

**ESTIMATING WORLD POPULATION BY 2050 USING MALTHUSIAN
MODEL**

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DECLARATION

This project work was carried out by OLOMOLA SANUMI PRAISE. I have not copied the work of any author. All work has been duly cited and acknowledged.

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CERTIFICATION

This is to certify that this project was carried out by Olomola Sanumi Praise in the Department of Mathematics, University of Benin, Benin City.

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DEDICATION

This project is dedicated firstly to the almighty God for guiding me throughout the course of my study. Secondly to my parent Mr and Mrs Olomolatan for their never ending words of encouragement and the constant push for the achievement of academic success.

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ABSTRACT

The population of man is a germane thing to know and analyze, from the north of the world to the South, the world is compose of huge numbers of human. From the East of the world to west of it, it is comprises of enormous numbers of man. knowing the world population is not enough but also being able to project its future reality.

In this project we consider using Malthusian model in estimating relative population reality by the 2050. It's very interesting because we really present the estimation in two categories; first, by continent, and then globally. This project serve its aim as it give a relative result that the present population can work with to expect and probably tackle the challenges that may arises.

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CHAPTER ONE

1.1 INTRODUCTION

The world population has doubled over the last fifty years and quadrupled over the past century. (UN)

Over the one hundred years from 1950 to 2050, the world population was growing the fastest in the period 1962-1965, when it was increasing on average by 2.1 per cent per year. Since then, the pace of population growth has slowed by more than half owing to reduced levels of fertility. In 2020, and for the first time since 1950, the rate of population growth fell below 1 per cent per year and it is projected to continue to slow in the next few decades and through the end of this century. Global population size and annual growth rate: estimates, 1950-2022, and medium scenario with 95 per cent prediction intervals, 2022-2050 Given its reliance on assumptions at the country level about the two components of global population growth—fertility and mortality—the projection of the global population is inherently uncertain, and it typically becomes more uncertain over time. However, the size of the world population in the near future is relatively certain because the size and age structure of the population over the next few decades are largely the result of demographic processes that have already taken place in the recent past. In particular, most of the women whose offspring will contribute to the population growth through 2050 are already alive. (UN, 2022)

Going forward as a people on the universe, having being with the ideal of our population, how it was and importantly this had given men before us the opportunity to plan the future effectively which eventually we are today. Projecting future population in various way could be of greater help as it helps the government to plan very effectively for the future, in areas like,

economy, agricultural production which brings food for consumption for the people on earth, land management, natural and human resources accurately appropriated, saving financially and development of innovations that can take care of the population reality of the people and their life demand. It also helps individual to plan his or her way for the future because today's demand may not equal to that of the future, because as there is significant increase on the population of man, demands increase as competition for survival rises, in food consumption, land and property acquisition, getting a job, taking care of family and enjoy life in whole. Also, can the population reality of 2050 make education sponsorable by the government to the extent that the common man on the street can acquire it or can it deprive them of it? Won't it be unbearable for them, as job issue is a major factor to consider, can the people afford to the cost of living with the population reality by 2050? But this is the United Nation's advice regarding these questions; *“Countries where fertility levels remain high should prepare to meet the needs of growing numbers of children and young people. Countries where a decline in fertility is creating an opportunity for a demographic dividend need to invest in human capital by ensuring access to health care and quality education at all ages and opportunities for productive employment. Countries with ageing populations should take steps to adapt public programmes to the growing proportion of older persons. All countries should take steps to facilitate migration in line with target 10.7 of the SDGs and the Global Compact for Safe, Orderly and Regular Migration. Whereas all countries should take actions to tackle climate change and protect the environment, more developed countries—whose per capital consumption of material resources is generally the highest—bear the greatest responsibility for implementing strategies to decouple human economic activity from environmental degradation”*. (UN, 2022)

But, actually we shall observe in this project a relatively population reality of human by 2050, then, we can know if it can affect the livelihood of humans generally, by using a mathematical model known as the “Malthusian model” to predict its possibility.

In addition while the population evolution of man is significantly important and interconnected with various factors. On the other hand the de facto standard source of demographic is the United Nation’s series of world population. The United Nation works from the basic demographic identity that the change in population at the global level, is equal to the numbers of the births less the number of deaths, with exogenous trajectories assumed for the fertility and mortality value or actual numbers decrease or increase respectively.

1.2. AIM AND OBJECTIVES

- Projecting population relative reality by 2050.
- Knowing the effect of Malthusian model or assumption on population reality.
- To know the actual population by 2050 and how it can affect the livelihood of humans generally considering factors of living like food, housing and so on.
- To consider vividly how realistic is the Malthusian estimation of world population by 2050, as there could be changes that may occur in the factors responsible for population rise and fall.
- To make necessary recommendations based on conclusion from this study and perhaps suggest ways out to deal with the challenges that population reality could bring by 2050.

