A framework of requirements for improving digitalization of human population dynamics tracking in Tanzania

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ABSTRACT

Tracking of human population dynamics in Tanzania is still elusive and hard to support the decision makers in making informed decision. Accurate and on time information on human population dynamics would result into effective resources planning and allocation, public services planning and allocation, environmental impact assessment and social economic development. Ineffective population dynamics tracking has been due to lack of unified requirements for tracking human population dynamics. This study establishes he unified requirements framework for digitalizing the tracking of human population dynamics in Tanzania. 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 engaged. The total of 187 respondents was involved in this study. 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. The research results show 51.1% male and 48.9% female participants; dominant education of respondents was bachelor degree who were 26.8%. The dominant age of respondents was between 30–40 years (44.4%). The objective of study is designing the requirements for population tracking by testing 20 hypotheses derived from five key information domains: birth, death, immigration, emigration, and total population dynamics. Structural Equation Modeling (SEM) yielded strong model fit indicators (CFI = 0.971, RMSEA = 0.038), with 18 of the 20 hypotheses accepted, validating the majority of requirement constructs. According to this study, the tracking of population dynamics in Tanzania is greatly influenced by requirements from birth, immigration, mortality, emigration, and overall real-time population dynamics data. The Framework shown in Table 6 provides a detailed description of the particular needs from each area. The results of this research help policymakers to put in place information and communication technology policies to explicitly state the adoption and deployment of digital systems as an innovative way for tracking human population dynamics by utilizing the framework of requirements established in this study. For successful, efficient, and long-lasting tracking of human population dynamics, the stakeholders should especially adopt and put into practice the requirements framework, which captures many perspectives of human population dynamics.

Keywords: Digitalization of Population Dynamics, Human Population Dynamics, ICTs, Tracking System, Framework of Requirements

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I. INTRODUCTION

Tracking human population dynamics is crucial for socio-economic planning, healthcare, and resource allocation. However, outdated data collection methods hinder real-time demographic insights, especially in Africa, where rapid population growth and high migration rates exacerbate the challenge (Kaba, 2020). Many African nations, including Tanzania, rely on infrequent censuses, which often fail to capture dynamic demographic changes in real-time. For instance, countries like Angola and Eritrea have not conducted a national census in the past 20 years, while others conduct them only once every decade or less frequently(Mbondji et al., 2014); (Kobiane, 2024). This lack of up-to-date data hampers effective planning and resource allocation. Additionally, the absence of historical data limits scientists' abilities to effectively understand demographic transformations. These challenges highlight the need for more frequent and comprehensive data collection methods to accurately monitor population dynamics.

Tanzania faces significant developmental hurdles due to its reliance on outdated demographic tracking methods, resulting in inefficient urban planning and poor resource allocation. The limitations of traditional census approaches, often conducted at lengthy intervals, lead to inaccurate population projections, hindering effective planning for rapidly growing urban areas(Disaster Management Department, Tanzania., 2022);(State of World population Report 2020, 2020). This lack of real-time data contributes to the proliferation of unplanned settlements, overburdened healthcare services, and strained infrastructure, as resources cannot be efficiently allocated to meet the dynamic needs of the population(World Bank, 2019). Consequently, healthcare facilities struggle with understaffing and under-resourcing, leading to compromised service delivery, while infrastructure development lags behind the pace of urbanization, causing issues like overloaded water and sewage systems(Ministry of Health, Tanzania., 2021).Furthermore, the absence of a digital, real-time tracking system weakens emergency response capabilities, making it difficult to coordinate relief efforts and track the spread of diseases during public health crises (Disaster Management Department, Tanzania., 2022). Implementing a modern, digital system would enable more accurate population projections, enhanced resource allocation, and improved urban planning, ultimately fostering sustainable development and enhancing the quality of life for Tanzanian citizens.

Implementing a digital population tracking system in Tanzania faces substantial challenges, primarily due to the nation's underdeveloped digital infrastructure. According to (ITU, 2023)significant impediment of digital population tracking is facing the challenge of low internet penetration, coupled with fragmented data systems that lack interoperability, hindering the seamless exchange of information. This fragmentation is further exacerbated by government agencies operating disparate databases, resulting in inefficient decision-making due to the inability to effectively communicate and integrate data (Tanzania e-Government Authority., 2022). Moreover, privacy concerns and weak governance frameworks create apprehension among individuals regarding the sharing of personal data, thereby limiting the effectiveness of digital tracking systems(Privacy International., 2021). The consequence of privacy concern and weak governance frameworks challenges is a lack of reliable population data, which directly impacts urban planning(Ismagilova et al., 2022) .

The integration of digital technologies such as artificial intelligence, machine learning, and big data analytics can further enhance the accuracy and efficiency of population tracking systems(Mwaura, 2024). The potential for advanced technologies to revolutionize demographic tracking in Tanzania is significant. These technologies, encompassing sophisticated analytical tools, can process real-time data from diverse sources, such as mobile devices and satellite imagery, to generate granular insights into population movements and growth patterns(UN-Habitat., 2020). This capacity to gather and interpret dynamic data streams offers a substantial advantage over traditional census methods, which are often static and quickly outdated. By leveraging these innovations, governments can transition to data-driven decision-making, leading to improvements in infrastructure development, optimization of public service delivery, and a reduction in socio-economic disparities(United Nations Economic Commission for Africa, 2018). The ability to visualize and analyze real-time population data can enable proactive urban planning, targeted resource allocation, and more efficient responses to emergencies and public health crises (World Economic Forum, 2019)

Following the above mentioned challenges, Tanzania faces an urgent imperative to design and implement a digital framework for real-time human population dynamics tracking. A system integrating mobile technology and cloud computing can facilitate effective decision-making(Al-Malahmeh, 2023). In order to improve population dynamics track in and sustainable development, this study intends to investigate workable methods for deploying digital tracking in Tanzania, addressing technological, infrastructure, and legislative challenges(Mataro et al., 2020).

1.1 Statement of the Problem

Effectively tracking of human population dynamics is a global task that has a big influence on resource allocation, healthcare delivery, and socioeconomic development. Even while developed countries struggle with antiquated data collection techniques that hinder real-time insights, Africa is where the problem is most severe. High migration rates, rapid population expansion and limited technology infrastructure make the issue worse and force people to rely on irregular censuses, which postpone the creation of policies and encourage inefficient use of resources(Fadda, 2024). Furthermore, the region's inadequate digital infrastructure, which is typified by dispersed data systems and poor internet penetration, makes it difficult to deploy digital population tracking effectively and prevents precise monitoring of demographic changes(Peters et al., 2016).

