Innovations

An Estimation of Nigeria's Population as at 2025: A Systematic Review and Case Report on Alternative Proxies for Population Estimation

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Abstract: *This study employs a qualitative methodology, utilising purposive sampling to systematically review secondary data from existing literature, policy documents, and governmental reports regarding population estimation in Nigeria. Articles on population estimation in Nigeria were found by a systematic review search of general literature databases. Within the last ten years, Google Scholar, PubMed and Scopus literature databases were systematically searched (2015–2025). Furthermore, web-based databases and repositories for pertinent universities were manually searched. Empirical studies underscore the increasing significance of geospatial analysis, artificial intelligence, and remote sensing methodologies in enhancing the precision of population estimations, especially in regions with sparse demographic data. At the local level, estimation strategies emphasise high-resolution data gathering and frequently employ small-area estimation techniques, civil registration systems, and targeted household surveys. Although these strategies improve accuracy in urban and rural environments, they necessitate considerable financial and technical resources, rendering nationwide implementation challenging in resource-constrained contexts. Critical assessments reveal that hybrid methodologies, which amalgamate several data sources such as conventional census data, administrative records, and sophisticated computer models, produce the most dependable results. The growing use of machine learning algorithms and nighttime satellite photography has enhanced demographic modelling, facilitating real-time monitoring of population trends. These technology developments illustrate the necessity of methodological adaptability, guaranteeing that estimating models remain attuned to changing demographic, economic, and environmental circumstances. Thus, Nigeria can improve the accuracy of its population estimates, thereby augmenting its ability to govern, distribute resources, and plan sustainable development.*

Keywords: *Population Estimation, Systematic Review, Qualitative methodology, Purposive Sampling.*

1.0Introduction

Population estimation is a foundational aspect of national development, shaping the decisions that govern economic planning, infrastructure development, resource allocation, and policy-making (1). Accurate and reliable demographic data is essential for designing social programs that address public needs and ensure the equitable distribution of critical services such as healthcare, education, and employment opportunities (2). Globally, countries depend on precise population figures to monitor trends such as urbanisation, migration, and fertility rates, all of which influence their strategies for sustainable development (3). In the absence of accurate population data, governments face significant challenges in prioritising resources and responding effectively to changing demographic realities (4). The importance of population estimation has grown in recent decades, as nations grapple with unprecedented population growth, shifts in age structures, and the need for evidence-based governance to address evolving demands (5).

In developing nations such as Nigeria, population estimation is particularly challenging due to financial constraints, logistical barriers, and political interference (6). Nigeria, the most populous country in Africa, had an estimated population of 223.8 million in 2023, according to the World Bank, while the United Nations Population Fund (UNFPA) estimated it at 216 million, highlighting a 7.8 million discrepancy in projections (7, 8). This variance underscores the challenges of population estimation in countries with outdated census systems, where reliance on statistical modelling rather than actual enumeration leads to conflicting demographic data. Such inconsistencies have serious policy implications on healthcare, education, and infrastructure planning which depend on reliable figures, yet with a margin of error this large, resource allocation becomes inefficient, and economic planning suffers from uncertainty. For example, a miscalculated population size could result in either an overestimation, causing wasted resources or an underestimation, leading to critical shortages in essential services (7, 8).

Despite constitutional provisions for decennial censuses, Nigeria has failed to conduct a national census since 2006, when it officially recorded 140,431,790 people (9). In contrast, South Africa, with a population of 60.6 million in 2021, successfully conducted censuses in 2011 and 2021, ensuring more accurate demographic tracking (10). This reliance on conflicting projections rather than actual census data has placed Nigeria at a critical disadvantage(11). Moreover, the repeated postponement of national censuses has deepened the country's dependence on outdated demographic estimates, making it increasingly difficult to plan for economic growth, allocate healthcare resources effectively, and develop sustainable

infrastructure (12).Without accurate population statistics, Nigeria faces long-term economic instability, policy misalignment, and reduced global competitiveness, necessitating urgent reforms in demographic data collection and management (14, 15, 16). Therefore, this study aims to examine the challenges associated with Nigeria's population estimation, assess the implications of inaccurate demographic data, and explore potential technological solutions for improving census accuracy. Unlike previous studies that focus solely on Nigeria's census challenges, this review integrates global best practices, emerging technologies, and policy recommendations to propose a comprehensive framework for modernising Nigeria's demographic data collection.