1.3 Important Definitions

1.3.1 Population

Population refers to the total number of people living in a particular area or country at a given time. It is commonly measured using a specific reference date or period, and can be further classified into various demographic groups, such as age, sex, race, ethnicity and occupation. Population size is an important factor in understanding social, economic and political dynamics, as well as in planning healthcare, education, infrastructure, and other public services. It can also have implications for environmental sustainability and resource management.

1.3.2 Population growth rate

Population growth rate is the rate at which the population of a given area or country increases over a specific period of time. It is usually expressed as a percentage and is influenced by factors such as birth rates, death rates, immigration and emigration. A positive population growth rate indicates a population is increasing, while a negative growth rate indicates a population is decreasing.

1.3.3 Birth Rate

The birth rate is the number of live births per 1,000 individuals in a given population within a specific time period, usually calculated on an annual basis. It is an important demographic indicator that helps understand the population growth or decline of a country or region. The birth rate is influenced by various factors including social,

economic and cultural factors, as well as government policies related to family planning, education and healthcare. A higher birth rate can lead to population growth, while a lower birth rate can result in population decline or aging population.

1.3.4 Death Rate

The death rate is a measure of the number of deaths in a population per unit of time, typically calculated as the number of deaths per 1,000 individuals per year. It is used to assess the mortality level and trends in a population and is an important indicator of the overall health and well-being of a community. The death rate can vary significantly across different populations and age groups and it is influenced by factors such as age distribution, healthcare access, quality of healthcare services, disease prevalence and lifestyle factors.

1.3.5 Migration

Migration refers to the movement of individuals, groups, or populations from one place to another, typically involving a change in residence. Migration can occur within a country (internal migration) or between countries (international migration).

There are various reasons for migration, including economic factors, such as seeking better job opportunities or higher wages, social factors, such as joining family members or fleeing conflict or persecution and environmental factors, such as natural disasters or climate change. Migration can have significant impacts on both the sending and receiving regions. In the sending regions, migration can lead to brain drain, where highly skilled individuals leave their home country, potentially resulting in a loss of talent and expertise. On the other hand, migration can also bring benefits, such as financial remittances sent back to the home country by migrants or

the development of networks and connections between countries.

In the receiving regions, migration can contribute to economic growth by filling labor market gaps, bringing in skills and expertise and increasing cultural diversity. But migration is divided into two aspects: immigration and emigration.

1.3.6 Immigration

Immigration refers to the act of moving permanently to a different country from one's home country. It typically involves the process of obtaining legal permission, known as a visa, to live and work in the destination country. People choose to immigrate for various reasons. Some common motivations include seeking better economic opportunities, escaping political or social instability, reuniting with family members already living in another country, or accessing education and healthcare.

Immigration has both positive and negative impacts on countries and societies. On the positive side, immigrants contribute to the cultural diversity, economic growth, and innovation of their host countries. They often bring valuable skills, knowledge, and perspectives that can enhance the workforce and enrich the social fabric. However, immigration also poses challenges related to integration, social cohesion, strain on public services, and sometimes competition for jobs.

1.3.7 Emigration

Emigration refers to the act of leaving one's country of residence to permanently settle in another country. It is the opposite of immigration, which refers to the act of entering and establishing oneself in a foreign country. Emigration is often motivated by various factors

such as economic opportunities, political instability, war or conflict, pursuit of higher education, or reuniting with family members who have already emigrated. Emigrants typically undergo a legal process to obtain the necessary visas or permissions to enter and settle in the destination country. Emigration can have significant impacts on both the country of origin and the destination country, including changes in population demographics, workforce composition and cultural diversity.

1.3.8 Overpopulation

Overpopulation refers to a situation where there is an excessive number of people living in a given area, which exceeds the carrying capacity of the environment. This can lead to various social, economic and environmental problems.

Some of the main causes of overpopulation include high birth rates, lower mortality rates, increased life expectancy, and improved healthcare. These factors, combined with insufficient resources and inadequate infrastructure, can result in overcrowding, congestion, unemployment, poverty and food and water shortages.

Overpopulation can also lead to environmental degradation, including deforestation, pollution, habitat loss and depletion of natural resources. It can strain ecosystems, lead to extinction of species and contribute to climate change. Efforts to address overpopulation have involved promoting family planning, educating communities on population control, and improving access to contraceptives. Additionally, sustainable development practices, such as controlling consumption and utilizing renewable energy sources, are also important in managing overpopulation.

1.3.9 Underpopulation

Underpopulation refers to a situation in which the population size of an area or region is substantially lower than what is considered optimal for that particular area. This can occur for a variety of reasons, including low birth rates, high mortality rates, persistent out-migration, or a combination of these factors. Underpopulation can have significant social, economic and environmental implications. From a social standpoint, underpopulated areas often face challenges such as an aging population, reduced labor force and limited access to services and amenities. This can lead to a decline in quality of life, lower levels of productivity and difficulties in maintaining essential infrastructure.

