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Population Forecasting for Design of Water Supply System in Injibara Town, Amhara Region, Ethiopia

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Abstract
This research was conducted to explore the real problems occur in population forecasting of Injibara town and then pin points of the better means of potentially water supply development of Injibara town, Amara Regional state, Ethiopia.Population forecast is a scientific procedure to work out future population of given town. In order to sustain the town water supply scheme over the period of time and to propose the improvement in the existing town water supply scheme consumption and design parameters are depending on population of today and coming 2-3 decades. The design population is estimated considering all the factors governing the future growth and development of the project area in the industrial, commercial, educational and social and administration spheres. Special factors causing sudden immigration or influx of population should be considered.In present study population of four decades, from 2014, 2015, 2016 and 2017 are taken as base population and forecasted from the year 2019 to 2040. Increase in population over decade is calculated and present the population forecasting is done for five kebeles of Injibara town water supply systems, using average results obtained by Arithmetic progressive method, Incremental increase method, Geometric progression method and Exponential growth rate methods.The statistics of projected population is the basic criteria for the addition of diameter of pipe and length of distribution system. Also the magnitude of total head assigned to reservoir, power capacity of pump, treatment plant, systems of water supply and distribution system, per-capital demands of water and fire demand may be prescribed as design parameter of Injibara town water supply scheme.
Keywords: Arithmetic method, Incremental method, Geometric method and Exponential methods, in Injibara town.

I. NTRODUCTION

Population forecasting is very important to know the growth rate and to estimate future population of particular area. Agricultural resources development, water demand and urban facilities (infrastructures) are managed based on Population projection. Variations in population are agents of change, inducing many of the environmental, economic, political and social changes, concerns about human survival, health, education and wellbeing are the reasons for our interest in global change. Forecasts of the population and its various structures are the most important inputs to global change scenarios. Planning for the future requirements of the population has become the major concern of the planners and requires accurate estimates of the future population growth rate. Assumptions used forms a critical input in mathematical analysis. Caution must be taken while making or using the population projections in the context of various conditions imposed.

In the present study we develop population projection for Injibara Town water supply scheme by using average of Arithmetic progressive method, Incremental increase method, Geometric progression method and Exponential growth rate methods (WSEE.2011).

Detailed implementation procedure and the outcomes are presented in the subsequent sections.

1.1. Statement of the Problem

Injibara town has been the problem of inadequate safe water supply, due to lack of proper forecasting of existing population and future population of town. The people of this study area have been fetching water from rivers, spring and traditional hand dug wells due to lack of adequate water supply. It had been an Administration center from long period of time for the Awi Zone in Amhara regional state, Ethiopia. As clearly suggested by the United National Development Program (2006), nearly one six of the World population's obtained drinking water from the unimproved sources, and in many developing areas, progress in expanding clean water coverage is smallest. Moreover, access to and use of unsafe drinking water can be cause many problems related to health, productivity, and social development. However, many people in developing countries continue to reply on unprotected water sources.

A rapid and steady growth of population in and around the town has forced Injibara town to give proper and timely response to urban service demands like water supply. This increases anticipated growing more with the emergence of various governmental, non-governmental and private institutions and job seeking migrants in the future means for rising demand for additional urban services including water supply. So, it has been fast spatial expansion necessitates a suitable action plan to improve their urban infrastructure particularly water supply. The situation of the water supply in Injibara is very similar to that of other developing countries' towns where water

supply situation in the town has been deteriorating. The problems associated with inadequate water supply services in this town contribution to urban environmental degradation and cause damages to public health. Hence, the dwellers explained problem of water supply in Injibara town was not only the problem of population forecasting, adequacy and quality but also it has been the problem of distribution and reliability.

1.2 Objectives of the study

The general objective of this research is to assess and identify the future population forecasting of the Injibara town. The specific objectives of the study are;-

a) To assess and describe the future population of town by using four methods of population forecasting.
b) To examine the best population forecasting methods of the town for future
c) To assess the population growth rate of the town
d) To estimate the future water demands of the town based on future population numbers
e) To estimate the expansion rate of the town
f) To find out the challenges in enhancing population growth rate in Injibara town;
g) To assess the capacity of the town

1.3. Scope of the Study

The scope of the study is limited to population forecasting. This town was selected because of its fast growing nature with inadequate water provision and as per investigators and it have been get there was no research conducted population forecasting for water supply and other infrastructure of the study area (personal communication).

1.4. Limitation of the Study

The study was the limited access of the numbers of population immigration and emigration of Injibara Town due to lack of enough data collection of total population in Injibara town per day, month and year.

Furthermore, lack of sufficient time and finance limit the size and natures of the study areas to collected the numbers peoples from each household of the town.

