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MEASURES OF SPATIAL POPULATION DISTRIBUTION IN MOROGORO REGION

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ABSTRACT

Measuring the spatial distribution of populations has been a complex process and has been a concern of demographers, researchers, geographers, and academics around the world. This paper attempts to take a step forward by consciously taking it. It is a very complex undertaking because it involves facts from the population or the study area. And in practice in developing countries, the facts or practical information are hard to come by. The paper objectively focuses on measuring the extent of population distribution in the Morogoro region using the approaches of Otis (1957). The study was intended to provide a basis for planning for policymakers, governments, non-governmental organisations and community-based organisations. The methodology chosen in this paper is an exhaustive documentary analysis, as the data on this type of study is almost always credible and available to the public. Extensive use of secondary data was used. After review, recalculation, preliminary discussion and recast; the region's population has been shown to be unequally distributed, less concentrated in one settlement and less dense per square kilometre, even below the national average of 51 inhabitants per square kilometre. It suggests an uneven distribution of resources, making parts of the region populated and others less populated. Government has a role to play in ensuring that population distribution reflects available resources. Every measure selected and applied has some challenges or shortcomings, whether it is the availability of data or the accuracy of the tool.

Contribution/Originality: In general, this study is important as it aims to clarify the extent to which the population of the Morogoro region is widespread. This study lays the foundation for further research in the field of population geography and is a reference for future academics and researchers in the field of geography.

1. INTRODUCTION

Population distribution has been a topical topic of discussion for a researcher because it determines how the world's resources are allocated and distributed on a global scale. Madulu (2003) defines population distribution as the proportional distribution of the population over available land area. In another way, population distribution refers to how the population is spread across the country, which reflects available resources such as land, social services, economic services, and physical infrastructure. Otis (1957) argues that analyzing and explaining population is the problem of demographers, population geographers, researchers and economists. Factors related to population have been extensively discussed in much of the literature, but the methodology for measuring population distribution has not been extensively discussed. In this paper, measures of population distribution in Morogoro are discussed using the framework developed by Otis (1957).

In developing countries, the population distribution pattern is primarily due to the availability of socioeconomic activities rather than land. It is of great concern to various population researchers as one of the most important determinants of the country's resource allocation and distribution. The population is unevenly distributed across the globe; Today the world has a population of 7.9 billion, of which 60% [4.6 billion] in Asia, 17.2% (1.3 billion people) in Africa, 9.6% (0.747 billion people) in Europe, 8th .4% (0.653 billion people). live in Latin America and the Caribbean, 4.7% (0.368billion people) live in North America, and 0.5%(0.042 billion people) live in Oceania (United Nations Department of Economic and Social Affairs Population Division, 2019a). In Africa, too, population distribution is uneven; Of 1.3 billion people, 84 percent live in just 20 countries, which equates to 40 percent of 54 countries. According to this, only 16 percent of the population lives in 34 countries, which corresponds to 60 percent of all countries. Interestingly, even within the same region, the population distribution is not the same within a continent, for example in Asia; China has a population of 1.4 (31%) billion people, India has 1.3 (29.5%) billion. Of the 4.6 billion people on the Asian continent, 60 percent live in China and India alone, while the remaining 46 countries are inhabited by the remaining 40 percent of the population (United Nations Department of Economic and Social Affairs Population Division, 2019b). Interestingly, the population distribution is not the same even in the same country.

1.1. Morogoro Region Profile

Morogoro region is one among 31 regions in Tanzania. It is located between $5^{0.}$ 58" to 10^{0} 0" Latitudes South of the Equator and 35^{0} 25"to 35^{0} 30"to the East. It has seven neighbours' regions namely; the north border by Tanga and Arusha Coastal region in the East, Dodoma and Iringa west and Ruvuma and Lindi to the South. The region has a total land area of 70624, which is 8.2percent of the total area of Tanzania. The region ranked 2nd out of 31 regions with the largest land areas in Tanzania below the Tabora region with land reaching 76150 square kilometres (Tanzania in Figure 1).