Economically, underpopulation can result in decreased consumer demand, limited job opportunities and reduced economic growth. In such situations, businesses may struggle to thrive and expand due to a lack of customers and a smaller workforce. This can cause a negative cycle, leading to a further decline in population as people move to areas with better economic prospects. Underpopulation also has environmental consequences. In some cases, underpopulated regions may experience land abandonment, leading to the degradation of natural landscapes and ecosystems. Additionally, the lack of human presence can reduce environmental stewardship and conservation efforts.

1.4 The concept of sampling

Sampling refers to the act of selecting a subset of individuals or items from a larger population to gather data or information. It is commonly used in various fields, including market research, opinion polls, scientific studies and quality control.

Sampling allows researchers to make inferences about the entire population based on the characteristics and data collected from the selected sample. It is often more efficient and cost-effective than studying the entire population, especially when the population is large or geographically dispersed.

Different sampling methods can be employed based on the research objectives and the characteristics of the population. Common sampling techniques include random sampling, stratified sampling, cluster sampling, convenience sampling and purposive sampling.

The quality of the sample and the accuracy of the findings depend on how well the sampling method represents the population of interest. Factors such as sample size, representativeness and sampling bias need to be carefully considered to ensure reliable results and minimize potential errors.

1.4.1 Types of Sampling Technique

In this project we will be considering six different types of Sampling techniques they are as follows.

1. Simple random sampling: All members of the population have an equal chance of being selected.
2. Stratified sampling: The population is divided into subgroups (strata) based on specific characteristics and then random samples are taken from each stratum.
3. Cluster sampling: The population is divided into clusters (groups or geographical areas) and then a random sample of clusters is selected. All members within the chosen clusters are included in the sample.
4. Systematic sampling: The researcher selects a random starting point and then selects every n th

individual from the population to be included in the sample.

5. Quota sampling: The researcher ensures that the sample has a specific composition based on pre-determined characteristics, such as age, gender or occupation.

6. Purposive sampling: The researcher intentionally selects participants who have specific characteristics or knowledge relevant to the research.

CHAPTER TWO LITERATURE REVIEW

2.1 Modeling

Modeling can refer to various activities and industries, but it generally refers to the practice of representing and simulating real-life objects, systems, or processes using mathematical, physical, or conceptual models. Overall, modeling is a versatile and widely applicable practice used in various fields to understand, predict and communicate information about the real world.

2.1.1 Types of modeling

According to Ackoff and Sasieni (1984) modeling is classified into three types. They are; iconic, analogue and symbolic.

2.1.2 Iconic Models

Iconic models use significant property of the real thing to represent the property themselves, usually with change of scale. Hence iconic generally look like what they represent but differ in size; they are images. Some common examples are photographs, drawings. Iconic models are generally specific, solid and difficult to manipulate for experimental purposes. Ekoko (2016)

2.1.3 Analogue Models

Analogue models use set of properties to represent another set of properties. Contour lines on a map, for example are analogue models of elevation. The arrangement of the contour lines can be used to interpret the gradient. A hydraulic system can be used as an analogue of electrical,

traffic and economic systems. Analogue models are less specific, less concrete but easier to manipulate than iconic models. Ekoko (2016)

2.1.4 Symbolic models

In symbolic models, letter, numbers, and types of symbols are used to represent variables and the relationship between them. That is why they are the most general and most abstract type of models. They are usually the easiest to manipulate experimentally. Symbolic models take the form of mathematical relationship (usually equations or inequalities) that reflect the structure of that which they represent. See Ekoko (2016).

2.2 Model Development

Model development refers to the process of creating and refining a mathematical or computational model that represents a real-world system or phenomenon. It involves several steps, including:

1. Problem definition: Clearly defining the problem that the model aims to solve or understand.
2. Data collection: Gathering relevant data that will be used to inform and validate the model. This may involve collecting data from experiments or surveys or using existing datasets.
3. Model formulation: Formulating the model by defining the relationships, parameters and variables that will be used to represent the system or phenomenon.

This may involve mathematical equations, statistical models, or computer algorithms.

4. Implementation: Translating the model formulation into a computer program or code that can be executed. This may involve using software tools or programming languages.

6. Validation: Checking whether the model's predictions align with real world observations or experimental data that were not used during calibration. Validation verifies the model's accuracy and reliability.

Overall, model development is a complex and iterative process that requires a combination of domain knowledge, data analysis skills and programming expertise. It involves a continuous feedback loop between model formulation, validation, and refinement until an accurate and useful representation of the real-world system is achieved.

