**Business Understanding:**

“Predict the population of 2122.” Such a task is quite daunting on the surface, as many factors need to be considered- not just the changes in population per country, but also how a growing population’s continuous use of resources affects further growth. This resource consumption is charted through either a population’s “carrying capacity” (the maximum possible population for a given species based on the resources its environment holds and how many resources are required to sustain one individual)[[1]](#footnote-1) dependent upon where that population is located, or through cataclysmic developments caused by those resources- either directly, such as a forest fire razing an entire harvest of crops, or indirectly, such as a war over the control of a valuable resource such as oil. For this reason, current population and expected population growth per country, as well the chance for catastrophe and wars, will be used to chart the predicted population in 2122.

The primary datasets used come from an article in Our World in Data[[2]](#footnote-2), published in 2013 and most recently revised in 2019. It contains data such as population density (as some countries are more densely or sparsely populated than others, and as such, their growths would differ from that of other countries), current population estimates for each country, and current global population estimates. Each of these three metrics are similarly useful for projecting population, and thus, all three will be factored into a final number, averaging the results of each.

**Ways to Measure Population- Global Growth Rate:**

The naïve solution to this problem is to project and extrapolate an exponential equation for the next one hundred years (Pn = Po \* er\*t), where Po is the “starting population” at a given time t=0 (corresponding to 2022), e is Euler’s number, r is the population’s growth rate, and t is the time elapsed in years (in this case, 100, from our current year). Using the most recent year’s measured change in population (an increase of about 80 million people, or 1% of the population)[[3]](#footnote-3), Pn should be 7,953,952,567 \* e0.01\*100 = **21,621,084,727** people in 2122.

Chart, line chart

Description automatically generatedFigure 1: Simple Exponential Estimate of Population in 2122

However, this number is highly skewed, as the growth rate of humanity in the last one hundred years has eclipsed the growth of Earth’s population of previous years by several orders of magnitude, meaning the current “growth rate” is not at all what it used to be, even a hundred years ago.

Chart

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Figure 2: World Population Graph[[4]](#footnote-4)

This number also does not account for the *carrying capacity[[5]](#footnote-5)* of the earth, which scientists estimate to be slightly more than ten billion people. As the carrying capacity largely limits the growth of a population, human population growth can more *closely* be modeled logistically (otherwise, the population would otherwise reach and exceed this ‘carrying capacity’ within a few decades) as Pn = K / (1 + ((K – Po) / Po) \* e-r\*t, where K is the carrying capacity of the Earth (in this case, estimated to be 10.5 billion). Thus, our new population would be 10,500,000,000 / 1 + ((10,500,000,000-7,953,952,567) / 7,953,952,567) \* e-0.01\*100 = **9,393,807,594** people in 2122.

Chart, line chart

Description automatically generatedFigure 3: Carrying Capacity-bound Estimate of Population in 2122

A population growing closer to the carrying capacity of its environment will gradually slow its growth, and this is reflected in the population’s average growth rate over the last seventy years.

Chart, line chart

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Figure 4: Average Population Growth Rates from 1950 to 2022[[6]](#footnote-6)

According to Our World in Data, “The UN projects that the global population increases from a population of 7.7 billion in 2019 to 10.9 billion by the end of the century. By that time, the UN projects, fast global population growth will come to an end.”[[7]](#footnote-7) As this is less than an order of magnitude off from the number resulting from a logistic model factoring in a carrying capacity, we can reasonably conclude that the carrying capacity of the Earth is at least *close* to 10.5 billion people, and that this final metric of **9,393,807,594** people in 2122 is reasonable.

**Ways to Measure Population- By Country, Percent Change in Population:**

The world’s population can also be estimated by analyzing each country’s population growth trends and summing the predicted results of each country’s projected population in 2122. As Our World in Data features estimated and imputed data from as far back as 10,000 B.C., which does not accurately reflect modern population trends, only population numbers from 1800-2021 were used to create a “total change in population” over this almost-two-hundred-year timespan.

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Figure 5: Prediction Algorithm- Percent Change by Population

With this estimate of growth, this number can then be used to extrapolate the population in 2122. This method predicts a population of **9,280,786,519** people in 2122.

