the country (Wang et al., 2004)	Standardized addressing system managed by Deutsche Post, ensuring uniformity and reliability (Hickey, 2003)	Aim to introduce standardized addressing system to enhance efficiency in service delivery and emergency response, with stakeholder engagement to ensure adherence to standards
Digital Integration	Widespread integration of digital technologies such as GPS coordinates and online mapping services (Esekhaigbe et al., 2020)	Embraced digital technologies to improve address verification and delivery logistics (Gatrell, 1989)	Implementation of innovative digital solutions like the "Three-Dimensional Digital Map" for address accuracy and navigation	Leveraged technology extensively with advanced mapping and navigation services widely available (Chang et al., 2005)	Embraced digitalization with online address verification services and digital mapping platforms	Focus on leveraging digital technologies such as mobile mapping and GIS to enhance address accuracy and accessibility, especially in informal settlements
Accessibility	Comprehensive coverage, but challenges may exist in rural areas	Extensive address coverage, with accessibility challenges in remote regions	Accessible addressing system supported by precise formats and advanced mapping technologies	Efficient addressing system accessible nationwide (Jung et al., 2006)	Comprehensive coverage with accessibility enhanced by digitalization	Focus on ensuring address accessibility across urban and rural areas through stakeholder engagement and digital solutions
Challenges	Challenges include inaccuracies in rural addresses and inconsistencies in address databases		Despite accuracy, challenges may exist in complex address formats			Addressing challenges include informal settlements, lack of infrastructure, and geographic diversity requiring tailored solutions

TABLE 5 Addressing systems in Kenya.

Urban address example with gaps	Rural address example with gaps	Informal settlement (slum) with gaps
John Njoroge 123 Nakuru Road Kaptembwa Nakuru, P.O. Box 56,789–00100 KENYA	Mary Chepkoech 456 Farmhouse Kapkatet Village Kericho KENYA	Amina Mwangi Plot 789, Block 12 Kibera Nairobi KENYA
Gaps	Gaps	Gaps
• Lack of a standardized format. • Limited use of specific identifiers, such as a postal code. • Inconsistency in address components.	• Absence of detailed components like street names. • Lack of a postal code or other location-specific identifiers. • Limited information for precise mail delivery.	• Lack of formal street names or numbers. • Absence of postal codes or other standardized location identifiers. • Inconsistent or informal address components. • Limited information for precise mail delivery.

The table highlights challenges for each setting, i.e., urban, rural and informal settlements.

incorporating Japan's block and plot system or South Africa's sector and house number system can provide a clear and organized structure. By integrating these suggested hybrid models into Kenya's National Addressing System, there is potential for the system to accommodate the complexities of villages with identical names in different counties. This, in turn, could ensure more precise location identification and efficient mail delivery. The solutions for urban, rural, and informal settlements are detailed in the nine models proposed below.

5.3.1 Proposed hybrid model 1—UK and Kenya

Taking inspiration from the UK's well-developed addressing system, this hybrid model introduces a more comprehensive set of address components. These include the recipient's name, street address, locality, county, and postal code. By incorporating elements from the UK system, the aim of this model is to improve the identification of locations and ensure greater accuracy in mail delivery within Kenya (see Table 5).

5.3.2 Proposed hybrid model 2—USA county integration

Expanding on the USA's practice of including counties in addresses, this model seeks to differentiate villages in various counties by including the county name in the address. This adopted approach from the USA has the potential to enhance the precision of locations and enable more precise delivery of mail (refer to Table 4).

5.3.3 Proposed hybrid model 3—Germany and Kenya

This hybrid model integrates features from Germany's structured addressing system, which includes the recipient's name, street address, postal code, and city. By combining elements from Germany with Kenya's existing framework, this model aims to create a comprehensive and efficient addressing system. Additionally, it proposes the establishment of satellite postal offices for distributing mail to specific streets (Table 4).

5.3.4 Proposed hybrid model 4—USA and Kenya

In this hybrid model, we propose incorporating elements from the addressing system used in the USA. We will leverage the two-part system, consisting of the city or town name and state, to increase accuracy. This model retains key components of Kenya's current system while improving precision, especially when identifying locations with similar names (Table 5).

5.3.5 Proposed hybrid model 5—USA state integration

Building upon the notion of differentiating locations based on states, this model encompasses both county and state names to achieve more precise identification. By incorporating elements from the state-based addressing system of the United States, this model provides a solution to the intricacies posed by villages with similar names in various counties (see Tables 5, 6).

6 Proposed implementation

We present an implementation plan to address the unique challenges posed by villages with similar names in different counties, we propose models inspired by successful applications for example in the USA, where cities with the same name are distinguished by the state.

6.1 Criteria for an address assignment scheme for Kenya

To develop an appropriate address assignment scheme for Kenya, the following criteria are proposed, based on the successful practices observed in Botswana.