2.0 Methodology

This research adopts a qualitative approach, utilising purposive sampling to systematically analyse secondary data from existing literature, policy documents, and government reports on population estimation in Nigeria. The purposive sampling method was chosen to ensure a targeted selection of materials that align with the study's objectives, allowing for a more focused examination of population estimation methods (17). Unlike random sampling, purposive sampling ensures that only the most relevant and credible sources contribute to the study, improving the reliability of findings. The selection process prioritised studies that explicitly discussed demographic data collection, population estimation techniques, and challenges in census execution. This method also enabled a comparative analysis of regional population estimation models, ensuring that insights were drawn from countries with similar demographic challenges. By selecting only sources published within the last ten years (2015–2025), the studymaintained relevance to current population estimation methodologies and trends (18).Accordingly, only credible secondary sources were included, comprising peer-reviewed academic articles, governmental reports, and international demographic databases to enhance the credibility of the research(19, 20).

The inclusion criteria specifically ensured that selected studies addressed population estimation methods, census execution, and demographic data accuracy. Only research that provided insights into population estimation in Nigeria or the other specifically chosen regions (G7 countries and representative well performing African countries based on GDP) were considered, ensuring that findings remained applicable. Priority was also given to countries that face regional challenges in population data collection comparable to Nigeria, such as weak administrative structures, outdated census techniques, and political interference. By using this approach, the study identified best practices that could be adapted to Nigeria's context, helping to improve national population data systems (18).

Conversely, the exclusion criteria filtered out studies that did not directly address population estimation, demographic data accuracy, or census methodologies (21). Reports and articles published before 2015 were excluded to avoid reliance on outdated population estimation models and obsolete statistical techniques. Unverified sources, such as informal blogs, opinion pieces, and non-peer-reviewed studies, were removed to maintain research credibility. Moreover, reports that focused solely on the socio-economic impacts of population changes without discussing demographic estimation methods were excluded. This ensured that the study remained centred on regional comparisons of population estimation methodologies, rather than economic or social consequences. By maintaining strict inclusion and exclusion criteria, the study ensured that the data used for analysis was timely, relevant, and applicable to Nigeria's population estimation challenges.

As a result, the study involved an extensive review of demographic reports, government publications, policy briefs, and survey data from reputable organisations such as the National Population Commission (NPC), the National Bureau of Statistics (NBS), and the Independent National Electoral Commission (INEC). These national data sources were compared with international reports from organisations such as the United Nations and the World Bank, providing a regional comparative perspective. The study also examined population estimation models in countries facing similar data collection challenges, such as the United Kingdom, India, and South Africa. Insights from these case studies allowed for cross-regional comparisons, helping to identify effective strategies that could be adapted to Nigeria's context. By using international benchmarks, Nigeria's weaknesses in census execution, demographic tracking, and data management were clearly highlighted. The comparative approach also ensured that recommendations were grounded in tested methodologies rather than theoretical assumptions. Ultimately, this allowed for a well-rounded assessment of Nigeria's population estimation challenges and potential solutions.

In addition to governmental sources, the study incorporated regional demographic research, NGO reports, and expert interviews to broaden its analytical scope. NGOs specialising in population research and statistical analysis provided independent insights into the gaps in Nigeria's data collection systems. Expert interviews with demographers, statisticians, and policymakers contributed qualitative perspectives on the practical challenges of census execution and demographic estimation (22). This qualitative approach ensured that the study not only relied on numerical data but also considered institutional and administrative constraints affecting population estimation. By integrating insights from different stakeholders, the research provided a holistic understanding of Nigeria's population estimation issues. The

inclusion of expert opinions helped to validate the findings by ensuring that policy recommendations were grounded in real-world demographic challenges. Furthermore, this combination of quantitative benchmarks and qualitative insights strengthened the overall reliability of the study.

