

Toward a digital model for tracking human population dynamics in Tanzania: A multi-actor interaction mechanism

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ABSTRACT

Accurate, real-time tracking of human population dynamics is essential for evidence-based policymaking, effective service delivery, and sustainable development. In Tanzania, systems such as the National Identity System and birth, death, and migration systems operate largely in isolation, resulting in fragmented human population dynamics data and limited interoperability. This study develops a multi-actor interaction mechanism to address these limitations. The study is guided by the Model of Population Dynamics Theory (MPDT), Actor-Network Theory (ANT), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the DeLone and McLean IS Success Model. A cross-sectional mixed-methods design was implemented in Dodoma and Mpwapwa Local Government Authorities (LGAs). Data were collected from 187 participants representing government agencies dealing with human population dynamics tracking, LGA employees, community leaders, health workers, ICT specialists, and accommodation providers through surveys, interviews, focus groups, and document reviews. In this study, data were analysed using multiple regressions, primarily to evaluate the hypotheses developed by use of SPSS Version 21. Findings show moderate to strong positive correlations ($r = 0.60$ to 0.74), indicating that there is stronger collaboration in tracking human population dynamics between Village Executive Officers (VEOs), accommodation providers, religious leaders, and health officers. These findings highlight that improved cooperation among actors enhances data integration, reduces inconsistencies, and strengthens service delivery. From this study the proposed mechanism assigns clear roles, establishes standardised data-sharing protocols, and incorporates both formal and informal communication channels to strengthen system interoperability. Adoption of this multi-actor mechanism offers substantial potential to improve human population dynamics tracking in Tanzania, enabling inclusive, integrated, and responsive population governance.

Keywords: Civil Registration and Vital Statistics (CRVS), Digitalisation of Population Dynamics, Multi-Actor Collaboration, Multi-Actor Interaction Mechanism, Tracking Human Population Dynamics

I. INTRODUCTION

Globally, governments and policy institutions are increasingly recognizing the urgent need for accurate, timely, and comprehensive population data due to accelerating demographic transitions, rapid urbanization and shifting migration patterns (Lauwo et al., 2022). Such data serve as the cornerstone for informed governance, resource allocation, health service delivery and sustainable development planning. Tanzania exemplifies this challenge. As a low and middle-income country, it is experiencing a complex demographic profile marked by high fertility rates, declining mortality, increasing internal migration and significant rural to urban population shifts. However, the current systems for tracking these dynamics primarily decennial population censuses, death, birth and migration systems are inherently limited in their capacity to capture real-time demographic changes (Georganos et al., 2022).

To address these limitations, there is a growing global shift toward establishing Civil Registration and Vital Statistics (CRVS) systems as continuous, real-time sources of demographic data. CRVS systems are designed to record vital life events births, deaths, and migrations in a systematic, legally recognized, and universally inclusive manner. When properly implemented and integrated, CRVS systems offer a powerful alternative to episodic data collection efforts by providing real-time insights into the structure, distribution, and movement of the population (Habaasa & Natamba, 2018). These systems not only improve the timeliness and accuracy of demographic statistics but also serve a broader developmental and human rights agenda by granting individuals legal identity and access to public services.

In Tanzania, ongoing efforts to modernize population data infrastructure have included various pilot projects, digitization of birth and death registration, and strategic plans for strengthening national CRVS capacity. However, several challenges persist. The current institutional ecosystem remains fragmented, with parallel and often

uncoordinated efforts by key stakeholders such as the National Bureau of Statistics, the Ministry of Health, local government authorities, and information technology providers (Habaasa & Natamba, 2018). Data silos, weak interoperability, limited technical capacity, and inadequate legal frameworks hinder the realization of a fully integrated and responsive digital CRVS platform (Kahouei et al., 2021)

A digitally integrated CRVS system that combines real-time civil registration with migration data, fertility trends, and digital identity verification holds transformative potential for Tanzania. It would enable not only continuous population monitoring but also facilitate automated service delivery in areas such as healthcare, education, and social protection (Silva, 2022). Furthermore, the convergence of digital identity systems with CRVS infrastructure aligns with international best practices in public administration and governance, as evidenced by countries such as Estonia and Rwanda, where integrated systems have improved efficiency, transparency, and inclusivity in public service delivery (Okon, 2024).

Establishing a sustainable digital CRVS system requires more than technological innovation, it demands coordinated governance and inclusive stakeholder engagement. The success of such systems relies on how government agencies, civil society, communities, private tech firms, and development partners collaborate in shaping data flows and usage (Silva, 2022). Without structured mechanism for multi-actor collaboration, data governance, and accountability, human population dynamics tracking becomes fragmented. In many countries, weak institutional ownership has undermined both long-term sustainability and public trust in digital CRVS systems (Bera et al., 2024). To avoid these pitfalls, CRVS initiatives must prioritize inclusive planning, cross-sector collaboration, and clear governance mechanisms from the outset. This study therefore, introduces a multi-actor interaction mechanism for digitalizing the tracking of human population dynamics in Tanzania.

1.1 Statement of the Problem

Accurate and real-time tracking of human population dynamics is critical for evidence-based decision-making in national development, public health, disaster response, social protection, service delivery and national development planning. In Tanzania, despite the adoption of several digital systems for tracking human population dynamics including the Birth and Death Registration Systems, Migration systems, National Identification Authority System and Health Information Management systems such as GoTHoMIS, these systems function largely in isolation, without a cohesive mechanism for coordinated interaction among actors (Holl et al., 2024). This fragmentation undermines the effectiveness of population data systems, resulting in duplication, data inconsistencies, and operational inefficiencies.

The institutional landscape is characterized by siloed operations, where agencies such as RITA, NIDA, NBS and the Ministry of Health manage separate databases with limited interoperability. Health workers, local leaders, ICT officers, and policymakers operate within disconnected workflows, leading to missed opportunities for real-time data synchronization and evidence-based decision-making. This disjointedness is further exacerbated by the absence of standardized data-sharing protocols, feedback mechanisms and role clarity among stakeholders.