1.5. Significance of the Study

Population forecasting is the major challenge in entire world predominant in third world countries, like sub-Saharan Africa, particularly Ethiopia. Because the people moving (i.e. immigration and emigration) one place to other place, that means from Ethiopia to other countries or other countries to Ethiopia without any gap. These types of problem are occurred in Injibara town time to time through the year.

Finally, to forward the possible suggestion to the policy makers, academic community, NGOs, CBO and other stake holders who are concerned used for designing a more effective method of population forecasting, there by contributing to narrowing the knowledge gap between population forecasting, supply and demand for safe water supply service; can help private institutions to engage in the delivery of this service, provided they are permitted to get involved in the sector.

2. LITERATURE REVIEW

The design population forecasting is estimated with due to all factors governing the future growth rate and development of the project area in the industrial, commercial, educational, social and administrative spheres. Special factors causing sudden emigration or influx of population should also be foreseen to the extent possible (WSEE 2011).

The development of a particular city (town) or a region depends upon natural, physical and socio-economic factors. Among these factors the population assumes significance in determining the future pattern of progress and development.

Design of water supply and sanitation scheme is based on the projected population of a particular city or town, estimated for the design period. Changes in the population of the city over the years occur and the system should be designed taking into account of the population at the end of the design period (Waste water treatment.2012).

Factors affecting changes in population are: increase due to births, decrease due to deaths, increase/ decrease due to migration and increase due to annexation (Water Supply and Environmental Engineering).

The present and past population record for the city can be obtained from the census population records. After collecting these population figures, the population at the end of design period is predicted using various methods as suitable for that city considering the growth pattern followed by the city (WSEE 2011).

Perhaps no single factor is more important for local government planning than the size and composition of a town's population and the way it will change in the future. Even though the total population may remain constant, changes in its composition can fundamentally alter the need for public facilities and services:-

Klosterman (1990),

3. MATERIALS AND METHODS

3.1. DESCRIPTION OF STUDY AREA

The study was conducted in Injibara Town, Amhara Regional State, Ethiopia. Its relative location is in the south western part of the region and North western part of the county, Ethiopia. It is about 447 km away from the capital city of Ethiopia, Addis Ababa and 118 km from Bahir Dar, the capital city of the Amhara Regional state. Geographically, Injibara is found in 10059'N and 36055'E longitude. The highest and lowest altitude of Injibara is recorded to be 2540m.a.s.l and 3000m.a.s.l respectively (Zenebe consultant, 2009). According to the town's Administration the total area of the town is estimated to be 28.3 km2. It is divided into five urban Kebeles under the town administration. The current development plan for Injibara Town was prepared in 2004 by National Urban Planning Institute. The development plan shows that there are areas allocated for residential, commercial, industrial and service-giving institutions. With the growth of the private sector in the economical activity of the town, there will be a high demand for basic services among which water is the prime necessity (National Administeration.2004).

The proposed town development plan supplemented with on-site observation, topographic maps and consultation with the local community, governmental and non-governmental organizations are among the basis for water demand computation and design of future water supply system.