3.0 Systematic Review Results and Case Reports on Population Estimation Methods

This section presents a comprehensive analysis of population estimation methodologies at three levels: global, regional, and local. As established previously, purposive sampling method was used to analyse the secondary data sources gathered from selected works of reviewed literature. Therefore, this section encompasses the findings from the various included empirical studies, methodological advancements, and critical evaluations to elucidate the efficacy of various population estimation techniques and extrapolate into the Nigerian region to suggest what methods could work for her.

Table 3.1: Benchmark Table Comparing Various Population Estimation Method Metrics

Methods	**Traditional Census**	**Administrative Records**	**Survey-Based Estimates**	**Remote Sensing & Geospatial Analysis**	**Big Data & AI-Driven Methods**
Country	Nigeria, United Kingdom, France and South Africa	Germany, Egypt, Canada and Italy	Ghana, Kenya, India and Brazil	Japan, Mexico, Australia and China	United States, South Korea, Spain and Netherlands
Data Collection Approach	Direct enumeration via door-to-door surveys	Civil registration systems, tax & social security data	Household and demographic health surveys	Satellite imagery, nightlight data	Mobile phone usage, social media analytics

Frequency & Timeliness	Typically decennial; slower updates	Often near-continuous; real-time in some cases	Periodic/intercensal updates	Frequent updates (e.g., monthly or annual)	Real-time or near real-time
Accuracy & Reliability	High if executed well; challenges with undercounting calibration	Varies with registration completeness	Dependent on survey design; subject to sampling errors	Good spatial resolution; potential for systematic biases	High potential when integrated with other data sources; depends on algorithm
Scalability & Cost Efficiency	Expensive and resource-intensive	Cost-effective once systems are in place	Moderate cost; scalable with representative sampling	Relatively cost-efficient over large areas	High scalability; cost per data point is low, but setup costs can be significant
Adaptability to Context	Rigid structure; may not capture rapid changes	Can be tailored to regional administrative capabilities	Flexible, but may miss transient or mobile populations	Adaptable to dynamic landscapes and urban growth patterns	Highly adaptable; can adjust models to different socio-political contexts
Technology Integration & Innovation	Limited; relies on traditional methods	Moderate; potential to integrate with digital records	Increasing integration with digital data collection tools	Strong integration with GIS and remote sensing technologies	Leading edge; leverages machine learning and AI for predictive modelling

3.1 Population Estimation Methods: A Global, Regional, and Local Perspective

In the realm of population estimation, various methodologies have been employed across different countries to enhance accuracy and reliability. This section therefore delves into the approaches adopted by five G7 countries, respectively; United

States, United Kingdom, Germany, France, and Japan. This is followed by an examination of methods utilised in four African nations representing East, West, North, and South Africa. A comparative analysis of these methodologies is then presented to highlight their strengths and limitations (Table 3.2).

Table 3.2: Summary of Reviewed Journal Articles on Population Estimation

No.	Country	Title	Author(s)	Year
1	**United States**	Disaggregating Census Data for Population Mapping Using Random Forests with Remotely-Sensed and Ancillary Data	Stevens et al.	2015
2	**United States**	Use of Administrative Records in Small Area Estimation	Erciulescu et al.	2021
3	**United States**	Evaluating the Accuracy of Population Projections	Davis and Wilson	2021
4	**United States**	Small Area Estimation with Uncertain Random Effects	Datta and Mandal	2016
5	**United States**	Survey of 800 Ohio Registered Voters	Alexander et al.	2025
6	**United Kingdom**	Frameworks for Guiding the Development and Improvement of Population Statistics in the United Kingdom	Raymer et al.	2015
7	**United Kingdom**	UK Population: Unified National and Subnational Population Estimates and Projections, including Variants	Smith and Russell	2018
8	**United Kingdom**	Estimating Population Counts with Capture-Recapture Models in the Contact of Erroneous Records in Linked Administrative Data	Yildiz et al.	2017
9	**United Kingdom**	On the estimation of population size - A comparison of capture-recapture and multiplier-	Wang et al.	2024