2.3 The concept of mathematical modeling and model

Mathematical modeling is the process of creating a mathematical representation of a real-world system or phenomenon. It involves using mathematical equations, algorithms and computational techniques to describe and analyze the behavior, patterns and relationships within the system. In mathematical modeling, real-world problems are translated into mathematical terms to better understand and predict their outcomes. This allows researchers, scientists, engineers and policymakers to gain insights, make predictions and test various scenarios or strategies. Mathematical models can be used in a wide range of fields, including physics, engineering, economics, biology, medicine, environmental science and social sciences. They can be simple or complex, depending on the level of detail and accuracy required for a particular problem.

Key steps in mathematical modeling include problem formulation, identification of relevant

variables and parameters, development of mathematical equations or algorithms, data collection and analysis, testing and validation and interpretation of results.

Mathematical models can be deterministic, where outcomes are entirely determined by the initial conditions and the mathematical relationships, or stochastic, where randomness and probability are incorporated into the model to account for uncertainties and variability. Overall, mathematical modeling provides a powerful tool for understanding and solving complex problems by using mathematical concepts and techniques to represent, analyze and simulate real-world systems.

2.4 Insight on Malthusian Model

About the turn of the 19th century, the British economist Thomas Malthus (1766- 1834) observed that biological population (Human in consideration) tends to increase at the rate proportional to the population size. The Malthusian or exponential model leave a lot to be desired as a description of human population growth, since it takes into account hardly any of the important characteristics reproductive behavior noting that would distinguish us from laboratory colonies of bacteria. The Malthusian model, is a theory of population growth and its relationship with resources and economic development. Malthus proposed this model in the late 18th century and it remains influential in understanding population dynamics. (Smith, 1977) According to the Malthusian model, population grows exponentially while resources grow linearly, leading to a population that exceeds the available resources. Malthus argued that the population would eventually reach a point where the limited resources could not sustain the growing population, resulting in a crisis such as famine, disease, or war.

Malthusian theory suggests that population growth is checked by what he called "preventive"

and "positive" checks. Preventive checks refer to voluntary actions taken by individuals to limit population growth, such as delaying marriage or practicing birth control. Positive checks refer to natural or social forces that limit population growth, such as natural disasters, diseases, or wars.

Malthusian theory has been criticized by many for its neglect of technological advances and innovation, which can increase resource availability and improve living conditions. Critics argue that historical evidence does not fully support Malthus's predictions, as advancements in agriculture, medicine, and technology have allowed societies to sustain larger populations with adequate resources.

However, others argue that Malthusian theory still holds some relevance in certain contexts, particularly in regions where resources are limited and population growth outpaces economic development. They argue that the Malthusian model serves as a reminder of the potential consequences of unchecked population growth, especially in environments with limited carrying capacity.

2.5 Developing the model

Population growth can be modeled in continuous time, which is more realistic for population that reproduce continuously like human being which is the one in consideration, rather than sectionally. Continuous time-models allow use of calculus which provides many powerful analytical tools. In this project we will eschew the calculus and simply present some results.

Malthus assume that population growth is exponential which means that the rate of population growth is proportional to the size of the population.

Consider the differential equation

$$\frac{dN}{dt} = rN \quad (1)$$

The lefthand side represent instantaneous rate of change in population size. Bysolving equation (1) above by direct integration;

$$\frac{dN}{dt} = rN$$

Dividing both sides by N we have get equation (2) to be as follows

$$\frac{dN}{Ndt} = r \quad (2)$$

By multiplying both sides by dt we have

$$\frac{dN}{N} = rdt \quad (3)$$

Integrating both sides of the equation we have;

$$\int_{N_0}^{N(t)} \frac{dN}{N} = \int_0^t rdt \quad (4)$$

Equation (4) become

$$\ln\left(\frac{N(t)}{N_0}\right) = rt \quad (5)$$

To Cancelled out the ln we find the exponential of the equation

$$e^{\left(\ln\left(\frac{N(t)}{N_0}\right)\right)} = e^{rt} \quad (6)$$

$$\frac{N(t)}{N_0} = e^{tr} \quad (7)$$

By making $N(t)$ the subject of the formula we do cross multiplication which give us

$$N(t) = N_0 e^{r\Delta t} \quad (8)$$

Where r is the rate of increase or decrease in population and Δt is the change in time, N_0 is the initial population. And $N(t)$ is the actual population to be determined.

In equation (8) above if the r which is the rate of the population increase or decrease is less than 0 then there is a population decay or simply decrease, but if r is greater than 0 then there's an increase in population or simply population growth.

In a nutshell equation (8) is the formula or modeled equation for the estimation to be carried out, as we are going to be using it in this project going forward.

2.6 The limitations of Malthusian Model

Despite its important the Malthusian model above have its limitations

- Malthusian growth model of physical phenomenon only apply within limited regions, as unbounded growth is not physically realistic.
- Although growth may initially be exponential, the modeled phenomenon will eventually enter a region in which previously ignored negative feed back factors become significant leading to a logistical growth model or the underlying assumptions of the exponential Growth model, such a continuous or instantaneous feedback, breakdown.