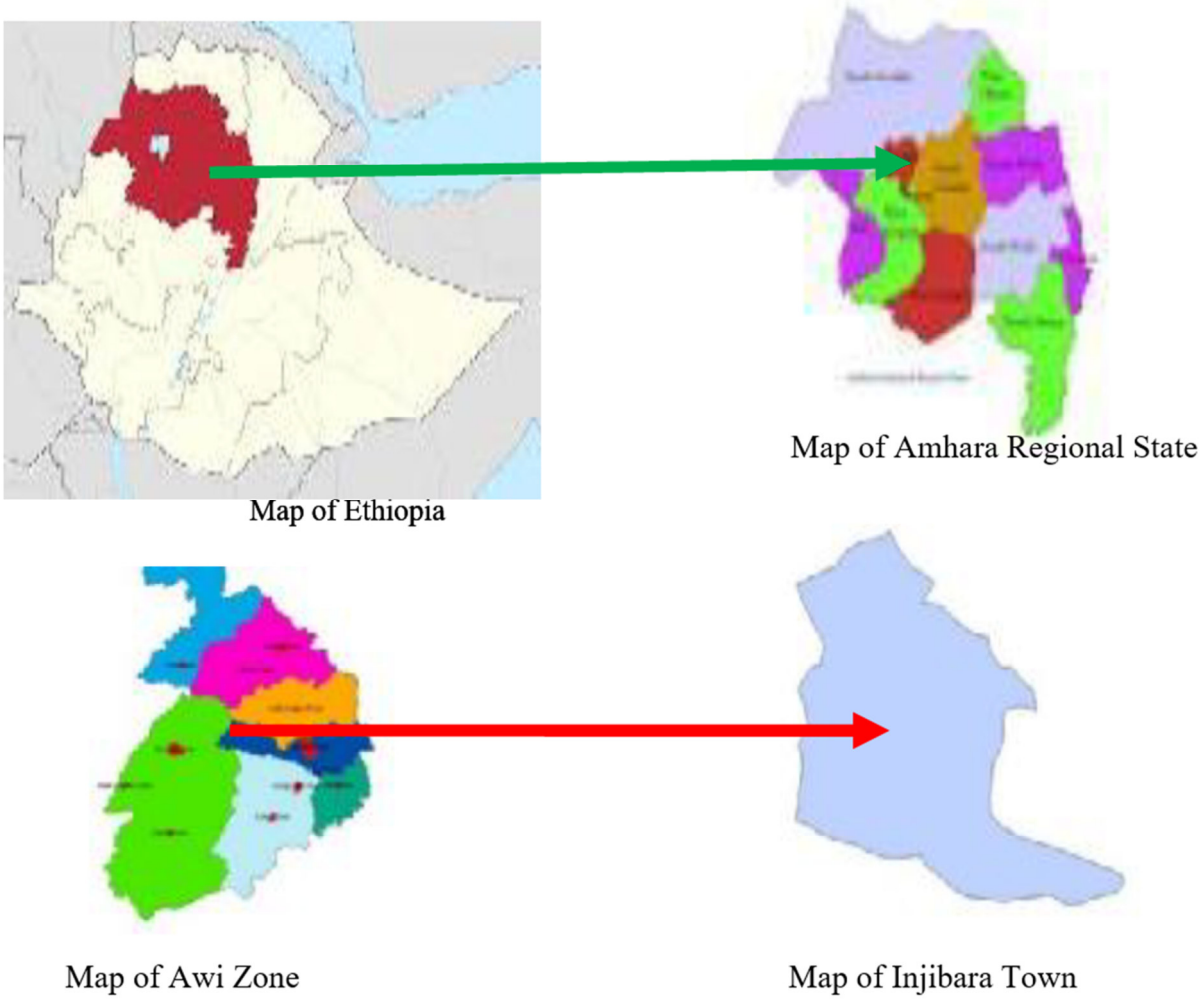

Figure 1 Map of Ethiopia, Amhara Regional State, Awi Zone and Injibara Town

3.2. Climate

According to the metrological data obtained from the National Metrological Service Agency, the average annual rainfall at Injibara town is 1813 mm and its mean monthly precipitation is 38 mm (Meteorological agency.2018). The average maximum monthly temperature is 29.90C while the average minimum temperature is 2.60C. The months maximum temperature are from February to April the lowest temperature is recorded during the months of December& January (Meteorological agency.2018).

According to the climatologically classification, Injibara area belongs to the "Dega" Temperate Rainy climate".

3.3. Infrastructure and Services

Injibara has road connections by asphalt road and is accessible all year. Injibara enjoys the benefits of a digital automatic telephone system. Mobile telephone and postal service are also available. Injibara receives a 24 hour electric supply from the country's hydroelectric grid system. There are about 20km of gravel roads within Injibara. The existing water supply source is a spring located in the western outskirts of the town (Injibara Town Administration.2004). .Government and public institutions in Injibara town are given in the below table:-

Table 1 Government and Public Organizations of Injibara town

Name of Organization	Number
Government offices	54
NGO offices	2
Orthodox Churches	6
Protestant church	4
Mosques	1

Source: - Injibara Town Administration 2018

3.4. Economic Situation

Injibara is a Zonal capital and is therefore an important administrative and communication centre with more population. Injibara is also major transit centre as it located on the main road from Addis Ababa to Bahir Dar. The town also serves as a major marketing centre with thousands of rural people flocking into the town.

The major economic activities according to the town's administration office are trading, hotel services and small-scale industries.

According to the development plan of Injibara, social and personal services are the dominant sector in the town's economy followed by trade and tourism.

The status of Injibara town as a Zonal Capital means that administrative and law enforcement institutions are centered here.

Manufacturing is the other dominating sector providing employment. It is mostly grain and oil milling activity but the potential to diversification and growth is high. The construction sector is a relatively young sector linked to the growing demand for modern buildings.

Table 2 Business Institutions in Injibara Town

Type of Enterprise	Number
Hotels	38
Bars and Restaurants	20
Metal and wood work	41
Garages	15
Retail &Wholesale trade	156
Grain Mills	20
Transport service	5
Small and micro industry	23
Town Agriculture	11
Abattoir	1
Tea rooms and Cafeteria	135
Fuel Stations	3
Oil mill	6
Bakery	8

Source:-Injibara Town Municipality, 2018

3.5. Future Development of the Town

A Master Plan for the town was prepared in 1994. According to towns administration the town's development plan in terms of land use and area is: - Residential 273.4 hectare, Commercial 93.75 hectare, Institutional 7.68 hectare, Recreational 3.6 hectare, Agricultural 3.6 Hectare, Manufacturing 2.63 Hectare and Others 1.05 Hectare (Injibara Town Administration.2004).