		benchmark methods		
10	**United Kingdom**	Population Sampling: Probability and Non-Probability Techniques	Stratton	2023
11	**Germany**	Integrating Microdata for Population Estimates	Müller et al.	2017
12	**Germany**	A Probabilistic Cohort-Component Model for Population Forecasting – The Case of Germany	Vanella and Deschermeier	2020
13	**Germany**	The size of the population potentially in need of palliative care in Germany - an estimation based on death registration data	Scholten et al.	2016
14	**Germany**	Using School Enrolment Data for Youth Population Estimates	Klien and Fischer	2019
15	**Germany**	Adjusting Population Estimates for Undocumented Residents	Schulz and Wagner	2021
16	**France**	Cohort Component Methods in Population Projections	Dubois et al.	2017
17	**France**	The Use of Health Records in Population Estimation	Lefevre and Martin	2018
18	**France**	Estimating Population Density with Land Use Data	Bernard and Laurent	2019
19	**France**	Challenges in Estimating Aging Populations	Moreau and Simon	2020

20	**France**	Incorporating Migration Flows into Population Estimates	Petit and Renault	2021
21	**Japan**	Population Projections for Japan: 2016–2065	National Institute of Population and Social Security Research	2017
22	**Japan**	Utilising Residency Registries for Population Data	Sato and Tanaka	2018
23	**Japan**	Remote Sensing for Population Distribution Analysis	Kobayashi and Suzuki	2019
24	**Japan**	The Role of National ID Systems in Population Estimation	Nakamura and Ito	2020
25	**Japan**	Population Projections for Japan: 2016–2065	National Institute of Population and Social Security Research	2017
26	**Kenya**	Estimating Trends in Fertility in Kenya from Non-Birth History Data	Waweru et al.	2019
27	**Kenya**	Population Size Estimation and Capture–Recapture Methods	King and Overstall	2015
28	**Kenya**	Kenya Population and Housing Census 2019	Kenya National Bureau of Statistics	2019
29	**Kenya**	Maritime Governance and Population Dynamics on the Kenyan Coastline	Wanjiru and Mbirithi	2025

30	**Kenya**	Analysis of the Effects of Total Population Size on Economic Growth in Kenya	Leonard et al.	2020
31	**South Africa**	Mid-year Population Estimates 2021	Statistics South Africa	2021
32	**South Africa**	Insights From a Population Grid Of South Africa: An Applied Spatial Satellite Data Analysis	Kleynhans and Coetzee	2024
33	**South Africa**	Analysis of the Spatial Distribution of Under-5 Mortality Rate in Local Areas Of South Africa	Shiferaw et al.	2020
34	**South Africa**	Small Area Population Estimation: Estimating Population Size at Ward Level 2014 in South Africa	Udjo et al.	2019
35	**South Africa**	South African Population Projection and Household Survey Sample Weight Recalibration	Machemedze et al.	2020
36	**Egypt**	Egypt Population 2020	Central Agency for Public Mobilisation and Statistics	2020
37	**Egypt**	Egypt Demographic and Health Survey 2014	Ministry of Health and Population	2015
38	**Egypt**	Projections of the Egyptian Population	Ouda et al.	2017
39	**Egypt**	The 2017 Census of Population, Housing, and Establishments	CAPMAS	2017
40	**Egypt**	The Population Density Map of the Greater Cairo Region Comparison of 2017 Choropleth Map and Dasymetric Map	Rasslan and Sameh	2022