In Tanzania, issues including unchecked urbanization, resource misallocation, and inadequate social service planning are made worse by the lack of a digitalized, real-time population tracking system. The country's persistent dependence on recurring surveys and censuses misses dynamic demographic shifts, especially in patterns of migration from rural to urban areas(Gupta et al., 2024). The effectiveness of demographic tracking is further hampered by inadequate interagency cooperation, data privacy issues, and a lack of compatibility between current databases.

By laying out a systematic approach for improving Tanzania's digitization of human population tracking, this study aims to address these significant gaps. A well-designed digital system can enhance the accuracy of demographic data, enable real-time decision-making, and promote sustainable development in important areas like social welfare, urban planning, and public health by removing technological, infrastructure, and policy-related obstacles(Younus & Qodir, 2023). In a demographic situation that is changing quickly, this framework is intended to go beyond static data collecting and offer the dynamic and detailed data required for efficient government.

1.2 Research Objectives.

i. Identify organizations currently tracking human population information and the type of information they track in Tanzania.
ii. Identify required information for tracking human population dynamics in Tanzania.

1.3 Research Hypothesis

The following hypothesis are tested in this study;

H1-H5: Birth information Digital Tracking of Human Population Dynamics (DTHPD)
H6-H8: Mortality Information Digital Tracking of Human Population Dynamics (DTHPD)
H9-H12: Immigration Information Digital Tracking of Human Population Dynamics (DTHPD)
H13-H16: Emigration Information Digital Tracking of Human Population Dynamics (DTHPD)
H17-H20:Total real time population dynamics information Digital Tracking of Human Population Dynamics (DTHPD)

II. LITERATURE REVIEW

2.1 Theoretical Review

Effectively developing a framework for digitalizing the tracking of human population dynamics in Tanzania integrates three key theories. The Model of Population Dynamics Theory (MPDT) forms the foundation by identifying the core demographic variables necessary for tracking human population dynamics. To address the complex interactions between people, technologies, and institutions involved in implementing the framework, Actor-Network Theory (ANT) offers assists to address how networks of human and non-human actors shape framework functionality. Similarly, the Unified Theory of Acceptance and Use of Technology (UTAUT) recognizing the importance of user behavior and explains the determinants of technology adoption among stakeholders.

The extensive review and analysis of each theory is hereby done by highlighting their strengths, limitations, and relevance to developing the framework of requirements for digitalizing the tracking of human population dynamics tracking in the Tanzanian.

2.1.1 Model of Population Dynamics Theory (MPDT)

The Model of Population Dynamics Theory (MPDT) serves as a key framework for understanding how populations change over time basing in the key demographic variables namely births, deaths, immigration, and emigration (Natta & Goodkind, 2024). It employs quantitative mathematical and statistical models to analyze population structures, it also projects future trends of population (Ševčíková et al., 2016). The primary strength of MPDT lies in its capacity to offer a scientific method for tracking and forecasting (Burch, 2018).

In this study, MPDT plays a crucial role by identifying the essential requirements for digitalizing the tracking of human population dynamics which include birth, death and migration parameters. However, MPDT does not adequately account for the complex social, political, and technological factors that inevitably influence how population data is collected, interpreted, and ultimately used (Civelek, 2023). It tends to overlook practical implementation challenges such as institutional readiness, user acceptance, and the inherent role played by technology.

To address these gaps revealed by MPDT, Actor-Network Theory (ANT) is introduced as a complementary theory. ANT shifts the focus to the interactions between both human actors such as policymakers, data collectors, and citizens and non-human actors namely, software, databases and digital devices(Kaur, 2021; Ezenwa, 2017).

Therefore, while MPDT provides the essential theoretical basis for tracking human population dynamics, ANT offers the necessary views to understand how the design, implementation, and use of a digital tracking system are embedded within and influenced by its surrounding socio-technical environment. Together, these theories provide a more comprehensive understanding for designing the framework for digitalizing the tracking of human population dynamics.

2.1.2 Actor-Network Theory (ANT)

Actor-Network Theory (ANT), developed by Latour, Callon and Law, presents a socio-technical views through which both human and non-human entities known as “actants” are treated as active participants in network formation(Kaur, 2021; Ryan et al., 2024). ANT emphasizes the process of translation which involves stages such as problem identification, inter assessment, enrollment and mobilization, through which actors negotiate roles, align interests and form stable networks. This makes ANT useful for studying how technologies, institutions, policies, and users network in the adoption and use of digital systems.

The strength of ANT lies in its ability to explain the complex network between social and technical factors. In the context of digitalizing population tracking in Tanzania, ANT helps to analyze how government policies, IT infrastructure, developers, citizens, and the data itself interact to form a functioning system. For instance, a poorly designed interface may hinder data collection, while strong political support may accelerate adoption. ANT recognizes these interactions and provides a flexible theoretical foundation for analyzing them.

However, ANT does not model outcomes but instead focuses on explaining how networks are formed and stabilized(Kaur, 2021). Additionally, ANT can be difficult to operationalize, especially in large-scale systems, because its abstract concepts are not always easy to translate into measurable constructs. Despite these limitations, ANT is essential for this study because it provides insight into how various stakeholders and technologies interact during the implementation of the digital tracking system. Nevertheless, the adoption of digital systems depends not only on technical reliability or network alignment but also on user acceptance (Venkatesh et al., 2012). This necessitates the inclusion of a behavioral theory, such as the Unified Theory of Acceptance and Use of Technology (UTAUT).

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

The Unified Theory of Acceptance and Use of Technology (UTAUT) provide a model to predict and explain how individuals accept and use new technologies(Venkatesh, V., et al., 2003). It identifies four core determinants of user behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions, which are moderated by moderating variables including age, gender and experience.

In developing countries such as Tanzania where variations in digital literacy, infrastructure, and social norms may significantly affect technology use UTAUT helps assess whether end-users, including government officials, enumerators, and citizens, are likely to adopt the digital tracking system(Amdani, 2024). Its strength lies in its empirical reliability, having been validated across multiple domains including e-government, health, and education (Venkatesh et al., 2003). It provides measurable variables that can guide system design to enhance usability and acceptance.