CHAPTER THREE

PROJECTING WORLD POPULATION BY CONTINENT AND GLOBALLY

3.0 Introduction

In this important chapter, we are going to practicalize how to use the modelled equation or formula in the previous chapter to project the world population. This will be done in two categories, first by continent and then globally.

3.1 Africa

Africa is the second-largest and second-most populous continent in the world, located primarily in the Eastern Hemisphere. It is bordered by the Mediterranean Sea to the north, the Atlantic Ocean to the west, the Indian Ocean to the southeast and the Red Sea to the northeast.

Africa is known for its vast natural resources, including minerals, oil and gas. It has diverse ecosystems, ranging from deserts in the north to rainforests in the central and western regions. The continent is home to iconic wildlife, such as elephants, lions, giraffes and gorillas, making it a popular destination for eco-tourism.

Overall, Africa is a continent with a vast and complex history, diverse cultures and a mix of challenges and opportunities. It continues to evolve and play a significant role in the global community.

According to the United Nations Africa population in the year 2022 was 1,426,736,305 and 1,393,676,444 in the year 2021. (Worldometer). Having gotten these data, we need to first

calculate the rate of growth of the population of Africa via the model in consideration.

Recall equation (8)

$$N(t) = N_0 e^{r\Delta t}$$

Where $N(t)$ is the current population and N_0 is the population of the year we choose to be our initial population, and Δt is the change in time between those years, this implies deducting the actual year from the initial.

Calculating the rate

Recall equation (7)

$$N(t) = N_0 e^{r\Delta t}$$

$$1,426,736,305 = 1,393,676,444 \times e^{r(2022-2021)}$$

$$\frac{1,426,736,305}{1,393,676,444} = e^r$$

$$\ln\left(\frac{1,426,736,305}{1,393,676,444}\right) = r$$

$r = 0.0234$ which is equivalent to 2.34%.

Having known the rate, then the calculation of the projection by 2050 is going to be done below;

$$N(t) = 1,426,736,305 \times e^{0.0234 \times (2050-2022)}$$

$$N(t) = 1,426,736,305 \times e^{0.0234 \times 28}$$

$$N(t) = 1,426,736,305 \times 1.925527584$$

$$N(t) = 2,750,570,127.$$

So, the population of Africa as projected here will be 2 million, 744 million,

3.2 Asia

Asia is the largest continent in terms of both land area and population. It is home to a diverse range of cultures, languages and religions. Some famous landmarks in Asia include the Great Wall of China, the Taj Mahal in India, Angkor Wat in Cambodia and the Burj Khalifa in Dubai.

Asia is known for its rich history and vibrant traditions. It has made significant contributions to various fields such as art, literature, philosophy, and science. Asian cuisine is also widely celebrated globally, with dishes like sushi from Japan, curry from India and pad thai from Thailand.

Whether you're interested in experiencing bustling cities, tranquil beaches, or lush mountains, Asia has something to offer for everyone. It is a fascinating and vibrant continent that continuously captivates travelers with its beauty, diversity and hospitality.

Asia has a population 4,722,634,763 in 2022 and 4,694,576,167 in the year 2021.
(Worldometer)

Calculating the growth rate is as follows;

Recall equation (8)

$$N(t) = N_0 e^{r\Delta t}$$

$$4,722,634,763 = 4,694,576,167 \times e^{r(2022-2021)}$$

$$\frac{4,722,634,763}{4,694,576,167} = e^r$$

$$\ln\left(\frac{4,722,634,763}{4,694,576,167}\right) = r$$

$r = 0.005959$ which is equivalent to 0.5959%.

Projecting Asia population by 2050 go as follows

$$N(t) = N_0 e^{r\Delta t}$$

$$N(t) = 4,722,634,763 \times e^{0.005959 \times (2050-2022)}$$

$$N(t) = 4,722,634,763 \times e^{0.005959 \times 28}$$

$$N(t) = 4,722,634,763 \times 1.181579379$$

$$N(t) = 5,580,167,849.$$

So therefore, the population of projected here by 2050 is 5billion, 580million,167thousand, 849 people.

3.3 Europe

Europe is a continent located in the Northern Hemisphere and mostly in the Eastern Hemisphere. It is bordered by the Arctic Ocean to the north, the Atlantic Ocean to the west and the Mediterranean Sea to the south. Europe is known for its rich history, diverse cultures, stunning landscapes and iconic landmarks.

Some of the famous countries in Europe include France, Germany, Italy, Spain, the United Kingdom, Greece and Switzerland, among many others. Each country has its own unique traditions, languages, cuisines and attractions, making Europe a fascinating and vibrant continent to explore.