Existing frameworks such as the Model of Population Dynamics Theory (MPDT) offer macro-level perspectives on population behavior but overlook the micro-level actor interactions critical for socio-technical system success. Similarly, the Unified Theory of Acceptance and Use of Technology (UTAUT) and the DeLone & McLean Information Systems Success Model address system adoption and performance but lack structured mechanisms for inter-actor coordination. Actor-Network Theory (ANT) shows potential in this regard, yet remains underdeveloped for application in Tanzania's digital population tracking. The absence of an integrated, actor-centered interaction framework hampers the country's capacity to establish a continuous and responsive population tracking system, in contrast to nations like Estonia and Rwanda that have achieved full-cycle tracking through coordinated actor engagement. Consequently, fragmented practices persist, undermining data quality, system sustainability, and policy relevance. Therefore, this study addresses this gap by proposing a multi-actor interaction mechanism to enable effective collaboration among stakeholders, ensuring the delivery of real-time demographic data for strategic decision-making.

1.2 Research Objectives.

- i. Identify needed actors for digitalizing the tracking of human population dynamics in Tanzania.
- ii. Design the multi-actors' interaction mechanism for digitalizing the tracking of human population dynamics in Tanzania.

1.3 Research Questions

The following research questions to be answered in this study;

- i. What actors are needed for digitalizing the tracking of human population dynamics in Tanzania?
- ii. How can the multi-actors' interaction mechanism for digitalizing the tracking of human population dynamics in Tanzania be designed?

II. LITERATURE REVIEW

2.1 Theoretical Review

Designing an effective multi-actor interaction mechanism for digitalizing population dynamics tracking in Tanzania draws on four key theoretical foundations. The Model of Population Dynamics Theory (MPDT), Actor-Network Theory (ANT), Unified Theory of Acceptance and Use of Technology (UTAUT) and DeLone and McLean Information Systems Success Model. Each theory is critically reviewed to assess its strengths, limitations, and relevance to developing a robust interaction mechanism among actors tracking human population dynamics in Tanzania.

2.1.1 Model of Population Dynamics Theory (MPDT)

The Model of Population Dynamics Theory (MPDT) explains demographic changes via natural increase and migration, supporting policy planning for services like healthcare and infrastructure (Dismas et al., 2023). It highlights the importance of real-time data and digital CRVS systems managed by RITA, NIDA, and Immigration (Fecht et al., 2020). However, MPDT overlooks the interaction between key actors such as registrars, ICT staff, vendors, and health workers and lacks attention to feedback loops in system adoption Geels (2011), suggesting the need to incorporate Actor-Network Theory in this study.

2.1.2 Actor-Network Theory (ANT)

Actor-Network Theory (ANT) offers a useful lens to examine how human and non-human actors such as technologies, policies, and institutions interact to shape the effectiveness and sustainability of digital systems for tracking human population dynamics (Cresswell & Sheikh, 2013). In Tanzania, ANT highlights that successful digitization requires aligning varied stakeholders like RITA, NIDA, immigration, local leaders, religious institutions, and software vendors (Majchrzak & Shepherd, 2021). However, challenges such as unequal digital readiness and weak institutional capacity reveal the socio-technical complexity of such systems. Yet, ANT overlooks user behavior, performance expectations, and effort expectancy, signaling the need to incorporate the Unified Theory of Acceptance and Use of Technology in this study.

2.1.3 Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) provides a behavioral lens for analyzing engagement with digital population tracking systems, emphasizing four key factors: performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003). In Tanzania, adoption is shaped by user readiness and institutional support, with civil registrars relying on ICT staff and developers adjusting systems based on frontline feedback. While UTAUT highlights the socio-technical nature of system use, it does not fully address system and information quality, suggesting the need to integrate the DeLone and McLean Information System Success Model into this study.

2.1.4 DeLone and McLean Information Systems Success Model

The DeLone and McLean Information Systems Success Model assess digital population tracking systems using six dimensions: system quality, information quality, service quality, use, user satisfaction, and net benefits (Iqbal & Rafiq, 2025). In Tanzania, system success relies on both technology and stakeholder collaboration. System quality depends on reliable, usable designs shaped by engineers and registrars (Lee et al., 2021). While accurate data ensures information quality. Service quality involves training and support and user satisfaction reflects ongoing adoption. The model highlights how collaboration impacts the sustainability of these systems (Putra & Retnowardhani, 2024).

2.2 Empirical Review

This study reviews previous research, systems, and reports to identify existing knowledge and gaps regarding the requirements for tracking human population dynamics. The review focuses on the parameters, methods, interaction mechanism and digital systems used for human population dynamics tracking.

2.2.1 Challenges in Traditional Human Population Dynamics Tracking

Traditional systems like censuses, birth, death, and immigration records have long underpinned population tracking. However, in rapidly changing contexts like Tanzania with high fertility, declining mortality, and urbanization these systems fail to capture real-time dynamics, highlighting the need for more responsive and detailed data solutions (Mkwashapi et al., 2023). The next subtopic explores these challenges in greater detail.

Infrequency Constraints: A key limitation in tracking population dynamics is infrequent data collection, especially in Tanzania where censuses occur every ten years the last in 2022 and the next in 2032. Interim tracking is

often ad hoc, leaving demographic shifts like urban migration or disease outbreaks poorly captured (Reed et al., 2021). This time lag leads to outdated statistics that hinder timely governance and effective resource planning.

Underreporting and Geographic Inequities: Vital events often go unreported in rural areas due to poor infrastructure, challenging terrain, and limited trained personnel, particularly affecting birth, death, and migration data essential for legal identity and services. In Tanzania, rural regions have especially low registration rates due to logistical issues and low public awareness (Reed et al., 2021). This spatial disparity results in data gaps, undermining national statistics and skewing policy planning and resource allocation.

Implications for Equity and Inclusion: Weak data systems often exclude marginalized groups such as women, children, nomadic communities, and persons with disabilities limiting their access to services and legal recognition. For instance, undocumented births can block children from education or healthcare, while unregistered deaths hinder tracking of maternal mortality (Mikkelsen et al., 2015). This exclusion prevents responsive policymaking.

2.2.2 Successes and Failures of Existing Systems for Tracking Human Population Dynamics

Many countries are transitioning to digital CRVS systems to replace fragmented paper records with real-time platforms (Kickbusch et al., 2021). While some countries like Rwanda and Estonia show strong progress, others still face institutional and technical challenges (Maheshwari et al., 2025). These diverse experiences reveal key success factors and barriers, which are explored in the next subtopic.