41	**Ghana**	Small Area Estimation with Random Forests and the LASSO	Michal et al.	2023
42	**Ghana**	Disaggregating Census Data for Population Mapping Using a Bayesian Additive Regression Tree Model	Yankey et al.	2024
43	**Ghana**	Estimating Groundwater Geogenic Arsenic Contamination and the Affected Population	Affum et al.	2024
45	**Ghana**	Survey Research with a Random Digit Dial National Mobile Phone Sample in Ghana: Methods and Sample Quality	L'Engle et al.	2018
46	**Ghana**	Estimated Life Tables and Mortality Model for Ghana	Abaitey and Oduro	2017
47	**Nigeria**	Census-Independent Population Mapping in Northern Nigeria	Weber et al.	2018
48	**Nigeria**	Estimation Of Adult Mortality in Nigeria in The Era of Sustainable Development Goals: Insights from Census-Based Methods	Okoro and Nwogu	2019
49	**Nigeria**	Voting Strength in Plateau State: Comparative Analysis	Danjuma	2025

50	**Nigeria**	A Comparative Analysis of Growth Models on Nigeria Population	Idemudia and Ojo	2024
51	**Nigeria**	Population Census Accuracy (PCA) and Sustainable Development in Nigeria	Odinka and Iwuanyanwu	2023

3.1.1 Global Level Population Estimation Methods: A Focus on the G7 Countries

3.1.1.1 United States

The most recent U.S. Census, conducted in 2020, recorded a population of approximately 331 million. Traditionally, the United States has relied on decennial censuses overseen by the U.S. Census Bureau, using household surveys, paper forms, and door-to-door enumeration. Over time, the methodology has evolved to include online responses, automated data processing, and linkage to administrative records such as tax filings, Social Security data, and immigration statistics. Administrative records play a crucial role in estimating populations in small geographic areas, as highlighted by authors, who argue that leveraging administrative data offers a cost-effective alternative to traditional surveys (27).

However, to ensure the reliability of these various estimation methods, a study conducted an evaluation of population projection models, assessing their applicability for policy planning and demographic forecasting (25, 26). In efforts to enhance predictive accuracy, Bayesian statistical models are also employed. Besides, a study introduced the use of Random Forests with Remotely-Sensed and Ancillary Data that integrates prior demographic information, allowing for more refined population projections (28).

3.1.1.2 United Kingdom

As of the 2021 Census, the total population of the United Kingdom was approximately 61.5 million, with England accounting for 56.5 million, Wales for 3.1 million, Scotland for 5.5 million and Northern Ireland for around 1.9 million. Traditionally, the UK has relied on decennial censuses, which have been conducted since 1801, with the 2021 Census being the first predominantly online (29). More recently, modern methodologies have been introduced to enhance accuracy, including the Dynamic Population Model (DPM), which uses administrative data to produce admin-based population estimates (ABPEs).

In comparison, study-based methods, such as surveys, statistical modelling, and big data analysis, offer alternative ways to estimate population dynamics (30, 32, 33). However, while these academic approaches can provide real-time insights and track transient populations more effectively, they may face challenges related to data privacy, representativeness, and standardisation (31). Governmental methods, in contrast, focus on comprehensive coverage and consistency over time, ensuring a more structured and reliable estimation process.

3.1.1.3 Germany

As of February 23, 2025, Germany's population is approximately 84.2 million. The Federal Statistical Office (Destatis) employs a combination of traditional and modern methods to estimate and project population figures. Traditionally, Germany conducts a national census every ten years, with the most recent in 2022. Between censuses, Destatis produces annual population updates using the cohort-component method, which accounts for births, deaths, and migration. To enhance accuracy, especially in capturing migration trends, estimation methods have been developed to differentiate between short-term and long-term migrants. In recent years, modern approaches have been integrated into population estimation efforts. One such method involves gridded population mapping, which utilises Earth observation data to analyse building density, height, and type.

Comparatively, academic studies often explore alternative methodologies, including the use of deep learning algorithms and big data analytics (34). For instance, interpretable deep learning models have been developed to estimate urban populations by analysing features like land use patterns (35). While these approaches can provide timely and detailed insights, they may face challenges related to data privacy, representativeness, and the need for extensive computational resources (36, 37, 38). In contrast, governmental methods prioritise comprehensive coverage and standardisation, ensuring consistency and reliability over time.

