ISSN 0024-5623

Local Government Quarterly

July - September 2024

A Journal of the
All India Institute of Local Self-Government

- ★ Cities and Climate Change Issues
- ★ Population Measures, Methods and Applications: Life Expectancy of Top 10 World Populous Countries
- ★ Waste Management Problems in Nigerian Urban Cities
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About All India Institute of Local Self-Government (AIILSG)

All India Institute of Local Self-Government (AIILSG), established in 1926 has been actively working in the field of urban development management and is a diligent partner in promoting the cause of local governance in India and overseas.

The Institute has been the steadfast friend, philosopher and guide to Urban Local Bodies (ULBs) across the Country. For more than eight decades it has contributed to the principles and practice of urban governance, education, research and capacity building. It has designed and developed a vast array of training literature and courses and trained more than 1.5 million stakeholders in diverse areas of urban governance and urban services delivery.

These activities of the AIILSG are practiced through 30 regional centres located in different regions of the Country. The Institute anchors the Regional Centre for Urban and Environmental Studies (RCUES) of the Ministry of Urban Development, Government of India for Western India region. This Centre is actively involved in building capabilities of municipal officials, staff and elected members from the States of Goa, Gujarat, Maharashtra, Rajasthan and the Union Territories of Diu, Daman, and Dadra & Nagar Haveli by upgrading their knowledge and skills required for effective administration and implementation of various urban development programmes.

With a view to cater to the growing requirement of ULBs in regard to services, the AIILSG runs specialized capacity building institutions such as the National Fire Academy, the Nrupur Institute of Nursing Science and Research and the Centre for Environment & Disaster Management at Vadodara, PRUDA at Ahmedabad, National Resource Centre for Urban Poverty, International Centre of EQUI-T, the Disaster Management Cell and the Centre of GIS at Pune. It runs the Solid Waste Management Cell of the Government of Maharashtra. In recent years, AIILSG has ventured into rural and tribal capacity building and hand holding of rural institutions of self-governance.

In addition to the domestic activities, the Institute organises several tailor-made capacity building programmes for various countries in South Asia, viz, Bangladesh, Nepal, Sri Lanka and in other regions, including South Africa, Ethiopia, Indonesia, Malaysia, China, etc. The Institute has linkages with renowned international organizations including UNCHS (Habitat), UNDP, UNICEF, UNFPA, WHO, DFID, CITYNET, CLGF, US-AEP and the Ford Foundation. It is the anchor institution for Urban Management Programme (UMP-UNCHS-Habitat) for South Asia.

Vol : XCIV, No. 3 July - September, 2024

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Local Government Quarterly
Published by the
All India Institute of Local Self-Government

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Local Government Quarterly

Printed by Dr. Jairaj Phatak I.A.S. (Retd.), The Director General, All India Institute of Local Self-Government, at Copytronics, Bandra (E), Mumbai - 400 051 and published by him at the All India Institute of Local Self-Government, 11, Horniman Circle, Mumbai - 400 023.

Editorial

Local Self-Government Day

August 31st is observed as Local Self-Government Day. For AIILSG, with is deep-rooted connect with local governance, this day is among the most important ones in its calendar. The Day is celebrated at the Head Office as well as the regional centres of AIILSG prominently.

Urbanisation is a key feature of the development trajectory of the world. Rapid and relentless urbanisation marks the landscape of all countries, more so of those in the developing world. Urbanisation has continued to deliver improved quality of life for citizens everywhere – be it education, healthcare, livelihoods, or leisure. The primary role of leveraging the potential of urbanisation for the benefit of mankind is performed predominantly by local governments. Local Self-Government Day serves to re-emphasize this connect and to enable, support, and empower local governments to perform their tasks effectively.

Along with the opportunities, urbanisation presents challenges too. So much so that the phenomenon seems to have overwhelmed the system sometimes. Meeting aspirations of the migrant populations as well as the native urbans, addressing issues of disparity which are often starkly evident in an urban setting, the unmet needs of urban residents mainly relating to housing, waste management, water supply, etc. are among the challenges engaging urbanists, urban government officials, and elected representatives. AIILSG has continued to work closely with urban local bodies, empowering them and fostering collaboration among ULBs across cities, states, and regions. AIILSG has worked with them to leverage the potential of the national urban rejuvenation missions like Swachh Bharat Mission, Smart Cities Mission, AMRUT, and HRIDAY, and deliver the intended benefits to citizens in a substantive manner.

As in the urban setting, local self-government in the rural and tribal setting is also receiving much focus by all sections of society. While the rural landscape hosts

a larger proportion of our country's population, there is disparity vis-à-vis their urban counterparts in terms of physical and social infrastructure, amenities, incomes, etc. AIILSG has been working with the rural and tribal populations in various parts of the country including through its CSR platform for the upliftment of these populations, especially the more marginalized and disadvantaged sections. This work covers a wide spectrum - literacy and education, healthcare including women's reproductive health, women's empowerment, etc.

Alongside the Local Self-Government Day, we saw, during this time another landmark event – the Tenth Anniversary Celebration of AIILSG's magazine Urban Update. During these ten years Urban Update has worked to bring information, knowledge, and insights from across the globe to urban practitioners, local government officials, elected representatives, and others. It has also devised and implemented various initiatives to bring together urbanists to enable exchange of thoughts, ideas and experiences. The Urban Dialogues series in various cities is one such intervention. These efforts have been acknowledged by a cross-section of stakeholders as valuable and enriching. Alongside, AIILSG and Urban Update have worked to highlight the need for sustainable urbanisation in India. While cities have been working to fulfill the aspirations of city-dwellers, issues of water security, air quality, effective waste management, road safety & congestion, community security, etc. have come to the fore.

We believe that all needs of cities and citizens must be fulfilled in an inclusive, yet sustainable manner. The dangers of climate change are already well upon us and have begun to disrupt lives and livelihoods in various parts of the country. Extreme precipitation, and prolonged droughts have been threatening people for some years now. Loss of green cover and bio-diversity is an equally grave issue. Their outcomes like floods, landslides, and water crises can be felt across the country. The tragic landslide in Wayanad and in some northern states have highlighted the fragility and vulnerability of some regions like the Western Ghats ecosystem and the hill regions of the North. Experts opine that anthropogenic activity including overexploitation of the hill regions for tourism related infrastructure is responsible to a great extent for the damages. The condition of the ocean system along India's vast coastline is also cause for concern. Here too, extensive tourism has likely resulted in unsustainable exploitation of nature's bounty. These issues will present significant challenges to local governments of cities and towns in hills and along the coastlines.
AIILSG is working with the local governments everywhere in embedding sustainability in their initiatives and interventions. There have been targeted efforts in the area of waste management for example, using the principle of 'refuse, reduce,

reuse, repurpose, recycle.' This along with 'Segregation at source' is the preferred and sustainable solution to the mounting problem of waste and its management. Innovation needs to be at the heart of the efforts while also working to create awareness among the populations. This is obvious, yet complex. AIILSG's International Center of EQUI-T too has joined hands with corporates to leverage and synergize with the Corporate Social Responsibility (CSR) framework to put in place a more benign lifestyle. The work extends across the urban-rural landscape in various dimensions including empowering the disadvantaged populations, gender justice, climate resilience and disaster risk reduction.

We believe that Local Self-Government Day is an opportunity each year to rededicate ourselves to the cause of sustainable living on the planet. We shall renew and fortify our efforts with each passing day to build an inclusive and safe world for all. In our efforts we shall look forward to the support and cooperation of all our well-wishers.

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Cities and Climate Change Issues

V. Gnaneshwar

Abstract

Since ancient times human civilizations thrived in cities standing as landmarks of civilized life, art and culture. In modern times, cities are growing as major centers of industry and business attracting all superlatives of development. The mind boggling urban sprawl, booming economic activities and rapidly growing population are characteristics of modern cities. Today we take pride in the economic contribution of cities but they depict a contrasting picture especially in the developing countries. At one end, one witnesses appalling living conditions lacking minimum civic facilities, slums, haphazard growth, transportation blockades and severe flooding. At the other end, the modern cities have an attractive skyline, flowing wealth and vibrant life. On the environment side, if high densities and concrete buildings are producing severe heat waves, mushrooming industrial, transport and building activities are releasing harmful greenhouse gasses contributing to global warming. Increasing pollution levels have become a public health threat. In recent years, cities are experiencing extreme weather events like severe heat waves and flooding resulting in huge economic losses and disruption of public life. The critical issue is urbanization has become inevitable due to population explosion, specially in some developing countries while cities are becoming environmentally unsustainable. This paper examines the role of cities in climate change, and discusses the impacts of climate change on urban life and the emerging issues and potential solutions.

1. Introduction

Industrialization and urbanization are the two major spectrums of modern societies, if the former represents economic dimension the latter concerns spatio-demographic

dimension. In the development context, industrialization and urbanization are happening in a closely connected way. On the positive side they are key players in the modern development process but on the negative side both have environmental implications. The major environmental issue is their contribution to climate change issues like global warming and pollution. If increasing greenhouse gas emissions are contributing significantly to global warming concerns, the gasses like carbon monoxide, nitrogen oxide and sulfur oxide and their compounds pollute the atmosphere causing public health issues. The WHO reported that globally 4.2 million premature deaths were reported in 2019 due to ambient/outdoor air pollution across the world. The 2019 global statistics brought out that of 4.2 million, 37 percent of deaths were due to Ischemic heart disease and stroke, 18-23 percent were due to chronic obstructive pulmonary disease and acute lower respiratory infections and 11 percent due to cancer within the respiratory tract. Further, 89 percent of these deaths occurred in low and middle income countries (WHO, 2019)[1]. At the other end, increasing global temperatures led to extreme weather events causing huge shelter and economic losses. This paper, while examining the role of cities and other urban areas in climate change and global warming, discusses the consequential impacts and probable solutions.

2. Urban Population Explosion

The global population in general has been witnessing fast growth during the last 4-5 decades. The world population was 1 billion in 1800 which grew to 2 billion by 1927 in 127 years; in the next 33 years it was 3 billion by 1960, and it grew to 4 billion by 1974 in 14 years, and it doubled to 8 billion by 2022 in 48 years. The future estimations indicate that the population will reach 9 billion by 2037, 10 billion by 2050 (WIKIPEDIA)[2]. Countries like India are growing very fast and in 2023 it overtook China's population by registering about 1.4 billion. As the population grows, more and more people migrate to urban areas in search of employment and services leading to urbanization rise. In the post industrialization periods, the urban shift was gradual. With the rapid growth of the global population, the pace of urban growth also increased. In the industrialization period, urban growth was predominant in the developed countries which are now mostly urbanized. The urban growth has picked-up fast in the developing countries especially in the Afro-Asian regions in tune with population growth. The pace of global urban population increase has been phenomenal. For instance, the world urban population was 1 billion in 1959.

[1]WHO (20022), Ambient air pollution, 19 December, https://www.who.int.
[2]WIKIPEDIA, Population growth, https://en.wikipedia.org

It took 26 years to reach 2 billion in 1985, 17 years to reach 3 billion in 2002 and just 13 years to reach 4 billion in 2015. It is already 4.5 billion now and is expected to increase to 5 billion by 2028 and 6.6 billion by 2050. In the future almost every decade will be adding one billion. Further, urban population which was 55.3% in total population in 2018 is expected to increase to 60% by 2030 and 68% by 2050 as per UN estimations. Further, the UN reported that the developed world has only 23.6% of world urban population as against 76.4% in less developed countries in 2018, which is estimated to increase to 79.7 by 2030. If the above trends reveal the pace of urban growth, the more complex problem is the intensity of urban growth. Rapid urban sprawl is leading to growth of mega cities engulfing the peripheral semi-urban settlements. Of the world's urban population, 42.1% is living in 548 million plus cities. Further, 12.5% are living in 33 mega cities of over 10 million population distributed across 20 countries (UN, 2018)[3]. This speaks of the level of urban concentration occurring in the world.

China and India are experiencing heavy urban population pressure due to fast population growth in recent decades. The urban growth trend in India indicates that the urban population which was 78 million in 1961 increased to 377.1 million by 2011 that is, doubling in each decade on an average. The critical factor is net decadal addition of urban population which rose from 30 million in 1971 to 91 million by 2011. The census operations are not conducted in 2021 due to COVID outbreak. But the estimations indicate that the urban population was 498 million in 2021and 508 million in 2022. Since 2019, it was observed that the urban population growth was about 2 percent per year due to cumulative effect of migration and natural population growth (Macrotrends)[4]. In the earlier periods, urbanization was gradual hence, the cities were developed with great foresight and good infrastructure facilities. But, the pace of urban growth has been rapid in developing countries over the past 50-60 years. The civic administrations could not meet the growing demands of the people. As a result, communities were developed in unplanned, congested and haphazard ways lacking basic civic infrastructure and facilities. Over a period such areas have become vulnerable to natural disasters. These areas are prone to more flooding and civic disruptions causing problems to the people.

3. Contribution of Cities to Global Warming

Urbanization involves not just a population shift from rural to cities and towns but a radical change in the occupational pattern of the people from

[3]UN (2018), World Urbanization Prospects, p 11,13,58.
[4]Macrotrends , India Urban Population - 1960-2024, https://www.macrotrends.net

agriculture to non-agricultural occupations in the industrial and innumerable service sectors. Urbanization changes the entire spatial landscape and way of life called urbanism. The problems of rapid urbanization like slums, transportation bottlenecks, shelter, civic service and infrastructure issues are widely discussed but the aspect concerning the role of cities in global warming is also receiving attention in recent years.

The discussions on global warming primarily boil down to the increasing greenhouse gasses in the atmosphere. Greenhouse gasses in simple are the gasses that have the property of absorbing infrared radiation that is heat energy, emitted from Earth's surface and reradiating it back to earth's surface[5]. Major greenhouse gasses are carbon dioxide (CO2), methane (CH4) and water vapor, while nitrous oxide (N2O) and other fluorinated gasses are lesser contributors to greenhouse effect. Because of the nature of absorbing and redirecting heat energy onto the earth, increased greenhouse gasses contribute to global warming. Warming in general understanding is heating-up of the Earth. The methane greenhouse gas on the other hand is 84 times more powerful than CO2 by contributing to air pollutant ozone (WHO)[6]. The water vapor, carbon dioxide, methane, black carbon, nitrous oxide and ozone intercept the process of flow of heat emitted by the earth to space back to the tune of 83 percent on an average. Within these, water vapor is the most significant gas in the atmosphere which accounts for more than 90 percent of the atmosphere's ability to intercept heat. The next is carbon dioxide which is almost the same all over the globe unlike water vapor, which accounts for about 7 percent of the atmosphere's ability to intercept heat (Steven E. Koonin, 2021)[7]. Black carbon is the sooty black material emitted from the incomplete combustion of fossil fuels, biofuels, and biomass like wood burning. As an air pollutant it affects the health of the people creating public health problems. Due to the ability of the black carbon to absorb light as heat, it warms the air thereby contributing to changes in the patterns of rain. Further, this heat absorption quality also can cause melting of the polar ice (EPA)[8]. In comparison to CO2 which lives in the atmosphere for hundreds of years, the nitrous oxide, methane and black carbon are considered short lived particles in the atmosphere. Of these, the nitrous oxide lives in the atmosphere for about 114 years followed by the methane gas which exists in the atmosphere for about 12 years while the black carbon very short lived existing just for some days. Though methane and black carbon are short lived climate pollutants, their global warming potential is greater than CO2. In the urban setting, CO2,

[5]Michael E.Mann, Greenhouse gas, Britannica, December 11, 2023, britannica.com
[6]WHO, Pollutants not only severely impact public health but also, but also the earth's climate and ecosystems globally, https://www.who.int
[7]Steven E. Koonin (2021), Unsettled, Ben Bella Books.
[8]Environmental Protection Agency (EPA), Black carbon research and future strategies, https://www.epa.gov

methane and black carbon are the major GHGs.