According to the information from the town's administration office the economy of the town is expected to improve significantly. The office believes that almost all sectors of the economy are expected to grow in the coming years.

It is expected that small scale industries will grow substantially followed by the building sector and hotel

industry. Trading and transport sectors are also to grow significantly. Planned investment projects in the town, according to the information of the municipality are: - Real state, Hotel and tourism and Social services.

3.6. Basic Social Services

3.6.1. Educational Service

In addition to the existing ones, considering the fair distribution of educational services for every corner of the town this study reserved sites for: one teacher education college and one university at Chagni and Bahir Dar exit respectively and one technical college and two private colleges and one primary & junior secondary school in western & another junior secondary school in the northern part of the town, Bahunk primary & junior secondary school is recommended to grow to high school. This additional land adjacent to Bahunk School is added for future expansion, one primary school is also proposed as the western part (to Chagni exit) of the town and, kindergartens should be built in every neighborhood at a minimum of children walking distance during detail plan preparation. The University site called Awi University shows the map in the southwestern part of the town (filed observation).

3.6.2. Health

One Hospital, health centre and two private clinics are found in Injibara town. The hospital has more bed room and laboratory class and health centre has 6 beds. The number and percentage of incidences (Ten top diseases) in the year 2007/08 is given in Table 3.

According to officials of the health institutes in Injibara, intestinal parasites and skin infections are the most common water related diseases linked to poor water quality. High prevalence of these is an indication of the status of water supply and personal hygiene

Table 3 Top Ten Diseases of Injibara town

Name of Disease	No of Patients	%
Intestinal parasites	529	22
Rheumatisms	311	13
Pleurisy with infusion	265	11
URI	251	10
Infection of skin	205	8
Gastritis	198	8
Dog bit	198	8
Skin disease	176	7
Lober Pneumonia	150	6
Other Diseases	147	6
Total	2430	100

Source: Health office of Injibara Town in 2018

3.6.3. Existing Water Supply of Injibara Town

The primary source of supply for Injibara town is from sutang spring. The spring source is known locally as sutang spring constructed in 1985. The spring is located on the west said of the town boundary and this source of water supply is augmented with the spring water constructed by town municipality and water office discharge rate of 9 liter per second. Water from the spring box gravities into a 10m3 collection chamber and it pumped in 75m3 existing stone masonry reservoir from where in gravitates into distribution system. The water is distributed to the consumers through houses, yard connection, yard shard connection and public fountains.

The water shortage is the major problem with existing system, according to the information from the water supply and sewerage offices during a data collection visit by the consultant, almost all the households are dissatisfied with quantity of water supplied, while all of them considered the quality as good. Also all hotels and businesses are dissatisfied with the quantity of water. Domestic supplies are supplemented from secondary source from the river, small springs and hand dug wells. But at present time there is additional two boreholes are operational cumulative discharge rate of 36 liter per second (i.e individual discharge is 18l/second); this boreholes are constructed in 2014-15. The total discharge rate is 45 liters per second (water supply and sewerage offices, 2018).

At this time existing water supply of Injibara town is not enough to communities, due to quantity and quality of water. The demand and supply is not proportional to numbers of population of the town due to these reason the system of water supply is intermittent system, the water is coming 3-4 day for 8 hours in week with poor quality. These are due to lack of proper forecasting of town population (Water Supply Office of Town.20018).

3.6.4. Sanitation Services

The overall sanitation of the town is poor and sanitation associated diseases are prevalent. There is no system for collecting, transporting, and dumping waste in the town (Water Supply Office of Town.20018).

3.7. Population of Injibara Town

The population or universe of the study is the whole population residing in the planning boundary of Injibara town.The population of the town is increasing due to rural to urban migration, as well as natural population increase within the town. Due to the capital city of Awi zone, people migrate to Injibara town for searching work and also the weather condition is favorable for life, the total population of the town was rapidly increasing through time. The total numbers of population in 1994 and 2007 Central Statistical Agency (CSA) 0F Injibara has an estimated population of 5129 and 21,065 respectively and also at this time in 2014, 2015, 2016, 2017 and 2017 are 37718, 39654, 41735 and 43777 respectively (Injibara town Administration, Finance and Economic development office, 2018), these shows rapid growth of the town population year to year

3.8 Methodology of the Study

The overall approach of the study follows the methods of triangulation. It employed both quantitative and qualitative methods of data collection and analysis. To keep its validity and reliability, the study was guided by the principles of multiple sources and subsequent cross-checking of information as well as by applying various data collection information's. Details of the methodology are briefly presented in the next section

3.9. Research Design

The research design of the study was descriptive survey method for to asses' population forecasting processes in Injibara town, which generate and analysis the relevant data through questionnaire and interview on the existing population condition in the study area and on factors that implied the provisions of population and also this survey method was a hoped to gate an appropriate description of the current status and immediate past of population situations of Injibara town. The study followed qualitative and quantitative approaches because the study requires both qualitative and quantitative data which are obtained from primary and secondary data.