Enabling Success Factors: Integration with digital identity systems is key to successful CRVS digitization. In Rwanda, linking biometric IDs with health systems has improved registration and data quality. Estonia connects CRVS to its national e-ID, enabling automated event recording and streamlined services (Björklund, 2016). Similarly, Bangladesh's digitized birth registration has enhanced accuracy and expanded access to services like education and immunization (Saha et al., 2023).

Bottlenecks and Failures: In many low- and middle-income countries, CRVS digitization faces challenges like weak legal frameworks, poor governance, and fragmented responsibilities, limiting data integration. In Uganda, early investments have not ensured full coverage due to internet issues and inefficiencies (Habaasa & Natamba, 2018). Fragmentation is worsened by the lack of data standards and limited community engagement, fueled by mistrust and low awareness (Brolan, 2019; Trofimets, 2021). For Tanzania, lessons emphasize the need for strong governance, coordination, infrastructure, and community involvement.

2.2.3 Role of Actor Collaboration and Governance

The success of digital public service systems like CRVS depends not only on technology but also on strong collaboration and governance frameworks that enable coordination, accountability, and sustainability (Lauwo et al., 2022). In population tracking, effective collaboration among different actors such as government ministries, local authorities, ICT providers, civil society, and international partners is essential for achieving shared objectives and improving system outcomes. This collaboration has a number of advantages as explained in the preceding paragraph.

Enhancing Data Completeness and Quality: Multi-actors mechanism integrates data from civil registration, health facilities, and immigration to improve accuracy and reliability through triangulation, reducing underreporting. This is crucial in Tanzania, where rural and marginalized populations are often missed by traditional systems (Sharma et al., 2023).

Promoting System Interoperability and Integration: The involvement of multiple actors encourages the adoption of interoperable standards and shared protocols, enabling different digital systems such as CRVS, national ID databases, and health management information systems (HMIS) to communicate effectively. Such integration minimizes data silos and duplication while supporting the development of unified population registries (Nesbitt & Murphy, 2022). This is essential for tracking longitudinal changes and supporting real-time analytics for planning and emergency response.

Aligning Roles and Responsibilities: Multi-actors mechanism relies on clear roles, legal mandates, and data-sharing agreements to avoid overlap and ensure accountability. In Tanzania, coordination among RITA, NBS, the Ministry of Health, Immigration, and Local Governments is vital for timely, complete data (Lauwo et al., 2022). Such mechanisms also promote role specialization creating a more efficient system.

Strengthening Capacity and Resource Sharing: Multi-actors engagement fosters the sharing of technical, financial, and human resources, which is vital in low- and middle-income countries with limited capacity. International organizations such as WHO, UNICEF, and the World Bank often provide financial support, training, and digital tools to national governments, while civil society organizations play a critical role in raising community awareness and advocating for legal identity and data inclusion (Reding, 2018). Public-private partnerships also enable innovation, especially in the deployment of mobile and cloud-based technologies for data collection and integration.

Supporting Policy Coherence and Evidence-Based Governance: When diverse actors contribute to and utilize population data systems, the outputs are more likely to inform coordinated and cross-sectoral policies. Population tracking data is relevant not only to the health sector but also to education, social protection, disaster response, and

economic planning. Multi-actors mechanism thus serves as platforms for data-informed governance that align sectoral policies with demographic realities and national development priorities (Tiller et al., 2021).

2.2.4 Existing Multi-Actor Systems in Tracking Human Population Dynamics

Tracking population dynamics requires coordination across CRVS, censuses, digital IDs, migration systems, and health data platforms. While countries like Norway, Estonia, and India achieve real-time integration, Tanzania struggles with weak infrastructure, fragmentation, and limited interoperability, underscoring the need for harmonized and inclusive digital approaches.

Civil Registration and Vital Statistics (CRVS) Systems: Norway and Japan have fully digitized, legally mandated CRVS systems integrated with health and identity platforms, allowing real-time demographic reporting. In contrast, Tanzania's CRVS managed by RITA and NIDA relies on both manual and digital reporting by health workers. Despite legal frameworks, low digitization, weak coordination, and paper-based rural practices persist (Trofimets, 2021). Collaboration gaps among key actors further hinder effective population tracking.

Population Censuses and Household Surveys: In U.S. and Canada, decennial censuses are supplemented by rolling surveys like the ACS, coordinated by national statistical offices using digital tools and trained enumerators, with methodological support from international agencies (Powers et al., 2015). In Tanzania, the NBS conducts censuses and DHS with backing from donors like USAID and UNFPA. These top-down systems produce high-quality but infrequent and costly data, underscoring the need for more dynamic and integrated tracking approaches.

Digital Identity and Integrated Population Registers: Estonia and India use integrated digital ID systems like e-ID and Aadhaar for secure service access and real-time demographic tracking. Tanzania's NIDA also collects biometric data, aiming to link digital IDs to CRVS and health systems. However, limited interoperability, rural internet gaps, and institutional silos hinder progress (Kisusu et al., 2019). While digital IDs enhance accuracy, they raise concerns about exclusion and privacy. This study examines how actor collaboration can reduce fragmentation in population tracking.

International Migration Data Systems: In the EU, agencies like Eurostat and Frontex use harmonized systems for real-time migration data. In Tanzania, migration data is gathered by the Department of Immigration and Ministry of Home Affairs, often with support from IOM, UNHCR, and NGOs, using border data, refugee camps, and surveys. However, limited interoperability and political sensitivities hinder data sharing (Msokwe, 2018). While these systems aid crisis response, they face issues like underreporting and poor integration with CRVS, making internal migration hard to track.

Health Information Systems: Health Information Systems such as DHIS2 are widely used in countries like Rwanda and Nepal for tracking health indicators, including births and deaths. These systems are integrated into health service workflows, and actors health workers, planners, and statisticians interact via dashboards and mobile applications to support planning and surveillance (Sanjel et al., 2024). Tanzania uses GoTHoMIS for managing Health information. These existing systems fail to capture real-time population dynamics data due to ineffective involvement of some of actors.