Warming in general understanding is heating-up of the Earth. The official global temperature measurements are just 100-125 years old. NASA started satellite based measurement of global temperature in 1979 which are considered much more accurate. The effects of overheating the globe are many, one leading to the other, as life on the Earth is an interrelated and interconnected system. These interconnected processes are broadly discussed under the broad umbrella of climate change. Several human activities like agriculture, industries, building and transport contribute to GHG emissions by using energy which is largely produced by fossil fuels. The burning of fossil fuels produces greenhouse gasses which in turn lead to global warming. As populations and their activities increase, the threats of GHG emissions, global warming and the related climatic issues continue until radical changes occur in the energy production and use. The crucial aspect here concerns the role of cities in the increasing GHG emissions.

The urban areas across the world are the centers of economic activities as they contribute to 80 percent of the global GDP. By these activities, cities are contributing to higher energy consumption. As bulk of the energy is produced by fossil fuels today, the urban areas also contribute to higher GHG emissions. For instance, the International Energy Agency estimated that the cities account for 75 percent of the global energy consumption, thereby contributing to about 70 percent of global GHG emissions and these figures are expected to increase unless radical changes take place in the energy production and use in future. Interestingly, 10 percent of the increase in global GHG emissions since 2015 is attributed to urbanization. The statistics also reveal that despite huge consumption of energy by cities, about 100 million people are living in cities without access to electric grid energy, and more than 90 percent of areas are located in Sub-Saharan Africa which is the fastest urbanizing region of the world (IEA,2021)[9].

In the urban environment, bifurcating each sector to calculate its contribution to energy use and GHG emissions is a bit difficult as each sector affects the other sector. In general, building and transport sectors are the major contributors for the GHG emissions. The carbon footprint of the buildings reveals that building and the construction sector account for 36 percent of the global energy consumption thereby contributing to 39 percent of energy related carbon dioxide emissions (CURBED, 2019)[10]. Building related emissions could be in two major ways - first is day to day

[9]IEA (2021), Executive summary-Empowering Urban Energy Transitions, https://www.iea.org
[10]CURBED (2019), How do buildings contribute to climate change?, September 19, archive.curbed.com

operation of lighting, heating and cooling areas, and the second is related to building material manufacturing, transporting building materials to construction sites and actual construction process, all called embodied carbon. Globally the building operations account for 28 percent of carbon emissions and the embodied carbon account for 11 percent of emissions. To limit global warming to 1.5 degrees Celsius by 2030, the energy use by the building sector must be reduced by 30 percent. Unfortunately, the energy use by the building sector is increasing due to rapid building construction activity across the globe to meet the housing needs of increasing populations. As per the Paris Agreement, the buildings must meet the net zero carbon emissions by 2050 but, not even one percent of the buildings are considered net zero carbon today according to the World Resources Institute (CURBED)[11].

Transport is another important sector contributing to energy use in cities and towns. The level of economic activities in cities, the spatial distribution of economic and residential activities, number and types of vehicles, extent of personal transport, public transport infrastructure, energy efficiency of vehicles, densities, etc. are the main factors that decide the levels of energy consumption. Use of outdated vehicles and older vehicles involves more fuel consumption. Inadequate and inefficient public transport systems compels people to depend on private transport while longer distances between workplaces and residences due to urban sprawl involves more energy consumption. All these factors add-up for higher energy consumption in cities. Generally people and governments are more concerned about local pollution generated by urban transport as it affects people's health but give lesser importance to its contribution to global warming and climate change issues. Even on pollution concerns, if the governments take appropriate policies to reduce fossil fuel consumption in the transport sector, it will indirectly help in reducing the GHG emissions at the global level. It is estimated that transport sector globally contributes about one-fourth of all energy related greenhouse gasses (UNEP)[12].

Much of the industrial development has taken place in urban and semi urban areas in the world. Historically, industrialization has been the main driving force for urbanization across the countries. Industrial establishments in cities and towns also contribute to considerable GHG emission as the industries consume considerable energy. The urban energy sector is the major GHG contributor by way of CO2 emissions. The urban landfills on the other hand are the

[11]CURBED, op.cit..
[12]UNEP, Transport, https://www.unep.org

major sources for release of the methane gas, one of the important GHG gasses having GHG and pollution implications.

4. Impacts of Global Warming in Cities

Extreme weather events and sea level rise are the major impacts of global warming and climate change. People both in urban and rural areas suffer from the emerging natural calamities. Every year hundreds and thousands of people are affected by rising sea levels, increase in precipitation, floods, severe cyclones and storms, and periods of extreme heat and cold across the globe. The phenomenon of extreme weather events is a much talked and discussed aspect in recent years. In India too, the million plus cities are growing fast in numbers and their populations. Some cities like Delhi, Mumbai, Bangalore and Hyderabad are prone to flash floods which have become common in recent years. In Indian cities, people encroach upon the tanks and water bodies and develop these as living areas. Such areas become more vulnerable to floods. Even small flooding makes these areas horrible creating several disruptions to normal life.

Sea levels rise due to warming of the ocean surface temperatures and melting of the polar ice. It is estimated that the Earth is now losing 1.2 trillion tons of ice each year as per the American Association for the Advancement of Science. As the ice melts and mixes with seawater, the sea levels will rise creating problems in cities and towns. It is estimated that 100 percent of urban population in Guyana, Maldives, Belize, and 81 percent of Thailand and Bahrain urban populations live at elevations lower than 10 meters above the sea level. Further, the Center for Earth Science Information Network under Columbia University, estimated that more than 10 percent of the world population lives in urban or semi-urban areas of less than 10 meters above sea level. These cities are at risk whenever severe floods occur. (Roubini N, 2022)[13]. The UN estimated that about 90 percent of million plus cities are located in coastal areas (UNEP)[14].

Large cities like Mumbai are found to be most vulnerable. A study of climate change impacts in the world's port cities identified Mumbai as the most risky coastal city due to its geographical situation and very high population (Hanson et al, 2011)[15]. For example, July 26, 2005 floods recorded 994 mm rainfall in 24 hours explains the extent of vulnerability in Mumbai. This apart, the city is vulnerable to rise in sea levels due to its geographical location surrounded by sea water. In Mumbai the soil erosion is also high especially in the northwest beaches.

[13]Roubini Nouriel (2022), Megathreats, Little Brown and Company, p 219,220, 221.
[14]UNEP, Cities and Climate Change, https://www.unep.org
[15]Quoted in R. Mani Murali, Riyas MJ, Reshmas KN, Santosh Kumar, Climate Change Impacts and Vulnerability Assessment of Mumbai City, India, Natural Hazards, Vol 102 (2), 2020, pp 575-589.

Juhu beach which is more popular in the city is also considered the most prone area. The rate of soil erosion was measured at 10.2 m/yr in these areas and it was calculated in study that a total of 2.39 sq Km of area was eroded in 43 years during 1972-2015 period. Miami, USA (Roubini, 2022)[16] is situated on a barrier reef less than seven feet above sea level and is also at high risk. In economic terms, it is estimated that Miami's estimated taxable value of assets of real estate at risk exceeds $ 20 billion. New York City is 10 meters above sea level yet Hurricane Sandy affected the city in 2012 when flood waters filled several subways, the repair of which took 9 years and cost $ 5 billion. The situation is similar in other US cities like San Diego, Boston, and in other parts of the world.

The climate change impacts result in huge economic, shelter and human losses. For instance, the Natural Resources Defense Council which assessed global economic costs due to climate change found that in four areas namely hurricane damage, real estate, energy and water were about $1.9 trillion every year ((Roubini, 2022)[17]. This estimate is still considered conservative. The Asian Development Bank (ADB, 2014) reported that the climate change effects on India will be about 1.8 percent of the annual GDP of by 2050. Further, India suffered 56 billion dollars due to weather related disasters during 2019 and 2023[18]. In urban areas, the economic damages mostly relate to shelter and infrastructure sectors. Human losses due to these disasters are reported every year.

Apart from the economic losses, the climate change induced calamities could lead to other problems like loss of lives and spread of diseases in urban areas. The WHO considers Climate Change a fundamental threat to human health as 3.6 billion people now live in areas highly susceptible to climate change. Every year thousands of people die due to climate change induced health hazards like storms, extreme heat, floods, drought and wildfires in different countries. The problems are severe in developing countries where the infrastructure systems are weak. These either directly or indirectly are increasing the risks of human loss due to spread of non-communicable diseases, emergence of various infections, and the consequential health emergencies and loss of precious human losses. Another revealing fact is that 37 percent of heat related deaths across the globe are due to climate change. It also predicts that about 2,50,000 additional deaths due to undernutrition, malaria, diarrhea and heat stress alone will be caused by climate change impacts by 2030 (WHO, 2023)[19]. The deaths due to other health conditions would be still higher.

[16]Nouriel Roubini (2022), op.cit. pp, 220, 221
[17]Nouriel Roubini (2022), op.cit. pp, 229, 230
[18]Asian Development Bank (2014), Assessing the Costs of Climate Change and Adaptation in South Asia, June, https://www.adb.org
[19]WHO (2023), Climate Change, 12 October, https://www.who.int

5. Adaptive Approach to Climate Change

The global agencies like the UN and its organizations are giving top priority to the climate change issues. Global targets like net zero carbon emissions are devised and their implementation progress is being assessed and reviewed annually. The governments at their level are trying to implement these goals in a targeted manner. All the economic sectors including agriculture, industry, building and transportation including the urban sector must prepare action plans and implement time-bound programmes. The developing countries are in an advantageous position to deal with the climate related issues and problems but the poorer and developing countries have to struggle as they lack necessary technological expertise and financial resources. Apart from this, every country has specific issues like population growth, poverty, unemployment, etc. to deal with. Despite these limitations each country has to move forward.

In the urban sector, the key issue is conceptualizing the net zero emissions at the city level in practical terms. The first constraint is that the inventory data at the city level is often not available. Another problem relates to the smaller spatial scale and embeddedness within larger-scale social, ecological and infrastructural systems at the city level. Further, urban economic and energy systems depend on long-distance exchanges. Therefore, accounting for transbounding carbon flows is challenging for considering the city as an analytical unit for carbon measurements (UN-HABITAT, 2022)[20]. In this situation, the city level plans must be oriented to achieve the broader national level goals and strategies.

As the cities and towns are facing several climate related disasters in recent years, they should take appropriate adaptive strategies. Urban climate adaptive planning at city level becomes significant at the present juncture of the climate change crisis. The UN-HABITAT recommended urban climate adaptation plans as a mitigation measure to deal with climate change problems. The urban adaptation planning of the local governments refers to designing the strategies and activities to reduce the adverse effects of climate change on natural, built and social systems. Typically the major activities in urban settings include water management, land-use and green infrastructure. It further observed that "a new paradigm is emerging in adaptation planning that recognizes climate change as an ongoing, dynamic phenomenon in contemporary societies requiring multiple actions, feedback and adjustments as the wellbeing of the city

[20]UN-HABITAT (2022), World Cities Report, 2022- Envisaging the Future of Cities, p 142.

entails multiple dynamic processes and a diverse set of actors (UN-HABITAT, 2022)"[21]. As climate change is a dynamic ongoing process involving various sectors, their interconnections must be scientifically studied and understood. Based on this understanding action plans must be prepared at the city level. This may require significant background work and adaptation efforts. Plans to meet the weather extreme events like floods and heat and cold waves must be effectively prepared and kept ready to meet the emergencies any time. The governments also need to take necessary steps to avoid or reduce the effects of natural calamities through comprehensive planning in terms of civic infrastructure, rehabilitation and public health facilities. The central, state and local governments should provide the necessary financial support whenever calamities occur without indulging in politics. The funding arrangements must be made in a sustainable manner apart from crisis management. Normally, the governments act effectively in crisis times but become complacent in normal times. As calamities are unpredictable, sustainable efforts are essential. The adaptation strategy proposed by the UN-HABITAT also entails such an approach.

Habitat planning and building regulations and their effective implementation are vital for development of sustainable communities. In developing countries like India, planning regulations are very lax resulting in haphazard and congested development. Therefore, the civic administration must be strict in implementing the regulations to ensure enough green spaces are provided, tanks and public spaces are not encroached upon and communities are developed in an orderly and environment friendly manner.

Energy is critical in the modern development process and the urban sector is not an exception. Shifting completely to alternate sources like solar energy, wind and other energy is a long term goal. In the meantime, there is a need to adopt an energy efficiency approach to reduce the burden on the present fossil fuel based energy system. The cumulative impacts of long term and short term measures are expected to be more effective and sustainable on both counts-energy consumption and GHG emissions. The ongoing technological innovations focussing on energy efficient products and operations are also expected to provide considerable energy saving leverage. For instance, LED lighting, an energy efficient mechanism, is becoming more popular not only in street lighting but also in homes and offices in developing and developed countries. Another important area to be focussed in urban areas is transport. The number of

[21]UN-HABITAT (2022), 2022, p 159.

vehicles plying on urban roads has been increasing fast contributing to more GHG emissions. Two strategies appear to be useful in the transport sector. One is focusing on energy efficient vehicles and the second is improving public transport to reduce the number of private vehicles on the road. Further, there is much focus on electricity fueled vehicles called EVs today. If more and more people move to EVs, there will be lesser GHG emissions.

There is a need to study the CO2 impacts on major sectors like transport and building and based on the findings solutions must be identified and the necessary target oriented action plans should be prepared in cities. The Drawdown Project (Hawken Paul, 2017)[22] is one such global study. The project team studied the impact of identified solutions in cities and towns across the world for a 30 year period from 2020 to 2050. They categorized the solutions into two broad categories - buildings and cities. The main objective was to find out the savings on carbon dioxide emissions in cities and towns. In the buildings sector, following solutions are identified.

1) Building Automation to control energy use system by adjusting according to the actual need and use;

2) Green Roofs and Cool Roofs installations to reduce the air temperature and the consequential radiation to reduce present cooling loads;

3) Developing and adopting high efficient Heat Pumps to reduce cooling loads;

4) Proper insulation of the buildings to reduce heating loads;

5) Promoting Retrofitting and Net Zero buildings;

6) Installing smart glasses that could control infiltration and emissions of solar radiation; and

7) Installing solar hot water systems to pre-heat or heat water for residential and commercial buildings.

In the city development area, following solutions are recommended:.

1) Augmenting and promoting bicycle commuting;

2) Developing District heating systems which would be distributed to individual buildings in colder regions;

3) Capturing methane gas generated from anaerobic digestion of municipal solid waste in landfills and incineration of the captured biogas to generate electricity. Such projects are already established in some cities;

[22]Hawken Paul (2017), Drawdown, Penguin Books

4) Developing walkable cities by designing and retrofitting building environment to encourage walking;

5) Reducing water leakages and oversupply by efficient systems and management.

The researchers (Hawken Paul, 2017)[23] visualized three scenarios - one, a plausible scenario reflecting incremental development; second, a drawdown scenario indicating optimized results; and the third one is the most optimistic scenario that could achieve the net-zero built environment by 2050. The total reduction in carbon dioxide emissions anticipated globally by implementing the above solutions is 54.50 gigatons in the plausible scenario, 83.33 gigatons in the drawdown scenario, and 102 gigatones in the most optimized scenario. As far as cost considerations are concerned, implementation of all the above solutions in a plausible scenario is expected to cost $ 4,778 billion resulting in a lifetime savings of $17,906 billion. These financial estimations are approximations only. Further, all these solutions may not be applicable or workable in all the cities. To be practicable, solutions should be selected based on the local situations. All these solutions are widely discussed and initiatives already under way. Focus should be on a target based approach to achieve the goals.

