Population Density and the Economy: A Global Assessment

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Abstract

This research paper analyzes the population density by region of every country in the world with a total population above 1 million using methodology employing python code to create a global map. Each country has an income group it is classified in, ranging from low-middle to high-income. The aim of this paper is to investigate where places of high population density exist and conclude if it is tied to the income group of the country where it is. The motivation for which is to illustrate and introduce awareness of where high-density countries are in the world to point out the potential problem of future overpopulation as well as any economic problems because of the associated income group. The results and findings of the analysis in this paper from the map produced indicate that countries in eastern Asia like China and India have high regional population densities and are part of lower income groups. Countries belonging to the high-income group are in stark contrast with more areas that are less dense in population thereby leaving room for future growth. These results indeed conclude that there is a relationship that exists between the income group of a country and how dense their population is.

Introduction

Each country in the world is classified by a world income group, either falling into a high-, middle-, or low-income category. High and some middle-income countries make up the first world, while the low-income countries make up a majority of the third world. It can be assumed that the population is dispersed differently according to what income group each country is in. However, across the globe much of the population is clustered around or in cities and metropolitan statistical areas, giving these areas a high population density. This is seen everywhere especially in eastern Asian countries like China and India, that are objectively crammed and running out of space. The population density in other parts of a country outside of these urban regions is normally relatively low, such as in suburban and rural areas. The density of people living in other parts of a region in a country outside of urbanized areas could be looked at in a socio-economic manner. Where people are living could be tied to the income group their country is in. There are undoubtedly disparities in the populations of every country and there is an economic factor in that. The motivation for this analysis lies in the very real problem of overpopulation in the future and economic disparity. Showing how crowded humans are in some places and generating awareness is important. This report is going to focus on the following research questions: Where are population densities the greatest based on global sub-regional data? How are regional population densities in each country distributed considering associated world income groups?

Literature Review

A considerable amount of research and analysis has been done since the 1980s looking at population densities (as well as on a regional level), economics of the population, and the land cover types seen throughout a country. One research article, which is highly relevant to

this report, looks at the population density and annual income of Germany specifically to identify disparities. The methodology includes analyzing socio-demographic and economic datasets on a spatial level at a large scale based on two variables, population density and average annual income, and then generate choropleth maps from it and see imbalances in the population (Moos et al., 2021). The overall aim of this study was to gain insight into the socioeconomic spatial patterns of a country. Another research article looks at how geography and economic development are directly related to each other. In this, the authors assess the relationship between geographic regions and their economic growth and population density. One of the main conclusions is that geographic regions that aren't promoting economic growth have "high population densities" and "are experiencing rapid increases in population" meaning disadvantaged regions are falling behind (Gallup et al., 1999). The next article, from a scholarly journal, looks at low- and middle-income countries (LMICs) and if the rural populations' socioeconomic status varies on regional level. It concludes with evidence showing that the socioeconomic status of rural populations in LMICs, in Asia specifically, and its association with hypertension does in fact vary with geographical region (Busingye et al., 2014). A more recent study that also investigates low- and middle-income countries, examines the driving factors behind where people distribute themselves in these countries and why. The authors look at 32 countries across four continents and find that population densities vary by region based on geography (Nieves et al., 2017). Another article gives a history lesson by explaining how countries that were colonized in the past are now poor. The authors explain how, as opposed to geographic factors being the cause of this reversal, it was actually due to the reversal of institutions set up in these countries during the 16th century (Acemoglu et al., 2002). A journal with a similar topic investigates the "association between regional population densities in 1500 AD and current income equality", with the author coming to the conclusion that the population densities of the past aren't associated with income inequality, and that high population density is actually good for the economy of a region (Sylwester, 2003). The "Socio-economic influences of population density" is the title of the next paper and discusses how population density is important to look at socially and economically, with "individualistic behavior" positively correlated with it (Yegorov, 2009). Instead of population distribution, the next article talks about the distribution of income in populations at a national level, evaluating multiple theories looking at social and political systems (Crenshaw & Ameen, 1994). A journal on urban economics includes a section by an author analyzing the relationship between economic geography, fertility, and migration. It is found that fertility rates aren't tied to regional population density and migration from low to high population densities "occurs in an equilibrium" (Sato, 2007). The final article shows the authors talking about the relation between urban forest cover (in Chicago specifically) and household density and income. Ten land-cover classes were found for Chicago and based on the data gathered, the analysis concluded with household income and density being "strongly related to land covers in the region" (Iverson & Cook, 2000).