Table 1

Reviewed Theories and Identified Gap

Theory	Strength	Identified Gap
Model of Population Dynamics Theory (MPDT)	Provides a scientific and statistical incites for understanding human population dynamics. Focuses on key demographic variables like birth, death, migration rates. Useful for long-term forecasting.	Lacks consideration of socio-technical and behavioral factors. Does not address technology user adoption. Assumes reliable data input without addressing system implementation.
Actor-Network Theory (ANT)	Explains socio-technical interactions and network formation. Treats both human and non-human entities as active participants. Useful for understanding implementation dynamics of digital systems.	Lacks predictive and evaluative tools. Difficult to implement in large-scale systems. Abstract concepts may not easily translate to measurable variables.
Unified Theory of Acceptance and Use of Technology (UTAUT)	Empirically validated model for predicting user adoption. Addresses factors like performance expectancy and social influence. Provides practical guidance for designing user-friendly systems.	Assumes a stable environment; does not account for systemic or contextual changes. Focuses primarily on individual behavior, not network or system outcomes. Does not address post-adoption performance.

2.2 Empirical Review

The review of previous related studies, systems and reports was done in order to dig up incites to this study. In this study, the emphasis is on reviewing and elucidating what is already known about requirements for tracking human population dynamics tracking and what is not known. The discussion has been on parameters used to track human population dynamics, Methods used for tracking human population dynamics, digital systems used for tracking Human population dynamics as discussed below.

Tracking Human Population Dynamics Tracking Parameters

*Birth Parameter:*The influence of birth factor in tracking human population dynamics remains a debatable topic among scholars. Many scholars generally agree that accurate birth data is vital for addressing human population dynamics which can help for social planning and forecasting future population trends. According to Guillot, (2009) and Dörflinger & Loichinger (2024), birth rates directly affect population growth and age structure, making them essential variables in population dynamics. Similarly, Phillips et al. (2018) assert that reliable birth information is indispensable for assessing fertility patterns, planning maternal and child health services, and monitoring progress toward development goals such as those related to reproductive health.

Furthermore; other scholars agree that improving birth registration systems is critical to strengthening population data infrastructure. UNICEF Report (2025) note that civil registration completeness remains below 50% in many African countries, undermining demographic reliability. Other scholars such as Byrne & Morgan (2011) further emphasize that integrating birth registration into health facility systems improves timeliness and coverage. This is echoed by Paleker et al. (2023), who state that closing the birth registration gap is vital for ensuring that all children are counted and visible in population statistics.

However, some scholars argue differently on birth data when used in isolation, arguing that overemphasis on birth registration can divert attention from other critical demographic indicators. Huyskes (2025) warns against adopting a purely data-centric approach, highlighting the role of socio-political factors, cultural practices, and institutional contexts in shaping the collection and use of population data. Paleker et al.(2023) found that systemic barriers including lack of awareness, institutional mistrust, and logistical constraints continue to hinder accurate birth registration in rural Africa. Similarly, World Health Organization (2010) noted that birth data in many developing countries is often delayed or incomplete, thus limiting its utility for real-time planning and policy implementation.

Disagreements continue to emerge regarding the feasibility of incorporating birth data into digital population tracking models. Mahapatra et al. (2007) identified significant infrastructural, technological, and governance-related challenges that hinder the effectiveness of civil registration and vital statistics (CRVS) systems in many developing countries. Similarly, Onoja et al. (2021) emphasizes that successful digital transformation requires not only technical infrastructure, but also robust legal and regulatory frameworks to support data governance, systems integration, digital services, and secure transactions. Further underscores the need for sustained institutional capacity development and long-term investments across all strategic pillars. In contrast Mills et al.(2019) argue that when adequate institutional commitment and digital infrastructure are in place, integrating civil registration systems such as birth registration with Electronic Immunization Registries (EIRs) can significantly enhance data quality. This integration enables birth data to serve as a reliable foundation for national planning, targeted service delivery, and effective monitoring of population dynamics.

Death Parameter: Some scholars emphasize that death information can alone influence the tracking of human population dynamics. Scholars such as (Haldane et al., 2021) argue that robust mortality data can be a central pillar in understanding demographic changes, such as life expectancy trends, excess deaths during crises, and shifting age structures—particularly when fertility is stable or declining. Similarly;Haldane et al. (2021) highlight that during pandemics , death data alone provided critical insights into population vulnerabilities, enabling governments to make urgent and targeted health interventions. It is also noted from Adair & Lopez (2018) who insists that continuous and complete death registration is sufficient to track mortality based population trends and inform policies in the absence of other data sources, especially where fertility and migration are relatively stable.

On the other hand, many scholars argue that death registration alone is not enough to track human population dynamics hence must be integrated with births, migration, fertility**,** and socioeconomic factors to fully track human population dynamics. Scholars such as Silva (2022) argue that civil registration and vital statistics (CRVS) systems, particularly death registration, are critical for population dynamics tracking, although they only provide a limited picture of population changes. A complete understanding involves the integration of data on births, migration, fertility, and socioeconomic variables. Similarly; Pandey et al., (2024) argues that incomplete death data, especially in rural and marginalized populations, limits its reliability. They advocate for integrating mortality data with birth registration, household surveys, and health system data to ensure a holistic demographic picture. According to Doolin & Lowe, (2002) applying Actor-Network Theory, critiques the idea of death data as a neutral, standalone measure. He argues that death registration is intertwined with broader socio-technical systems, and thus must be contextualized with data on healthcare access, education, and governance to interpret its true demographic meaning. Furthermore; Cobos Muñoz et al.(2018) suggest that population dynamics are best tracked through integrated CRVS systems that combine birth and death records with migration, fertility trends, and digital identity systems**.** They emphasize interoperability and data sharing across institutions for accuracy.

Immigration Parameter: Immigration parameter for tracking human population dynamics has been the debatable topic among scholars. Some scholars assert that immigration data, when done accurately and comprehensively, can significantly enhance the understanding of population dynamics, particularly in countries where migration is a major driver of demographic change. Scholars such as Mohamed et al.(2025) insist that when immigration tracking is done comprehensively to the large extent can help to understand human population dynamics. Furthermore, Tjaden (2021) argue that in countries with high immigration or emigration, immigration records can be a strong standalone indicator for tracking short- and long-term population dynamics. They emphasize that immigration has a direct impact on age structures, labor force composition, and urban growth. Bosco et al.(2022) support this by highlighting the use of migration flow data in real-time policy decisions, especially in developed nations where birth and death rates are relatively stable, and migration is the key factor shaping population growth or decline. Furthermore; Bijak et al. (2013) suggest that for regions like the EU, with strong border and immigration registration systems, migration statistics alone can provide valuable insight into population redistribution, city planning, and social services.