6. Conclusion

Today the developing world is witnessing rapid urbanization due to population growth pressure. Urbanization is inevitable in the context of cities becoming prime movers of economic development. If urbanization is inevitable, balanced urbanization is the only long term solution. This cannot be achieved without government intervention. In India, balanced economic development was proposed long ago but the government decisions went in the opposite direction resulting in the concentration of economic growth in a few large urban agglomerations. But this trend appears to be more pronounced across the globe. Due to these, higher population densities, mushrooming industries in and around the cities, concrete building structures, congested living, disappearing green spaces and expanding transportation network have become the characteristic features of modern cities. Increasing commutation in personal vehicles is not only leading to traffic bottlenecks but increased greenhouse gas emissions.

The increasing greenhouse gas emissions by the transportation, building and the industrial sectors in urban areas are contributing to global warming. Global warming is considered the key factor for climate change, extreme weather events and

[23]Paul Hawken, op.cit.

sea level increases. The congested and concrete based buildings are causing severe heat conditions in cities and towns. Rising global temperatures are considered main causes for the melting of the polar ice and warming of the ocean surface. These two factors are making sea levels rise, posing a submerging threat to the coastal cities and regions. Historically, most of the greater cities of the world are located near the seas that facilitate international trade. Over a period such cities grew into large metropolises. The other significant environmental concern is greenhouse gas emissions in cities. Today industries, transportation and building areas are the major areas contributing to greenhouse gas emissions due to their huge consumption of energy which is mostly produced by burning the fossil fuels. Further, due to weather changes cities are experiencing severe hot conditions and flooding caused by unpredictable severe rains. Severe flooding not only disrupts normal life but also leads to huge infrastructural damages involving financial losses in billions to the governments and to people primarily living in the low lying areas and the hilltops. In extreme cases they are also causing loss of precious lives.

It is clear from the above narration that cities, large metro cities specifically, have become environmentally unsustainable. As urban development cannot be reversed, the national and city governments are advised by global agencies to devise adaptive strategies to effectively deal with the severe climate and weather conditions. The problems concerning climate and weather change are global in perspective but their repercussions are local in nature. The situation of the cities and towns is ironic in the sense, they are contributing to the environmental problem significantly and at the same time, cities and their people are impacted and suffering from the same problem. It is hoped that governments, city planners, builders and communities become wiser in the light of the emerging unfortunate weather related problems. Comprehensive target oriented measures as suggested by the global and local experts should be implemented strictly so that weather related calamities could be dealt effectively, and the built environment and life styles in cities and towns become environmentally sustainable and livable.

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Population Measures, Methods and Applications: Life Expectancy of Top-10 World Populous Countries

Manjamuthu Viruthambal Vaithilingam

Abstract

The study of population was dealt formerly with the discipline of demography, which was narrow in scope. Demography is the study of human population in relation to the changes brought about by the interplay of births, deaths and migration, which primarily focusses on what and how many, whereas the population studies is an extension of demography which deals with not only what and how many but also why and how the population changes take place. Population studies cover all the aspects of population behavior. As an area of study, it has benefitted in recent years from the recognition that attempts to understand and explain a community's demography in terms of its economic characteristics have seldom proved successful. Increased attention has been devoted to describing and attempting to model the complexity and contingency of the mutual relationships between economic, social and demographic variables. Population measures, in terms of fertility, mortality, migration and marriage, are more useful practically in understanding the change in the population components and for policy formulation and programme implementation to ensure the desired conditions. As it is important to study the population measures and their practical utility, this study aims to explain the life expectancy and its application in top-ten world populous countries. The results reveal that the average life expectancy at global level is 73 years in 2024. The United States of America stands first with 79 years, and Nigeria stands last with 56 years of life expectancy among the top 10 world populous countries. Monaco stands first with 87 years among the top 10 countries in the life expectancy. The improved health care and advances in medicine; improved hygiene and living conditions; improved lifestyle and exercise; and improved food and nutrition have influenced for the higher life expectancy in the United States of America, Monaco and other countries

with higher life expectancy; whereas, diseases, poverty, unemployment and illiteracy have been attributed as the main causes for the low life expectancy in Nigeria and other countries with low life expectancy. It may be suggested that the policy formulation and programme implementation of the countries with higher life expectancy may be replicated in the countries with low life expectancy.

Keywords: Application, Life expectancy, Methods, Population measures, World populous countries, etc.

1.0 Introduction

Life expectancy is the fundamental indicator and one of the essential terminologies for analyzing the population's economic, environmental, and biological health (Gulis, 2000). Although life expectancy is the concept of the number of years expected to live based on the statistical average (Mandal, 2016), the average life expectancy depends on several factors, as identified by several studies. Low levels of infant mortality, a safe living environment, sufficient provisions, and preventive treatments would also lead to high life expectancy (Reidpath and Allotey, 2003). Senturk and Amjad (2021) stated that environmental degradation, purchasing power, and level of education contribute significantly to life expectancy. Studies also find an undefined positive relationship between life expectancy with short-term democracy (Lin, et. al., 2003). Besides, these variables, income per capita, nutritional intake, literacy rate, number of doctors per 1000 population, and economic globalization were found to have a significant effect on life expectancy (Halicioglu, 2010). Higher income implies better access to housing, education, health care, and other items, all of which lead to better health, lower mortality rates, and longer life expectancy. As a result, it is assumed that aggregate income has historically been a pretty good predictor of life expectancy (Bacci, 2017).

The health status of the people and their life expectancy have improved globally in more or less all the countries of the world irrespective of their socio-economic and demographic conditions. The demographic transition has been a pre-requisite for the health transition. Demographic transition is a description of the observed long-term trends in fertility and mortality, and a model attempting to explain them. In traditional societies, fertility and mortality are high. In modern societies, fertility and mortality are low. In between there is the demographic transition (Demeny, 1972). The health transition is used to refer to the transitions in morbidity and mortality from infectious to non-communicable disease, as a

consequence of medical interventions and improvements in material conditions of living. Anthropologists and other social scientists have illustrated, however, that epidemiological trends are influenced by cultural, social, and behavioral determinants of health (Manderson, 2017).

Until the 1960s, gains in life expectancy were cited as the leading indicator of improving population health. Life expectancy in the United States is defined by the period life tables produced by National Center for Health Statistics, and the trend toward increasing life expectancy is the first health statistic cited in its recent annual report of health in the United States (Hyattsville, 2007). The statistic may be reported in a number of ways. Life expectancy at birth is often taken as an overall measure of population health, because it aggregates mortality rates for all ages. Life expectancy may also be reported as conditional on achieving a specific age or for subsets of the population. For example, the period from 1970 to 2006 saw an increase in life expectancy at birth in the United States from 70.8 years to 78.1 years (Arias, 2007). In 2005, life expectancy at age 65 was 18.7 years; at age 75, it was 12.0 years. Female life expectancy at birth in the United States was 80.4, exceeding male life expectancy by 5.2 years (National Center for Health Statistics, 2007). In 2003 the United States ranked 26th in female life expectancy at birth among 37 selected countries and territories ranging from Japan (ranked 1st at 85.3 years) to the Russian Federation (ranked 37th at 71.8 years) (National Center for Health Statistics, 2007).

Keeping the importance of life expectancy in measuring the health status of the population, this paper discusses the levels and plausible reasons for the higher and lower levels of life expectancy among world top-10 populous countries.

2.0 Literature review

There have been many studies on the levels of life expectancy across the global countries. But very few studies have attempted to unearth the reasons for high and low levels of life expectancies in the world top-ten populous countries. The human life expectancy may be defined as a statistical measure of the estimate of the average remaining years of life at a given age. The most commonly used measure is life expectancy at birth.

Life expectancy can be defined in two ways. Cohort LEB is the mean length of life of a birth cohort (in this case, all individuals born in a given year) and can be computed only for cohorts born so long ago that all their members have died. Period LEB is the mean length of life of a hypothetical cohort (Esteban, 2017; Office for

National Statistics, 2023) assumed to be exposed, from birth through death, to the mortality rates observed at a given year (Shryock and Siegel, 1973). The cohort life table presents the mortality experience of a particular birth cohort—all people born in the year 1900, for example—from the moment of birth through consecutive ages in successive calendar years, the cohort life table reflects the mortality experience of an actual cohort from birth until no lives remain in the group. To prepare just a single complete cohort life table requires data over many years. It is usually not feasible to construct cohort life tables entirely based on observed data for real cohorts due to data unavailability or incompleteness (Shryock, et. al., 1971). For example, a life table representation of the mortality experience of a cohort of people born in 1970 would require the use of data projection techniques to estimate deaths into the future (Moriyama and Gustavus, 1972; Preston, et. al., 2001). The period life table, by contrast, presents what would happen to a hypothetical cohort if it experienced throughout its entire life the mortality conditions of a particular period in time. For example, a period life table for 2020 assumes a hypothetical cohort that is subject throughout its lifetime to the age-specific death rates prevailing for the actual population in 2020. Consequently, the period life table may be characterized as rendering a "snapshot" of current mortality experience by showing the long-range implications of a set of age-specific death rates that prevailed in a given year. In this report, the term "life table" refers only to the period life table and not to the cohort life table. Life tables can also be classified in two ways according to the length of the age interval in which data are presented. A complete life table contains data for every single year of age. An abridged life table typically contains data by 5-year or 10-year age intervals. A complete life table can easily be combined into 5-year or 10-year age groups (Sirken, 1966).

The life tables have their own importance in various fields. Ecologists and demographers (scientists who study human population dynamics) have found life tables useful in understanding patterns and causes of mortality, predicting the future growth or decline of populations, and managing populations of endangered species. Predicting the growth and decline of human populations is one very important application of life tables. As you might expect, whether the population of a country or region increases or decreases depends in part on how many children each person has and the age at which people die. But it may surprise you to learn that population growth or decline also depends on the age at which they have

their children. Another use of life table is in species conservation efforts, such as in the case of the loggerhead sea turtle of the southeastern United States (Crouse et. al., 1987). Generally speaking, the loggerhead population is declining and mortality among loggerhead eggs and hatchlings is very high. These facts led conservation biologists to advocate for the protection of nesting beaches. When these measures proved ineffective in halting the population decline, compiling and analyzing a life table for loggerheads indicated that reducing mortality of older turtles would have a greater probability of reversing the population decline. Therefore, management efforts shifted to persuading fishermen to install turtle exclusion devices on their nets to prevent older turtles from drowning (Donovan and Welden, 2002). A different measure, such as life expectancy at age 5 (e5), can be used to exclude the effect of infant mortality to provide a simple measure of overall mortality rates other than in early childhood. For instance, in a society with a life expectancy of 30, it may nevertheless be common to have a 40-year remaining timespan at age 5 (but not a 60-year one).

The history of life expectancy is studied with the help of the studies of various pioneer demographers. The earliest documented work on life expectancy was done in the 1660s by John Graunt (Glass and Sutherland, 1963) Christiaan Huygens, and Lodewijck Huygens (Johnson, 2021). The life expectancy of human population has increased over a period of time at global level and also in all the countries. However, the level of increase in level in life expectancy varies with the level of socio-economic development, health infrastructural facilities, and environmental conditions in various regions and countries. Human remains from the early Bronze Age indicate an LEB of 24 (MacLennan WJ, Sellers, 1999). In 2019, world LEB was 73.3 (WHO, 2023). A combination of high infant mortality and deaths in young adulthood from accidents, epidemics, plagues, wars, and childbirth, before modern medicine was widely available, significantly lowers LEB. For example, a society with a LEB of 40 would have relatively few people dying at exactly 40: most will die before 30 or after 55. In populations with high infant mortality rates, LEB is highly sensitive to the rate of death in the first few years of life. Because of this sensitivity, LEB can be grossly misinterpreted, leading to the belief that a population with a low LEB would have a small proportion of older people (Laden, 2013). The longest verified lifespan for any human is that of Frenchwoman Jeanne Calment, who is verified as having lived to age 122 years, 164 days, between 21 February 1875 and 4 August 1997. This is

referred to as the "maximum life span", which is the upper boundary of life, the maximum number of years any human is known to have lived (Santrock, 2007). According to a study by biologists Bryan G. Hughes and Siegfried Hekimi, there is no evidence for limit on human lifespan. However, this view has been questioned on the basis of error patterns (Hughes and Hekimi, 2017). A theoretical study shows that the maximum life expectancy at birth is limited by the human life characteristic value δ, which is around 104 years (Liu, 2015).

There are great variations in life expectancy between different parts of the world, mostly caused by differences in public health, medical care, and diet. Human beings are expected to live on average 30–40 years in Eswatini (CIA, 2024) and 82.6 years in Japan (Coale and Banister, 1996). An analysis published in 2011 in The Lancet attributes Japanese life expectancy to equal opportunities, excellent public health, and a healthy diet (Boseley, 2011). The World Health Organization announced that the COVID-19 pandemic reversed the trend of steady gain in life expectancy at birth. The pandemic wiped out nearly a decade of progress in improving life expectancy (WHO, 2024).

Understanding the importance of population health measure of life expectancy, this paper attempts to explain the life table functions under each column with the help of United States Life Table 2022, and examine the life expectancy in world top-ten populous countries and unearth the plausible reasons for their lower and higher levels.

3.0 Major objectives

This study has the major objectives such as: (1) to demarcate the levels of life expectancy among world top-ten populous countries; and (2) to examine the reasons for higher and lower levels of life expectancy in the respective countries.

4. Data and Method

The data for this study were used from (1) World Population Prospects 2024 by Department of Economic and Social Affairs, Population Division, United Nations; and (2) SRS based abridged lifetables 2016-2020 by Office of the Registrar General & Census Commissioner, India, Ministry of Home Affairs, Government of India. Bi-variate analysis has been carried out to realize the objectives of the study.

5. Results and Discussion

5.1 Levels of life expectancy at birth

The global life expectancy at birth is 73 years in 2024. Among the top-ten world populous countries, the values of

life expectancy at birth is highest in the USA (79.25 years) followed by China (77.64 years), Brazil (76.37 years), Mexico (75.57 years) and Bangladesh (73.82 years) are higher than the global average (73.33 years) as compared to Russia (73.12 years), Indonesia (72.50 years), India 70.62 years), Pakistan (67.94 years), and Nigeria (56.05 years) (Figure 1a).

Among the top-ten countries in the life expectancy at birth according to the United Nations ranking, Monaco stands first (87.1 years) followed by Hong Kong (85.9 years), Macau (85.6 years), Japan (85.1 years), Liechtenstein (84.9 years), Switzerland (84.5 years), Singapore (84.4 years), Italy (84.4 years), South Korea (84.2 years) and Spain (84.2 years) (Figure 2a). Among the bottom-ten countries in the life expectancy at birth, Nigeria stands first with the least life expectancy (54.1 years) followed by Chad (54.1 years), Lesotho (55.1 years), Central African Republic (56.1 years), South Sudan (57.1 years), Somalia (58.1 years), Ivory Coast (60.3 years), Guinea (60.7 years), Mali (60.8 years), and Burkina Faso (61.1 years) (Figure 2b).

5.2 Trends and change of life expectancy

As far as the percent change in the life expectancy at birth among the top-ten populous countries during 1951-2024 is concerned, the world stands with 59.4%, in a span of more than seven decades. It has been spelled out more in India (97.3%) followed by Pakistan (92.5%), Bangladesh (88.3%), Indonesia (79.3%), China (78.2%), Nigeria (69.8%), Brazil (57.7%), Mexico (54.7%), Russia (30.5%) and USA (16%) (Figure 1b). All the 9 countries have a gradual and constant increase in the life expectancy, except Russia which has a fluctuation during 1981 to 2001.