Methodology

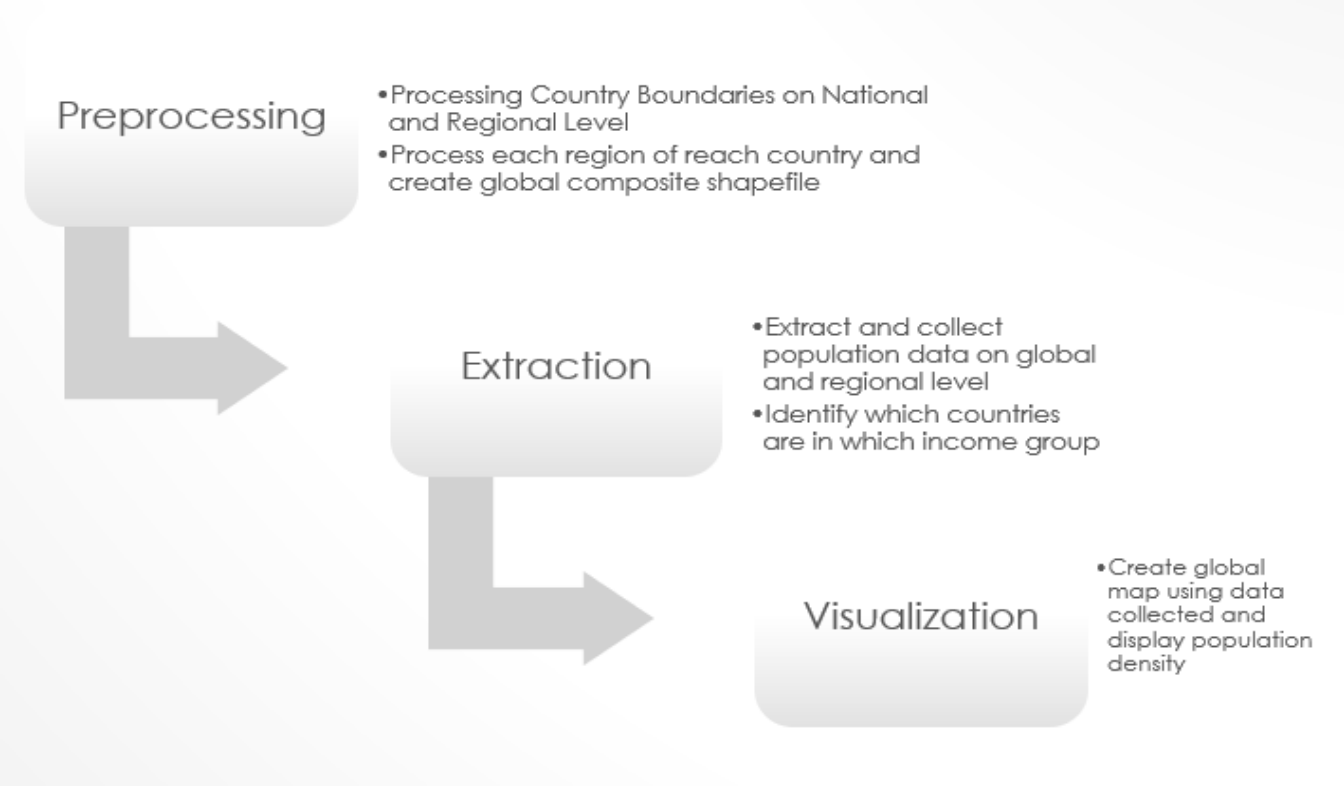

Diagram 1. Box diagram illustrating the sequencing of processing steps in creating results.