6.1.1 Unified place and area names

To ensure smooth service delivery, it is essential to have a uniform set of place and area names throughout the country in the address assignment scheme. This will guarantee consistency and accuracy among various stakeholders, such as Kenya Post, government agencies, and others. We can learn from South Africa's experience, where the use of multiple names in an address has caused confusion. Thus, it is imperative to prioritize the adoption of a common nomenclature.

6.1.1.1 Example

4 River Street, East Leigh, 0181, Kenya (postal address)
4 River Street, East Leigh, Nairobi, Kenya (residential address)

TABLE 6 Example of address models based on integration of best practice models and their strengths on the proposed models for Kenya.

Model	Address example	Strengths
Proposed Hybrid Model 1—UK and Kenya	Alice Wanjiku 567 Greenfield Lane Nairobi, Kiambu KE 00200 KENYA	• Incorporates the detailed structure of the UK's addressing system. • Blends seamlessly with Kenya's existing addressing practices.
Proposed Hybrid Model 2—USA County Integration	John Kiprop 123 Rift Valley Road Kapkatet Village, Elgeyo Marakwet County KENYA	• Effectively distinguishes villages with similar names in different counties. • Aligns with the USA's approach of integrating county names.
Proposed Hybrid Model 3—Germany and Kenya	David Njoroge 456 Mawingu Straße 12345 Nairobi KENYA	• Adopts the precision of Germany's structured system. • Retains elements of Kenya's current system for continuity.
Proposed Hybrid Model 4—USA and Kenya	Jane Kamau 789 Serene Avenue Nairobi, KE 00100 KENYA	• Combines the familiarity of Kenya's current system with the accuracy of the USA's two-part addressing. • Maintains adaptability to local practices.
Proposed Hybrid Model 5—USA State Integration	John Kiprop 123 Rift Valley Road Kapkatet Village, Elgeyo Marakwet County KENYA	• Provides a granular level of detail with county and state integration. • Mirrors the USA's practice of distinguishing cities with the same name by state.
Proposed Hybrid Model 6—USA County Integration	John Kiprop 123 Rift Valley Road Kapkatet Village, Elgeyo Marakwet County KENYA	• Effectively distinguishes villages with similar names in different counties. • Aligns with the USA's approach of integrating county names.
Proposed Hybrid Model 7—USA County Integration	John Kiprop 123 Rift Valley Road Kapkatet Village, Elgeyo Marakwet County KENYA	• Effectively distinguishes villages with similar names in different counties. • Aligns with the USA's approach of integrating county names.
Proposed Hybrid Model 8—Japan and Kenya	Amina Mwangi Plot 789, Block 12 Kibera, Nairobi KENYA	• Incorporates Japan's block and plot system, which is effective in densely populated areas. • Maintains local identifiers familiar to residents, ensuring ease of use.
Proposed Hybrid Model 9—South Africa and Kenya	Peter Otieno House 45, Sector 3 Mathare, Nairobi KENYA	• Uses South Africa's sector and house number system, which provides a clear and organized structure. • Adapts to Kenya's informal settlement layout, making it practical for local implementation.

6.1.2 Address types for different areas

Tailoring address types to the varied physical layouts of urban, rural, informal and farm areas is essential. This accommodates distinct infrastructural characteristics and data structuring needs for effective address assignment. While urban areas benefit from existing infrastructure, ongoing efforts, like the LAPCAS project, are addressing the identification and surveying challenges in villages and rural areas. The heterogeneous data formats from different service providers surveying farms emphasize the need for standardization.

6.1.3 Address numbering assignment principles

The address assignment scheme must anticipate future expansions and changes in the numbering system. Address retirement or renaming, often dictated by increasing household numbers, is a common occurrence in villages and rural areas. The non-sequential nature of numbering, dependent on the house construction timeline, necessitates a flexible system. Geo-coding from topographic imagery data ensures accurate house numbering, especially during relocations due to road constructions, while also aiding in maintaining precise coordinates in a master database.

6.1.4 Integration of referencing systems

Seamless integration of various referencing systems, including physical addresses, postal addresses, cadastre (land parcel identifiers), and village or rural addresses, is critical. Learning from Botswana's benchmarking experiences in Sweden and South Africa, Kenya should consider international standards, such as the UPU S42 standard. This standard dictates the structure of addresses on mail items, emphasizing factors like postcode, post office or area name, and delivery point.

6.1.5 Single authoritative master database

Maintaining a singular authoritative master database covering the entire country is paramount. Regular updates to reflect the most recent addresses minimize duplication, eliminate redundancies, and enhance overall address accuracy. This centralized database significantly streamlines efforts and resources and prevents inconsistencies in address data.

Adopting and customizing these criteria to Kenya's unique context ensures the development of an effective address assignment scheme that aligns with international standards and best practices.