Other scholars strongly caution against relying on immigration information in tracking human population dynamics. Schweitzer (2022) insists that immigration data is often incomplete, irregular, or politically influenced, especially in low and middle-income countries. He argues that without birth and death data, immigration alone cannot explain net population changes. Hilbrecht(2024) emphasizes that migration is interlinked with other demographic events like fertility, mortality, and urbanization. Thus, tracking only immigration without understanding why people move, their health, or their family structures provides a partial and potentially misleading view.Karakaya et al.(2022) advocates for the integration of immigration data within broader civil registration and vital statistics (CRVS) systems and population censuses, noting that such integration is necessary to address gaps in data reliability. Furthermore; Bosco et al. (2022), from a socio-technical point of view, argues that immigration data is shaped by policy decisions, technology use, and institutional biases, making it essential to interpret it alongside social, economic, and health indicators for accurate population dynamics assessment.

Emigration Parameter: Tracking human population dynamics using emigration has been the debatable parameter among scholar with different views. Marois et al. (2020) argue that accurate emigration data alone can offer valuable information on population loss, workforce depletion, and aging dynamics. Shumway & Otterstrom (2010) address that emigration records when collected through exit permits and electronic border control system scan support national planning in areas such as education, healthcare and labor force development. Careja & Bevelander (2018) argue that emigration data are essential for calculating net migration and updating population registers, especially in countries with real-time or continuous population data systems. These scholars emphasize that where fertility and mortality are relatively stable, well maintained emigration registers can serve as standalone tools for understanding how populations are redistributed and declining due to emigration.

Nevertheless, a greater number of scholars caution that emigration data is not enough for tracking human population dynamics. They contend that in order to fully depict population dynamics, it needs to be integrated with data on immigration, births, and deaths. Abel & Sander (2014) caution that emigration statistics are sometimes incorrect or underreported, especially in nations with no exit restrictions or when migrants depart irregularly. The effect of emigration on overall population dynamics is not fully understood in the absence of equivalent birth and immigration data. Emigration, according to de Haas (2021), is a social process that cannot be seen in isolation from the broader processes of change of which it is a constituent part it must be understood as part of economic, social, cultural, and demographic dynamics. He emphasizes the significance of comprehending migrant fertility patterns, household structures, and push/pull factors all of which are not captured by emigration data alone. In order to accurately assess net population change, Mills et al.(2019) advise that emigration registration be incorporated into integrated demographic data systems, such as civil registration and vital statistics (CRVS). National population estimates run the danger of being altered in the absence of these connections. Using a socio-technical viewpoint, Martini et al. (2016) contend that emigration records are created within technological and bureaucratic frameworks and should be understood in light of social, cultural, and economic variables in order to accurately depict demographic changes.

2.2.1 Methods for Tracking Human Population Dynamics and their Role in Tracking of Vital Statistics

Tracking human population dynamics is essential for planning resource allocation, and enhancing resilience to social and environmental changes. Multiple methods are employed in this endeavor, each contributing unique strengths and limitations. Among these, the use of vital statistics comprising systematically recorded data on births, deaths and migrations emerges as the most effective approach for consistently monitoring population dynamics. Here below are the methods used to track human population dynamics.

Vital Registration Systems: These systems, which are the foundation of Civil Registration and Vital Statistics (CRVS) systems, continuously record events such births and deaths. According to AbouZahr et al.(2015) recommends that these records are essential for computing life expectancy, fertility, mortality and natural population growth. *Population and Housing Censuses:* Conducted typically every ten years, censuses provide comprehensive data on the size, structure, and spatial distribution of populations. However, the conducted national censuses are often outdated, incomplete and not frequent enough to effectively track rapid population changes especially in settings with high migration hence there is the need for alternative data systems and new technologies to provide more timely population dynamics tracking (Wardrop et al., 2018)

Demographic and Health Surveys (DHS): These gather information on fertility, mortality, family planning, and health outcomes. DHS protocols often fail to capture dynamic household structures and mobility patterns, such as circular migration, which limits their ability to support ongoing and accurate demographic monitoring (Brear et al., 2022)

Geospatial and Remote Sensing Technologies: Geographic Information Systems (GIS) and remote sensing enable spatial analysis of population density and settlement patterns. These tools are valuable for visualizing population environment interactions, especially in disaster contexts (Sunny, 2024; Ali et al., 2024).

Big Data and Digital Traces: Emerging sources such as mobile phone data and social media provide insights into population mobility and behavior. Despite their potential, these methods face challenges related to privacy, representativeness, and data access (Okmi et al., 2023).

Administrative Records: Data from school enrollments, tax files, and health records offer supplementary demographic insights, though often fragmented and limited in scope (Figlio et al., 2017).

Among the methods listed, the tracking of vital statistics is arguably the most effective and robust strategy for monitoring population dynamics, for several critical reasons: *Continuous and Real-Time Data Collection:* Unlike censuses or surveys, which are periodic and retrospective, vital registration systems provide *continuous, real-time data.* This allows for the prompt identification of demographic changes, which is especially crucial in responding to public health emergencies, natural disasters, and migration crises (AbouZahr et al., 2015). *Direct Measurement of Population Change: Vital* statistics are the only method that directly measures *natural population change (*births minus deaths), offering the most accurate account of demographic trends. As emphasized by AbouZahr et al., (2019), understanding population growth, fertility transitions, and mortality patterns hinges on the availability of high-quality vital data.

Policy and Legal Integration: Vital registration systems are integrated within national legal frameworks, making them not only a demographic tool but also a *rights-based instrument* for individual legal identity, access to services, and social protection (Brolan & Gouda, 2017). This legal backing ensures greater population coverage and long-term sustainability.

*Foundation for Other Data Systems:*Vital statistics serve as a *reference baseline* for validating estimates from censuses, surveys and big data sources. Without reliable civil registration, projections derived from indirect methods risk being inaccurate or biased (AbouZahr et al., 2015).

Equitable Inclusion and Vulnerability Analysis: High quality CRVS systems can help identify disparities in demographic events across regions and social groups, thereby facilitating *targeted interventions* for marginalized or at risk populations. This is particularly important in disaster risk management where disaggregated data is essential for vulnerability mapping and equitable resource allocation (Arunachalam et al., 2023; DeSalvo, 2023).

Cost-Efficiency and Scalability: Although initial investments in CRVS systems may be significant, they offer long-term cost efficiency compared to the recurrent expenditures required for large scale surveys or censuses. Once institutionalized, they become a *scalable and sustainable* demographic monitoring infrastructure(Mills & Amponsah, 2019).

2.2.2 Models used for Tracking Human Population Dynamics

Several models are employed in population dynamics tracking, each offering unique methodologies for demographic analysis and prediction. A critical component in many of these models is the use of human vital data, which incorporates birth, death, immigration and emigration.