5.3 Factors influencing life expectancy

Access to quality healthcare, advancements in medical technology, and improvements in disease prevention, diagnosis, and treatment play a significant role in increasing life expectancy. This includes vaccinations, antibiotics, surgical procedures, and the management of chronic conditions can greatly increase life expectancy of a country or region (United Nations, 2022).

USA: Kosick (2022) states that the United States has higher life expectancy due to improved healthcare and advances in medicine, improved hygiene and living conditions, improved lifestyle and exercise, and improved food and nutrition.

China: The higher level of China's life expectancy can be attributed to technological advancements, a better standard of living, and an increase in healthcare availability (United Nations, 2022).

Brazil: Brazil, being one of the developing nations, the healthcare infrastructure in the country needs significant reinforcement to improve the life expectancy age of the country (Global data, 2021). Greater equity, a more inclusive welfare system, high political participation, strong civil society and access to employment, housing, safe water, a clean environment, and education are attributed for potential structural determinants driving differential performance in population health outcomes including life expectancy in the countries such as Brazil, Ethiopia, and the United States (Freeman, 2020).

Mexico: Technological advancements, better standard of living, increased healthcare availability, birthrate decline, advancements in living conditions, and health care improvements have influenced the higher life expectancy in Mexico (Aguila, et. al., 2012).

Bangladesh: Lower inflation and unemployment rate and higher number of physicians were found to be the factors influencing higher life expectancy in Bangladesh (Atia, 2022).

Russia: Some studies have revealed the reasons for such fluctuation. Mortality trends in contemporary Russia have exhibited wide fluctuations, characterized by periods of improvement and deterioration (Gavrilova, et al., –2000; Shkolnikov, et. al., –2001, –2004). The collapse of the Soviet Union in 1991 was accompanied by a sharp rise in death rates, known as the "post-communist mortality crisis" (Stuckler, et. al., –2009). While mortality rates slightly declined in the middle of the 1990s, they rose again toward the end of the 1990s (Gavrilova, et. al., –2000). Although mortality increased and decreased throughout the 1990s, in recent years, there has been a steady improvement in death rates. Life expectancy has continued to rise for both men and women since the 2000s, and researchers now argue that Russia has finally departed from the past pattern of substantial mortality fluctuations (Shkolnikov, et. al., –2013).

Indonesia: Declining income inequality and poverty, higher income per capita, technological advancements, a better standard of living, and increased healthcare availability have contributed for the improvement of life expectancy in Indonesia (Paramita, et. al., 2020).

India: The life expectancy in India overall seemed to be radically increasing over a period, despite past experiences of the toll of deaths caused by many infectious diseases. The fluctuations in the life expectancy over a period were due to a number of infectious diseases such as HIV and influenza in India (Malaisamy, et. al., 2022).

Pakistan: The food production index, urbanization, birth rate, infant mortality rate, and education have positive effects, while inflation, per capita income, population growth rate, death rate, health expenditure, and CO2 emissions have negative effects on the life expectancy in Pakistan (Azam, et al., 2022).

Monaco: The quality of life and access to care have contributed for the increase of life expectancy in Monaco (Theo Briand, 2024; Monaco Statistics, et.al., 2022; Small, 2023).

Hong Kong: Decline of mortality from infectious diseases, lower mortality from cardiovascular diseases, cancer for females, and transport accidents for males, cardiovascular disease, and lowest absolute smoking have contributed for the increase of life expectancy in Hong Kong (Michael, 2021).

Macau: A well-regulated life-style, allocation of resources and capital to maximize preventive health care, access of free services including vaccination, cancer screening, consultations on how to quit smoking, government's collaboration with non-profit medical institutions, for services including patient transportation, home care, and regular home visits have contributed for the increase of life expectancy at birth in Macao (The Macao News, 2021).

Japan: Japans high life expectancy can be attributed to a combination of factors including their healthcare system, balanced diet, active lifestyle, social support, and reduced smoking rates (Shiina, 2024).

Liechtenstein: Technological advancements, a better standard of living, and an increase in healthcare availability can be attributed for the higher life expectancy in Liechtenstein (United Nations, 2022).

Switzerland: The life expectancy in Switzerland is influenced by government investments in the healthcare system, as well as changes in lifestyle, higher incomes, and better education (International Wealth, 2023).

Singapore: The availability of more health care resources and higher levels of socioeconomic advantages are more likely to increase life expectancy in Singapore (Chan, et. al., 2015).

Italy: Diet and lifestyle choices, universal healthcare system (World metrics) and high healthcare expenditure influenced the increase of life expectancy in Italy (Martina, 2023).

South Korea: South Koreans' longevity can be attributed to a combination of factors such as their healthy diet, active lifestyle, cultural practices, access to healthcare, low smoking and alcohol consumption rates, good air quality, advanced

technology in healthcare, emphasis on education, and strong social safety net, and standard of living (Namhan South Korea, 2023).

Spain: Per capita income, and the rate of hospital beds, medical staff and nurses were found to be impacting on life expectancy at birth in Spain (Cervantes, 2019).

5.4 Factors affecting life expectancy

Nigeria: Diseases, poverty, unemployment and illiteracy have been attributed as the major reasons for the low life expectancy in Nigeria (Nigerian Finder, 2018).

Chad: Genetics, prenatal and childhood conditions, and socio-economic status have been found to be the factors affecting life expectancy in Chad (Globaldata, 2021).

Lesotho: Healthcare and medical advances, socio-economic status, environmental factors, social support and relationships, access to and quality of education, public health measures, and immigration and emigration affect the life expectancy in Losotho (database.earth).

Central African Republic: Life expectancy is low in the Central African Republic (CAR) due towidespread violence and displacement as well as health concerns such as malaria, HIV, and chronic malnutrition (Choi). The top causes of early death and disability in the CAR are diarrhea, neonatal disorders, pneumonia, HIV/AIDS, and tuberculosis (Adetunji, 2018). In addition, more than 40% of the population suffers from chronic malnutrition (World Bank Group, 2023). Violence and displacement of people are also some of the main causes of the low life expectancy (Nayak).

South Sudan: The main causes of low life expectancy are medically based conflicts, poor nutrition (kidney problems), infant mortality and poverty in general. Unfortunately, the life expectancy of recent years is not further known. The 2013-2020 war has exacerbated the problems (African Mission).

Somalia: Several decades of civil war have diminished Somalia's health system and displaced 2.6 million people within the country (World Bank, 2020). The ongoing flooding, droughts, locust plagues, and conflict in Somalia have caused sustained food crises and, ultimately, famines during 2010–2012 (Morrison and Malik, 2023).

Ivory Cost: The low life expectancy in Ivory Cost is influenced by several factors such as: high infant mortality rate; maternal health issues; infectious diseases; poor sanitation and clean water access; healthcare access; and education (McBride).

Guinea: The low life expectancy in Ivory Cost is influenced by several factors such as high infant and maternal mortality rates; widespread poverty; malaria and other diseases; limited access to healthcare; political instability; and malnutrition (Carr).

Mali: The low life expectancy in Mali is influenced by several factors such as malnutrition; lack of access to clean water; high fertility rate; deaths; immigration and emigration; being one of the least developed countries in the world; and many people work on farms in order to grow crops to provide for their families and communities (Boyle).

Burkina Faso: The low life expectancy in Burkino Faso is influenced by several factors such as malaria, high fertility rates; high growth rates; security crisis; and continued growth projections (Budd).

6.0 Conclusions and Suggestions

Human life expectancy is a statistical measure of the estimate of the average remaining years of life at a given age. It is an indicator of human development index and health of a country and its population. Calculation of life expectancy is a challenging task in the field of population studies and demographic research. It was found that the average life expectancy at global level is 73 years in 2024. The United States of America stands first with 79 years, and Nigeria stands last with 56 years of life expectancy among the top 10 world populous countries. Monaco stands first with 87 years among the top 10 countries in the life expectancy. The improved health care and advances in medicine; improved hygiene and living conditions; improved lifestyle and exercise; and improved food and nutrition have influenced for the higher life expectancy in the United States of America, Monaco and other countries with higher life expectancy; whereas, diseases, poverty, unemployment and illiteracy have been attributed as the main causes for the low life expectancy in Nigeria and other countries with low life expectancy. It may be suggested that the policy formulation and programme implementation of the countries with higher life expectancy may be replicated in the countries with low life expectancy.

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Notes:

i. Table A1, qx value (0.001320) for the age-group 20-21 years.

ii. Table A2, lx value (99,508) for the age-group 1-2 years.

iii. Table A2, lx value (99,381) for the age-group 10-11 years.

iv. Table A2, lx value (99,157) for the age-group 20-21 years.

v. Table A2, lx value (45,424) for the age-group 85-86 years.

vi. Table A1, dx value (585) for the age-group 0-1 year.

vii. Table A1, dx value (130) for the age-group 20-21 years.

viii. Table A1, dx value (549) for the age-group 100 and over years.

ix. Table A1, Lx value (98,676) for the age-group 20-21 years.

x. Table A1, lx value (98,741) for the age-group 20-21 years.

xi. Table A1, Tx value (5,434,518) for the age-group 20-21 years.

xii. Table A1, ex value (55.0) for the age-group 20-21 years.

APPENDIX 1
EXPLANATION OF THE COLUMNS OF THE LIFE TABLE

Column 1. Age (between x and x + 1): It shows the age interval between the two exact ages indicated. For instance, "20–21" means the 1-year interval between the 20th and 21st birthdays.

Column 2. Probability of dying (qx): It shows the probability of dying between ages x and x + 1. For example, for males in the age interval 20–21 years, the probability of dying is 0.001320i (Table A1). This column forms the basis of the life table; all subsequent columns are calculated from it.

Column 3. Number surviving (lx): It shows the number of people from the original hypothetical cohort of 100,000 live births who survive to the beginning of each age interval. The lx values are computed from the qx values, which are successively applied to the remainder of the original 100,000 people still alive at the beginning of each age interval. Consequently, out of 100,000 female babies born alive, 99,508ii will complete the first year of life and enter the second; 99,381iii will reach age 10; 99,157iv will reach age 20; and 45,424v will live to age 85 (TableA2).

Column 4. Number dying (dx): It shows the number dying in each successive age interval out of the original 100,000 live births. For example, out of 100,000 males born alive, 585vi will die in the first year of life; 130vii between ages 20 and 21; and 549viii after reaching age 100 (Table A1. Each figure in column 4 is the difference between two successive figures in column 3.

Column 5. Person-years lived (Lx): It shows the number of person-years lived by the hypothetical life table cohort within an age interval x to x + 1. Each figure in column 5 represents the total time (in years) lived between two indicated birthdays by all those reaching the earlier birthday. Consequently, the figure 98,676ix for males in the age interval 20–21 is the total number of years lived between the 20th and 21st birthdays by the 98,741x males (column 3) who reached their 20th birthday out of 100,000 males born alive (Table A1).

Column 6. Total number of person-years lived (Tx): It shows the total number of person-years that would be lived after the beginning of the age interval x to x + 1 by the hypothetical life table cohort. For example, 5,434,518xi is the total number of years lived after reaching age 20 by the 98,741x males who reached that age (Table A1).

Column 7. Expectation of life (ex): The expectation of life at any given age is the average number of years remaining to be lived by those surviving to that age, based on a given set of age-specific rates of dying. It is calculated by dividing the total person-years that would be lived beyond age x by the number of people who survived to that age interval (Tx /lx). Consequently, the average remaining lifetime for males who reach age 20 is 55.0xii years (5,434,518xi divided by 98,741x) (Table A1).

Source: Elizabeth and Xu (2022)

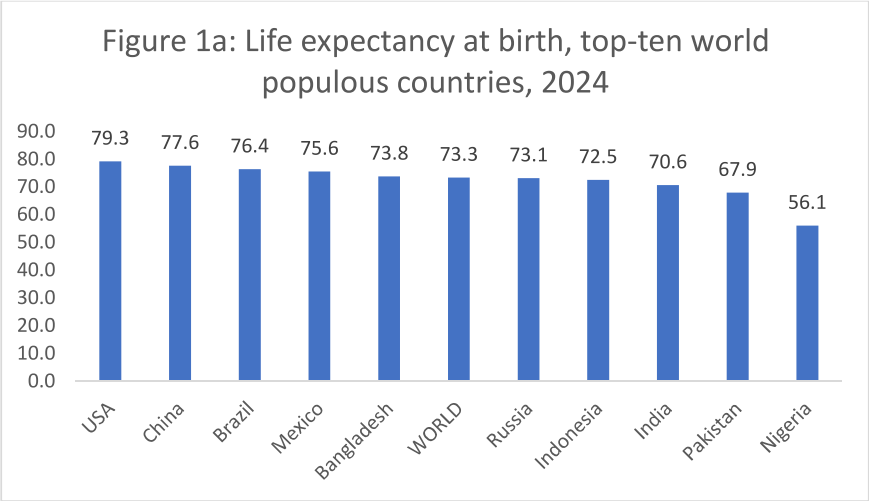
Figure 1a: Life expectancy at birth, top-ten world populous countries, 2024
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
79.3
77.6
76.4
75.6
73.8
73.3
73.1
72.5
70.6
67.9
56.1
USA
China
Brazil
Mexico
Bangladesh
WORLD
Russia
Indonesia
India
Pakistan
Nigeria

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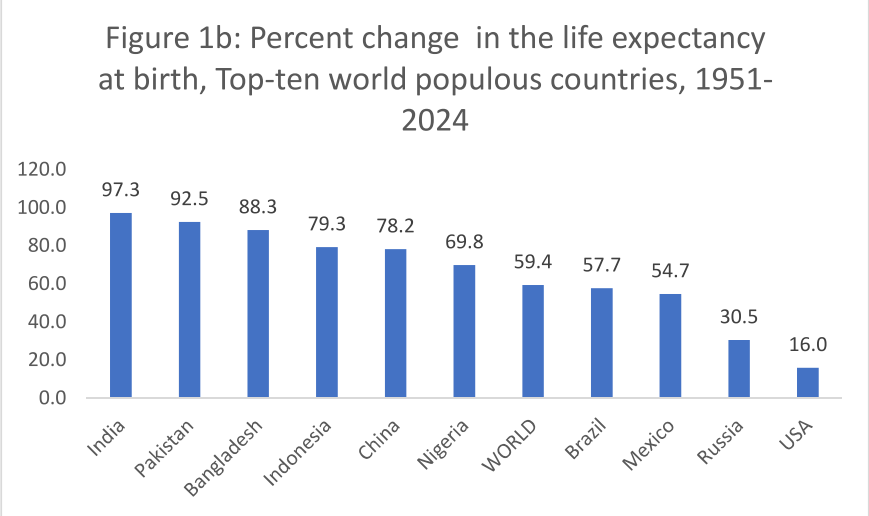
Figure 1b: Percent change in the life expectancy at birth, Top-ten world populous countries, 1951-2024
120.0
100.0
80.0
60.0
40.0
20.0
0.0
97.3
92.5
88.3
79.3
78.2
69.8
59.4
57.7
54.7
30.5
16.0
India
Pakistan
Bangladesh
Indonesia
China
Nigeria
WORLD
Brazil
Mexico
Russia
USA