Figure 1. Map of Morogoro administrative district.

According to the Tanzania National Bureau of Statistics (2013) of Tanzania, 49.3 percent of the people live in the urban and 50.7 percent in the rural areas of Morogoro. The region has a total of 30 divisions and 30% of the divisions are located in Kilosa District and only 1 percent in Mvomero District. The region has a total of 141 districts, of which 26% are in Kilosa District and only 12.1% are in Mvomero District. The region has a total of 275 roads, all of which can be found in Morongo Urban, which is 100%. The region has a total of 3224

hamlets, of which 31.9 percent of all hamlets are in Kilosa District, followed by Morogoro Rural (20.4%) and 11 percent in Kilombero District.

Table 1. Morogoro region administrative areas.

District	Division	%	Wards	%	Village	%	Street	%	Hamlets/Vitongoji	%
Kilosa	9	30	37	26.2	161	29.8		0	1030	31.9
Kilombero	5	17	19	13.5	81	15.0		0	355	11.0
Ulanga	5	13	24	17.0	65	12.0		0	605	18.8
Movomero	4	3	17	12.1	101	18.7		0	577	17.9
Morogoro Urban	1	20	19	13.5		0.0	275	100		0.0
Morogoro Rural	6	20	25	17.7	132	24.4		0	657	20.4
Total	30	100	141	100.0	540	100.0	275	100	3224	100.0

Source: Morogoro region profile (2006).

2. OBJECTIVE

This paper intends to understand the spatial distribution of the population in the Morogoro region. Specifically, this paper aims to measure the extent to which the population within the region is fairly or less fairly distributed. In addition, this study intends to examine whether the region is densely populated or less populated.

3. METHODOLOGIES

This paper has undertaken extensive documentary analysis to calculate and explain the spatial population in the study areas. Most secondary data sources from government, individual researchers, publishers, and textbooks have been used extensively in this paper. In addition, the internet sources have extracted those related to the world population. The study calls for authentic data, mostly owned by the government. Several government reports were collected for analysis, notably the census report, which collects a lot of data, and the data from the National Bureau of Statistics of Tanzania. In addition, the framework developed by Otis (1957) was adopted and used in this work, although it is an old textbook. Also, the modern framework for measuring population distribution has not been extensively developed, so the old framework has been used as the main tool in this paper.

4. RESULTS AND DISCUSSION

This section of this paper presents the measure of population distribution in the Morogoro region. Some data are unavailable or don't exist, and in the end, the calculation has not been done. According to Otis (1957) measures of population distribution can be grouped into two broad categories, namely spatial measures and categorical measures. Spatial measures are more subdivided into five techniques which are:

- Numbers and density in a geographical unit.
- Population potentials.
- Centrographic measures.
- Measures of spacing.
- Measures of concentration.

Categorical measures are more refined into;

- Rural-urban classification.
- Community size distribution.
- Concentration by proximate.

i. Numbers and density in a geographical unit

Tanzania does a population census exercise every 10 years; the last census was done in 2012, which form the basis for this discussion. The Morogoro region is divided into eleven constituencies, 9 districts, 30 divisions, 141 wards, 540 villages,275 streets and 3224 hamlets. The census exercise collects information from every resident of this country and trends, patterns and movements of the population are revealed through the exercise. Geographers have developed means to show the numerical side of the population such as the dot map (Otis, 1957). This method provides accurate information to a particular context and faces challenges displaying small and very large population distribution. It is very hard to have a price conclusion based on a dot map. In other contexts, it cannot measure the population distribution. Another popular measure of population is population density. It's just calculated by taking population divided by land available, taking the population of Morogoro by May 2020; the total population was 2,974,427 and total land habitant land is 70624 square Kilometres, then population density of Morogoro region is calculated as;

$$P.Density = \frac{Population}{Total\ area\ in\ Sq\ km} = \frac{2974427}{70624} = 42.1\ per\ sq\ km$$