3.9.1. Source of Data

In this research work Investigator used both Primary and secondary sources.

Primary data was collected from sampled households about population forecasting of future water supply; through questionnaires, interviews, and field observation which include necessary information, opinion, views and attitudes.

Secondary data was collected from published and unpublished documents, maps, plans, journals, magazines, books, standard documents, central statistical agency information and other related material collected from different sources etc that helped to review the overall population forecasting situation in the area of study.

3.9.2. Data Collection Instruments

To obtain sufficient information from the selected sources, different data collection tools were used which were questionnaire, interviews, personal observation and document analysis. Where, the questionnaires were the major tools of data collection for the study that were used and other tools were used to make stronger or fill the gap that might seen the data collected by questionnaires which was the major tools of the data collection.

3.9.3. Questionnaire

Questionnaires (both closed and open ended questions) and Focal Group discussion**:-**questionnaires were prepared to gather information about accessibility of water supply based on population forecasting of future. These questions were conducted with concerned heads and officials of the city staff (Administration office, Water, mineral and energy head office and expert, Healthy center administrator, development agent (DA), Finance and Economic development office head or representative and expert), Zone water resource office head and higher professional, and urban development and statistics department and also the concerned bodies, interrelated official of kebeles representative and Water board of the Injibara town based on population forecasting of future water supply of town. All of the questionnaires were first prepared in English and then translated in to Amharic. Amharic version questionnaires were pre-tested on respondents in the communities. This was done purposely for clarity, acceptability, flow and reduction of repetition.

3.9.4. Interview

The purpose of interview was to collect more supplementary opinion, so as to stabilize the questionnaire response. Semi-structured interview was posed to the selected Officers for interviews and discussing with them directly face to face contact this officers were head of administration and human resource management of the office these were selected due to their position and the issue more concern in different means. The interview about the urban facilities like water supply, health condition that was related with water particularly accessibility, reliability, and adequacy to identify the condition in the town.

The reason behind using a semi-structured interview was due to its advantages of flexibility in which new questions were forwarded during the interview based on the responses of the interview. The interview was conducted in Amharic language to avoid language barrier and supported by Audio (tape recorders) in order to minimize loses of audio information. The recorded data was categorized based on similarities of responses and then translated in to English language during the transcription. This was helped the investigator to get relevant

and more reliable information.

3.9.5. Field observation

From the affairs started relates with the situation of life of the people and distribution area of population, participatory observation was enable the researcher to observe and discuss with the selected groups on the mater by preparing checklists. Thus, field observation had the necessity of becoming part of the selected group and observes how they get; fetch water and asking clarification on their actions. As the same way, observation was used by the investigators in order to obtain further or additional information to validate the information from the scheduled interview.

3.9.6. Document analysis

It was used to collect appropriate information to investigate the existing problems in the town with reference to municipality that with water supply problem due population forecasting and consequences. Due to its strengthen (helped/validated) the consistency of scheduled interview data like other primary techniques. Particularly, for this study the investigator was used total population issue related articles, minutes and written materials in the sectors of the town.

3.10 Methods of Data Analysis

After the completion of data collection, coded, tabulated, analyzed, described, interpreted properly and descriptive statistical techniques (percentages, using table, using figures, frequency and rank order etc) were employed as methods of data analysis that means both quantitative and qualitative. In addition the data was analyzed by using different techniques.

Additionally, qualitative data collected through close-ended and open-ended questionnaires, interview, observation and document analysis data were logically interpreted and analyzed to strengthen and support the quantitative data collected through questionnaires.

Relevant computer software, like GIS, Micro Soft Excels, Global Positioning System (GPS), etc. with sufficient verbal description was used for data processing and analysis.

4. RESULTS AND DISCUSSION

4.1. Population Forecasting

The design population is estimated with due to all factors governing the future growth and development of the project area in the industrial, commercial, educational, social and administrative spheres. Design of water supply and sanitation scheme is based on the projected population of a particular city or town and also estimate the design period of the components of all structures of water supply and sanitation are depends on projection of population. Changes in the population of the city over the years occur, and the system should be designed taking into account of the population at the end of the design period.