Cohort Component Model (CCM) and Vital Data Integration: The Cohort Component Model (CCM) stands as a cornerstone in demographic forecasting, projecting population changes based on fertility, mortality and migration patterns(Burch, T. K., 2018).The accuracy of the CCM is significantly enhanced by the integration of robust vital data. The CCM integrates the following components;

Fertility Component and Birth Registrations: Accurate birth registration systems are essential for tracking fertility rates. These systems provide crucial data on the number of births, birth timing and maternal characteristics, enabling detailed analysis of fertility trends (Blanc, A. K., Wardlaw, T., & AbouZahr, C., 2016)

Mortality Component and Death Registrations: Death registration systems, when comprehensive and timely, provide vital information on mortality rates, causes of death and life expectancy. These data are critical for monitoring public health trends and evaluating the impact of health interventions(Setel, P. W., Macfarlane, S. B., Szreter, S., Mikkelsen, L., Jha, P., Stout, S., ... & AbouZahr, C, 2007).

*Migration Component and Population Registers***:** Population registers, often linked to vital registration systems, facilitate the tracking of migration patterns. These registers record changes in residence, enabling the analysis of internal and external migration flows(Zlotnik, 2004).

The CCM has demonstrated its efficacy in systems like Sweden’s Population Register System and Canada’s Vital Statistics Program enabling real time demographic insights. However, its effectiveness hinges on the availability of highly structured and continuously updated vital statistics databases, a challenge in many developing nations including Tanzania, which limits their capacity for accurate population dynamics tracking(Ludvigsson et al., 2016)

Logistic Growth Model and Environmental Vital Data: The Logistic Growth Model describes population growth within an environment with finite resources, incorporating the concept of carrying capacity, the maximum population size an environment can sustain (Cybellium, 2024). Vital data can be combined with environmental data such as resource availability and pollution levels to enhance the model's accuracy in predicting population growth limits.

Lee-Carter Model and Mortality Vital Data: The Lee-Carter Model is extensively used for forecasting mortality rates, finding applications in actuarial science, social security projections and pension planning (Lee & Carter, 1992).

This model relies on historical mortality vital data to project future trends(Kim et al., 2007).

Systems Dynamics Model for Population Growth and Comprehensive Vital Data: The Systems Dynamics Model conceptualizes population changes as a network of interconnected feedback loops. This approach enables policymakers to simulate long term demographic changes by integrating comprehensive vital data including birth rates, mortality rates, migration, resource consumption and economic conditions into predictive simulations(Pitoyo et al., 2018). (Navarro, 2019).

Malthusian Theory and Historical Vital Data: The Malthusian Theory as proposed by Thomas Malthus provides a broader theoretical perspective on population dynamics. Historical vital data such as records of famines and disease outbreaks can be used to examine the validity of Malthus's predictions(Kaba, A., 2020).

The review of population dynamics models and the critical role of vital data underscore the paramount importance of establishing a robust framework of requirements for tracking human population dynamics. The diverse models from the Cohort Component Model to Systems Dynamics modeling, all rely on accurate and timely data to function effectively. Challenges such as inadequate vital registration systems, data fragmentation and limited technological infrastructure in many areas highlight the urgent need for a structured approach.

Table 2

Summary of Population Dynamics Models

Model/Theory Name	Existing Components for Population Dynamics Tracking
Cohort Component Model (CCM)	- Fertility rates tracking (births) - Mortality tracking (deaths) - Migration analysis (internal & external)
Logistic Growth Model	- Carrying capacity constraints - Population growth rate control - Resource availability estimation
Lee-Carter Model	- Mortality forecasting - Actuarial and pension planning - Life expectancy modeling
Systems Dynamics Model	- Feedback loops for birth/death rates - Economic and environmental impact simulations - Policy scenario testing
Malthusian Theory	- Population growth monitoring - Resource availability trends - Crisis prediction (e.g., famine, overpopulation)

2.2.3 Research Gap

From the reviewed literature, it is identified that there is contradictory evidence on the framework of requirements for tracking human population dynamics. Some scholars argue that individual parameters such as birth or emigration are sufficient under specific conditions(Attafuah et al., 2024;Tkachenko et al., 2017). On the other hand, Kayondo et al.(2019) and Hooten et al.(2020) insist on multi-parameter integration for accuracy and completeness in tracking human population dynamics.This divergence creates uncertainty about the minimum essential parameters a digital tracking system must include.

Therefore, this study aims at establishing the requirements for implementation of an adequate digitalization of tracking human population dynamics in Tanzanian context. Thus after thorough reviews of the literature the different hypothesis were established in relation to each dimensions for improving digitalization of tracking human population dynamics (DTHPD) as per chapter 1.2.

2.3 Research Model Development

Based on various perspectives from the literature review, the overall hypothesis that was developed is that tracking human population dynamics can be improved if the government implements a modern technological mechanism for improving ways of tracking human population dynamics. According to a literature review, birth information, mortality information, immigration information, emigration information and total real time population dynamics information are set as hypothesis as requirement of frameworks to improve tracking of human population dynamics. Figure 1 depicts the relationship between independent and dependent construct as derived from the literature.