****

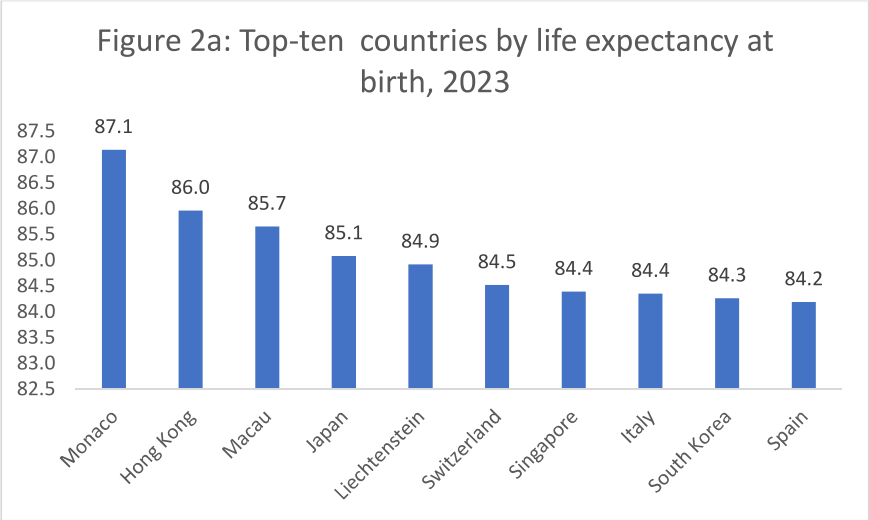
Figure 2a: Top-ten countries by life expectancy at birth, 2023
87.5
87.0
86.5
86.0
85.5
85.0
84.5
84.0
83.5
83.0
82.5
87.1
86.0
85.7
85.1
84.9
84.5
84.4
84.4
84.3
84.2
Monaco
Hong Kong
Macau
Japan
Liechtenstein
Switzerland
Singapore
Italy
South Korea
Spain

****

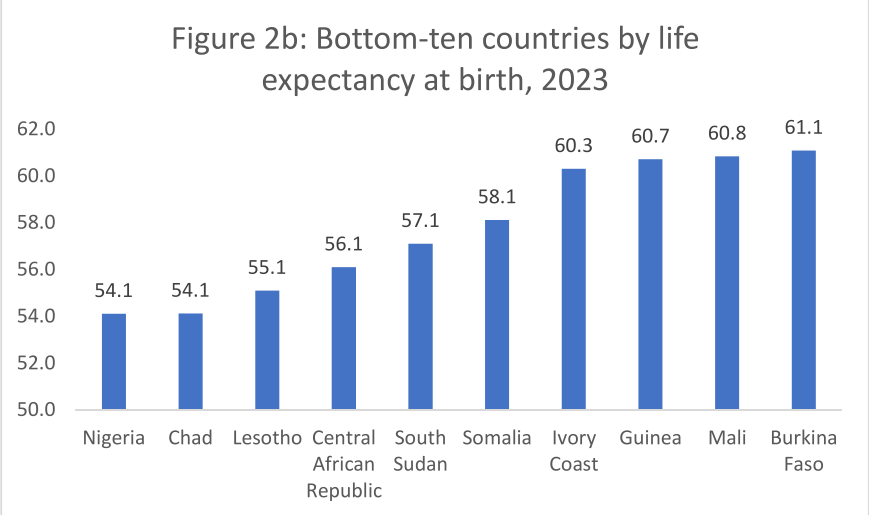
Figure 2b: Bottom-ten countries by life expectancy at birth, 2023
62.0
60.0
58.0
56.0
54.0
52.0
50.0
54.1
54.1
55.1
56.1
57.1
58.1
60.3
60.7
60.8
61.1
Nigeria
Chad
Lesotho
Central African Republic
South Sudan
Somalia
Ivory Coast
Guinea
Mali
Burkina Faso

APPENDIX 2
TABLES

Table A1. Life table for males: United States, 2020
[Spreadsheet version available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/71-01/Table02.xlsx]

Age (Years)	Probability of dying between ages *x* and *x* + 1	Number surviving to age *x*	Number dying between ages *x* and *x* + 1	Person-years lived between ages *x* and *x* + 1	Total number of person-years lived above age *x*	Expectation of life at age *x*
	q_x	l_x	d_x	L_x	T_x	e_x
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
0–1	0.005849	100,000	585[vi]	99,491	7,418,817	74.2
1–2	0.000403	99,415	40	99,395	7,319,326	73.6
2–3	0.000259	99,375	26	99,362	7,219,931	72.7
3–4	0.000208	99,349	21	99,339	7,120,569	71.7
4–5	0.000155	99,329	15	99,321	7,021,230	70.7
5–6	0.000144	99,313	14	99,306	6,921,909	69.7
6–7	0.000132	99,299	13	99,292	6,822,603	68.7
7–8	0.000121	99,286	12	99,280	6,723,311	67.7
8–9	0.000109	99,274	11	99,268	6,624,031	66.7
9–10	0.000096	99,263	10	99,258	6,524,762	65.7
10–11	0.000091	99,254	9	99,249	6,425,504	64.7
11–12	0.000107	99,244	11	99,239	6,326,255	63.7
12–13	0.000159	99,234	16	99,226	6,227,016	62.8
13–14	0.000255	99,218	25	99,205	6,127,790	61.8
14–15	0.000385	99,193	38	99,174	6,028,585	60.8
15–16	0.000529	99,155	52	99,128	5,929,411	59.8
16–17	0.000676	99,102	67	99,069	5,830,283	58.8
17–18	0.000831	99,035	82	98,994	5,731,214	57.9
18–19	0.000991	98,953	98	98,904	5,632,220	56.9
19–20	0.001152	98,855	114	98,798	5,533,316	56.0
20–21	0.001320[i]	98,741[x]	130[vii]	98,676[ix]	5,434,518[xi]	55.0[xii]
21–22	0.001483	98,611	146	98,537	5,335,842	54.1
22–23	0.001620	98,464	159	98,385	5,237,305	53.2
23–24	0.001717	98,305	169	98,220	5,138,920	52.3
24–25	0.001785	98,136	175	98,048	5,040,700	51.4
25–26	0.001840	97,961	180	97,871	4,942,652	50.5
26–27	0.001899	97,781	186	97,688	4,844,781	49.5
27–28	0.001966	97,595	192	97,499	4,747,093	48.6
28–29	0.002050	97,403	200	97,303	4,649,594	47.7
29–30	0.002148	97,203	209	97,099	4,552,291	46.8

Table A1. Life table for males: United States, 2020
[Spreadsheet version available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/71-01/Table02.xlsx]

Age (Years)	Probability of dying between ages x and $x + 1$	Number surviving to age x	Number dying between ages x and $x + 1$	Person-years lived between ages x and $x + 1$	Total number of person-years lived above age x	Expectation of life at age x
	q_x	l_x	d_x	L_x	T_x	e_x
30–31	0.002251	96,994	218	96,885	4,455,192	45.9
31–32	0.002351	96,776	228	96,662	4,358,307	45.0
32–33	0.002448	96,549	236	96,430	4,261,644	44.1
33–34	0.002539	96,312	245	96,190	4,165,214	43.2
34–35	0.002627	96,068	252	95,942	4,069,024	42.4
35–36	0.002722	95,815	261	95,685	3,973,082	41.5
36–37	0.002827	95,555	270	95,419	3,877,397	40.6
37–38	0.002931	95,284	279	95,145	3,781,978	39.7
38–39	0.003033	95,005	288	94,861	3,686,833	38.8
39–40	0.003140	94,717	297	94,568	3,591,972	37.9
40–41	0.003264	94,420	308	94,265	3,497,404	37.0
41–42	0.003411	94,111	321	93,951	3,403,138	36.2
42–43	0.003580	93,790	336	93,622	3,309,188	35.3
43–44	0.003769	93,455	352	93,278	3,215,565	34.4
44–45	0.003983	93,102	371	92,917	3,122,287	33.5
45–46	0.004231	92,731	392	92,535	3,029,370	32.7
46–47	0.004515	92,339	417	92,131	2,936,834	31.8
47–48	0.004831	91,922	444	91,700	2,844,704	30.9
48–49	0.005181	91,478	474	91,241	2,753,003	30.1
49–50	0.005570	91,004	507	90,751	2,661,762	29.2
50–51	0.005985	90,497	542	90,226	2,571,012	28.4
51–52	0.006450	89,956	580	89,666	2,480,785	27.6
52–53	0.007004	89,375	626	89,062	2,391,119	26.8
53–54	0.007657	88,749	680	88,410	2,302,057	25.9
54–55	0.008381	88,070	738	87,701	2,213,647	25.1
55–56	0.009115	87,332	796	86,934	2,125,947	24.3
56–57	0.009859	86,536	853	86,109	2,039,013	23.6
57–58	0.010668	85,683	914	85,226	1,952,904	22.8
58–59	0.011568	84,768	981	84,278	1,867,678	22.0
59–60	0.012548	83,788	1,051	83,262	1,783,400	21.3
60–61	0.013599	82,736	1,125	82,174	1,700,138	20.5
61–62	0.014668	81,611	1,197	81,013	1,617,964	19.8
62–63	0.015723	80,414	1,264	79,782	1,536,951	19.1

Table A1. Life table for males: United States, 2020
[Spreadsheet version available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/71-01/Table02.xlsx]

Age (Years)	Probability of dying between ages x and $x + 1$	Number surviving to age x	Number dying between ages x and $x + 1$	Person-years lived between ages x and $x + 1$	Total number of person-years lived above age x	Expectation of life at age x
	q_x	l_x	d_x	L_x	T_x	e_x
63–64	0.016751	79,150	1,326	78,487	1,457,169	18.4
64–65	0.017793	77,824	1,385	77,132	1,378,682	17.7
65–66	0.018910	76,439	1,445	75,717	1,301,551	17.0
66–67	0.020241	74,994	1,518	74,235	1,225,834	16.3
67–68	0.021617	73,476	1,588	72,682	1,151,599	15.7
68–69	0.023122	71,888	1,662	71,057	1,078,917	15.0
69–70	0.024700	70,226	1,735	69,358	1,007,860	14.4
70–71	0.026327	68,491	1,803	67,589	938,502	13.7
71–72	0.028145	66,688	1,877	65,749	870,913	13.1
72–73	0.030318	64,811	1,965	63,828	805,163	12.4
73–74	0.032487	62,846	2,042	61,825	741,335	11.8
74–75	0.036455	60,804	2,217	59,696	679,510	11.2
75–76	0.039507	58,588	2,315	57,430	619,814	10.6
76–77	0.043893	56,273	2,470	55,038	562,384	10.0
77–78	0.048013	53,803	2,583	52,511	507,346	9.4
78–79	0.053409	51,220	2,736	49,852	454,835	8.9
79–80	0.058234	48,484	2,823	47,072	404,983	8.4
80–81	0.064014	45,661	2,923	44,199	357,910	7.8
81–82	0.070301	42,738	3,005	41,236	313,711	7.3
82–83	0.077280	39,733	3,071	38,198	272,475	6.9
83–84	0.086551	36,663	3,173	35,076	234,277	6.4
84–85	0.095951	33,490	3,213	31,883	199,201	5.9
85–86	0.107089	30,276	3,242	28,655	167,319	5.5
86–87	0.116675	27,034	3,154	25,457	138,663	5.1
87–88	0.130906	23,880	3,126	22,317	113,207	4.7
88–89	0.146410	20,754	3,039	19,234	90,890	4.4
89–90	0.163192	17,715	2,891	16,270	71,656	4.0
90–91	0.181227	14,824	2,687	13,481	55,386	3.7
91–92	0.200462	12,138	2,433	10,921	41,905	3.5
92–93	0.220810	9,705	2,143	8,633	30,984	3.2
93–94	0.242150	7,562	1,831	6,646	22,351	3.0
94–95	0.264330	5,731	1,515	4,973	15,705	2.7
95–96	0.287167	4,216	1,211	3,611	10,731	2.5

Table A1. Life table for males: United States, 2020
[Spreadsheet version available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/71-01/Table02.xlsx]

Age (Years)	Probability of dying between ages *x* and *x* + 1	Number surviving to age *x*	Number dying between ages *x* and *x* + 1	Person-years lived between ages *x* and *x* + 1	Total number of person-years lived above age *x*	Expectation of life at age *x*
	q_x	l_x	d_x	L_x	T_x	e_x
96–97	0.310455	3,005	933	2,539	7,121	2.4
97–98	0.333969	2,072	692	1,726	4,582	2.2
98–99	0.357477	1,380	493	1,133	2,856	2.1
99–100	0.380747	887	338	718	1,723	1.9
100 and over	1.000000	549	549[viii]	1,005	1,005	1.8

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

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Table A2. Life table for females: United States, 2020
[Spreadsheet version available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/71-01/Table03.xlsx]

Age (Years)	Probability of dying between ages x and $x + 1$	Number surviving to age x	Number dying between ages x and $x + 1$	Person-years lived between ages x and $x + 1$	Total number of person-years lived above age x	Expectation of life at age x
	q_x	l_x	d_x	L_x	T_x	e_x
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
0–1	0.004918	100,000	492	99,572	7,988,224	79.9
1–2	0.000310	99,508[ii]	31	99,493	7,888,652	79.3
2–3	0.000199	99,477	20	99,467	7,789,159	78.3
3–4	0.000161	99,457	16	99,449	7,689,692	77.3
4–5	0.000123	99,441	12	99,435	7,590,242	76.3
5–6	0.000115	99,429	11	99,423	7,490,807	75.3
6–7	0.000103	99,418	10	99,413	7,391,384	74.3
7–8	0.000094	99,408	9	99,403	7,291,971	73.4
8–9	0.000089	99,398	9	99,394	7,192,568	72.4
9–10	0.000087	99,389	9	99,385	7,093,174	71.4
10–11	0.000089	99,381[iii]	9	99,376	6,993,789	70.4
11–12	0.000098	99,372	10	99,367	6,894,413	69.4
12–13	0.000117	99,362	12	99,356	6,795,046	68.4
13–14	0.000147	99,350	15	99,343	6,695,690	67.4
14–15	0.000185	99,336	18	99,327	6,596,347	66.4
15–16	0.000230	99,317	23	99,306	6,497,020	65.4
16–17	0.000276	99,295	27	99,281	6,397,714	64.4
17–18	0.000324	99,267	32	99,251	6,298,434	63.4
18–19	0.000371	99,235	37	99,217	6,199,183	62.5
19–20	0.000418	99,198	41	99,177	6,099,966	61.5
20–21	0.000468	99,157[iv]	46	99,134	6,000,789	60.5
21–22	0.000519	99,110	51	99,085	5,901,655	59.5
22–23	0.000570	99,059	56	99,031	5,802,570	58.6
23–24	0.000617	99,002	61	98,972	5,703,540	57.6
24–25	0.000662	98,941	65	98,909	5,604,568	56.6
25–26	0.000705	98,876	70	98,841	5,505,659	55.7
26–27	0.000750	98,806	74	98,769	5,406,819	54.7

Table A2. Life table for females: United States, 2020
[Spreadsheet version available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/71-01/Table03.xlsx]

Age (Years)	Probability of dying between ages *x* and *x* + 1	Number surviving to age *x*	Number dying between ages *x* and *x* + 1	Person-years lived between ages *x* and *x* + 1	Total number of person-years lived above age *x*	Expectation of life at age *x*
	q_x	l_x	d_x	L_x	T_x	e_x
27–28	0.000798	98,732	79	98,693	5,308,050	53.8
28–29	0.000853	98,653	84	98,611	5,209,357	52.8
29–30	0.000914	98,569	90	98,524	5,110,746	51.8
30–31	0.000978	98,479	96	98,431	5,012,222	50.9
31–32	0.001044	98,383	103	98,331	4,913,791	49.9
32–33	0.001111	98,280	109	98,225	4,815,460	49.0
33–34	0.001176	98,171	115	98,113	4,717,234	48.1
34–35	0.001243	98,055	122	97,994	4,619,121	47.1
35–36	0.001315	97,933	129	97,869	4,521,127	46.2
36–37	0.001393	97,805	136	97,737	4,423,258	45.2
37–38	0.001471	97,668	144	97,597	4,325,521	44.3
38–39	0.001548	97,525	151	97,449	4,227,925	43.4
39–40	0.001629	97,374	159	97,294	4,130,476	42.4
40–41	0.001720	97,215	167	97,132	4,033,181	41.5
41–42	0.001826	97,048	177	96,959	3,936,050	40.6
42–43	0.001946	96,871	188	96,776	3,839,090	39.6
43–44	0.002079	96,682	201	96,582	3,742,314	38.7
44–45	0.002226	96,481	215	96,374	3,645,732	37.8
45–46	0.002393	96,266	230	96,151	3,549,358	36.9
46–47	0.002579	96,036	248	95,912	3,453,207	36.0
47–48	0.002780	95,788	266	95,655	3,357,295	35.0
48–49	0.002996	95,522	286	95,379	3,261,639	34.1
49–50	0.003231	95,236	308	95,082	3,166,260	33.2
50–51	0.003484	94,928	331	94,763	3,071,178	32.4
51–52	0.003768	94,598	356	94,419	2,976,415	31.5
52–53	0.004097	94,241	386	94,048	2,881,996	30.6
53–54	0.004475	93,855	420	93,645	2,787,948	29.7
54–55	0.004885	93,435	456	93,207	2,694,303	28.8