Factors affecting changes in population are:-Increase due to births, decrease due to deaths, Increase/ decrease due to migration, Increase due to annexation, change(in education, politics, recreation and economic), increase in facilities of transport system and sudden increase in religions importance of the city of town (Water supply and Environmental Engineering 2011 and town administration 2018).

The present and past population record for the city can be obtained from the census population records. After collecting these population figures, the population at the end of design period is predicted using various methods as suitable for that city considering the growth pattern followed by the city.

4.1.1. Methods of Population Forecasting of Injibara Town

There are four methods population forecasting of future population of Injibara town for 22 (2019-2040 GC) years. Those are: - Arithmetic progressive method, Incremental increase method, Geometric progression method and Exponential growth rate methods.

1. Arithmetic progressive method

Arithmetic progressive method is the average rate of increase in population is assumed to be constant from decade to decade. Average increase per decade is found out from the previously available census data. The product of this amount obtained and number of decades for which the population is to be worked out is added to the present population of the subjected area to get the approximate population after n decades (WSEE.2011). By using the formula given below the future population is worked out.

$P_n = P_0 + n*k$ Where, P_n = future population after n decades

P_0 = present population

n = number of decades

k = average increase per decade

2. Geometric increase method

This method is based on the assumption that the percentage increase in population from decade to decade remains constant. In this method the average percentage of growth of last few decades is determined; the population forecasting is done on the basis that percentage increase per decade will be the same (WSEE.2011).

Average percentage increase per decade is found out from the previously available census data. By using the formula given below the future population is worked out.

$P_n = P_o * (1+G)^{\wedge n}$ Where, P_n= future population after n decades

P_0= present population

n= number of decades

G= average percentage increase per decade

3. Incremental increase method

This method is improvement over the above two methods. The average increase in the population is determined by the arithmetical method and to this is added the average of the net incremental increase once for each future decade (WSEE.2011). Future population is worked out from the equation given below.

$P_n = P_o + n^* (k_1+K2)$ Where, P_n = future population after n decades

P_o = present population

n = number of decades

K1 and K2= average increase per decade

4. Using Ethiopian Statistical Authority (Exponential)

This method is used by the central statistics Authority of Ethiopia. It is expressed by the following equation (WSEE.2011).

$P_n = P_{o*} e^{r*n}$ where P_n = future population after n decades

P_o= present population

n = number of decades

r=growth rate

e= Exponential

4.1.2. Base population of the town

An accurate population of the town is absolutely necessary since a town or city population determines water requirements for the different purpose of water supply system. It must be includes all peoples, who utilize water for drinking, washing clothes, cooking, bathing, cleaning utensils and watering animals. The base population of the Injibara town is 37718, 39654, 41735and 43777 in 2014, 2015, 2016 and 2017 respectively (CSA).

Table 4 Base population of Injibara town

Year	2014	2015	2016	2017
Population	37718	39654	41735	43777

Sources: central statistical agency of Ethiopia and (Injibara town Administration, Finance and Economic development office, 2018)

Population Growth rate: - The "population growth rate" is the rate at which the number of individuals in a population increases in a given time period, expressed as a fraction of the initial population. Specifically, population growth rate refers to the change in population over a unit time period, often expressed as a percentage of the number of individuals in the population at the beginning of that period (National population growth rate.2018). This can be written as the formula, valid for a sufficiently small time interval:

Population growth rate = $\frac{P(t2)-P(t1)}{P(t1)(t2-t1)}$ Where P = population of town

t1=the beginning of that period

t2=the end of the period

A positive growth rate indicates that the population is increasing, while a negative growth rate indicates that the population is decreasing. A growth ratio of zero indicates that there were the same number of individuals at the beginning and end of the period a growth rate may be zero even when there are significant changes in the birth rates, death rates, immigration rates, and age distribution between the two times.

Table 5 population projection (2018-2048)

Year	2015	2018	2023	2028	2033	2038	2043	2048
Annual growth rate	4.3%	4.4%	4.1%	4.0%	4.2%	4.1%	4.0%	4.2%

Sources: the 2007 Central Statistical Agency National figures are used as a base

Table 6 Calculation of population projection of the average increase per decade from base population

Year	Population	Arithmetic increase	Geometric increase	Incremental Increase
2014	37718		-	-
2015	39654	1936	0.05	-
2016	41735	2081	0.05	145
2017	43777	2042	0.05	-39
Total	162884	6059	0.15	106
Average		2019.67	0.05	53

From the above table used population projection constants to calculate population by three methods are:-

