**Hello and welcome to Just Have ANOTHER Think, our twice monthly look at the environmental, ecological and social impacts of the twenty first century climate emergency.**

**Two of the questions I get asked most often on this channel are…number one ‘is the human population increasing out of control?’ and number two ‘what are the risks to human health in the coming decades as a result of climate change?’**

**Both very important questions indeed. So important in fact that far better minds than mine have been carrying out painstaking research over recent years to establish the answers and offer as accurate a picture as possible of how the twenty first century is likely to play out.**

**It would be pretty much impossible to do justice to both of those questions in just a single video, so this week I’m going to focus in on population growth.**

**Let’s start with a very quick look at how the human population has developed throughout history.**

**The brilliant website Our World in Data provides a chart based on United Nations population estimates going back 12,000 years. Obviously, we didn’t have anything like a census all the way back then, but based on the best available scientific analysis, the UN estimates that the number of humans thawing out after the last ice age was just under 2.5 million. By the beginning of the rise of Ancient Egypt, around 3000 BC, the population had risen to about 45 million and by 1 AD we were up to about 190 million or so. That number rose fairly modestly all the way to the fourteenth century when famine and bubonic plague brought an abrupt halt to population growth. Things eventually got going again though, and by 1750 there were just over 800 million humans on the planet.**

**Then things went a little bit crazy. Largely as a result of the industrial revolution, population more or less doubled within a hundred and fifty years. So, we entered the twentieth century at one point six five billion. And that was just the bottom of an exponential curve. When my Dad was born, in 1943, the population was two point three four billion, and by the time I came along, in 1969, that had shot up to the three point six three billion. Over the course of just my lifetime, world population has more than doubled again, and today’s number is seven point eight billion and counting. Here’s the clock at the Worldometer website showing how the number is currently increasing based on statistics for births versus deaths.**

**Looks quite alarming doesn’t it.**

**But although the absolute population number is still going up, the global fertility rate, which is the average number of children per woman, has actually been rapidly declining since the middle of the last century.**

**In 1950, women on average had just over five children each. That number varied dramatically from country to country of course. Places like Rwanda, Kenya and the Philippines had an average of seven children per woman. China and India were just over six. And the United States and most of Europe stood at somewhere between two and a half and just over three. Only one country had a fertility rate less than the statistical replacement rate. And that was tiny little Luxembourg.**

**And when I say replacement rate, I just mean the simple arithmetic that says if each man and woman on average have two kids, then those two kids will just replace the parents when the parents die, and population will remain static. Statisticians more precisely put that number at two point one, for reasons that are, to be honest, just too dull to talk about.**

**Anyway, anything above replacement rate results in increasing population and anything below replacement rate results in a declining population.**

**Since about 1965, the world has seen a drop in fertility rates never before experienced in the whole of human history. The global average now stands at just over two point four and is projected by the United Nations to be about two point one by the end of this century.**

**But UN projections also say the global population will hit eleven billion by the end of this century. So how can we square that apparent discrepancy?**

**Well, the population projections are based on what the UN assume to be an inevitable fill up of adult human beings based on current demographics.**

**In 2014 there were 7 billion people on the planet. That number was made up of about two billion kids below the age of fifteen, another two billion between fifteen and thirty, a billion people between 30 and 45, another billion between the age of 45 and 60 and then a final billion over-60 years old. There’s clearly three billion people missing from these age groups. So where are those people? Well, some of them aren't there because they died early, but most of them aren't there because they were never born in the first place because of course in the twentieth century there were fewer people overall and therefore fewer women to have babies. If we run the clock one generation into the future, this older age group dies while this younger age group grows up and has roughly two billion kids. Move everyone on another generation and now it’s time for this older age group to depart and this younger age group to have their own two billion kids. Go another generation again and the same thing happens, and hey presto, within three generations, you get your inevitable fill up taking the population to 10 billion people as we enter the second half of the century. And then the UN adds a billion or so on top of that to account for longer average life expectancy.**

**So, eleven billion by 2100 has been the generally accepted thinking for quite some time.**

**But in September 2020, the Institute for Health Metrics and Evaluation, or IMHE, published a brand paper using what they claim to be more accurate statistical analysis techniques than the UN.**

**That paper found that global population could peak at about nine point seven billion by 2064 and then decline to as little as eight point eight billion by the end of the century.**

**So how do they work that out then?**

**Well, unsurprisingly their models also accounted for fertility and mortality rates, as well as projected migration patterns.**

**But to analyse fertility, the IMHE developed statistical models for what they refer to as ‘Completed cohort fertility at age 50 years, or CCF50’. And that’s the sort of scientific jargon that regular viewers of this channel will know that I just can’t get enough of!!**

**Apparently… according to the IMHE, completed cohort fertility modelling is much more stable over time than the usual statistical method, known as Total Fertility Rate or TFR. So, I’ll do my very best to translate why they think that’s the case.**