These numbers indicate that Morogoro is less populated. The population density as of 2013 was 31 and 2020 was 42.1 people per square kilometre (Tanzania National Bureau of Statistics, 2013). Comparatively, its density is below the national average of 67 people per square kilometre. In general view, Morogoro is so sparse in terms of population distribution and density, but the density has been increasing from 31 2013 to 42.1 2020. Taking into account the average family size of 4.4 per household, then each kilometre has an average of 7 or 10 households. The population density is high in Morogoro urban (1212 people per km), followed by Movomero district (42. People per km), while the lowest density was observed in the Ulanga district (6.4 people per square kilometre) (Morogoro Region Socio-Economic Profile Report, 2006). However, population density measures the aggregate level of population per square kilometre but doesn't tell the neatness of individual lives in particular areas. Figure 2 presents the population density of Morogoro Region by Districts by 2013.

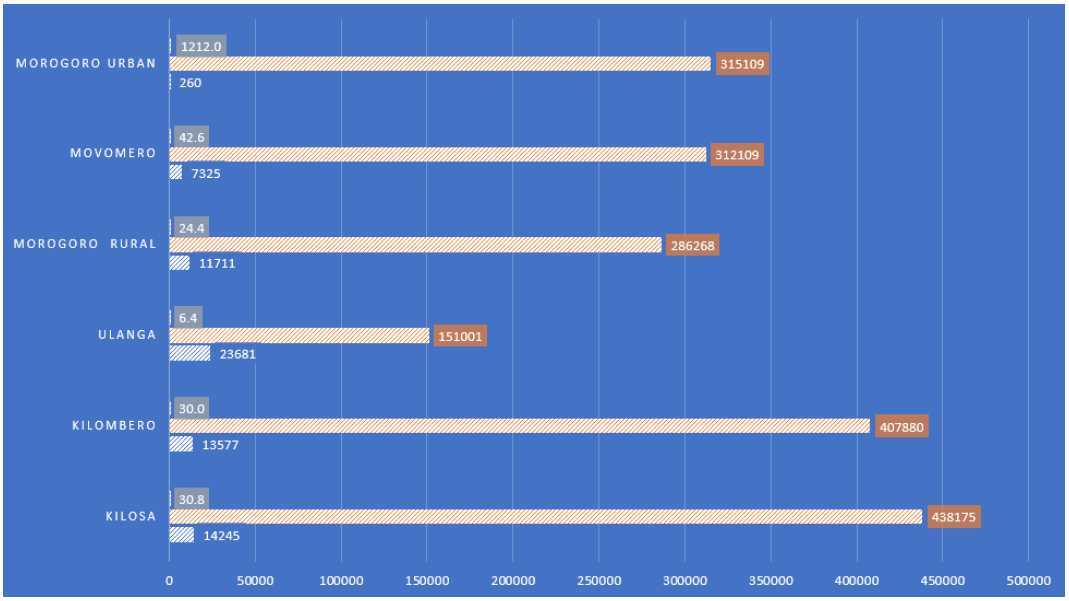

Figure 2. Population density of Morogoro region by District 2013.
Source: Tanzania National Bureau of Statistics (2013).

According to Otis (1957) population density has two major shortcomings: it depends on the system unit of the country, and it is hard to decide intervals in constructing isopleths or dasymetric density maps. The attempt to

address these shortcomings is an attempt to address whether the use of a mathematical model or function has not been good enough. More research is required to improve these shortcomings.

4.1. Measures of Concentration

Population density varies considerably, whether within villages, wards, division districts or in a region. Some areas have more population than others. Population concentration focuses on studying unevenness of the population contrary to population density which focuses on overall density in the country. Otis (1957) asserts that population concentration may have two meanings, namely, it refers to the degree of unevenness in a country or the increase or decrease of unevenness over time. There are two measures of population concentration namely the Lorenz curve and Gini concentration ratio and the index of concentration or index of dissimilarity.