K1= 2019.67 G = 0.05 K2 =53

Sample of calculation

For Arithmetic = (39654-37718)/1 = 1936

For Geometric = $\frac{\text{Arithmetic increase}}{\text{population}} = \frac{1936}{37718}$ =0.05

For Incremental = the difference of Arithmetic increase =2081- 1936=145

Table 7 population projection using four different methods

Year	Arithmetic increase	Geometric increase	Incremental Increase	Exponential
2017	43777	43777	43777	43777
2019	47816	48348	47922	47804
2025	59934	64791	60358	61136
2030	70033	82691	70722	74672
2035	80131	105997	81085	92122
2040	90229	135870	91448	113081

Sample calculation for each method

Where p_0 is number of population at base year (2017) is:-

For Arithmetic (p_{2019}) = p_{2017}+k1*n = 43777 + 2019.67 *2 =47816

For Geometric (p_{2018}) = $p_{2015*(1+G)^{n}}$ = 43777*(1+0.05) ^2 =48348

For Incremental (p_{2018}) = $p_{2015+n\,(k1+K2)}$ = 43777+3(2019.67 +53) = 47922

For Exponential (p_{2018}) = p_{2015*}e(n*r) = 43777*e(2*0.044) = 47804

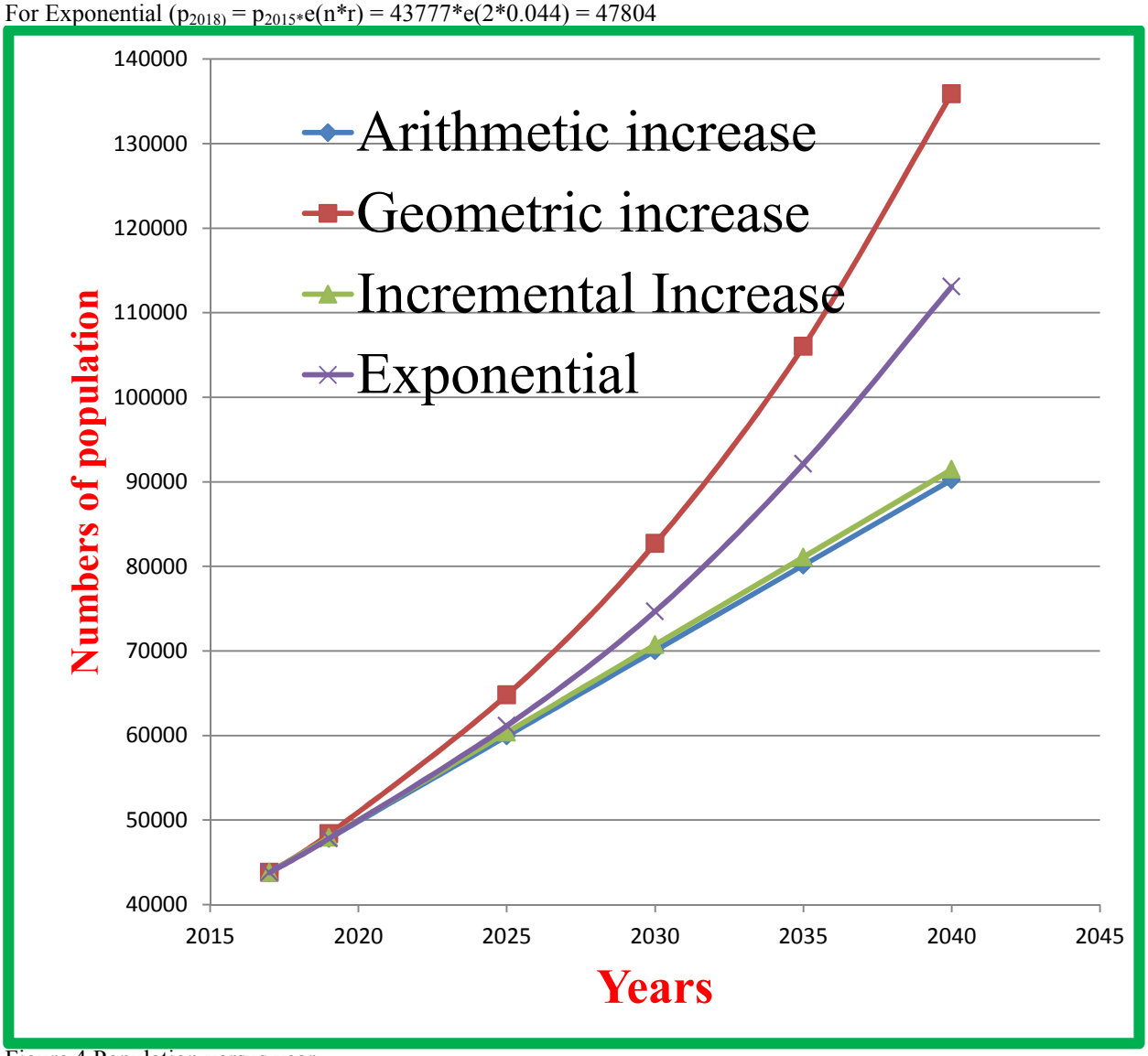

Figure 4 Population versus year

Selection of most reliable method

For the selection of the best methods for the Injibara town we have considered the following factors. The number