2.3 Research Gap

While Tanzania has made a lot of efforts in deploying digital systems such Birth, Death, immigration registration system and GoTHoMIS to track human population dynamics, the literature review reveals that these systems operate in parallel rather than as part of an integrated network. This is primarily due to the absence of a clearly defined mechanism for interaction among the key actors involved ranging from government institutions and local authorities to technical vendors and international partners (Sukums et al., 2021). Therefore, this study seeks to design an actor interaction mechanism grounded in a hybrid theoretical framework combining MPDT, UTAUT, Actor-Network Theory, and the DeLone & McLean Information Systems Success Model to address coordination failures and improve real-time demographic monitoring in Tanzania.

2.4 Research Model Development

Drawing on insights from the literature review, the study developed the conceptual framework for the study. The literature identifies key independent variables influencing the success of such a tracking model: human population dynamics, technology acceptance, system quality perception, and network stability. Figure 1 illustrates the research Model outlining the relationship between these independent variables and the dependent construct.

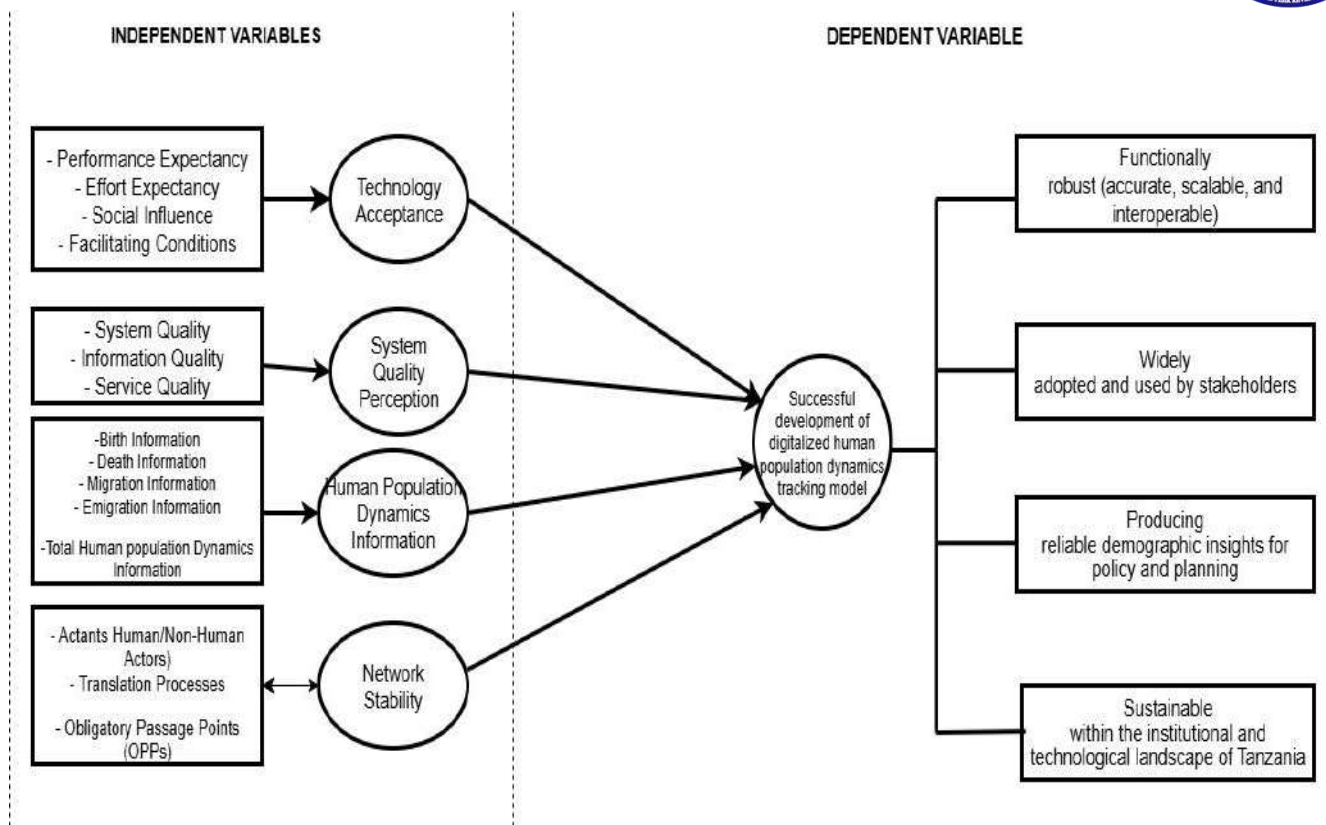


Figure 1
A Research Model

III. METHODOLOGY

3.1 Material and Method

Establishing a uniform framework of requirements for improving digital tracking of population dynamics in Tanzania is the aim of this study. The study Design, Study area, sampling technique, sample size and data collection process are all covered in this section. Data analysis methods, validity and reliability measures and ethical considerations are among the other issues covered.

3.2 Study Design

This study was done in Dodoma Region in Dodoma LGA and Mpwapwa LGA using a cross-sectional study design. Both qualitative and quantitative methods of data collection and analysis were employed. For qualitative methods key informants’ interviews and document/system reviews were used, while structured questionnaires were carried out for quantitative methods. Sampling of respondents was done using stratified random sampling.

3.3 Study Area

Six government agencies and offices were involved in this study: NIDA, RITA, Immigration, Police, Dodoma LGAs and Mpwapwa LGA in Tanzania. These were selected as the study's location for several reasons. First, NIDA, RITA, Immigration and Police are government agencies and organizations that deal with human population data. Second, Dodoma is a capital city where all offices headquarter. Thirdly, Dodoma is one of the regions in Tanzania which is experiencing high migrants almost from all regions of Tanzania. Thus, researching the human population dynamics in the Dodoma region allows the researcher to gather relevant and in-depth data.

3.4 Samples and Sampling Techniques

The Dodoma Region was purposively selected for this study due to its dynamic population characteristics, including rapid urbanization, significant rural-to-urban migration, and recent administrative restructuring following the relocation of Tanzania’s government headquarters to Dodoma (Miringay et al., 2022). These conditions provided a suitable context for examining human population dynamics and testing the effectiveness of digital population tracking systems.

Within the region, two contrasting Local Government Authorities (LGAs) were purposively selected: Dodoma City Council, representing a highly urbanized and rapidly expanding setting, and Mpwapwa District Council,



representing a predominantly rural context with unique patterns of migration, mobility, and settlement. This contrast enabled the study to capture a diverse range of demographic dynamics, thereby increasing the generalizability of the findings across the national context.