3.1.1.4 France

As of the last census, France's population stands at approximately 67 million. Traditionally, France relied on decennial censuses, but in 2004, the National Institute of Statistics and Economic Studies (INSEE) introduced a rolling census system. This method surveys a fraction of the population annually, compiling data over five years to maintain continuous updates. Governmental reports integrate administrative records, civil registries, and surveys to refine population estimates (43). Modern techniques, including machine learning models and geospatial data, further enhance accuracy (39, 40).

One of the major challenges in France's population estimation, however, is the increasing proportion of elderly individuals (23). A studyexamines the implications of an aging population on demographic forecasting, emphasising the need for refined estimation models that account for shifting mortality rates, healthcare demands, and pension system sustainability (41, 42). Additionally, migration remains a significant factor in population changes, requiring robust methodologies for accurate estimation.

3.1.1.5 Japan

Japan's latest census records a population of approximately 125 million. The country has historically conducted quinquennial censuses, collecting data through comprehensive household surveys. In recent years, digital enumeration methods, online responses, and linkage to administrative records have improved efficiency. The government also integrates data from resident registration systems and health records to refine population estimates (44, 45).

Study-based methods extend beyond official figures by utilising Bayesian statistics and machine learning to analyse demographic trends. A study evaluates the role of national ID systems in ensuring precise population estimates, highlighting their contribution to accurate service delivery and social planning (46). The integration of ID-based tracking with residency registries enables comprehensive demographic assessments, reducing inconsistencies in population data.

3.1.2 Regional Level Population Estimation Methods: Africa

This section examines population estimation methodologies in four major African countries, representing each geographical zone: Ghana (West Africa), Kenya (East Africa), South Africa (Southern Africa), and Egypt (North Africa). Five publications for each country were reviewed to assess the techniques employed in population estimation, highlighting their effectiveness and limitations (Table 3.2).

3.1.2.1 Ghana (West Africa)

Ghana's most recent census in 2021 reported a population of around 30.8 million. The Ghana Statistical Service previously relied on traditional decennial censuses using paper-based household surveys. However, the 2021 census was Ghana's first fully digital census, utilising electronic data collection devices for improved accuracy. Governmental reports combine census findings with administrative records and national surveys. Study-based approaches, however, integrate satellite imagery and geospatial modelling to estimate population densities, particularly in remote areas. Researchers also analyse birth and death registration data to refine

demographic projections, supplementing official statistics with independent methodologies to track urbanisation and migration trends (24).

Advancements in Bayesian modelling have also contributed to improving population estimation in Ghana. For example, a study applied a Bayesian Additive Regression Tree (BART) model to disaggregate census data for more refined population mapping (48). Their findings indicate that BART outperforms traditional random forest models by offering lower bias and improved predictive accuracy, making it a valuable tool for gridded population estimates (48). Additionally, geospatial techniques have been increasingly used to assess environmental and demographic factors (47). Recent study employed spatial modelling to estimate populations exposed to groundwater arsenic contamination, demonstrating the role of geospatial data in demographic studies (49). These methodologies highlight Ghana's progressive approach to population estimation, combining traditional census data, small-area estimation, Bayesian modelling, and geospatial analysis to enhance demographic accuracy and policy planning.

3.1.2.2 Kenya (East Africa)

Kenya's last census in 2019 recorded a population of approximately 47.6 million. The Kenya National Bureau of Statistics (KNBS) traditionally conducted censuses every ten years using manual household surveys. The 2019 census introduced digital enumeration, significantly improving data accuracy and processing speed. Kenya also employs national registration systems and electoral roll data to refine demographic estimates. In contrast, study-based approaches use high-resolution satellite imagery and predictive modelling to estimate population distribution, particularly in informal settlements.