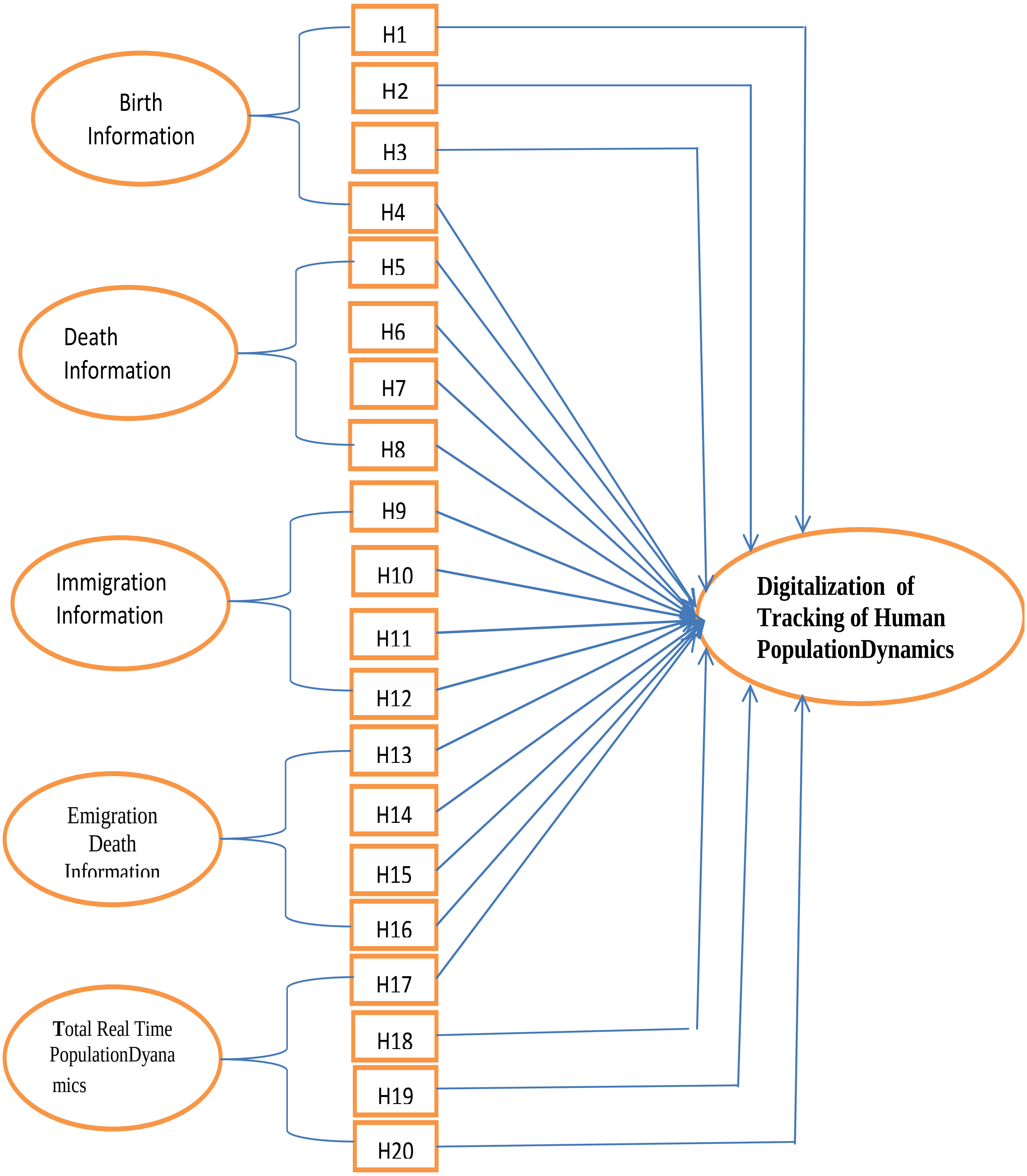

Figure 1
A Research Model

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(TZ PHC Initial Results, 2022;Kibonde, 2024). Thus, researching the human population dynamics in the Dodoma region allows the researcher to gather relevant and in-depth data (Mubako et al., 2022).

3.4 Samples and Sampling Techniques

The Dodoma Region was purposively selected for this study due to its pronounced human population dynamics, characterized by rapid urbanization, rural-to-urban migration, and administrative restructuring, especially after the government of Tanzania reallocating the administrative functions of the government to Dodoma(Miringay et al., 2022;Kessy, 2022). These factors provided an ideal setting for studying variations in human population dynamics and testing digital tracking system.

Within Dodoma Region, two Local Government Authorities (LGAs) (Dodoma City Council (urban area) and Mpwapwa District Council (rural area)) were purposively selected. The selection criteria were; Dodoma City Council represented highly urbanized and rapidly expanding populations and Mpwapwa District Council represented rural populations with distinct migration, settlement, and mobility patterns. Selecting these two contrasting LGAs allowed the study to capture diverse dynamics that are reflective of broader trends across Tanzania, thus enhancing the generalizability of findings.

From each LGA, a complete list of wards was obtained from district authorities. Cluster sampling was then applied to select three wards per LGA. The rationale was to ensure proportional representation of urban wards within Dodoma City Council and rural wards within Mpwapwa District Council. This approach allowed the inclusion of varied socio-economic settings within each LGA.From the selected wards, lists of all villages (or streets, for urban settings) were compiled. Then, using simple random sampling, fourteen villages/streets were randomly selected across the wards to ensure broad coverage and minimize selection bias.

Participants within the selected villages/streets were chosen using a structured and stratified approach. From each village/street, lists of residents engaged in different occupations (agriculturalists, pastoralists, business people, accommodation providers) and leadership or influential roles (Village Executive Officers (VEOs), Cell Leaders, Village Chairpersons and Religious Leaders) were obtained through local leadership and community organization records. Within each occupational/leadership category, stratified random sampling was used to select twelve participants per group in every LGA.

The participant categories were chosen based on their relevance to human population dynamics. Agriculturalists and Pastoralists represented traditional livelihood groups affected by migration, land-use changes, and settlement patterns. Business People and Accommodation Providers represented economic actors directly influenced by population movements and expansions. VEOs, Village Chairpersons, and Cell Leaders represented local governance structures responsible for managing, coordinating, and recording population data at the grassroots level. Religious Leaders represented influential figures in communities who play critical roles in social mobilization, migration ceremonies, conflict mediation, and community organization. Stratification by occupational and leadership roles ensured the inclusion of diverse experiences and perspectives on human population dynamics.

Beyond the LGAs, a purposive sampling strategy was applied to select key national agencies involved in population tracking namely; National Identification Authority (NIDA), Registration, Insolvency and Trusteeship

Agency (RITA),Immigration Services Department and Police Force (Criminal Records Management Units).Within these agencies, stratified random sampling was used to select participants based on professional designations such as heads of departments (HODs), normal officers/workers and IT Experts. This stratification ensured the study captured different ideas, experience from strategic, operational, and technical perspectives relevant to human population data management.

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);Vazquez-Prokopec et al.(2013); Kays et al. (2011) 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) and (Sigh, A.S and Masuku, M.B., 2014).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 138^{th} and 139^{th} numbers.
Step 3**:** Calculate the 138th and 139th numbers:138th number=50+137=187 138^{th} number =50+137=187
139^{th} 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 process models 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 3 in the next paragraph is the detailed sample size.

Table 3
Sample Size

LGA/TAPOS	AG	PA	BU	CL	GH	RL	VEO	VCP	PM(DEDs &HOD)	ITE	GS	ICTE	PM(HODs)	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 Providers RL= Religious Leaders, PM =Policy Makers, ICTE= ICT-Experts, GS= General Staff VCP=Village Chair Persons

3.6 Data Collection

Data for this study were gathered mainly using structured interviews, structured questionnaire, focus group discussion and documentary review/system reviews. Structured interviews, structured questionnaires and focus group discussion were used to collect primary data from citizens, operational staff, ICT experts and strategic level workers (policy makers). Document review was employed to gather secondary data to supplement data from interviews and focus group discussion. The documents reviewed include existing systems operation manuals and systems auditing report.