The method of acquiring results for the research question involved the use of python code in jupyter notebook, where all the data was collected and processed. As seen in Diagram 1 above, the preprocessing step involved a lot of preparation of the data that was to be worked on. The national boundaries of each country in the world with a population above 1 million were created using raw data acquired from GADM and a CSV file with country data (population counts, GID regions, income groups, etc.) premade for this analysis. These boundaries were also refined and simplified using premade code that removed any unnecessary small shapes that may have been part of a country's border from visualization at the end. For instance, countries with small islands that don't have a significant population or population at all are removed from the end result, as there is no need for them to be displayed. The regional boundaries for each country were processed after the national ones, and the shapes of the borders were simplified and made to look better when the data is eventually visualized. In the country CSV file that is used during this process, each country has a GID level associated with it that determines how complex the regions that exist there are. These levels can range from 0, 1, or 2, with 0 being the least complex and 2 being the most complex. After both the national and regional boundaries are created, every region in each country included in the code is processed and made into TIF files, including population data for each region. A global composite shapefile (used in ArcGIS

Pro and QGIS applications) is also made in the code, combining the boundaries of all regions, so that they can be displayed globally.

The final steps in the methodology to produce the results include the extraction and subsequent visualization of data. After TIF files are created for each region in each country in the dataset, a data frame is created for each including the rounded population of each region as well as the region identification number, iso3 code, country name, and income group. This data frame is then extracted into a CSV file. The population data files extracted for each country are then collected into a singular CSV file to make a global population dictionary. Using this file, the income groups of each country were assessed as either being lower-middle-income (LMC), upper-middle-income (UMC), or high-income (HIC). The global composite shapefile and the global population CSV file created earlier are then used to create a global map of population density from each region by merging them together in the codebase. To show the density of each region better, the population of the merged file is divided by the area of the region in square kilometers. Bins are then defined in the code to separate values, ranging from 10 kilometers squared to 50, and then increasing by 50 by each bin until reaching 300 kilometers squared. Using a plot command, a global map is created from the data including a legend and a title.