**Ways to Measure Population- Causality of Catastrophe:**

While it is unlikely that a large-scale catastrophe will ravage the population, many disasters can and have happened throughout the course of human progress- whether that be plagues and famines, wars and skirmishes, or natural disasters of calamitous proportion. For this analysis, a somewhat uncommon occurrence among these, though one that is very often talked about and predicted- an asteroid collision- is used. Asteroids are commonly monitored by NASA’s *Sentry* program[[8]](#footnote-8) that projects potential collision data up until even 2880 (even if the percentages are typically on the scale of 1.6 \* 10-4%), though most asteroids that are charted to even have a chance of hitting the earth will do so between 2040 and 2120- all of which lie before the projection year of 2122.

Several scientists have conducted experiments on the effects of an asteroid- simulating wind and shock waves at a smaller scale, effecting temperatures, and paving the way for *further* natural disasters. Because the impact of an asteroid is such an uncommon occurrence, it is nigh-infeasible to total all the potential impacts of such a crash, though, as a benchmark, a computer simulation conducted by the University of Southampton in England totaled over 8.7 million casualties when it struck London. However, that number stems just from the crash and resulting shock waves, alone- without even mentioning the innumerable deaths from the natural disasters (such as tsunamis, windstorms, and excessive heat) that could come afterwards. As NASA’s Clemens Rumpf states: “These asteroids aren’t an everyday concern, but the consequences can be severe.”[[9]](#footnote-9)

As Apophis was projected to strike the earth in 2068, the simulated population data of that year would be affected by this possibility of an asteroid strike, and its damages would then be carried over and rippled into the next fifty years. Without more concrete data of how each microcosm of the world would be affected, that far into the future, however, this model may lead to an overestimate of the population (as fields such as agriculture could be more harshly affected than simply killing farmers- for instance, waters can be poisoned, and crops can be razed). Thus, without addressing these aftereffects beyond simply extrapolating population changes and minor damages, if Apophis were to collide with the earth, the estimated population in 2122 would be **9,270,856,861**. While this number is very similar to results of other methods, it does not account for the asteroid’s rippling effects on *other* faculties of life, so the true damages of such a catastrophe would be significantly worse.

**Final Number:**

Each of these three methods has its own pros and cons. While a scientific adherence to carrying capacity corrects matches predicted behavior for a population quickly approaching the potential limit of the earth, it does not account for anything less than a global scale. Small-scale catastrophes or changes in political climate that can restrict specific countries are typically hidden by the breadth of a singular, large equation. Conversely, a population estimate that tracks each individual country’s population changes does not properly scope any wide-scale catastrophes or trends- which makes it quite hard to extrapolate with (especially over a great length of time) due to the lack of an overarching trend to follow. And, of course, while the likelihood of a natural disaster on par with an asteroid like Apophis is nearly zero, it is not negligible and thus still has weight when predicting populations over one hundred years- even if it’s true aftereffects can only be conjectured.

As all three of these methods possess inherent strengths and weaknesses, the most accurate estimate should average and draw from all three of these estimation methods, leveraging the strengths of all three to mitigate their respective weaknesses. Based on these three methods, the population in 2122 can be predicted to be ((9,393,807,594 + 9,280,786,519 + 9,270,856,861) / 3) = **9,315,150,324 people in 2122.**

1. https://www.science.org.au/curious/earth-environment/how-many-people-can-earth-actually-support [↑](#footnote-ref-1)
2. https://ourworldindata.org/world-population-growth#population-growth-by-country [↑](#footnote-ref-2)
3. https://www.worldometers.info/world-population/world-population-projections/ [↑](#footnote-ref-3)
4. https://www.worldometers.info/world-population/ [↑](#footnote-ref-4)
5. https://www.science.org.au/curious/earth-environment/how-many-people-can-earth-actually-support [↑](#footnote-ref-5)
6. https://www.worldometers.info/world-population/ [↑](#footnote-ref-6)
7. https://ourworldindata.org/future-population-growth [↑](#footnote-ref-7)
8. https://cneos.jpl.nasa.gov/sentry/ [↑](#footnote-ref-8)
9. https://www.sciencenews.org/article/heres-how-asteroid-impact-would-kill-you [↑](#footnote-ref-9)