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

This study complied with the ethical principles in research involving human subjects. Privacy and secrecy issues were considered and guaranteed. No information or identities of the individuals revealed in written or other communications. The purpose of the research specified at the introductory part of the questionnaire. Relevant permission was obtained before conducting the study, which includes obtaining the introduction letter and research clearance from Mzumbe University. Moreover, the intention of this study was clearly clarified throughout the data collection exercise. Generally, both written and oral consent was obtained before and during data collection.

IV. FINDINGS & DISCUSSION

As the purpose of this study was to establish the requirements of framework for improving digitalization of tracking human population dynamics, this study presents the results of the status of tracked information in Table 1, followed by the list of requirements needed in digitalization of tracking human population dynamics in Tanzania in Table 2.

4.1 Findings of Tracked Information Related to Population Dynamics

The data related to population dynamics information were analyzed in order to identify the extent the available systems captured the information related to human population dynamics. The analyzed data include birth, mortality, and emigration and immigration data.

4.1.1 Birth Information Tracking

According to the respondents, 80% believe that RITA plays a primary role in tracking birth information. This makes RITA the leading institution in this category, consistent with its mandate to register vital events. 60% of respondents recognize NIDA as also being involved in tracking birth data, likely due to its role in issuing identification numbers based on birth records. Similarly, 40% acknowledge the Immigration Department as tracking this data, possibly through its interaction with birth records when processing identification documents. This broad institutional involvement indicates that birth data is relatively well-tracked but also suggests some duplication or overlap in roles and lack of coordination and integrated system that captures birth, death and migration information that lead to total population dynamics tracking.

4.1.2 Mortality Information Tracking

Mortality data is predominantly tracked by RITA, with 70% of respondents affirming that it is the main institution handling this information. This is logical, as RITA registers deaths officially in Tanzania. Similarly, 50% of the respondents also scored NIDA with involvement in mortality tracking, which could relate to updating national identity databases after a person dies. Meanwhile, 30% believe the Immigration Department tracks mortality, which may reflect its administrative procedures for deactivating IDs or permits of deceased individuals. Overall, RITA is the central hub for mortality information, though some coordination appears to exist across institutions.

4.1.3 Immigration Information Tracking

A significant 80% of respondents identified that Immigration Department is the principal institution for tracking immigration information, which aligns with its core function. These include details such as migrant identity, duration of stay, work permits, and legal status. In contrast, only 10% of respondents credit NIDA with immigration tracking responsibilities. This could be due to NIDA's involvement in maintaining resident identity records that occasionally intersect with immigration data. The minimal role of other agencies indicates a specialized, centralized approach, but also highlights potential integration gaps with national ID and planning systems.

4.1.4 Emigration Information Tracking

It was also noted that 60% of respondents report that emigration data is primarily tracked by the Immigration Department. This includes information on individuals leaving the country, their destinations, and reasons for emigration. 10% recognize NIDA as having some role in this function, perhaps in updating identity records when a person relocates abroad. Notably, RITA is not recognized by respondents as being involved in tracking emigration, underscoring the singular focus of the Immigration Department in this area. While this is expected, the relatively lower tracking percentages compared to immigration suggests that exit data may be less robust or less systematically recorded.

4.1.5 Internal Migration Tracking

It was also identified that 90% of respondents state that internal migration is not tracked by any of the institutions mentioned. This highlights a critical weakness in the current system. Internal migration movement within the country from rural to urban areas or between districts is a significant driver of demographic change, especially in rapidly urbanizing countries like Tanzania. The absence of a system to capture this data suggests that planners and policymakers lack real-time insight into internal population shifts, making it difficult to allocate resources efficiently or address urbanization challenges. The table blow shows how each parameter was responded to be tracked by different organizations.

Table4

Population Dynamics Information Tracked

Tracked Information	RITA (%)	NIDA (%)	Immigration (%)	Not Tracked (%)
Birth information	80	60	40	0
Mortality information	70	50	30	0
Immigration information	0	10	80	0
Emigration information	0	10	60	0
Internal migrations	0	0	0	90

4.2 Unified Framework of Requirements

The results in Table 2 shows that most of the hypotheses tested were accepted as the requirements for improving digitalization of tracking human population dynamics in Tanzania. The accepted hypotheses have p-value < 0.01 significantly improves digitalization of tracking human population dynamics. However, only two hypotheses (H11 and H15) were found insignificant as the p-value > 0.01.The results in Table 2 imply that, all accepted hypotheses forms a framework requirements as a base for implementation of digitalization of tracking human population dynamics in Tanzania as were not considered in existing modes.

Table 5

Hypotheses Tested as Requirements for Tracking Population Dynamics

Dimension	Hypotheses	Accepted/ Rejected	P-Value (P <.01)
Birth information	H1: Total births in size and structure for the particular area improves DTPD.	Accepted	.000
	H2: The needed support for the new births improves DTPD	Accepted	.001
	H3: Fertility rate of the particular area improves DTPD..	Accepted	.005
	H4: The impact of occurring births and needed real time interventions improves DTPD.	Accepted	.002
Mortality information	H5: Total death in size and structure in a particular area improves DTPD.	Accepted	.000
	H6: The real time mortality rate of the particular area improves DTPD..	Accepted	.000
	H7: The most causes of deaths and possible interventions improve DTPD.	Accepted	.003
	H8: The impact of deaths to the family, the street, ward, district and nation improves DTPD.	Accepted	.000
Emigration information	H9: Total immigrants in size and structure in a particular improves DTPD.	Accepted	.000
	H10: The real time emigration rate of the particular area improves DTPD.	Accepted	.000
	H11: The most causes of emigrations and possible interventions improve DTPD.	Rejected	.050
	H12: The impact of emigrants and needed intervention.	Accepted	.002
Immigration information	H13:Total immigrants in size and structure in a particular area improves DTPD.	Accepted	.000
	H14: The real time immigration rate of the particular area improves DTPD.	Accepted	.000
	H15: The most causes of immigration and possible interventions improve DTPD.	Rejected	.090
	H16: The impact of immigrants and needed intervention improves DTPD.	Accepted	.000
Total real time population dynamics information	H17: Total real time human population in the particular area and in the country in size and structure (age, gender, education, disabled and other special need people) improves DTPD.	Accepted	.008
	H18: Real time economic status of particular area.	Accepted	.005
	H19: Real time employment status of the particular area and country improves DTPD.	Accepted	.000
	H20: Real national death rates, immigration and influential factors of causes of deaths, immigration and emigration improve DTPD.	Accepted	.002

As the purpose of this study is to establish unified framework of requirements, the hypotheses in relation to requirements were formulated and tested as shown in Table 2 above. The results of the accepted hypotheses were then used to establish the framework of requirements as shown in Table 6.