Sampling proceeded in a multi-stage approach. Initially, a complete list of wards in each LGA was obtained from local authorities, followed by cluster sampling to select three wards per LGA urban wards in Dodoma City Council and rural wards in Mpwapwa District Council. Within these wards, comprehensive lists of villages (or streets, in urban areas) were compiled, from which fourteen villages/streets were randomly selected to ensure broad geographic and socio-economic representation.

Participant selection within the sampled villages/streets employed structured and stratified random sampling. Lists of residents were categorized by occupation agriculturalists, pastoralists, businesspeople, and accommodation providers as well as leadership roles including Village Executive Officers (VEOs), Village Chairpersons, Cell Leaders, and Religious Leaders. From each occupational or leadership group, twelve participants per LGA were selected. These categories were chosen to reflect both economic and governance actors significantly impacted by or responsible for managing population movements and demographic changes.

In addition to local-level participants, the study also applied purposive sampling to key national agencies involved in population data management, including the National Identification Authority (NIDA), Registration, Insolvency and Trusteeship Agency (RITA), Immigration Services Department, and the Police Force’s Criminal Records Management Units. Within these institutions, participants were stratified and randomly selected based on professional designations such as Heads of Departments, general officers, and IT experts. This approach ensured that insights were gathered from strategic, operational, and technical levels, providing a comprehensive understanding of national population tracking systems.

3.5 Sample Size

The factors to consider in determining the sample size for this study include the representative of the sample and literature from similar previous studies including Tanzania Tanzania ePRS Report (2018) and Vazquez-Prokopec et al.(2013) employed the sample size ranging from 50 to 325 respondents. The sample size to be employed in this study considered the median number of sample size of 187 within range of sample size of 50 – 325 from similar previous studies as supported by Filho et al.(2018).Below is the calculations done to determine the sample size as supported by similar previous studies. The Median Formula was used: Considering Continuous Range (Integers from 50 to 325)

Considering all integers from 50 to 325:

Step 1:Determining the number of values: Count=325–50+1=276

Step 2:Since 276 is even, the median is the average of the 138th and 139th numbers.

Step 3:Calculate the 138th and 139th numbers, 138th number=50+137=187

139th number =50+138=188

The average is $\frac{187+188}{2} = 187.5$

Hence the sample size is 187

The sample size included Cell Leaders, VEOs, Village Chairpersons, guest houses service providers, Religious Leaders and selected farmers, pastoralists and business citizens. Policy makers’ employees, employees who interact with population dynamics existing systems and those with ICT key knowledge and ICT experts. The agriculturalists, pastoralists and business citizens were selected basing on the citizens who have migrated to the place and those who have stayed to the place for the long time. Therefore, this study used a sample size of 187 respondents based on the aforementioned justification. Table 1 in the next paragraph is the detailed sample size.

Table 1
Sample Size

LGAs/ APOS	AG	PA	BU	CL	GH	RL	VEO	VCP	PM(D EDs& ITE	GS	ICTE	PM(H ODs)	GS	TOTAL	
	12	12	12	12	12	12	12	12	10	14	125	-	-	-	135
	-			-			-	-	-	-	2	5	6		13
	-			-			-	-	-	-	2	5	6		13
NIDA	-			-			-	-	-	-	2	5	6		13
Police	-			-			-	-	-	-	2	5	6		13
Total Sample Size	12	12	12	12	12	12	12	12	10	14	125	8	20	24	187

AG=Agriculturalists, PA= Pastoralists, BU=Business People CL= Cell Leaders GH=Guest House Service ProvidersRL= Religious Leaders, PM =Policy Makers, ICTE= ICT-Experts, GS= General Staff VCP=Village Chair Persons

3.6 Data Collection

This study collected data through structured interviews, questionnaires, focus group discussions, and document/system reviews. Primary data were obtained from citizens, operational staff, ICT experts, and policymakers using interviews, questionnaires, and focus groups, while secondary data were drawn from system manuals and auditing reports to complement the primary findings.

3.7 Data Analysis

In this study, data were analyzed using multiple regressions, primarily to evaluate the hypotheses developed with SPSS Version 21. Multiple regression findings allowed for the test of correlations between latent variables representing constructs. The multiple regression tests was used to assess the direct and indirect impact of independent factors on dependent variables, as defined in the conceptual framework. This was performed by use multiple regression to test the hypotheses developed.

3.8 Ethical Consideration

The study adhered to ethical principles for research involving human subjects, ensuring privacy and confidentiality by not disclosing participant identities. The research purpose was clearly stated in the questionnaire introduction, and necessary permissions including an introduction letter and clearance from Mzumbe University were secured. Participants were fully informed of the study’s intent, and both written and oral consent were obtained prior to and during data collection.

IV. FINDINGS & DISCUSSION

As the purpose of this study was to design the interaction mechanism for improving digitalization of tracking human population dynamics, this study presents the results of the status of interactions among actors tracking human population dynamics as per table 2.

4.1 Multi-Actors Interactions in Tracking Human Population Dynamics

The objectives of this study was to identify key actors and their relationships in tracking human population dynamics and design the interaction mechanism for actors’ interactions in tracking human population dynamics in Tanzania. The results are presented in the following subsections.

4.1.1 Identified Key Actors and their Relationships

The study findings from table 2 indicate that key actors for tracking human population dynamics include Village Executive Officers (VEOs), Cell leaders, Religious leaders, Accommodation providers, Health Facility staff and Immigration officers. To assess the existing actors and their relationships Pearson correlation analysis was employed. The strength of these relationships were measured using a correlation matrix (Pearson/Spearman), as detailed below. The correlation values (r) were assigned as follows:

- r = 0.00 - 0.19: Very weak (almost no correlation)
- r = 0.20 - 0.39: Weak correlation
- r = 0.40 - 0.59: Moderate correlation
- r = 0.60 - 0.79: Strong correlation
- r = 0.80 - 1.00: Very strong correlation

Table 2 is a correlation matrix table that shows the relationship between actors involved in population dynamics tracking.