Table A2. Life table for females: United States, 2020
[Spreadsheet version available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/71-01/Table03.xlsx]

Age (Years)	Probability of dying between ages x and $x + 1$	Number surviving to age x	Number dying between ages x and $x + 1$	Person-years lived between ages x and $x + 1$	Total number of person-years lived above age x	Expectation of life at age x
	q_x	l_x	d_x	L_x	T_x	e_x
55–56	0.005300	92,979	493	92,732	2,601,096	28.0
56–57	0.005725	92,486	529	92,221	2,508,364	27.1
57–58	0.006192	91,956	569	91,672	2,416,143	26.3
58–59	0.006717	91,387	614	91,080	2,324,471	25.4
59–60	0.007296	90,773	662	90,442	2,233,392	24.6
60–61	0.007928	90,111	714	89,754	2,142,950	23.8
61–62	0.008578	89,396	767	89,013	2,053,196	23.0
62–63	0.009217	88,630	817	88,221	1,964,183	22.2
63–64	0.009834	87,813	864	87,381	1,875,962	21.4
64–65	0.010462	86,949	910	86,494	1,788,581	20.6
65–66	0.011129	86,039	958	85,561	1,702,087	19.8
66–67	0.011932	85,082	1,015	84,574	1,616,526	19.0
67–68	0.012871	84,067	1,082	83,526	1,531,952	18.2
68–69	0.014000	82,985	1,162	82,404	1,448,426	17.5
69–70	0.015265	81,823	1,249	81,198	1,366,023	16.7
70–71	0.016693	80,574	1,345	79,901	1,284,824	15.9
71–72	0.018272	79,229	1,448	78,505	1,204,923	15.2
72–73	0.020046	77,781	1,559	77,002	1,126,418	14.5
73–74	0.021730	76,222	1,656	75,394	1,049,416	13.8
74–75	0.024519	74,566	1,828	73,652	974,022	13.1
75–76	0.026862	72,737	1,954	71,761	900,371	12.4
76–77	0.029942	70,784	2,119	69,724	828,610	11.7
77–78	0.033037	68,664	2,268	67,530	758,886	11.1
78–79	0.037086	66,396	2,462	65,165	691,356	10.4
79–80	0.041213	63,933	2,635	62,616	626,192	9.8
80–81	0.045945	61,298	2,816	59,890	563,576	9.2
81–82	0.051104	58,482	2,989	56,988	503,686	8.6
82–83	0.057111	55,493	3,169	53,909	446,698	8.0

Table A2. Life table for females: United States, 2020
[Spreadsheet version available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/71-01/Table03.xlsx]

Age (Years)	Probability of dying between ages *x* and *x* + 1	Number surviving to age *x*	Number dying between ages *x* and *x* + 1	Person-years lived between ages *x* and *x* + 1	Total number of person-years lived above age *x*	Expectation of life at age *x*
	q_x	l_x	d_x	L_x	T_x	e_x
83–84	0.064163	52,324	3,357	50,645	392,789	7.5
84–85	0.072353	48,967	3,543	47,195	342,144	7.0
85–86	0.081451	45,424[r]	3,700	43,574	294,948	6.5
86–87	0.090029	41,724	3,756	39,846	251,374	6.0
87–88	0.101896	37,968	3,869	36,033	211,528	5.6
88–89	0.115015	34,099	3,922	32,138	175,495	5.1
89–90	0.129437	30,177	3,906	28,224	143,357	4.8
90–91	0.145190	26,271	3,814	24,364	115,133	4.4
91–92	0.162282	22,457	3,644	20,635	90,769	4.0
92–93	0.180688	18,812	3,399	17,113	70,134	3.7
93–94	0.200353	15,413	3,088	13,869	53,021	3.4
94–95	0.221184	12,325	2,726	10,962	39,152	3.2
95–96	0.243052	9,599	2,333	8,433	28,190	2.9
96–97	0.265792	7,266	1,931	6,300	19,758	2.7
97–98	0.289207	5,335	1,543	4,563	13,457	2.5
98–99	0.313074	3,792	1,187	3,198	8,894	2.3
99–100	0.337151	2,605	878	2,166	5,696	2.2
100 and over	1.000000	1,727	1,727	3,530	3,530	2.0

Source: National Center for Health Statistics, National Vital Statistics System, Mortality.

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Waste Management Problems in Nigerian Urban Cities

Oyemwinmina Christopher

Abstract

Municipal solid waste management has emerged as one of the greatest challenges facing environmental protection agencies in developing countries. Solid waste management is a subset of environmental sanitation. As a result of the rapid growth in population, the problem of waste and their disposal has become complex. The result of such complexity is the contact of diseases such as cholera, dysentery, typhoid fever, malaria etc. which increases the rate of morbidity and mortality. This paper is a review of existing literatures, observation and information on municipal waste management in Nigeria. This paper examined the hindrances or obstacles to effective solid waste management in Nigeria and proffer the strategies for addressing the problems. It was discovered that absence of concrete Government Policy and political will, lack of citizen mobilization, lack of effective private partnership involvement initiative, among others constituted the problems. Citizen mobilization, environmental education, legislation and proper monitoring and surveillance amongst others were recommended.

Keywords: Management, Waste, Municipal

Introduction

One of the most problematic phenomena in Nigeria today is the management or disposal of solid waste in the course of our daily activities, the generality of the people continue to manipulate the environment thereby creating garbage, which are nuisances that are inimical to the health of the people. These wastes are either biodegraded or non-biodegraded and are mostly found conspicuously along the streets and public drains.

Drains and water ways are blocked with refuse while streets are littered with papers, empty packs of sachet

water, leaves used in wrapping food, cellophane, etc. with all drains blocked thereby emitting offensive odour and liable to cause disease outbreak.

According to Akpovi (2004) indiscriminate disposal of refuse creates unhealthy conditions of unsightliness, air and water pollution, breeding of flies and other disease vector and agents. This invariably leads to outbreak of diseases such as malaria, cholera, dysentery etc. Njoku (2006) attesting to this, some of the Lagoon front in the country has been turned into a dump for human and all sorts of solid waste. Trucks fully loaded with feces queue up in large numbers to discharge the contents into the lagoon.

Cities are the engines of economic growth, but the environmental implications of such growth need to be assessed and managed better. The critical and most immediate problems facing developing countries and their cities are the health impact of urban services, poor urban and industrial waste management, as well as air pollution especially from particulates which constitutes part of solid waste (Iprogect, 2019).

About 2.4 billion people globally live under highly insanitary conditions (WHO, 2007) and have such poor hygiene behaviours that their proximity to risks of incidence and spread of infectious diseases are enormous. In Nigeria, there is rapid growth of informal settlements in cities with large urban population and it is also observed that poor sanitary habits by the populace are on the increase. Residents lack safe toilet facilities and proper solid waste management apparatus as they engage in open burning of refuse in their domain.

Before the colonial era, solid waste management did not pose a challenge as the density and content of waste generated were more of organic bio degradable wastes which were easily disposed of into the environment without these wastes constituting a hazard as the receptacle for the wastes were large forests and bushes. Settlements were not as clustered as they are today and most wastes generated soon became part of an intricate constituency of natural food chain. Waste disposal by this means was efficient as it posed no danger to man and his environment. However things changed through the urbanization of many Nigerian cities. The globalizing influences that resulted in this urban growth led to the emergence of a new pattern of waste generation and poor disposal planning compounded the already delicate nature of waste management. Presently waste management continues to be a policy challenge and an enforcement problem across the length and breadth of Nigeria.

In early 1983, a world environment survey report ranked Lagos, the then capital of Nigeria as one of the dirtiest cities in the world. This prompted the Buhari/Idiagbon Government in 1984 to declared War Against Indiscipline, which culminated into a war on filth (wastes). The presence of solid wastes in heaps around every corner of our surroundings is actually a source of worry and they occupy public places in the town at an alarming rate. Somehow, it mirrors the declining values of our society and Government itself is embarrassed by the poor image created by this development. (Egiyeno, 2010).

The problem of adequate solid-waste management in Nigeria's cities has reached mammoth proportion as heaps of refuse are found along major roads, riverbanks, and in open spaces. The level of awareness and environmental education about potential hazards relating to a polluted environment is still abysmally low as people are more concerned with daily survival. This paper aims at educating the concerned stakeholders and the citizenry on the problems of solid waste management in Nigeria with the view of identifying the various strategies to enhance a formidable management of solid waste.

CONCEPTUALIZATION

Management

Management is the harnessing and coordinating of personnel, funds, materials and equipment towards the actualization of the organizational goals and objectives. The concept of performance is central to management. It is however obvious that management is not one-person business which means that the concept of management is co-operative effort of the people in carrying out assigned or specific duties, (Aibieyi, 2012). According to Edosa and Agbadudu (2004) management is the act of getting things done through and with people. In other words, it is the employment of available materials, financial and human resources in such an efficient manner for the achievement of predetermined goals.

Waste

Waste is any substance which is discarded after primary use or is worthless, defective and of no use. Examples include municipal solid waste, hazardous waste, waste water, radioactive waste and others (Wikipedia).

Municipality

Municipality is a single urban administrative division having corporate status and powers of self-government or jurisdiction as granted by national and state laws to which it is subordinate (Wikipedia).

Theoretical Framework

The theoretical framework adopted for this study is a system theory which

is the functionalist theory of Talcott Parsons. System theory is an organizational theory that explains complex systems. It describes any system that works together to produce some results. The general systems theory analyses the nature of relationship between the components of a system; the effectiveness among the various components of a system to the survival of the whole system; and what changes and direction in which the change occurs. Talcott Parsons view society as a system; he argued that any social system has four basic functional prerequisites - adaptation, goal attainment, integration and pattern maintenance. For effective solid waste management, it is necessary to engage Parsons functionalist model as a potent way to deal with the subject.

The goals of solid waste management remain the proper isolation of hazards from the populace. The failure of past governments to deal with solid waste can be explained from this theoretical viewpoint as governments have failed to adapt to the emerging problems posed by solid wastes in Nigeria. Also no conscious effort to deal effectively with the waste collected as open dumpsites remain poorly organized by the respective authorities. It has become a matter of necessity for the relevant authorities to adapt the latest technologies and right managerial approach to deal with the menace and also the engagement of the private sector and many such initiatives that can achieve goals of solid waste management.

Types of Solid Waste

There are two major types of waste, namely High Risk Waste and Low Risk Waste.

Low Risk Waste (Communal Waste)

All solid waste belongs to this category. These include plastics cans, cellophane bags, bottles, office paper, boxes, edible items, packaging materials, etc.

High Risk Waste

Under this category is the Healthcare waste. These include:

1. **Infectious Waste:** Waste from surgical and autopsy on patients with infectious diseases, as well as waste from surgery patients in isolated ward such as excreta and dressings from infected patient.

2. **Pathological or Anatomical Waste:** These consist of human tissues, body parts, placenta, etc from surgeries.

3. **Sharp Waste (used or unused):** These consist of needles, syringes, scalpel blades, knives, infusion sets, saws, contaminated broken glass and nails.

4. **Pharmaceutical Waste:** These include expired, unused, split and contaminated pharmaceutical product, drugs and vaccines.

5. **Genotoxic Waste:** These are vomit, urine or faeces from patient treated with cytotoxic drugs.

6. **Chemical Waste:** These consist of discarded solid, liquid and gaseous chemicals.

7. **Radio Active Waste:** Any solid, liquid, or pathological waste contaminated with radioactive isotopes of any kind.

8. Pressurized Containers e.g acroso, can (Egiyeno, 2010).

Types of Solid Waste Management

According to Seo (2004) there are four most common methods of municipal solid waste management, namely land filling, incineration, composting and anaerobic digestion. Incineration, composing and anaerobic digestion are value reducing technologies.

Landfilling is economical, especially in developing countries where it typically involves pitching refuse into a depression or closed mining site. Its health and social impacts include odour nuisance; fire and explosion hazards from build-up of methane; increase in the number of vermin which act as disease vectors (birds, rodents and insects) (Daskalopoulous, 1998).

Leachate forms as water percolates intermittently through the refuse pile, and can contain high levels of nutrients e.g. nitrogen, potassium etc. leachate from landfill can enter ground systems, leading to increases in nutrients levels that cause eutrophication (El-Fadel, 1997).

Incineration is the high-temperature combustion of wastes. Non-combustibles must be sorted out before incineration. It reduces the volume of waste and used for the production of energy in the form of electricity and heat (Seo et al, 2004). Incineration impacts society by production of odours and in the unsightliness of facility (Garrod and Willis, 1998).

Composting and anaerobic digestion use natural microbial organisms to decompose the organic fraction of solid waste (Seo, 2004). The non-organic fraction must be landfilled or incinerated. And the end products can potentially be used as agricultural fertilizers or motor vehicles fuel (Sonesson, 2002). Many microorganisms found in compost are known respiratory sensitizers that can cause a range of respiratory symptoms including allergic rhinitis, asthma, and chronic bronchitis (Swan, 2002).

The Problems of Solid Waste Management in Nigeria Municipal Cities

Nigeria is a nation that exemplifies chronic solid waste management problems in conjunction with population growth. It is the most populous country in Africa, with over 120 million residents (World Bank 1996) and over the past 50 years has had the third largest urban growth rate in the world at 5.51% annually.

The sheer magnitude of solid waste problem in Nigeria is hard to comprehend. There are no public waste bins, so the amount of trash that accumulates in a matter of hours would be more than waste collectors could haul in a day. Nigerian garbage 'dumps' are located on the sides of highways at the fringe of cities and slums. Since there are no means for containment, trash often spreads to the road, blocking traffic (Nnamdi, 2012).

The poor and improper management of waste in Nigeria is a result of the following:

1. Lack of Effective Private Partnership Involvement Initiative

In Edo State, the problem of waste processing is particularly noticeable. For many years garbage was located in premise, markets, residential areas, and drainages. The overwhelming number of citizens believes that the activities of private operators are much more effective. They remove waste faster than the state-owned companies. Private organizations clean up the inner zones more often while state companies mostly work on the main roads (Akande, 2018). However, there is legal tussle between the private waste evacuators and the government operated waste evacuators over rights to operate side by side. The case is currently in the court of appeal. But most of the people in the state believe that the private operators have been more efficient in the operation.

In Ondo State barely 35 per cent of the state capital is currently served by the state agency who rather than increase tariff on a concentrated population, should have increased its coverage of the waste collection services to boost the revenue generation for the state (Alemms-Ozwrawa, 2017).