In addition to its rich history and cultural heritage, Europe offers a wide range of activities and experiences for travelers. From skiing in the Alps to exploring the ancient ruins of Rome,

from experiencing the Northern Lights in Scandinavia to relaxing on the beaches of the Mediterranean, there is something for everyone in Europe.

Whether you're interested in art, history, cuisine, nature or simply experiencing different cultures, Europe has it all. It's a continent that never fails to impress and offer memorable experiences for travelers from all around the world.

Europe population in the year 2022 was 743, 555,765. And 745,173,774 people in 2021 according to macrotrends report. (macrotrends). This is implying that there is a decrease in their population growth or we can say they have population decay.

Calculating the growth rate

Recall equation (8)

$$N(t) = N_0 e^{r\Delta t}$$

$$743,555,765 = 745,173,774 \times e^{r(2022-2021)}$$

$$\frac{743,555,765}{745,173,774} = e^r$$

$$\ln\left(\frac{4,722,634,763}{4,694,576,167}\right) = r$$

$$r = -0.0021737 \text{ which is equivalent to } 0.21737\%$$

Then the population projection of Europe by 2050 is as follows

$$N(t) = 743,555,765 \times e^{-0.0021737 \times (2050-2022)}$$

$$N(t) = 743,555,765 \times e^{-0.0021737 \times 28}$$

$$N(t) = 743,555,765 \times 0.940952$$

$$N(t) = 699,649,970.$$

So, therefore the projected population of Europe by 2050 is 699million, 649thousand, 970

people.

3.4 North America

North America is a continent located in the western hemisphere. It is made up of countries such as the United States, Canada, Mexico and several others. North America is known for its diverse geography, including vast forests, stunning mountain ranges, beautiful coastlines and expansive plains.

One of the most famous landmarks in North America is the Grand Canyon, located in Arizona, USA. This natural wonder attracts millions of visitors each year with its breathtaking views and unique geological formations.

North America is also home to vibrant cities like New York City, Los Angeles, Toronto and Mexico City. These cities are bustling with cultural events, entertainment options and a rich history to explore.

North America had a population of 376,870,696 in the year 2022 and 375,278,947 in the year 2021. (Macrotrends).

Calculating the growth rate

Recall equation (8) above

$$N(t) = N_0 e^{r\Delta t}$$

$$376,870,696 = 375,278,947 \times e^{r(2022-2021)}$$

$$\frac{376,870,696}{375,278,947} = e^r$$

$$\frac{376,870,696}{\ln(375,278,947)} = r$$

$r = 0.0042325$ which is equivalent to 0.42325%.

Projecting its population by 2050

$$N(t) = N_0 e^{r\Delta t}$$

$$N(t) = 376,870,696 \times e^{0.0042325 \times (2050-2022)}$$

$$N(t) = 376,870,696 \times e^{0.0042325 \times (28)}$$

$$N(t) = 376,870,69 \times 1.25818132$$

$$N(t) = 424,287,863.$$

So, the projected population of North America by the year 2050 here is 424million, 287thousand, 863 people.

3.5 South America and the Caribbean

South America is a continent located in the Western Hemisphere, mostly in the Southern Hemisphere and partly in the Northern Hemisphere. It is bordered by the South Atlantic Ocean to the east and the Pacific Ocean to the west. The continent is home to 12 countries including Brazil, Argentina, Colombia, Peru and Venezuela.

South America is known for its diverse landscapes, including the Amazon Rainforest, the Andes Mountains and the Atacama Desert. It has a rich cultural heritage with indigenous populations and influences from European colonization.

The Caribbean refers to the region located in the Caribbean Sea, which is a body of water in the Atlantic Ocean. It consists of thousands of islands, reefs and cays and is divided into the Greater Antilles (including Cuba, Jamaica, Hispaniola and Puerto Rico) and the Lesser Antilles (including Barbados, Trinidad and Tobago and the Virgin Islands).

The Caribbean is known for its tropical climate, white-sand beaches, turquoise waters and vibrant culture. It has a diverse population with influences from indigenous peoples, Africans, Europeans and Asians. The region is popular for tourism, particularly for its resorts, water sports and historical sites such as colonial-era forts and plantations.

While South America and the Caribbean are separate geographical regions, they share some similarities in terms of climate, biodiversity and cultural influences. Both regions are popular destinations for travelers seeking natural beauty, rich history and vibrant cultural experiences.

South America and the Caribbean in the year 2022, consist of 660,269,074 and in the year 2021 it was 656,098,097 people. (Worldometer)

Calculating its growth rate

Recall equation (8)

$$N(t) = N_0 e^{r\Delta t}$$

$$660,269,074 = 656,098,097 \times e^{r(2022-2021)}$$

$$\frac{660,269,074}{656,098,097} = e^r.$$

$$\ln\left(\frac{660,269,074}{656,098,097}\right) = r.$$

$r = 0.0064$ which is equivalent to 0.64%.