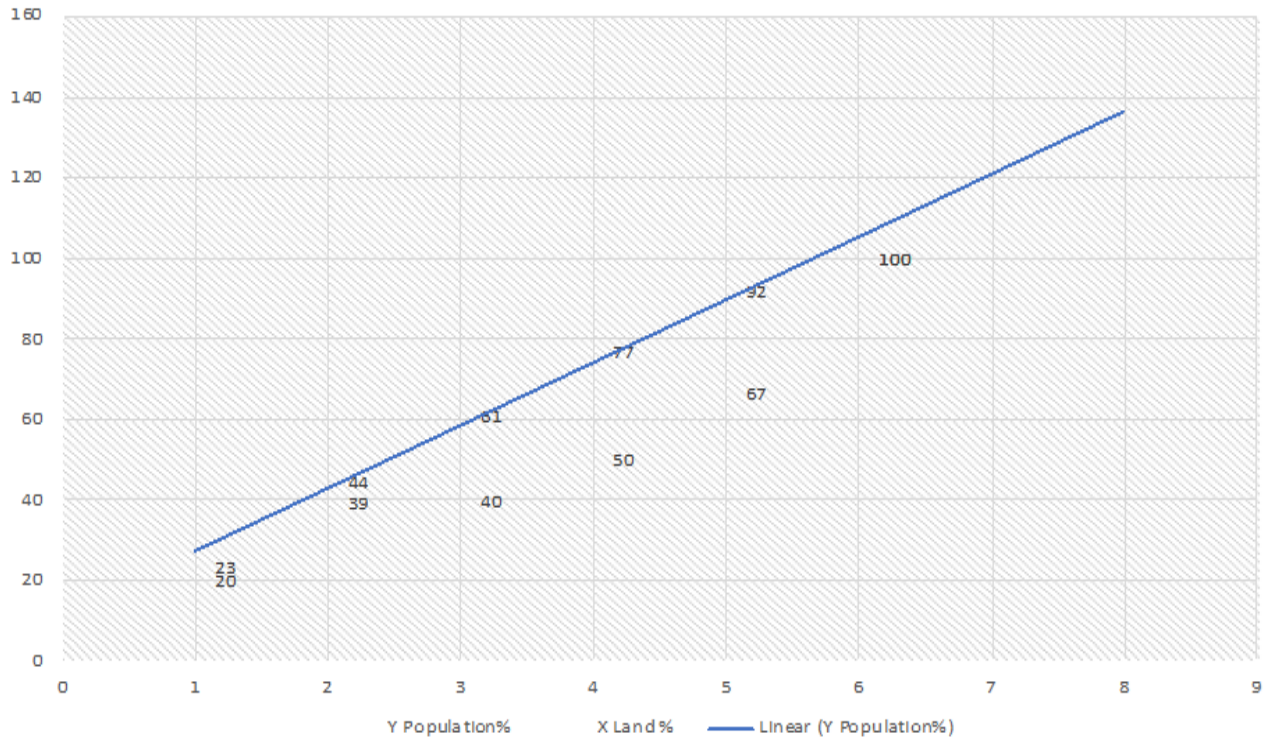

Figure 3. Lorenz curve of Morogoro region by 2013.

The data, Population and density, are grouped into intervals and computational of cumulative percentages of both. The Y and X are accumulated percentage of areas(square kilometres) and Population, if the population is evenly distributed then we shall have the same line of the accumulative percentage of land and population concentrated in one mathematical point, The variation of this hypothetical extreme of complete evenness and complete concentration is indicated by the degree to which the curve departs from the diagonal as above (Otis, 1957) but have a look at Figure 3 the cumulative percentage of land and population are not the same implying that population within the region is unevenly distributed. According to Wright (1937), the index number depends on the shape of the Lorenz curve and the degree to which it deviates from the diagonal. The figure above has a very wide gap showing the population concentration is extremely low in the Morogoro region.