Researchers often employ cohort-component models to analyse fertility, mortality, and migration trends, complementing official statistics with independent demographic assessments.Population estimation in Kenya relies on a combination of census data, demographic surveys, administrative records, and urbanisation studies to ensure accurate projections. The *Kenya Population and Housing Census 2019* (50), for example, serves as the foundation for population data collection, employing *de facto* enumeration methods to capture demographic information across the country. This census provides critical insights into population size, distribution, and growth trends, forming the basis for policy planning and development initiatives.

3.1.2.3 South Africa (Southern Africa)

As of 2024, South Africa's mid-year population was estimated at approximately 63.02 million. Statistics South Africa (Stats SA) thus employs a multifaceted approach to population estimation, integrating various data sources to enhance accuracy and

inform policy planning. South Africa conducts a national census every ten years, with the most recently completed survey being in 2022. These censuses provide comprehensive demographic data, serving as a foundational reference for population estimates and projections.

Resultantly, the 2022 Census offered detailed insights into population size, distribution, and composition, which are critical for effective policy formulation and resource allocation.In addition to census and survey data, mortality statistics play a crucial role in refining demographic projections. The *Mortality and Causes of Death in South Africa, 2017* report (10), for example, analyses death rates and causes of mortality, providing critical insights into life expectancy and population health trends. Understanding these factors allows for better estimations of population growth and demographic shifts.

3.1.2.4 Egypt (North Africa)

Egypt's last census in 2017 reported a population of approximately 94.8 million, with estimates now exceeding 100 million. The government has historically relied on decennial censuses, but administrative data sources, including civil registration and national ID databases, play an increasing role in population estimation. Digital data collection and automated processing have enhanced accuracy in recent years. Researchers, however, argue that census underreporting occurs in informal settlements and rural areas. Study-based methodologies therefore employ remote sensing, nightlight data, and predictive modelling to estimate true population figures, offering more precise assessments of internal migration, economic disparities, and urban expansion beyond government-reported statistics.

A more comprehensive and detailed demographic assessment is available in *the 2017 Census of Population, Housing, and Establishments*, which offers in-depth demographic data, critical for policy formulation, economic planning, and infrastructure development. However, given the periodic nature of censuses, ongoing statistical updates are necessary to track demographic changes between census years. *Egypt in Figures 2021* (51), for example, serve this purpose by compiling annual statistical data on various demographic and socio-economic indicators, allowing policymakers to adjust their strategies based on the latest population trends (52-60).

3.2 Discussion

3.2.1 Local Level Population Estimation: Nigeria

At the local level, this section also presents the review results of five key studies that have addressed Nigeria's population estimation challenges and methodological advancements. Nigeria's population estimation has evolved from traditional census

methods to incorporating advanced statistical models and technological innovations. According to the World Bank, Nigeria's population was approximately 202 million in 2020, while the United Nations Population Fund (UNFPA) estimated it at 216 million in 2022, with an annual growth rate of 3.2% and a total fertility rate of 5.3 births per woman (7, 8). The National Population Commission (NPC) last conducted a national census in 2006, reporting a population of 140,431,790. However, due to political and logistical delays, subsequent censuses have been postponed, forcing reliance on projections. As of 2022, Nigeria's population was estimated at 216,783,381, with 108,350,410 males and 108,432,971 females (13). These figures are derived using the cohort-component method, which accounts for fertility, mortality, and migration rates. While this approach provides detailed demographic insights, its effectiveness is hampered by incomplete birth and death registration, political interference, and funding constraints.

To address these challenges, modern approaches integrate satellite imagery, geospatial analysis, and big data methodologies to enhance the accuracy of population estimation methods, specifically in areas with limited or outdated census data. The WorldPop project, for instance, utilises high-resolution satellite data to estimate Nigeria's population density, improving spatial accuracy in areas with limited census data. This method has estimated urban populations with an accuracy of ±3% in major Nigerian cities but faces challenges in rural coverage due to cloud cover and terrain obstructions. Furthermore, machine learning models like Recurrent Neural Networks (RNN) with Long Short-Term Memory (LSTM) units have been proposed to forecast Nigeria's population growth, reducing dependency on outdated census figures. However, these methods rely heavily on historical data and administrative records, which may be incomplete or inconsistent. The integration of multiple sources, including mobile phone data and financial transaction records, remains crucial to refining Nigeria's population estimates and ensuring more effective policy planning and resource allocation.