2. Absence of Adequate Policies, enabling Legislation on Waste Management

The Government policies on waste management are piecemeal where they exist and are poorly implemented. Most people instead of cooperating with the waste operators, because they don't want to pay for the service rendered, they bring their wastes to the roads and markets to drop thereby

causing the roads to be filled with heaps of refuse. This is unacceptable and the Government appears to be turning a blind eye, resulting in ripple effects due to non-enforcement of the environmental law.

3. Wrong Attitude of the Public towards Solid Waste Disposal

Some residents at the urban areas are sabotaging Government's effort in waste management. This is a major challenge some cities have being facing for some time now. This is because some resident's not bagging their waste and disposing it appropriately and instead engaging in blocking the water channels with their refuse as a result of non acceptance of the refuse dumps that are meant to keep the state clean.

4. The State of the Dumpsites

According to an operator in Lagos State, the state of the dumpsites is appalling.Especially when it rains, it sometimes takes two or three days for a truck to dump its waste and their vehicles also get damaged due to the poor access road to dumpsites. Often a brand new truck that goes to the dumpsite becomes a rickety vehicle in under two months following the body dents from the caterpillar push. And despite several letters by their association to the government, nothing has been done. (Guardian, 2017).

5. Rapid Population Growth

The rapid population growth in the urban area has compounded the problems of solid waste management in the areas. Many reasons are responsible for this – the area has increased in geography, activities (attack) of Herdsmen in rural areas of Nigeria, lack of social amenities (electricity, pipe borne water, hospital etc.) in the rural areas –, unemployment etc. the rural dwellers are drifting to the cities in search of better life and in the process, the cities are over-populated having its effect on the waste management.

6. Poor Funding

According to Agunwamba (1998) up to now the activities of the state environmental agencies have been hampered by poor funding, inadequate facilities and human resources, inappropriate technology. All these require huge amounts of money which the government cannot handle alone, and in the process, effective solid waste management becomes a problem.

7. Lack of Motorable Roads

The lack motorable roads is one of the handicaps encountered in garbage collection in most residential areas. The lack of roads into many of the most densely populated sections of the urban areas does not allow access to the municipal garbage collection lorries.

In such areas, the length of the walk to the nearest garbage bins especially for women is a deterrent to their use.

The failure of the people to acquire the right attitudes towards garbage disposal is evident. This has prevented them from joining the system of having their garbage regularly carted away instead of throwing it away near their homes.

8. Poverty

Nigeria has one of the world's highest economic growth rates, averaging 7.4% according to the Nigeria economic report released in July 2014 by the World Bank. But poverty still remains significant in Africa's biggest economy (Wikipedia 2014). According to Akpovi (2012) poverty induces or forces people to avoid paying for the disposal of wastes and instead dispose the waste in any convenient place such as an open gutter or vacant plot.

Consequence of Hazards of Solid Waste

1. Public Nuisance (Unsightly)
2. It cause injuries
3. It produces offensive odour
4. Transmission of infectious diseases, such as cholera dysentery, hepatitis A, B, C HIV/AIDS
5. It can cause environmental pollution or degradation e.g. of air, water and soil
6. It may cause fires

Conclusion

Nigeria's cities are municipalities that have chronic solid waste management problems in conjunction with population growth. Successful solid waste management in Nigeria's cities requires a collective responsibility of both the government and the citizens.

Recommendations

For the attainment of effective solid waste management in Nigeria the following recommendations are proffered.

1. Waste management campaign should be conducted in the cities, by which the people are encouraged to preserve the environment, and prevent the pollution of the streets and natural sites.
2. Private companies should be allowed and encouraged to function alongside with the respective Government authorities charged with the responsibility of the waste management.
3. The habit of good sanitation should be inculcated into the urban dwellers.

4. The Government should introduce environmental sanitation day e.g the last Saturday of every month where every Nigerians will be mandated to carry out compulsory environmental clean-up around their respective dwellings for a few hours.

5. The Federal Environment Protection Agency (FEPA) which was established in 1988 to control the growing problems of waste management and pollution in Nigeria should be revived and strengthened to perform their statutory functions.

6. Non-compliance with the environmental laws should be penalized accordingly.

7. The Government should embark on the grading or construction of the road linking the various areas in the town to enable the waste disposal vehicles access the areas for the collection of waste without any obstacle or hindrance.

8. The dumping sites should not be too far from the town; the road should be made motorable to encourage proper disposal of the waste by the refuse vehicles.

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A Geographical Anaylysis of Road Density of National and State Highways in Karnataka State

Sowmya Shree K.L, Pradeep Kumar. K,

Abstract

This study analyzes the spatial distribution of road densities for national and state highways across the districts of Karnataka, India, excluding district, taluk, and village roads. By categorizing districts into high, medium, and low road density categories, the analysis reveals significant regional disparities in highway infrastructure. The findings indicate a lack of districts with high road densities, while several districts exhibit medium and low densities. Notably, northern districts have a higher density of state highways, whereas southern and western districts have a higher density of national highways. These disparities highlight the need for targeted infrastructure development to enhance connectivity and support balanced regional growth. The study provides valuable insights for policymakers and planners to prioritize infrastructure projects, aiming to improve transportation networks and promote equitable economic development across Karnataka.

1.0 Introduction

The transportation infrastructure of a region plays a pivotal role in its economic development, social integration, and overall accessibility. In India, the road network is one of the most significant components of the transportation system, facilitating the movement of goods and people across vast distances. Among the various categories of roads, national highways (NH) and state highways (SH) are crucial for connecting urban centers, rural areas, and facilitating trade. Karnataka, a state located in the southwestern region of India, boasts a diverse landscape and a rapidly growing economy, making the analysis of its road network particularly relevant.

The spatial distribution of road densities is an essential aspect of transportation planning and management. Understanding the road

density of national and state highways in Karnataka can provide insights into the effectiveness of the existing infrastructure, identify areas requiring improvement, and inform future development strategies. National highways, which are managed by the central government, typically have higher traffic volumes and are designed to accommodate long-distance travel, while state highways, under the jurisdiction of state authorities, serve as vital links within the state, connecting smaller towns and rural areas to major urban centers.

This research paper aims to conduct a comprehensive spatial analysis of the road densities of national and state highways in Karnataka. By employing geographic information system (GIS) techniques and spatial statistical methods, this study will map and analyze the distribution of road densities across the state. The findings will contribute to a better understanding of the relationship between road infrastructure and regional development, highlighting disparities in accessibility and identifying potential areas for investment and improvement.

2. Methodology:

The methodology for this study involves a comprehensive spatial analysis of road densities in Karnataka, focusing on national highways (NH) and state highways (SH). The data has been collected from the "Karnataka at a Glance" report. Road density (for both state highways and national highways) has been calculated for the total geographical area and total population of each district.

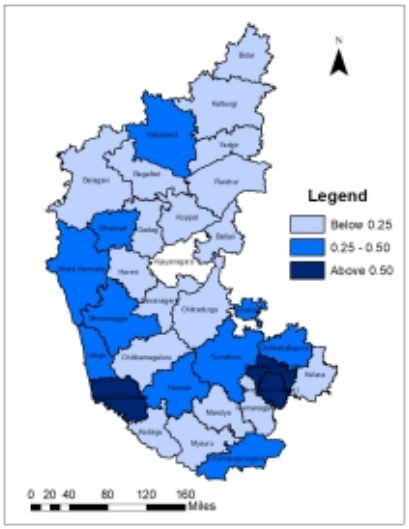
$$\text{Road Density} = \frac{\text{Total Road Length (km)}}{\text{District Population/ Area}} \times 10000/\ 10$$

3. Discussion

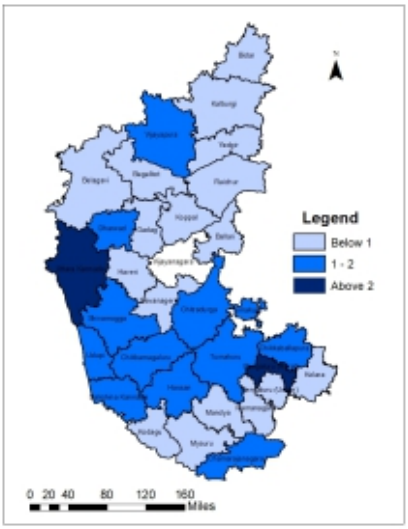
The development and distribution of highway infrastructure plays a crucial role in the economic growth and connectivity of any region. In Karnataka, understanding the spatial distribution of road densities for both national highways (NH) and state highways (SH) is vital for regional planning and development. Highways are essential for facilitating trade, enabling efficient transportation, and connecting rural areas to urban centers. This study focuses on analyzing the road density of national and state highways across different districts of Karnataka, explicitly excluding village roads. By examining these patterns, we can identify regions that are well-connected as well as those that require targeted infrastructure improvements. This comprehensive analysis provides valuable insights for policymakers and planners to ensure balanced regional development and improved transportation networks throughout the state.

Map.1 District wise Road Density of National Highway (KM) of Karnataka state per 10 sq km and per 10000 population

Road density of National Highway per 10sq KM



Road density of National Highway per 10000 population



The Map.1 illustrates the district-wise road density of national highways in Karnataka state, presented in two distinct methods: per 10 square kilometers (km²) and per 10,000 population.

In the first method, the map shows the road density per 10 km² across various districts. The northern and some central districts exhibit higher densities of national highways, indicating more than 0.50 kilometers of national highway per 10 km². These areas are better connected through national highways, facilitating transportation and potentially contributing to regional development. In contrast, many southern districts show varying densities, with several areas having less than 0.25 kilometers of national highway per 10 km². This suggests a sparser network of national highways, which may affect connectivity and accessibility in these regions.

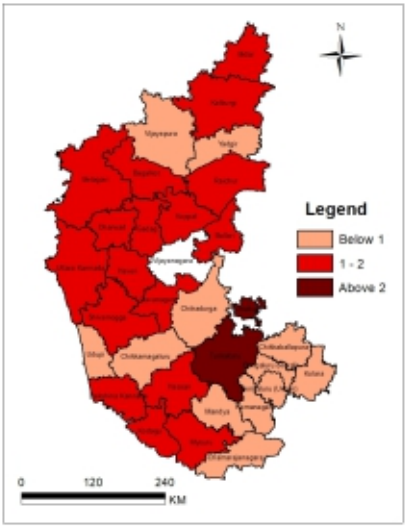
The second method on the map highlights the road density per 10,000 population. Similar patterns emerge, with northern districts again showing higher densities of national highways, reflecting more than 2 kilometers of national highway per 10,000

population. This indicates a greater availability of highway infrastructure relative to the population size, which can enhance mobility and economic activities in these districts. Conversely, the southern districts generally display lower densities, with fewer kilometers of national highway per 10,000 population. This suggests that the highway infrastructure is less extensive relative to the population, which may pose challenges for transportation and regional development. Overall, the maps reveal significant disparities in the distribution of national highways across Karnataka, both in terms of area and population. The northern districts are comparatively better connected, while the southern districts have relatively less highway infrastructure. Understanding these patterns is crucial for planning and policy-making to improve transportation networks and ensure balanced regional development.

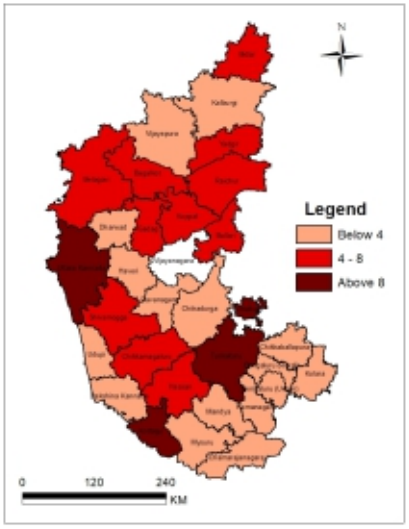
The road density map of state highways (Map.2) in Karnataka, India, reveals intriguing patterns of infrastructure distribution across the state. Most districts fall within the middle category of 1-2 km per 10 sq km, suggesting a relatively consistent

Map. 2 District wise Road density of State Highway (KM) of Karnataka state per 10 sq km and 10000 population

Road density of State Highway per 10sq KM



Road density of State Highway per 10000 population



state highway network throughout much of Karnataka. Notably, only one district, Tumakuru in the southern part of the state, boasts a road density exceeding 2 km per 10 sq km, indicating a particularly well-developed highway infrastructure in this region. Conversely, several districts, primarily in the southern and central parts of Karnataka, including Vijayapura, Yadgir, Chitradurga, and surprisingly, the Bengaluru urban area, exhibits lower road densities below 1 km per 10 sq km. This unexpected finding for Bengaluru might be attributed to the calculation method or the focus on state highways rather than other road types.

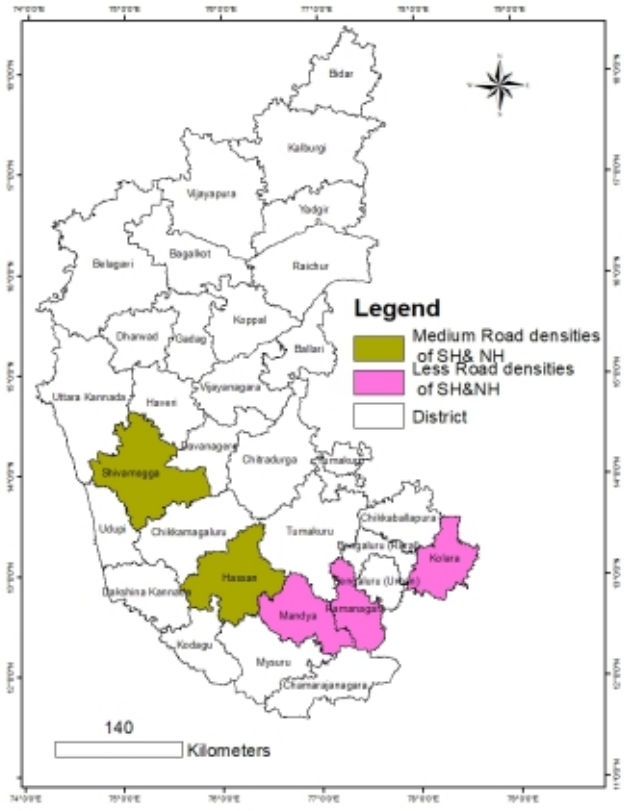
Generally, the northern and western parts of Karnataka demonstrate higher road densities compared to the southern and eastern regions, with some exceptions. Interestingly, many districts along the state's borders tend to have higher road densities, possibly indicating important inter-state connections. This comprehensive visualization offers valuable insights into the distribution of state highway infrastructure across Karnataka, highlighting areas of high connectivity and regions that may require further development to enhance the state's overall transportation network.

The map also reveals significant variations in the road density of state highways calculated per 10,000 population across different districts. Northern districts such as Bidar, Yadgir, and Raichur exhibit higher road density, falling within the 4-8 km range per 10,000 people. In contrast, several coastal and southern districts, including Dakshina Kannada, Udupi, and Chikkamagaluru, show lower road density of below 4 km per 10,000 population. Notably, a few districts stand out with very high road density exceeding 8 km per 10,000 people, particularly Uttara Kannada in the west and Tumakuru in the south-central region. Interestingly, the capital region of Bengaluru (both Urban and Rural) displays a lower road density. The distribution pattern across the state is mixed, without a clear geographic trend, though some contiguous regions show similar density levels. This varied distribution of state highway infrastructure relative to population across Karnataka's districts could be attributed to factors such as terrain differences, population distribution patterns, or historical development priorities, and provides valuable insights for regional planning and infrastructure development assessments.