Table 2
Relationship of Key Actors and Variables

	Birth	Death	Local Migration	International Migration	VEO	Cell Leaders	Religious leaders	Accommodation Provider	Immigration Officer	Health Facility staff
Birth	1	0	0	0	0.7	0.7	0.7	0.2	0	0.6
Death	0	1	0	0	0.7	0.7	0.7	0.2	0	0.7
Local Migration	0	0	1	0	0.7	0.7	0.7	0.7	0	0.6
International Migration	0	0	0	1	0.2	0.2	0.2	0	0.7	0
VEO	0.7	0.7	0.7	0.2	1	0.7	0.7	0.6	0	0.6
Cell Leaders	0.7	0.7	0.7	0.2	0.7	1	0.7	0.6	0	0.6
Religious Leaders	0.7	0.7	0.7	0.2	0.7	0.7	1	0.3	0	0.6
Accommodation Provider	0.2	0.2	0.7	0	0.6	0.6	0.3	1	0	0.6
Immigration Officer	0	0	0	0.7	0	0	0	0	1	0
Health Facility staff	0.6	0.7	0.6	0	0.6	0.3	0.6	0.6	0	1

From Table 2: findings show moderate to strong positive correlations ($r = 0.60$ to 0.74), indicating that stronger collaboration significantly improves the accuracy and efficiency of human population data (HPD) tracking. Notably, collaboration between Village Executive Officers (VEOs) and health officers in vital event registration yielded $r = 0.65$, while interactions between immigration officers and local registration authorities showed $r = 0.60$ ($p < 0.01$). These findings highlight that improved cooperation among actors enhances data integration, reduces inconsistencies, and strengthens service delivery.

4.1.2 Actor’s Interactions

The use-case diagram represents the identified interactions among the key actors tracking human population dynamics. The figure2 below shows the actors’ interactions.

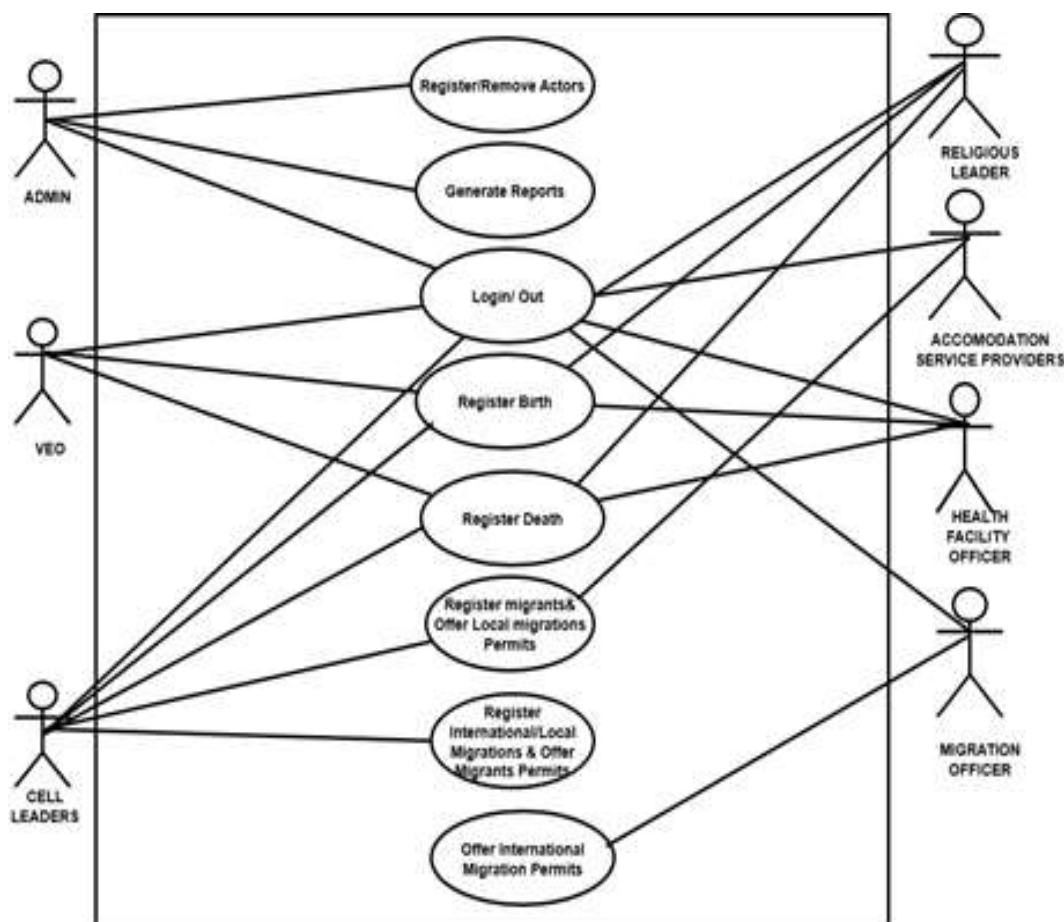


Figure 2
Actors’ Use Case Diagram

The interaction mechanism shown on use case diagram above defines actors’ roles in population dynamics tracking process. Health facilities record births with identifiers, parental details, health metrics, and deaths with causes and demographics. Community leaders and VEOs monitor local migration, ensuring timely resident movement data and validation. Accommodation providers track transient or temporary migrants, while migration authorities document international entries with passport and visa details, as well as exits with destination information.

4.1.3 Specific Roles for Actors Tracking Human Population Dynamics in Tanzania

This subtopic presents a summary of quantitative findings derived from Likert-scale survey responses on the roles and interactions of key actors in tracking human population dynamics in Tanzania. The findings support the classification of actor categories and their responsibilities based on their mean scores. Table 3 shows the statements versus their mean.