Projecting the population by 2050

$$N(t) = N_0 e^{r\Delta t}$$

$$N(t) = 660,269,074 \times e^{0.0063 \times (2050-2022)}$$

$$N(t) = 660,269,074 \times e^{0.0063 \times (28)}$$

$$N(t) = 660,269,074 \times 1.192915129$$

$$N(t) = 789,853,464.$$

Then the population of South America and the Caribbean projected here is 789 million, 853 thousand, 464 people.

3.6 Oceania

Oceania is a region made up of various island countries and territories in the central and South Pacific Ocean. It is the smallest continent in terms of land area and population. The region includes countries such as Australia, New Zealand, Papua New Guinea, Fiji and many smaller island nations. Oceania is known for its stunning natural landscapes, biodiversity and diverse cultures. It is also home to the Great Barrier Reef, one of the world's most famous natural wonders. The region has a mix of indigenous populations, as well as people of European, Asian and Pacific Islander descent. Oceania has a strong economy based on agriculture, tourism, mining and services.

In the year 2022 the Oceania had population of 45,038,552 people and 44,491,724 people in 2021. (Worldometer)

Then, calculating its growth rate is as follows

Recall equation (8)

$$N(t) = N_0 e^{r\Delta t}$$

$$45,038,552 = 44,491,724 \times e^{r(2022-2021)}$$

$$\frac{45,038,552}{44,491,724} = e^r$$

$$\frac{45,038,552}{\ln(44,491,724)} = r$$

$r = 0.0122$ which is equivalent to 1.22%.

Projecting the population by 2050.

$$N(t) = N_0 e^{r\Delta t}$$

$$N(t) = 45,038,552 \times e^{0.0122 \times (2050-2022)}$$

$$N(t) = 45,038,552 \times e^{0.0122 \times 28}$$

$$N(t) = 45,038,552 \times 1.407197306$$

$$N(t) = 63,378,129.$$

So, the projected population of the OCEANIA here by 2050 is 63million, 378thousand, 129 people.

3.7 Projecting World Population Globally

The World is an interesting place which we are going to consider next. After taking a look at the projection of world population by continent and see how it was then the entire world population in general is going to be next.

The world population in the year 2022 was 7,975,105,156 people and in 2021 it was 7,909,295,151 people. (Worldometer)

Calculating its growth rate.

Recall equation (8)

$$N(t) = N_0 e^{r\Delta t}$$

$$7,975,105,156 = 7,909,295,151 \times e^{r(2022-2021)}$$

$$\frac{7,975,105,156}{7,909,295,151} = e^r$$

$$\ln\left(\frac{7,975,105,156}{7,909,295,151}\right) = r.$$

$$r = 0.0083.$$

Projecting the entire population by 2050.

$$N(t) = N_0 e^{r\Delta t}$$

$$N(t) = 7,975,105,156 \times e^{0.0083 \times (2050-2022)}$$

$$N(t) = 7,975,105,156 \times e^{0.0083 \times 28}$$

$$N(t) = 7,975,105,156 \times 1.261624278$$

$$N(t) = 10,061,586,280.$$

So, the projected world population here is 10 billion, 061 million, 586 thousand 280 people.

CHAPTER FOUR

OBSERVATIONS IN THE LAST CHAPTER

4.1 Africa

Africa population projected in the previous chapter was 2,750,570,127 people. One of the observations in the process is that first, according to the model used the growth rate of the population wouldn't change from the population 2022 which was used as the initial through to 2050 which was the actual population we intend to know the relative possible value. Imagine if there is increase in immigration and decrease in emigration this literally means that the rate of population growth for every year could vary as the population could increase or decrease respectively. But the model made these factors constant which implies that there's no change in the growth rate from the initial population to the actual population value we are searching for.

Another one is, if it is possible that the population decrease at some point in between those periods of years between 2022 to 2050. It would mean that there is every probability of not getting the same value gotten in the previous chapter. But in comparison with the figure of some statistical and mathematical analysts about population have brought out, I can say the model is relatively accurate in projecting Africa population as one of the continents of the world by 2050.

4.2 Europe

Here the previous explanation is more glaring to understand as the population growth rate of Europe between 2021 and 2022 implies that Europe has decreased in population. Can we now say that European population will continue to decrease obviously the answer to that question is

no, but according to the figure it implies that there would be a decrease in Europe population up to 2050. Decrease of Europe population could be as a result of many factors which could be low-birth rate and low-death-rate, another factor could be low migration but according to reality in the society we can barely take that for an answer because the rate of migration to Europe especially from Africa, Asia and South America is glaring even for the blind man to see, majorly because they have good economy, availability of large workable environment and security and better pay.

4.3 Asia

Asia is the world largest continent that has the highest number of people. Although they have a relatively low population growth rate, they are still topping the chart of population in the world by continent. They have an initial population of 4,722,634,763 in the year 2022 but yet still have a projected population of 5,580,167,849 by 2050, even if the growth rate is small compared to Africa it is still the world highest.