According to Otis (1957) concentration index Δ, the conformity index is simply the maximum set of k values of $(X_i - Y_i)$. Geometrically it's the maximum vertical distance from the diagonal line as shown in Figure 3. Hoover (1941) developed an alternative formula for computing the index. The if x and y, are the accumulated percentages of population and area respectively, then; $\Delta = \frac{1}{2}\sum_{i-1}^{k}|x_i - y_i|$ or simply the sum of the positive differences between the two percentages.

In the Morogoro region the population concetration rate is calculated as; $\Delta = \frac{1}{2}\sum_{i-1}^{k}|x_i - y_i|$

$$\Delta = 0.5 \times I - 82I = 41$$

The population of the region is extremely less concentrated in one area and its wide spread across the region. The CR 0f 41 goes beyond the normal function of CR which ranges.

$$\Delta \leq RC \leq z\Delta - \Delta^2$$

CR and Δ can be made in terms of indexes of the sparse densities of the real unit by taking mean difference and mean deviation. In that view, concentration measures of dispersion of unit densities about the overall density are important. So, the mathematical indeterminacy of the density concept applies as well as to measures of concentration.

The Concentration ratio is high in the Morogoro urban district only. In the rest of the district, the population concentration is sparse with great unevenness across the Region.

4.2. Measures of Spacing

It's a combined approach adopting density and concentration in analysing population distribution. It measures the spacing of population in particular areas or units or administrative units. In the Morogoro region context, it measures how the population space in the region as a whole or district or division or ward or village or street is. According to Otis (1957) this approach was adopted from a plant ecologist working on the spacing of members of species in the plant community. As of now, the idea is widely applied in the field of population. Barnes and Robinson in their linear distance map technique began to use the approach in the field of population distribution. This type of map is recommended for showing variations in density for relatively dispersed populations. It focuses on transforming density by formula. The formula read:

$Average\ distance = \frac{1.11}{\sqrt{Density.}}$ As explained, density is taken as the number of farmhouses per square miles, and the average distance of a farmhouse to its six nearest neighbours is deduced on the assumption that farmhouses are evenly distributed (Otis, 1957). Mather corrected the constant replacing of at 1.11 with 1.07. For the sake of this paper, both constants are used;

i. Taking the first constant of 1.11 is given; $AD = \frac{1.11}{\sqrt{42.1}}$ where 1.11 is constant, and 42.1 is density of Morogoro by May 2020, $= \frac{1.11}{6.49}$=0.171 the space between one individual and another in the Morogoro region is not congested as 0.17 distance exists between them.

ii. Taking the second constant of 1.07 is given; AD= $AD = \frac{1.07}{\sqrt{42.1}}$ where 1.11 is constant, and 42.1 is density of the Morogoro region by May 2020 = $\frac{1.07}{6.49} = 0.16$ The space between one individual and another in the Morogoro region is not congested as 0.17 distance exists between them.

These techniques are clearer than just calculation of density, and these techniques improve the cartographic presentation. But several studies have been made on the subject and some new calculations have been created. One of the recent studies model that if a given region containing # units of population, let r_i be the linear distance of the ith unit to its nearest neighbouring unit, irrespectively of the direction. The r_i are measured for the entire population of units or a random sample thereof. Let p be the density of population units, areas being measured on the same scale as is used in determining the r_i .If rA is the mean of the r_i then $r_g = \frac{0.5}{\sqrt{p}}$ is an expected mean in an infinitely large

random distribution of density pThe observed mean varies below and the theoretical lower limit of zero as the distribution becomes more clumped or aggregated. The Observed mean may vary abover_g to the limit of $\frac{1.0746}{\sqrt{p_i}}$ which occurs in a perfect uniform distribution in which each unit has equal distance from 6 others. The ratio R, of the actual to expected distance, or $\frac{r_A}{r_E}$, may thus vary from zero to 2.1491.A significance test for the departure of R from the unit is available. Taking all into one-fold, Morogoro Region Density is 42.1; then