Table 3
The Mean Score of Functions for Each Organization

SN	Statement	Mean Score (1–5)
5.1	Government institutions oversee population data management	4.5
5.2	Government institutions manage civil registration	4.6
5.3	LGAs support tracking of migration and vital events	4.4
5.4	Health institutions issue accurate birth and death notifications	4.7
5.5	Community Health Workers & TBAs document home deliveries	4.2
5.6	Health institutions assist civil registration in rural areas	4.3
5.7	Law enforcement manages migration effectively	4.1
5.8	Law enforcement documents deaths for missing/unusual cases	4.0
5.9	Immigration officers document international migration	4.4
5.10	Community-based organizations support civil registration	4.3
5.11	Community leaders engage communities in civil registration	4.5
5.12	Community organizations raise awareness on population tracking	4.4
5.13	Tech/data bodies develop real-time tracking systems	4.2
5.14	Mobile-based systems are effective for tracking population events	4.0
5.15	Technology providers ensure integration with national databases	4.1
5.16	Accommodation providers help track transient populations	3.9
5.17	Employers assist in documenting migration of workers	4.0

Table 3 reveals varying institutional capacities in tracking population dynamics. Government institutions scored highest in population data (4.5) and civil registration (4.6), showing strong leadership in vital event recording. Local Governments (4.4) support decentralized monitoring, while health institutions excelled overall (4.7), especially in rural birth/death notifications (4.3). Community Health Workers and Traditional Birth Attendants scored 4.2 for home deliveries, suggesting moderate trust and integration potential. Law enforcement scored 4.1 (migration) and 4.0 (special death cases), needing better coordination. Immigration officers (4.4) support international migration data. Community actors leaders (4.5), organizations (4.3–4.4) show strong grassroots roles. Tech bodies (4.2), providers (4.1), and mobile systems (4.0) aid real-time tracking but need better investment. Employers (4.0) and accommodation providers (3.9) remain underused for labor and transient population data. From analyzed data the roles for key actors were extracted and designed as per table 4.10 in the next paragraph.

Table 4
Identified Key Actors and their Roles

Actor Category	Roles & Responsibilities	Specific Actors
Government Institutions	Oversee population data, manage civil registration, and track migration.	National Bureau of Statistics (NBS), RITA, Ministry of Home Affairs, Local Government Authorities (LGAs), WEOs, VEOs.
Health Institutions	Issue birth and death notifications, assist in rural areas, document home deliveries.	Hospitals, Clinics, Community Health Workers, Traditional Birth Attendants (TBAs).
Law Enforcement & Immigration	Manage migration, document deaths and handle missing persons.	Immigration Department, Police Department.
Community & Civil Society Organizations	Support civil registration, engage communities, encourage participation.	NGOs, International Organizations, Religious Leaders, Traditional Leaders, Local Cell Leaders.
Technology & Data Management Bodies	Develop digital solutions, enable mobile-based notifications, and support real-time tracking.	ICT Agencies, Digital Platforms, Mobile Network Operators.
Accommodation Providers & Employers	Track transient populations, document migration patterns.	Hostel Owners, Industrial Employers, Businesses.

4.1.4 Multi-Actors' Interaction Mechanism in Tracking Human Population Dynamics

From the analyzed data in sections 4.1.1, 4.1.2 and 4.1.3 the interactions among actors were identified. Figure 3 in the next paragraph shows the interactions mechanism among the key actors in tracking human population dynamics in Tanzania.

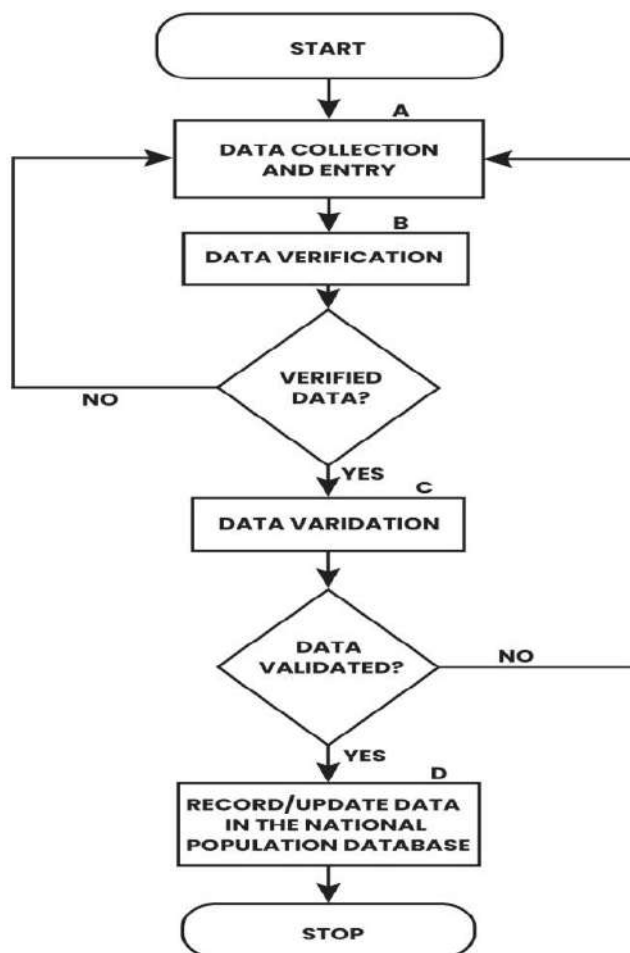


Figure 3
The Actors' Interactions Mechanism

The Actors are grouped in Group A and B: Village Executive Officers (VEOs), Cell leaders, Religious leaders, Accommodation providers, Health Facility staff and Immigration officers. Group C and D: Governmental Institutions mandated for Human population dynamics management

Actors Interaction process

Step 1: Data Collection

Village Executive Officers (VEOs), Religious centres, Hospitals and community health centers, Accommodation providers collect birth, death and migration data.

Step 2: Initial Verification and Entry

- i. Births verified and recorded at hospitals or community health centers.
- ii. Deaths verified and recorded by hospitals, police, VEOs or community leaders.
- iii. Migration Data gathered, verified and recorded by immigration offices, local leaders, and accommodation providers.
- iv. Births and Deaths Sent to RITA (Registration, Insolvency and Trusteeship Agency) and migration records submitted to the Immigration Department for further verification.
- v. Local government offices validate records to ensure consistency and prevent duplication.

Step 3: Data Updating and Storage

All verified data is stored and regularly updated in the National Population Database. This database is used as the primary reference for government planning and policy decisions.

4.2 Discussion

The purpose of this paper is to design the interaction mechanism among actors for digitalizing the tracking of human population dynamics in Tanzania. This section presents the discussion of the key findings of this study in relation to the findings of the previous similar studies and theories. Through the discussion, the disagreement of the findings is availed and this section also provides the reasons of such differences as presented in the next subsections.

4.2.1 Identified Actors and Interaction mechanism for in Tracking Human Population Dynamics

The findings of this study revealed that various actors such as Village Executive Officers (VEOs), Cell Leaders, Religious Leaders, Accommodation Providers, Health Staff, and officials from institutions like RITA, NIDA, and Immigration play a significant role in tracking human population dynamics (HPD). These results support the idea that multi-actor collaboration is critical to ensuring accurate, complete and real-time human population dynamics tracking.