of present population of the town, availability of data for the calculating of the projected population , the incremental situation of the population from decade to decade or from year to year, the oldness of the towns, the increment of population due to migration, under estimation of the population and percentage error. The percentage error calculated for all the methods used so that the one with a minimum error is selected as a design parameter of population forecast of Injibara town. The percentage error is calculated by assuming the actual population in the year 2017 is not given and determining it using all the methods. The constants were calculated excluding the year of 2017.

Table 8 Average increase for population projection by different methods excluding year of 2017

Year	Population	Arithmetic	Geometric	Incremental
2014	37718	-	-	-
2015	39654	1936	0.05	-
2016	41735	2081	0.05	145
Total	119107	4017	0.1	145
Average		2008.5	0.05	145

K1= 2008.5 G=0.05 K2=145

Table 9 calculated value for the year of 2017 using four different methods

Year	Arithmetic	Geometric	Incremental	Exponential
2016	41735	41735	41735	41735
constant	2008.5	0.05	145	0.043
n	1	1	1	1
2017(calculated)	43744	41736	43889	43569

Sample of calculation

For Arithmetic (p_{2017}) =p_{2016}+k1*n=41735+2008.5*1=43544

For Geometric (p_{2017}) = $p_{2016*(1+G)\,\wedge\,n}$=41735*(1+0.05) ^1=41736

For Incremental (p_{2017}) = $p_{2016+n(k1+k2)}$= 41735+1(2008.5+145)= 43889

For Exponential (p_{2017}) = p_{2016*}e (n*r) = 41735*e (1*0.043) = 43569

Table 22 true value versus calculated value for the year 2017 using four methods

Year	Arithmetic	Geometric	Incremental	Exponential
2017(actual)	43777	43777	43777	43777
2017(calculated)	43544	41736	43889	43569
percentage error	0.0075	0.047	-0.0056	0.0047

Sample calculation:

$$\text{Percentage error} = \frac{\text{Actual population of 2017} - \text{Calculated population of 2017}}{\text{Actual population of 2017}}$$

$$\text{Percentage error For Arithmetic} = \frac{43777-43544}{43777} = 0.0053$$

$$\text{Percentage error For Geometric} = \frac{43777-41736}{43777} = 0.047$$

$$\text{Percentage error For Incremental} = \frac{43777-41736}{43777} = -0.0056$$

$$\text{Percentage error For Exponential} = \frac{43777-43569}{43777} = 0.0047$$

From all the above methods Exponential increase method is selected. Because percentage error of Exponential increases method is the lowest value (minimum value) than other methods. Also this method is good for developing countries as well as developing town or city like Injibara town. Exponential increases method is used growth rate of population for calculation of the future population of town and also corresponding to population growth rate of given town. For these reason Exponential increase method is best method for forecasting Injibara town population for water supply, sewerage system and any infrastructure of the town based these population numbers. So population at the end of the design period 2039 is 99011.

5. Conclusion and Recommendation

5.1. Conclusion

The Exponential increase method is the best method of population forecasting based on past information the Injibara town population. This method tends to give a higher estimate than other methods normal since it behaves exponentially. It is more accurately describes the continuous and cumulative nature of population growth rate of the Injibara town. It is corresponding to population growth rate of the town present and future rather than other methods due its minimum percentage error and graph of future population of town and also good for developing countries as well as town or city like Injibara town.

Population forecasting is good for one developing town or city for implementation of different infrastructure addition to water supply of town and used to control the number of future population of the town

as well as total population numbers of one country. Because the numbers of the population is increases time to time without any gap, this is not good for developing town like Injibara town.

Generally identification of methods of future population forecasting of the town is good for determine different infrastructures of town addition to water supply of town.

5.2. Recommendation

There is more problem to estimate the future population of town because lack of exact numbers of past and present population of the town and also lack of system of town administration to record exact numbers of populations.

The time of central statistical agency is long; it is not good for exact number of population of the town after some years due to this reason to count with short time because good for control the population of town or city as well as population of country.

There are no records of all new born child per day, month and year exactly and numbers of migration people into and out of town.

The count of the population of one town as well as country must be computerized system because easily manage and control the numbers of population and implementation of infrastructure like school, distribution of water supply and etc.

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