7 Benefits and expected outcomes

The proposed National Addressing System (NAS) is set to provide numerous benefits that will positively impact various aspects of Kenyan society, both urban and rural. For example, the NAS is expected to enhance postal delivery efficiency in metropolitan areas, thereby improving the accuracy and timeliness of correspondence. By introducing a consistent and organized addressing framework, it will support better management of infrastructure and public services, making urban planning more effective. Additionally, the NAS will improve government service delivery by enabling precise location identification.

The NAS is also anticipated to significantly enhance ICT transactional traceability, which will support the growth of e-commerce. Reliable addressing will ensure the accurate and timely delivery of goods, fostering economic activity and increasing trust in digital transactions. As confidence in ICT services grows, it is likely to further accelerate the expansion of digital markets and online shopping.

Rural areas will benefit substantially from the NAS as well. By addressing challenges related to rural address coverage, the system will improve access to essential services such as healthcare, education, and emergency response. This enhanced accessibility will support rural livelihoods through more efficient resource allocation and better service delivery. Additionally, improved market access and logistical efficiency will contribute to the economic development of rural areas, benefiting producers and entrepreneurs.

The proposed NAS is expected to bring economic and social benefits, for instance, the NAS is expected to formalize the mainstream economy and add to the nation's digital transformation ecosystem (Ministry of ICT, Innovation and Youth Affairs, 2023). By providing a reliable addressing system, the NAS will facilitate the growth of e-commerce and small and medium enterprises (SMEs), which are crucial for economic development. It is anticipated that the NAS will spur economic growth by improving the efficiency of goods and services delivery, reducing costs for businesses, government, and civil society (Kenya Engineer, 2023; Ngare et al., 2018).

Studies have shown that proper addressing systems can significantly streamline business operations. For example, in South Africa, the implementation of a standardized addressing system has improved the efficiency of postal services and facilitated better service delivery in both urban and rural areas. Between 2011 and 2022, access to electricity increased by 9.6 percentage points to 94.3%, and weekly refuse removal increased by five percentage points to 67.1% (Statistics South Africa, 2022). Similarly, in India, the introduction of the Postal Index Number (PIN) system has enhanced the accuracy and speed of mail delivery, supporting the growth of e-commerce and reducing logistical costs. The implementation of the DIGIPIN system is expected to further boost logistics efficiency and public service delivery (Kumar and Singh, 2019).

In Germany, the structured addressing system has contributed to efficient postal services and logistics. The German postal service, Deutsche Post, reported a 95% on-time delivery rate for domestic mail, highlighting the effectiveness of their addressing system (Deutsche Post, 2023). In the United Kingdom, the use of the postcode system has significantly improved service delivery. The Royal Mail reported that 93% of first-class mail was delivered the next working day, demonstrating the efficiency of their addressing system (Royal Mail, 2023).

Socially, the NAS will enhance the quality of life by improving access to essential services. For example, precise location identification will enable better emergency response times, potentially saving lives. Improved access to healthcare and education in rural areas will support social development and reduce inequalities. The NAS will also foster social inclusion by ensuring that all regions, including informal settlements, are integrated into the national framework, thereby promoting equitable development. Studies have shown that efficient postal services significantly improved delivery during the COVID-19 pandemic. In the U.S., the Postal Service saw a 32% increase in package volume in 2020, maintaining service levels despite challenges (U.S. Government Accountability Office, 2021). In the UK, postal services adapted to restrictions and managed the surge in e-commerce deliveries effectively (Groves et al., 2023).

By 2030, it is projected that 50% of Kenyans will live in urban areas, with a significant portion still residing in informal settlements unless substantial improvements are made (World Bank, 2016). The NAS will play a critical role in addressing these challenges by providing a structured and reliable addressing system that supports both economic and social development.

8 Conclusion

This paper highlights the critical need for a responsive National Addressing System (NAS) in Kenya to address the challenges posed by rapid urbanization and population growth, which have outpaced the development of the addressing system. While recent efforts, notably the NASK project, have put Kenya on a promising path—achieving Universal Postal Union (UPU) certification and developing foundational standards—significant gaps remain.

A comparative analysis of global addressing systems offers valuable lessons for Kenya. Germany's standardized approach exemplifies how rigorous, uniform addressing frameworks can resolve issues such as toponymic ambiguity and colonial place names. Similarly, Japan's integration of advanced digital technologies demonstrates how such innovations can enhance address precision and accessibility, particularly in underserved rural areas.

This study recommends global practices for Kenya to consider. For instance, adopting Germany's comprehensive standardization could improve address reliability and consistency, while incorporating Japan's digital integration strategies could bridge gaps in rural address coverage and enhance overall accessibility.

These adaptations, aligned with Kenya's existing policies and frameworks, hold the potential to create a more effective and inclusive addressing system. Such a system would not only meet international standards but also address Kenya's unique geographical and

socio-economic contexts. By leveraging these global best practices, Kenya can strengthen its addressing infrastructure, supporting both its current development needs and future urbanization efforts.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: Not applicable.

Author contributions

IK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. IN: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that they have no commercial or financial relationships that could be construed as a potential conflict of interest in the conduct of this research.

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