**studies have, generally, forecast a total fertility rate in a given country’s female population and then estimated specific fertility rates at different ages using assumed numbers that they think are statistically about right. In a country where the Total Fertility Rate is higher than the replacement number of 2.1, then the strong relationship between declines in fertility and increases in female education and access to birth control shows up quite well in the long-term numbers.**

**But when the total fertility rate goes below replacement level, some countries show declines followed by upturns and other countries, like Singapore for example, show declines followed by stagnation at very low levels. Because better educated women tend to go to work and delay childbirth until later on in life, the total fertility rate over a period of time often goes down and then up again, even though the overall fertility over the course of a reproductive lifespan for any sample group of women may still be declining or stagnant. If those timeline fluctuations are not properly accounted for then uncertainties can creep into the Total Fertility Rate models that have a tendency to skew the fertility rate numbers up slightly.**

**The IMHE method of completed cohort fertility at age 50 years is defined as the average number of children born to an individual woman from an observed sample population if that woman lived to the end of their reproductive lifespan, which is defined as being from age fifteen to age forty-nine.**

**The statistical formulae from working out all the specific numbers include fancy things like ‘time series random walk functions’ which quite frankly are well beyond the scope of this short video, but if you really feel like blowing your mind then as always, I’ll leave links in the description section to the full paper and all the appendices. But to illustrate the effect of the variation between the two modelling techniques, the good folks at IMHE provide us with these charts comparing five countries, with fertility rates above or below 2.1. The point they’re making is that the further above replacement levels you go the closer the two modelling methods seem to be in agreement. But you can see that in the three countries where those fertility rates move towards and even below replacement, then the line for the Total Fertility Rate model does indeed get a bit wobbly compared to the CCF50 model, and in all three cases the line seems to be ticking back up as the graph hits 2020, even though it’s known that the fertility rates in those countries is either static or falling. Extrapolating those little discrepancies over the rest of the century is, according to the IMHE, where the UN models are tending to build in inaccuracies. By contrast the CCF50 line shows a pretty stable progression that can be more accurately projected into the future.**

**So that’s fertility cleared up then. Nice and easy.**

**When it comes to mortality rates, the IMHE employed similarly complex statistical calculation methods, including something called an ‘autoregressive integrated moving average or ARIMA’, which I’m not even going to try to explain, plus some other slightly more understandable variables like the Socio-demographic index, crude population growth rate and deaths from wars and natural disasters. They also factored in economic factors like gross domestic product.**

**Once they’d crunched all the numbers, they found that the mid-point of the model predictions was a global average fertility rate of just 1·66 by 2100 compared to the UN’s projection of 2.1.**

**And there are some pretty dramatic swings in the populations of the top ten countries too.**

**China’s population is predicted to fall by almost a half from one point four billion to seven and thirty two million, which means they’ll be overtaken, believe it or not, by Nigeria, which is set to rocket up from it’s current two hundred and six million to almost eight hundred million by 2100.**

**In the United States the fertility rate continues to fall sufficiently quickly to cause an overall drop in population, but once immigration is factored in, the IMHE projects that the number will actually creep up slightly over the coming decades, keeping them in fourth place.**

**Brazil, Russia, Bangladesh and Japan all show rapidly declining populations, taking each of them outside the top ten by the end of the century.**

**Those four spots will be taken by Ethiopia, Egypt, The Democratic Republic of Congo and Tanzania.**

**Tanzania**

**TANZANIA!**

**It’s worth reminding ourselves that the IMHE, the UN and every other relevant organisation all agree that the two biggest factors in reducing fertility rates are better education and equality for women and girls, plus much better access to birth control. Nowhere are those two challenges more acutely demonstrated than the vast continent of Africa. If all women and girls were allowed those basic human rights in every African nation tomorrow, then the overall 2100 population would be far smaller, perhaps as much as several hundred million fewer people than the even IMHE model is predicting.**

**And of course, population is only one metric to assess how our species will fare in the future. Levels of consumption vary massively between rich industrialised nations and poorer countries, with most African nations showing the lowest levels of all, so although their populations may be rising, their overall environmental and climate impact will most likely be disproportionately lower.**

**And then there’s all the other risk factors like sea level rise, droughts, floods, famines and diseases that will all have a massive bearing not just on our own species survival, but also on all the other species that we share this planet with - which brings me all the way back to the second of the two questions I posed at the start of the program**

**‘what are the risks to human health in the coming decades as a result of climate change?’**

**That question has been comprehensively assessed by an international collaboration of academic institutions and United Nations agencies called the Lancet Countdown, who published this paper at the start of 2021.**

**And over the course of the next few weeks, I’ll be taking a detailed look at the somewhat daunting predictions outlined in that report.**

**So, there we are then folks, another sightly mind-boggling set of data for you to chew over at your leisure!**

**I’ll be back here to ‘just have another think’ in two weeks-time and of course I’ll also be over in my regular slot looking at the latest developments in sustainable technology on the Just Have a Think channel video this Sunday.**

**Thanks very much for watching, and I’ll see you soon.**