This outcome aligns with Social Capital Theory, which posits that the strength of relationships within communities facilitates cooperation and improved governance outcomes (Gourdine et al., 2025). The strong positive correlations ($r = 0.6-0.7$) observed between actors like VEOs, health staff, and religious leaders reinforce the argument that trust-based networks improve data sharing and the registration of vital events. Similarly, Killagane et al. (2025) demonstrated that informal community structures enhance policy implementation effectiveness in Tanzanian local governance.

The findings also revealed that collaboration among these actors occurs through both formal and informal mechanisms. This mirrors conclusions from Latulippe et al. (2024) emphasized the need for inclusive communication channels and trust for the success of Multi-Actor Partnerships (MAPs). These types of relationships create functional networks even in low-resource environments where formal digital infrastructures may be lacking.

Despite these encouraging findings, some studies argue that the effectiveness of multi-actor collaboration is context-specific and often hindered by systemic limitations. For example, Sanga et al. (2024) observed poor inter-institutional coordination and role ambiguity at sub-national levels in Tanzania. These findings help to explain the weak engagement of some actors like immigration officers, who, despite their importance, showed limited interaction with local registration processes.

Scholars such as Tunga et al. (2023) have similarly emphasized that weak coordination among sectors such as civil registration, health, and education poses a threat to effective population tracking and service delivery in Tanzania. The existence of parallel systems and lack of integration leads to information silos, limiting the potential benefits of cross-sector collaboration. This concern was echoed by participants in this study who identified mistrust and limited interoperability as major challenges.

From a theoretical standpoint, this study's results are congruent with the Unified Theory of Acceptance and Use of Technology (UTAUT), which emphasizes performance expectancy, effort expectancy, social influence, and facilitating conditions (Bayaga & Du Plessis, 2024). The widespread use of mobile phones and willingness to share information reflect how users adopt technology when they perceive it as useful and socially validated. This is consistent with Okon (2024) who found similar drivers of digital tool adoption in public health systems.

However, the observed gaps in system integration and policy alignment suggest partial divergence from UTAUT's assumption of enabling conditions. Specifically, actors like immigration officers lacked the systemic support necessary for sustained engagement. These findings suggest that the presence of technology alone is insufficient without corresponding institutional frameworks and resources.

The results also find resonance in Actor-Network Theory (ANT), which views both human and non-human actors as critical to networked coordination. The studied actors can be seen as nodes within an evolving socio-technical system. However, the lack of system interoperability and mutual accountability reflects a partial breakdown in network stabilization, which is essential for sustainable coordination (Azelmad, 2021).

DeLone and McLean's IS Success Model also provides insights, suggesting that system use, information quality, and user satisfaction are essential for digital system success. In this study, actors with strong relationships (e.g., health staff and VEOs) demonstrated higher participation and satisfaction, whereas weak links especially among immigration officials reflected low system interaction and fragmented data flow.

Nonetheless, discrepancies between this study's findings and those of other researchers must be critically evaluated. Methodological differences such as sample size, geographic coverage and analytical techniques may account for the stronger correlations observed here versus weaker associations elsewhere (Sanga et al., 2024). The choice of theoretical frameworks influences how outcomes are interpreted. While this study applied UTAUT and ANT, other studies that use models like the Technology Acceptance Model (TAM) or Diffusion of Innovations may arrive at different conclusions regarding the adoption and impact of collaborative digital systems.

Institutional and policy environments are also decisive. In countries or regions where policies supporting interoperability and data governance are lacking, multi-actor tracking models tend to underperform (Hussein et al., 2023). Hence, the strength of actor relationships alone cannot guarantee effective outcomes without supportive frameworks.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This study demonstrates that effective tracking of human population dynamics in Tanzania necessitates a coordinated, Multi-actor-centered mechanism that integrates digital infrastructure, institutional collaboration, and user behavior. Despite the existence of multiple population data systems such as birth, death, migration systems and GoTHoMIS, the findings reveal persistent fragmentation, weak interoperability, and underutilized actor roles, especially among community-based contributors like, community leaders religious leaders and accommodation providers.

The proposed multi-actor interaction mechanism grounded in the integration of the Model of Population Dynamics Theory (MPDT), Unified Theory of Acceptance and Use of Technology (UTAUT), Actor-Network Theory (ANT), and the DeLone and McLean IS Success Model offers a comprehensive framework to address these shortcomings. Empirical results from correlation analysis affirm that strong actor collaboration significantly enhances data accuracy, integration, and system sustainability. Moreover, qualitative insights underscore the critical value of informal networks and grassroots coordination in supplementing formal data collection mechanisms.

This research contributes a novel multi-actor interaction mechanism that not only delineates the roles and relationships among institutional, community, and technical actors, but also specifies the access levels and data flow protocols necessary for real-time demographic tracking. The adoption of this mechanism promises to bridge systemic gaps, improve service delivery, and strengthen governance by providing accurate and timely population data. As such, the study offers both theoretical advancement and practical pathways for policy reform, digital system integration, and sustainable demographic monitoring in Tanzania and similar low- and middle-income country contexts.

5.2 Recommendations

To overcome fragmentation in Tanzania's population tracking infrastructure, a centralized coordination body should be established with legal authority to enforce interoperability and oversee demographic data systems across institutions like RITA, NIDA and Immigration. Inspired by models from Rwanda and Estonia, Tanzania should develop a federated, interoperable digital ecosystem linking CRVS, digital ID, health, and migration systems, optimized for low-connectivity environments through mobile and offline capabilities. Regular system audits guided by the DeLone and McLean IS Success Model should ensure quality and data integrity. Successful implementation requires continuous capacity building across all levels, aligned with the UTAUT model to drive adoption, and formal integration of community and private-sector actors via simplified reporting and national policies. Legal reforms must update civil registration, identity, and data protection laws to mandate cross-sector interoperability while safeguarding privacy. Future research should evaluate long-term impacts of actor collaboration, cultural factors affecting digital uptake, and the potential of technologies like AI, geospatial analytics, and block chain to enhance real-time tracking, predictive planning, and secure data management.

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