Table 6
Framework of Requirements needed for Tracking Population Dynamics

Existing factors	List of requirements captured
Birth information	Total births in size and structure for the particular area. The needed support for the new births. Fertility rate of the particular area. The impact of occurring births and needed real time interventions.
Mortality information	Total death in size and structure in a particular area. The real time mortality rate of the particular area. The most causes of deaths and possible interventions. The impact of deaths to the family, the street, ward, district and nation and needed interventions.
Immigration information	Total immigrants number and structure in a particular area. The real time immigration rate of the particular area. The most causes of immigration and possible interventions. The impact of immigrants and needed intervention.
Emigration information	Total emigration in size and structure in a particular area. The real time emigration rate of the particular area. The most causes of emigrations and possible interventions. The impact of emigrants and needed intervention.
Total real time population dynamics information	Total real time human population in the particular area and in the country in size and structure (age, gender, education, disabled and other special need people). Real time economic status of particular area. Real time employment status of the particular area and country. Real time services needed to the particular area. Real national death rates, immigration and birth influential factors of causes of deaths, immigration and emigration

4.3 Discussion

The purpose of this paper is to establish the framework of requirements needed 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.

4.3.1 Tracked Information Related to Population Dynamics

The findings of this study revealed that tracked information related to birth, death and immigration were found crucial as captured by systems from NIDA, RITA and immigration. For example, the information such as Name, age, gender, birth place, designation and reasons of death were significantly influencing digitalization of tracking human population dynamics. These findings were supported by Bosco et al. (2022) and Wood (2019) who say that in order to track human population dynamics capturing birth, death and immigration related information is vital. For instance study by Bosco et al.,(2022) and Reia et al., (2022) shows that capturing birth,death and immigration information is crucial for tracking human population dynamics.

Furthermore scholars such as (Attafuah et al., 2024) (Wilson et al., 2024) and (Micó, 2022) have identified that Birth, death and immigration information are important requirement components for tracking human population dynamics. However, emigration and local migration requirement components were not identified as the components for tracking human population dynamics. This study has identified that emigration and local migration components should be included as the components of requirements for tracking human population dynamics.

These findings imply that there is a need to restructure the requirements for digitalization of tracking human population based on birth, mortality, immigration, emigration as deemed important. This study goes beyond the existing literature by identifying more components that should be accommodated in tracking human population dynamics that includes internal immigrants and emigrants' information that need to be accommodated. Similarly, this study clearly describes more the mortality, birth and immigration sub components that need also need to be clearly identified in tracking human population dynamics that includes citizens names, age, birth/death place, place of domicile, designation and parents information. Therefore, the information related to birth, death and immigration need to be captured and considered to all organizations for improving digitalization of tracking human population dynamics in Tanzania.

4.3.2 Framework of Requirements for DTHPD

The findings of this study revealed that all hypotheses tested were accepted as the requirements for improving digitalization of tracking human population dynamics in Tanzania as per Table 6 results. The requirements are significantly improving digitalization of tracking human population dynamics. The findings of this study are similar with the findings of Ajibade (2017),Oliaha (2019) and Makinde (2020). For instance, in the findings of this study all requirements from birth information, mortality information, immigration information, emigration information, total real time population dynamics information were found significant to improve digitalization of tracking human population dynamics in Tanzania.

The findings show that there are requirements that contribute to the increase of population in the particular area. Findings show that birth and immigration requirements contribute to identify the increase of population. These findings were similar to Elsby et al.(2024) and Baffour et al.(2023) findings. This study also identifies that mortality and emigration requirements lead to identification of decrease population these findings are similar previous studies of Oliaha (2019) and Salerno et al. (2017).With these requirements hence human population dynamics tracking can be done efficiently and effectively.

Moreover, the hypotheses of the requirements such as “the most causes of emigrations and possible interventions improve DTPD” and “the most causes of immigration and possible interventions improve DTPD” were found insignificant and rejected as the p-value > 0.01. Conversely, the findings of Salerno et al.(2017) and (Torres et al., 2022) argue differently that “the most causes of emigrations and possible interventions improve DTPD” and “the most causes of immigration and possible interventions improve DTPD” are the significant requirements of emigration and immigration which are important to improve tracking of human population dynamics. The difference in the findings of this study and the findings of the previous studies is due to the fact that this study has used heterogeneous samples, large sample size and heterogeneous sampling techniques than in the previous studies. This implies that these requirements serve as the base for implementation of tracking human population dynamics.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The purpose of the current study is to establish the requirements of framework for improving digitalization of tracking human population dynamics in Tanzania. The research was restricted to a total sample size of 187. The results show that the unified requirement of framework significantly affects how well human population dynamics can be tracked digitally in Tanzanian context. Practically; these requirements can be used to develop the digital system that can be used for tracking human population dynamics. When tracking human population dynamics, birth, mortality, immigration, emigration and total real time population dynamics information should be integrated and work together for information sharing in the computerized system.

The findings of this study also demonstrate how the implementation of requirement of framework can significantly impact digitalization of human population dynamics, which have a significant impact on the economic development of the nation. Digitalization of tracking human population dynamics as a new technology needs to constitute integration of various element including birth, mortality, immigration, emigration and total real time population dynamics information for effective and efficient. The government and policy makers are, therefore, anticipated to use requirement of framework as a result of their willingness to pay for prompt, high-quality social services to the citizens. The policy makers through these findings can develop policies that can guide various organizations on using these requirements on developing digital systems on tracking human population dynamics. Similarly, researchers through these findings have gained the new knowledge on the requirements that are important for digitalizing the tracking of human population dynamics.

5.2 Recommendations

To enhance the digital tracking of human population dynamics in Tanzania, it is crucial for government agencies to adopt a unified framework of requirements for tracking human population dynamics that integrates births, deaths, migration and real-time population. Implementing an interoperable digital platform that connects institutions like LGAs, RITA, NIDA and Immigration will streamline data collection and foster institutional collaboration. Alongside this, investments in digital infrastructure, particularly in rural areas and capacity building through targeted training are essential to ensure the system’s sustainability and efficiency.

A robust legal and policy environment must accompany these technical efforts, ensuring data privacy, accountability, and public trust. Addressing current gaps such as the lack of internal migration tracking will significantly improve planning and service delivery, especially in rapidly urbanizing areas. Public awareness campaigns are needed to educate citizens on the benefits and rights associated with digitalization. Finally, leveraging emerging technologies like AI and geospatial tools will enhance the system’s predictive capabilities, enabling more responsive and inclusive governance(AbouZahr et al., 2018).

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