However, the road density map presents a detailed view of the distribution of state highways across Karnataka, using both per 10 km² and per 10,000 population metrics. The first metric highlights that northern and some central districts have higher

densities, with more than 2 kilometers of state highway per 10 km², suggesting enhanced connectivity and regional economic support. Conversely, districts with less than 1 kilometer per 10 km² may face accessibility and mobility challenges. The second metric shows that certain districts have more than 8 kilometers of state highway per 10,000 population, indicating better transportation facilities relative to population size, while others with less than 4 kilometers per 10,000 population may struggle with infrastructure inadequacies. These maps underscore the need for targeted infrastructure development to ensure balanced regional growth and improved transportation networks across Karnataka.

Map. 3 Districts of medium and low National highway and State highway Road Densities in Karnataka state



The Map.3 depicts the results of spatial queries identifying districts in Karnataka with varying levels of road densities for both national highways (NH) and state highways (SH). The map categorizes the districts into two groups based on the combined road densities of NH and SH: medium and low. Notably, the map does not indicate any districts with high road densities for both NH and SH.

Medium Road Densities of SH & NH:

The districts with medium road densities are depicted in green. These include:

Shivamogga and Hassan

These districts have a moderate level of infrastructure for both national and state highways. This suggests a balanced level of connectivity that supports regional mobility and economic activities. Medium road densities indicate that these regions have an adequate but not extensive network of highways, which can facilitate economic activities and regional connectivity.

Low Road Densities of SH & NH:

The districts with lower road densities are shown in pink. These include:

Ramanagara
Mandya
Kolar

These districts have a lower density of both national and state highways, indicating less developed infrastructure. This could pose challenges for transportation, accessibility, and economic development in these regions. Lower road densities suggest that these areas might struggle with connectivity, which can impact economic growth and access to services.

Finally the map does not show any districts with high road densities for both NH and SH, highlighting a potential gap in the infrastructure across the state. The presence of districts with medium and low road densities suggests that while some areas have a reasonable level of highway infrastructure, others lag significantly behind. The identification of these districts can guide policymakers and planners in prioritizing infrastructure development projects. By focusing on regions with lower road densities, efforts can be made to enhance connectivity and support local economies. This targeted approach can help create a more balanced and comprehensive highway network across Karnataka, promoting equitable growth and development throughout the state. In summary, the map underscores the need for strategic infrastructure investments to address regional disparities in road densities. By improving highway infrastructure in districts with medium and low road

densities, Karnataka can enhance its overall transportation network, facilitating economic activities and improving the quality of life for its residents.

4. Conclusion:

The disparities in road densities across Karnataka call for targeted infrastructure development efforts to create a more balanced and comprehensive highway network. By addressing these disparities, Karnataka can promote equitable growth and development, improving the quality of life for its residents and boosting the state's overall economic potential. This study provides valuable guidance for policymakers and planners in prioritizing infrastructure projects to achieve these goals.

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des.karanataka.gov.in

Appendix-1

KGISDist_1	NH	SH	NH density	SH density	Nh_area	SH_area
Bagalkot	126	879.01	0.666754	4.651457	0.191635	1.336897
Ballari	181	1017.26	0.735376	4.132974	0.214201	1.203858
Belagavi	201	2341.75	0.420639	4.900659	0.149832	1.745621
Bengaluru (Rural)	205	193.6	2.068778	1.953734	0.919695	0.868551
Bengaluru (Urban)	147	96.7	0.152782	0.100504	0.671233	0.441553
Bidar	82	693.1	0.481418	4.06916	0.150514	1.27221
Chamarajanagara	190	339.26	1.861302	3.323501	0.372476	0.665085
Chikkaballapura	148	263.88	1.208061	2.15394	0.348153	0.620748
Chikkamagaluru	176.25	610.21	1.546912	5.355693	0.244758	0.847396
Chitradurga	167	612.64	1.006354	3.691812	0.197867	0.725877
Dakshina Kannada	266	528.8	1.276621	2.537885	0.54665	1.086724
Davanagere	85	731.55	0.43659	3.757502	0.143484	1.234892
Dharwad	189	484.41	1.023285	2.622695	0.443662	1.137113
Gadag	74	709.52	0.695116	6.664851	0.158935	1.523883
Hassan	252.16	985.17	1.419643	5.546438	0.370062	1.445803
Haveri	103	587.21	0.64469	3.675419	0.21356	1.21752
Kalburgi	125	1235.71	0.246162	2.433476	0.114145	1.128399
Kodagu	0	537.97	0	9.701561	0	1.311482
Kolara	137.4	304.79	0.894298	1.983792	0.16697	0.370385
Koppal	124	709.02	0.892138	5.101157	0.211821	1.211172
Mandya	73	484.36	0.403609	2.677975	0.147148	0.976335
Mysuru	79	699.09	0.263234	2.329425	0.115261	1.019974
Raichur	0	1006.12	0	5.216268	0	1.473737
Ramanagara	73	315.53	0.674216	2.914183	0.189956	0.821051
Shivamogga	221	987.04	1.260874	5.63137	0.260705	1.164374
Tumakuru	325.9	6631.25	1.066261	21.695751	0.30754	6.257667
Udupi	142	353.71	1.205527	3.002866	0.365979	0.911624
Uttara Kannada	331	1238.71	2.303139	8.619098	0.32164	1.203683
Vijayanagara	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
Vijayapura	267	685.32	1.226272	3.147523	0.253297	0.650147
Yadgir	0	486.06	0	4.139249	0	0.939428

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Report Review

World Population Prospects 2024 – Summary of Results

Read the report here:

file:///C:/Users/Bom/Downloads/undesa_pd_2024_WPP_2024_advance_unedited.pdf

Human population on this earth, in various countries, regions, cities, etc. is a subject of much interest. It is so not only among policymakers, administrators, academicians, researchers, and students, but for the common man too. In fact many people view this matter of population with concern when they see in populous countries that there is a deficit of many services and amenities, seemingly because of the large populations where many people are vying for the same resources. It can include admissions in colleges, jobs & livelihoods, public services (like transport), and more. Alongside are concerns in some countries about an 'ageing' population, where the numbers of the aged persons increases and the numbers of the young decreases. The concerns relate to a shrinking working population, a declining workforce. Also it means that the numbers of the 'dependent' are increasing and that of 'providers' is declining.

In this context the World Population Prospects 2024 – Summary of Results put out by the United Nations Department of Social and Economic Affairs, Population Division is very much relevant. It will be well received by all stakeholders including policymakers. World Population Prospects 2024 is the twenty-eighth edition of estimates and projections of the global population published by the United Nations since 1951. The advance, unedited version is available now.

The report starts with 'Key Messages'. Some of these are:

- The World's population is likely to peak in the current century – from 8.2 billion in 2024 to 10.3 billion in the 2080s.
- The likelihood of this happening is very high at 80% compared with an assessment by the UN a decade ago where the likelihood of peaking in the 21st century was only 30%.
- In 63 countries and areas, representing 28 percent of the world population in 2024, the population has already peaked before 2024. This includes the populous China.
- In 48 countries and areas, representing 10 per cent of the world's population in 2024, population size is likely to peak

during the period 2025 - 2054. This group includes Brazil, the Islamic Republic of Iran, among others.

- For the balance 126 countries and areas, their population could continue growing beyond 2054, reaching a peak later in the century or further on. This group comprises several of the world's most populous countries including India, Nigeria, Pakistan and the United States of America.

- Angola, the Central African Republic, the Democratic Republic of the Congo, Niger and Somalia, could experience very rapid population growth during 2024-2054 and thus influence the trends at the global level.

- Current global fertility rate stands at 2.25 live births per woman down from 3.31 in 1990. 2.1 is considered the replacement (without migration) rate.

- Nearly one-fifth of all countries and areas have 'ultra-low' fertility rates of less than 1.4.

- In nearly 45 percent of the countries or areas globally, fertility rates are at or above 2.1 live births per woman.

- Early childbearing has harmful effects on young mothers and their children. In 2024, 4.7 million babies were born to mothers under 18 years of age. This could have adverse implications for the health of the mother and the child.

- Global life expectancy at birth reached 73.3 years in 2024. This is projected to reach around 77.4 years in 2054. Since 2022, global life expectancy has returned to pre-COVID levels.

- Increasing life expectancy is expected to arrest population decline or contribute to population growth in nearly all countries over the coming decades.

- Global population growth through mid-century will be mainly driven by the momentum of the past.

- Globally, the number of women in the reproductive age range (age 15 and 49) is projected to grow through the late 2050s. In countries where population has already peaked, the number of women in reproductive age is expected to shrink by about 33 percent between 2024 and 2054.

- It is projected that for almost all countries where population peaked before 2024, and for 75 percent of those that will experience peaking between 2025 and 2054, the opportunity for enhanced economic growth due to a youthful population and declining fertility

has already played out. However about 100 countries will continue to enjoy 'demographic dividend' due to working age population's rapid growth.

- Since women live longer than men they outlive men in older age groups. Therefore equitable social and economic policies are necessary for these women.

- Immigration could mitigate the effects of population decline. In countries such as Italy, Germany or the Russian Federation where population size has already peaked, that peak would have occurred sooner in the absence of immigration (inward migration). In countries with already low fertility and where population has peaked, the emigration (outward migration) of people in reproductive age could further depress the population growth.

- Gender equality and women's empowerment help to counter rapid population growth or decline. Often women and adolescents are prevented from exercising their own choices regarding sexual and reproductive health. This could postpone the reduction in fertility in fast growing populations.

- Raising the minimum marriage age, introducing family planning and safe motherhood in primary care could help reduce early childbearing.

- Gender parity in the division of domestic work, affordable, quality child-care options, among other measures, could remove discouragement for families to have larger families.

The introduction starts off by saying that population growth, an ageing population, urbanisation and international migration are the main themes shaping the world today. Since these offer opportunities as well as challenges, by managing these well, we can accelerate the efforts towards building a more inclusive and sustainable future for all. Since population trends are somewhat more predictable than others, these trends can provide policymakers with a tool to craft suitable policies to enable the achievement of the Sustainable Development Goals. The world population situation presents a diverse picture. Several counties continue to experience high levels of fertility and population growth while many others are experience ageing populations, high proportion of the older persons and even of declining populations.

Section I is titled *Awareness of population trends is critical for achieving a sustainable future*.

It discusses trends in the population growth at the global level and timing of

peaking. This peaking is expected to happen earlier and at a lower level than earlier estimated. Here there are interesting box items, one of which is 'Why do populations peak?' Several graphs and pictorial depictions make the contents very interesting and readable.

Here the report makes an important observation. It says that the number of women in reproductive age (15 to 49 years) is an important indicator of the potential for future population growth. Globally, this number is projected to grow through the late 2050s, when it will likely peak at around 2.2 billion, up from nearly 2.0 billion in 2024. Alongside, yet another valuable observation is *'Even if global fertility were to drop immediately to the replacement level, the momentum generated by past growth, which is reflected in the youthful age distribution of the current population, ensures that the population would continue to grow for a few decades.'*

Section II is Countries with populations that have already peaked.

This is the first cohort of countries classified by population peaking. It notes that in the 1980s, only 14 countries had peaked in size. Today, that number stands at 63 countries and areas. Among the countries are China, Japan, Germany, and the Russian Federation. Many of the countries in this category could see significant population loss in the next 30 years. China for example, now the second most populous country could see a population reduction by 204 million between 2024 and 2054. Issues of similarity and divergence among these countries are also discussed. Here a box item named 'Policies to support families and facilitate childbearing' is of interest for all.

Section III is Countries with populations that are likely to peak within the next 30 years.

Brazil, the Islamic Republic of Iran, Türkiye and Vietnam are among the most populous countries in this group. The report makes an interesting observation about this cohort. It says this group could face the same challenges and opportunities of countries in the previous group that have already peaked in population, and also of those countries in the next cohort that will see population peak beyond 2054. 'In the span of just 30 years, countries in this group will have to balance the immediate demands of a population that is still growing with the need to prepare for a population that is older and is likely to be smaller than their present one.', it says. The trends for different regions and countries are depicted in graphs. Relative contribution of demographic components – age structure, fertility, migration, mortality – are discussed

and depicted pictorially. Life expectancy of the population in this group of countries is expected to increase significantly from 76.5 in 2024 to 87.2 by the turn of the century.

At the end of this part, the report says that countries that will experience a growing number of older persons could consider measures to strengthen their healthcare systems, promote life-long learning, create opportunities for those who wish to continue working for longer years, address ageism, improve sustainability and equity of social protection systems, and so on.

Part IV is Countries with populations that are projected to continue growing through 2054, potentially reaching a peak later in the century or beyond 2100.

This group includes some of the most populous countries such as India, Indonesia, Nigeria, Pakistan and the United States of America. There are a total of 126 such countries and areas where the population could continue to grow through 2054 and peak towards the end the century or beyond 2100.

In figure IV.4, the trend of the world's ten most populous countries are plotted for the years 2024, 2054 and 2100. Notably, India will remain the most populous moving from 1451 million to 1692 million and then to 1505 million over this period. China, quite markedly is expected to move from 1419 million to 1215 million to 633 million (more than halve). For many countries in this group facing rapidly growing populations, there would be challenges of sustainable development and to their efforts to end poverty, eradicate hunger and malnutrition, ensure equitable access to education and healthcare, etc. The situation in several countries and regions is mentioned here. Notably, the population in several high income countries will increase due to immigration.

In this part, the report expresses concern about the likely environmental impacts that could rise out of enhanced economic activity. Countries in this group have largely been low-income, low consumers of material resources and low emitters of GHG. However as these step up economic activity to meet the needs and aspirations of the growing population, the environmental impacts could be substantial. The rich nations, the report says, will need to step in with support to address this, to enable decouple economic activity from environmental degradation.

The report ends with reference and an Annexure titled ‘What's new in the 2024 revision?’

This report, the current one in a series is a valuable document and a

notable addition to the treasure of knowledge on the subject of population, its growth, trends, and some prescriptions for a better future. It will be much appreciated by a wide range of stakeholders including policymakers, researchers, academicians, social scientists, and industry professionals.

V. Vijaykumar

An Invitation

The Local Government Quarterly invites contributions in the form of articles and research papers from its readers and well-wishers.

Contributions may be e-mailed to us in digital form as a Word file.

Articles could normally be between 3000 and 4000 words, though we do not wish to limit the size. As we print in black and white, tables, charts, graphs, images, etc. need to be compatible. We reserve the right to edit for sense, style, space, etc.

Contributors may e-mail their articles to:
aiilsgquarterlyjournal@aiilsg.org or info.algq@aiilsg.org

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OBJECTIVES

The main emphasis of the Institute's work is to see that the local bodies can contribute more effectively to the development process and provide the citizens with better living conditions by meeting their aspirations in terms of required amenities, infrastructure and better environmental conditions, thus contributing to social and economic development of the society as a whole by better management of the human settlements. While these are the long-term objectives, the immediate ones are:

- To advance knowledge of the principles and practices of Local Government by conducting research and by organising training courses and programmes at various centres in India for officials and elected representatives in the local bodies.
- To strengthen and improve Local Government Institutions by improving their performance through education, orientation and bringing them together for common endeavor by organising specialised conferences, conventions and seminars.
- To make available a platform for members of local bodies and officials for exchange of views and ideas related to urban development and administration.
- To represent the views of local authorities supported by research work to the concerned higher authorities from time to time.
- To publish bibliographies, articles, books and other literature on matters of interest to local bodies.
- To publish journals, bulletins and other literature on different aspects of Local Government and on the working of Local bodies in different states.
- To undertake research studies in public administration, problems of local bodies and also in related topics of urban and environmental factors and arrange for their publication etc.
- To establish and maintain an information-cum-documentation service for local bodies.
- To undertake consultancy assignments in various areas of urban development and problems of local bodies with a view to improve and develop organisational, managerial and operational efficiency.

In view of the above, the Institute has been collaborating with the relevant government departments, Central and State, Universities, Organisations and Research Institutions. The work of the Institute covers several aspects involving a multi-disciplinary teamwork.

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