$r_{g=\frac{0.5}{\sqrt{p}}}$ Expected mean and $R_{A=\frac{1.0746}{\sqrt{P_i}}}$ Actual mean then

$$r_{g=\frac{0.5}{\sqrt{p}}} = \frac{0.5}{\sqrt{42.1}} = \frac{0.5}{6.49}\,0.08\,rE$$

$$R_{A=\frac{1.0746}{\sqrt{P_i}}=\frac{1.0746}{\sqrt{42.1}}} = \frac{1.0746}{6.49} = 0.166\ \text{rA then;}$$

$= \frac{rA}{rE} = \frac{0.166}{0.08} = 2.075$ This indicates clearly that population space is big between one individual or household and another.

Otis (1957) argues that studying the human population individually would, of course, be found in the pattern of aggregation to at least the individual level.

4.3. Centrographic Measures

They are the techniques of trends and laws of the distribution of population/phenomena in relation to the centre of gravity. This measure tells two features of discrete distributions namely central tendency (mean, median and mode) and dispersion (decilides, centilides and quartiles). It referred as a centres of population, it means point, centroid , or centre of gravity, the point upon which population of a particular unit would balance, if it were a rigid plane without weight and the population were distributed thereon with each individual being assumed to have equal weight and to exert an influence on central point proportional to his distance from the point. Otis (1957) is a measure of dispersion around the centre of gravity. Two other measures of central tendency in real distributions have received considerable attention. The medium point is defined as the intersection of two orthogonal lines, each of which splits an area into two parts with equal numbers of inhabitants. The medium point varies with the rotation of the axes used in its calculation. The lines parallel to these axes may be calculated to divide the distribution into fourths in each direction. The intersection points are known as quartiles.

Taking the population distribution of Morogoro region 2020, the quartile is that the total population is divided into four equal parts which are 1st quartile, 2nd quartile,3rd quartile and 4th quartile. Using the Excel formular = $Quartile(array, quartile\ number)\ then\ 1st\ quartile =$ $292{,}728.25(20\%), 2nd\ quartile\ 313{,}609(22\%), 3rd\ quartile\ 384{,}687.25(27\%)\ and\ 4th\ quartile\ 438{,}147(31\%)$

The population of Morogoro is unevenly distributed as 31 % of the population are found in the 4th quartile, 27% of the population are found in the 3rd quartile, 22% in the 2nd quartile and 20 % in the 1st quartile. If the population had been distributed unevenly, the percentage of each quartile would have been the same—that is 25% in the 1st quartile, 25% in the 2nd quartile, 25% in the 3rd quartile and 25% in the 4th quartile.This principle can be extended to decilides, centilides etc sets of points that describe the degree and pattern of dispersion of the population over the territory. A somewhat different concept is that of the median centre or, more descriptively, the point of minimum aggregate travel. The location of the centre of gravity is affected by a change in the position of any unit of the population, whereas there can be considerable movement without affecting the medium point. Hart (1954) assert that

their mathematical properties render the centre of gravity most useful for studying the areal shifts of distribution over time, the median point for comparing different distributions at the same time, and the median centre for investigating locational optima for centralised services.

Taking the formula into context, the median of the population in the Morogoro region can be calculated as $= 313{,}609$ and $mean\ is\ 318{,}424$.

4.4. Population Potential

It is defined as the number of people that can be reached within 50 kilometres from the centre coordinates of any grid cell. The results then standardised at the study area average. Each individual at a point was considered to be inversely proportional to the distance from it, then the total potential of the population at a point $,L_0$ is the sum of the reciprocals of the distances of all individuals in the population from the point. Mathematically, it is computed assuming that all the individuals within suitably small areas are equidistant from each other $,L_0$ were.