Results

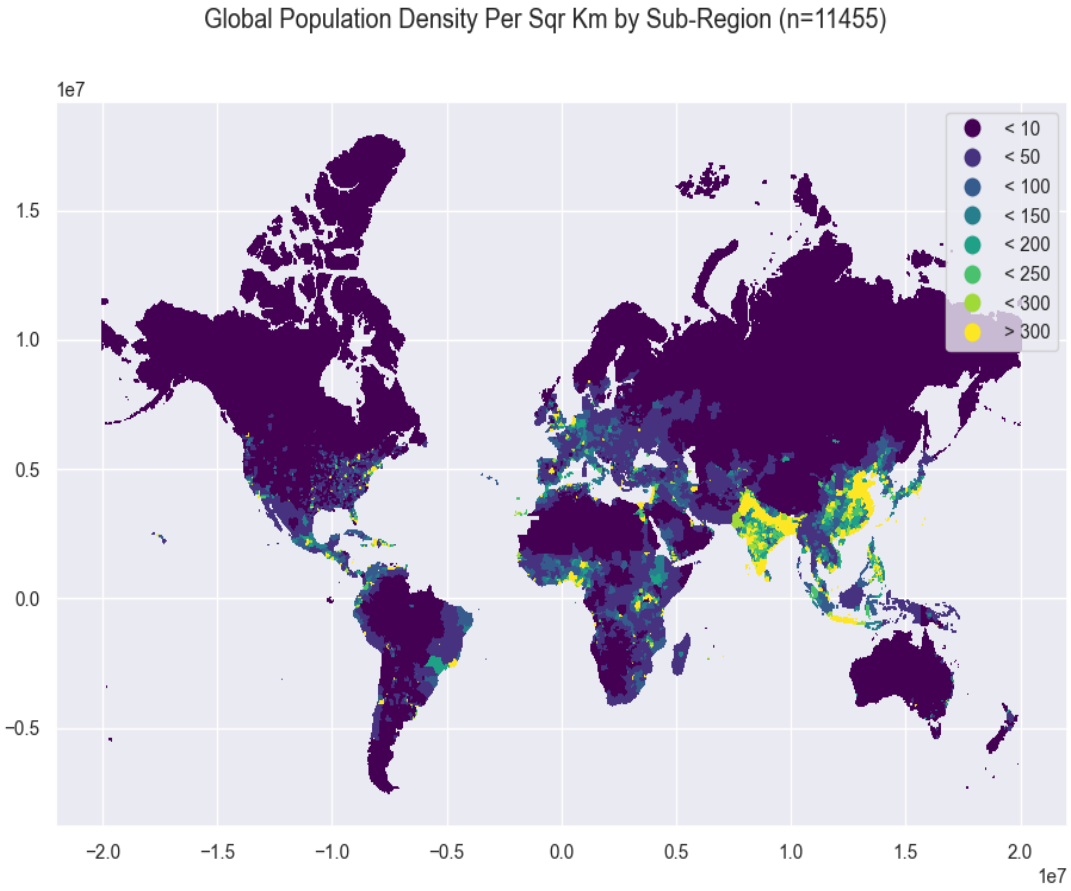

Figure 1: Global population density of each country with a population above 1 million by region (per sqr km)

The result produced from the extracted data in the code, as seen above in Figure 1, shows how populated some countries are compared to others. The legend of the map shows the density of a region in a country by square kilometer, meaning that 10 km^2 is the lowest and over 300 km^2 is the highest. Without looking too closely at the map there is a large patch of yellow (densities higher than 300 km^2) around eastern Asian countries, especially China and India. Both China and India have the largest concentrations of people in them, with over 1 billion in each, so it makes sense that they would be the densest locations seen. Indonesia and the Philippines are also shown to have high population densities. Eastern Asia isn't the only part of the world with a high density it seems. Looking closely, parts of Africa in countries such as Nigeria and Uganda have very high densities. Israel and Egypt in the Middle East also fall into the ">300" category. Certain areas of western Europe, North America, and South America show to have some pockets of high density. All these areas most likely correspond to the major cities in each country. For instance, the yellow pocket seen in southern Brazil is most likely there due to Rio de Janeiro being there. In the United Kingdom, the density seen there is likely the cause

of London and on the eastern seaboard of the United States, cities like Washington D.C., New York City, and Boston are the most probable cause of the major density.

Discussion

The map produced in Figure 1 clearly shows where the high-density regions of the world are and where they are not. This is the optimal result for the research questions stated in the introduction, since a correlation between high population density and the economic classification of countries can be made. It can be said that it is likely countries that are classified as being part of a lower-middle income group also have a high population density in a greater total of regions when compared to countries classified as being part of the high-income group. Countries that have extremely high densities in multiple regions are subject to overpopulation in the near future if nothing is done to remedy the constantly growing population. If a country belongs to an income group on the lower end, any overcrowding seen could be explained by that, or it happens because of the fact it is a poor country. Some potential areas of future research include the investigation of air pollution in countries with high density and what kind of land cover is seen in third world countries. There were a few limitations to this analysis, with the main limitation being that not all countries were processed. Greenland, Iceland, Fiji, and Malta were some of the ones excluded from the data, as they didn't have a large enough population or were too small geographically to show up on the global map. Another limitation was the potential of the data used not displaying correctly or being slightly off.

Conclusion

The main goal of the analysis in this paper is to investigate where areas of high population density are in the world and what income group in the countries where it is found are. This is to make aware the problem of overpopulation some countries may face in the next century and the spatial economic disparities that exist. Based on the results, it was found a majority of the high dense regions found on the global map exist in eastern Asian countries like China and India. This highlights the population problems these countries have in particular. On top of this a majority of the countries found with high densities were low to upper-middle income countries. High income countries like the United States and the United Kingdom have some high-density regions but have room to grow and move around as the population is not too big. There is a clear difference between the income group of countries that have a lot of dense regions and those that do not.

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