Asia has many countries in the continent that are developed, many are developing, and some are underdeveloped with the rate of increase in their population, can they take care of the population by 2050. In the midst of economy crises that many nations found themselves and the entire world at large, can people be able to afford the cost of living then, with the rate at which everything including currency especially are getting inflated every moment and cost of living is becoming higher than necessary. How can we be sure that the under-developed countries will not continue being under-developed this also goes for the developing countries, because citizens' demand will always be on the neck of their leaders.

4.4 North America

Here the population is relatively growing stealthily with a rate of 0.42325%. the growth rate here is not too high for my own observation and it's relatively fine for a continent that have resources to take care of their citizen in comparison to their land masses. Canada has one of the biggest land mass in the world but also have low population which means that migration forms one of the biggest mode of population growth as they have economy that is in need of large number of labour. With the necessary comparison with the United Nation's data I can say for real that North America population projected here is relatively correct.

4.5 South America

South America also known as the Latin America I can also say have relatively sensible growth rate at 0.64% but unlike Asia that have some developed countries who can still pull some economic growth through out the continent, it contains mainly developing countries who themselves needs help from countries who are outsiders so, they have high inflation and poverty level which could hinder the opportunity for qualitative education and better health care of their citizen with the current projected population it may be unbearable for the government or else they make effective plans to tackle them.

4.6 Oceania

The Oceania with the population of 45,038,552 in 2022 and 63,378,129. By 2050. It has a population growth of rate of 1.281%. I can also say it is fine given that they have land mass to take care of their livelihood as some country as there were some developed countries which could assist in developing their neighboring country. And,

also by comparison with United Nation's data I can say the estimated value here is relatively correct.

4.7 General Global World

Likewise in the previous chapter we shall draw some observations in the process of estimating population by 2050.

In the process we notice that the growth rate is relatively low at 0.0083 which is equivalent to 0.83% . Which implies that that world growth rate is relatively fine. With the initial population 7,975,105,156 in 2022 the world population projected in the previous chapter to be 10,061,586,280 people. Which implies that the world population will increase by over 2 billion people by the year 2050.

This can be a major concern as people increase so demands are triggered up, assuming that is the actual population by 2050, then the world may face many crises because of population explosion in some countries that have high birth rate and low death rate where people aren't with the orientation of how they can control birth and where people extol cultural belief more than modern day reality, that is they choose not to believe in population explosion and challenges that comes alongside. People like African who believe in larger procreation than the reality of modern day challenges of it. If this take place there would be a severe food insecurity, terrorism, banditry and whole lot of crime in the society where it really concerned. And, also the United Nations body will also feel its effect because they will need to deploy learned personnel to those area for orientation in collaboration with their government and also aids material to cushion the effect that arises.

Poverty is another thing maximize and increase in rage and many out of school children

will be many in those countries because of this reality.

CHAPTER FIVE

5.1 CONCLUSION

Human population estimation is germane in truth, important to know, essential to have a clue about, this brought a lot of benefits to our daily planning regarding our future reality.

In this project we look at the concept of population, sampling and its like, we also take a look at the insight into the assumption of Malthus and its effect on estimating population. We go further to develop the model from the assumption of which we use to do the estimation in the project.

Malthusian model being an assumption from a British economist is an important mathematical tool used in determine the actual number of humans by 2050. In this project we estimate the world population by two categories they are; on the Continental basics and general world basics, where we calculate the respective growth rate of each continent in the world, then we also observed some having decrease growth rate while some are relatively low and some a little bit high like the case of Africa. And we also estimate their respective population by 2050 which was projected.

We also estimate the world population (now not by continent but generally together), its growth rate and the projected population by 2050, which is the major goal of this project.

But on one side we also relate the outcome with the effect it could trigger in the society, how it can affect the livelihood of the people then perhaps. How it can even affect the government

because there's this popular saying "a problem known is half solved" so I think by this government and nation's leaders can make effective planning in dealing with the reality that may possibly occurs.

5.2 RECOMMENDATION

With my observation so far in this project, I will state the following recommendations, that would help society if they would take it into consideration.

As mathematical model has helped in reveal possibly future reality, then, there's need for adequate planning by those who it may concern.

- Government should improve investment in mechanize agriculture for maximum and bountiful scales of production of food that would take care of their citizen's livelihood.
- Like China, some densely populated poor countries should introduce measures to control birth rate which could be high there.
- The government should invest more on education in sensitizing the people on the important of birth control.
- The society and families should help more to train their wards to avoid child marriage and teenage pregnancy.
- The society should embrace and appreciate the effective use of mathematics in predicting and providing future data that may possibly occurs.
- Developing ourselves and our society technologically to meet up to future standard of living.

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