Potential at $,L_0 = \sum_{i=1}^{n} \frac{P_i}{D_i}$ where the P_i are the populations of the # areas into which a region/territory is divided and the D_i are the respective distances of these areas from $,L_0$ (usually measured from the geographic centre or from the approximate centre of gravity in each area).After computing potential for a number of points such as $,L_0$ it is possible to obtain values for other points by interpolation; or one may construct isometric maps showing lines which are loci of points having equal potentials. The configuration of equipotential lines is determined by the pattern of variation of density over a territory; one could say the same, of course, with respect to the interrelations of the various other measures of distribution that have been described. The population potential may be calculated $,L_0 = \sum_{i=1}^{n} \frac{P_i}{D_i}$

Then $,L_0 = \sum_{i=1}^{n} \frac{P_i}{D_i} = \frac{1902646}{885} = 2150$, this number results from a Google map distance estimate as it is hard to get already made data. From Morogoro urban centre, there are 2150 people living cross-peripheral from the centre. This results may be used to interpolate the point from the centre and an isometric map can be drawn based on the results above.

4.5. Residential Classification

It is a measure of spatial distribution of the population. It's computed without reference to any qualitative or classification information on the areal sub-divisions of the universe of the country/territory. In some context, classification of areas in respect to size, location, rural to urban character or the like. Otis (1957) argued that the measure of spatial distribution, in effect, becomes a summary statistic describing the frequency distribution of the population with respect to such a classification scheme.

The most familiar classification used in describing distribution is the division of the population into rural and urban residents. Probably the most commonly used criteria of urban status are size and legal or administrative classification of communities or political subdivisions.

In Tanzania, criteria for classifying urban includes; economic activities, populations, administrative units, and remoteness of the unit. As of the census of 2012, 49.3% of the population live in rural areas and 50.7% of the population live in urban centres in the Morogoro region. As of now more than a half of the population in the Morogoro region live in urban areas of which it's above the national average of 70.1percent (Tanzania National Bureau of Statistics, 2013).

The categories urban and rural are so broad that subcategories of each need to be introduced into any refined analysis of distribution. In the Morogoro region, the rural areas may be classified into villages and hamlets. The urban area may be classified into municipal, town and cities reflecting the economic activities and population size.

4.6. Community Size

Another fairly common practice is to subdivide urban population by the size of the community. Demographic differences by community size within the broad urban category may often be as important as gross rural-urban differences (Otis, 1957). As in the definition of urban places, the community-size distribution will be, in considerable part, a function of procedures for compiling the data. Community size distribution may be summarised with a variety of statistics. The proposed statistics for income distribution may be adapted to this purpose. But in developing countries, Tanzania inclusive, it is difficult to have community classification based on income. Classification based on income is difficult, but classification based on administrative structure is possible as in Table 1.

4.7. Other Categorical Measures

Otis (1957) asserts that a large number of measures of distribution can be generated by classifying areal units on some qualitative or quantitative basis and tabulating the number and proportional number of inhabitants in each class. There is an approach to studying population distributions such as studying gradients from the centre. In context, population distribution can be measured by ordering the unit by any variable that is of interest rather than using density.It results into a curve which follows an irregular path and even goes above the diagonal in whole or part. The study of the population distributions may combine two or more of the techniques which have already been discussed in this paper. In some literature, computational population density is done in separate manners: those of urban and rural in respect to distance to the nearest urban centre, size of centre, geographic region, and proximity to highways and town centres.

5. CONCLUSION

This work has attempted to measure the spatial distribution of the population in the Morogoro region. Using the framework of Otis (1957) where two measures were used, namely spatial measures and categorical measures. Although these methods have many weaknesses, but are still good indicators of the spatial population in each municipality, the data exist longer. Studies to measure population distribution have not been extensively conducted and therefore further studies can be conducted to develop mathematical models, formulas and other techniques to ensure that population distribution is accurately determined. In general, the Morogoro region is a less populated area in Tanzania, with lower concentration of population and less population per square kilometer. With the exception of Morogoro Municipal District, all six remaining district populations are more sparse

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