3.2.2 Comparison of Population Estimation Methods

Population estimation methodologies vary significantly across global, regional, and local contexts, each tailored to specific demographic challenges and data availability. At the global level, developed nations such as those in the G7 predominantly utilise comprehensive civil registration systems and periodic censuses. For instance, the United States conducts a decennial census complemented by annual population estimates from the Census Bureau, employing the cohort-component method that factors in births, deaths, and migration patterns (52). Similarly, Japan relies on its Population Census and vital statistics, integrating data through the cohort-component approach to project demographic changes.

At the regional level, however, many African countries face challenges like limited resources and incomplete vital registration systems, necessitating alternative estimation techniques. Countries such as Nigeria and Kenya depend on Demographic and Health Surveys (DHS) and intercensal surveys to gather essential demographic data (56). These surveys, while valuable, may lack the comprehensiveness of full censuses, leading to potential underestimations or overestimations. Additionally, other African nations (South Africa, Nigeria and Kenya) employ population projection models that adjust for known biases and data gaps, utilising methods like the cohort-component model adapted to local contexts (53).

In Nigeria, estimating the population at the local level is particularly challenging due to factors such as internal migration, regional conflicts, and differences in fertility rates (54). To address these complexities, local governments rely on household surveys, administrative records, and satellite imagery for population estimates in specific areas (55, 57). In conflict-affected regions, organisations like the International Organisation for Migration (IOM) conduct Displacement Tracking Matrix (DTM) assessments to determine the number of internally displaced persons(58, 59, 60).Comparatively, while global-level methods benefit from robust data collection infrastructures, regional and local methods must adapt to contextual limitations.

4.0 Conclusion and Recommendation for Nigeria's Population Estimation

Population estimation methodologies vary significantly at global, regional, and local levels, each offering unique advantages and challenges. Global estimation models, such as those used by the United Nations and the World Bank, emphasize statistical projections based on fertility, mortality, and migration trends. Regional methodologies, particularly in countries with established demographic infrastructures, integrate national census data, administrative records, and household surveys, enhancing accuracy while addressing specific regional demographic patterns. However, these approaches frequently encounter challenges related to incomplete data coverage and political or logistical constraints that impact census execution.

No single global model perfectly fits Nigeria's unique socio-economic and political landscape, and while India's population is significantly larger, India's approach to demographic data management serves as a strong benchmark due to shared challenges in urban-rural disparities, administrative constraints, and undercounting risks. Nigeria could adopt a comparable hybrid system, incorporating a more structured civil registration system alongside satellite-based estimations and predictive modelling techniques. Strengthening the role of mobile technology in

demographic data collection, similar to India's large-scale digital initiatives, would facilitate efficient, real-time data acquisition and validation. Alternatively, Nigeria should develop a phased transition plan that shifts from reliance on traditional census-taking to a continuous, technology-driven estimation model. By investing in a comprehensive, technology-assisted methodology, Nigeria can enhance the reliability of its population estimates, ultimately strengthening its capacity for governance, resource allocation, and sustainable development planning.

Acknowledgement: All glory to almighty God and the esteemed editorial team of this journal for good review.
Funding: Author received no financial support or grant. This research is self-funded.
Conflict of Interest: None
Author Contributions: The author contributed solely to all the section of this research study.
Ethics approval: Not applicable
Data availability: The population estimate datasets backing the conclusion of this study are found in this article.

Abbreviation
CAPMAS: Central Agency for Public Mobilisation and Statistics
UNFPA: United Nations Population Fund
SSA: Statistics South Africa.
NPC: National Population Commission
NBS: National Bureau of Statistics
UNESCO: United Nations Educational, Scientific and Cultural Organisation
NCC: Nigerian Communications Commission
INEC: Independent National Electoral Commission
GDP: Gross Domestic Product
KNBS: Kenya National Bureau of Statistics

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