Population and Climate Change: Relationships, Research and Responses

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Edited Transcript – Brian O'Neill

First of all, I'd like to thank Geoff and Joe for inviting me to this event. I haven't been to the Wilson Center before, but I've heard lots about it, and I have several colleagues who have passed through here at various times. And so I'm happy to finally be here in person. I would also like to, before jumping in, just acknowledge that a lot of the work that I'm going to show is product of a collaboration that involved lots of people. The three key ones I've listed up here, Mike Dalton, who's an economist with NOAA, Leiwen Jiang is a demographer at Brown University, and Shonali Pachauri, who's also an energy economist at IIASA in Austria.

I thought I would take a starting point of about seven years ago. At that time, I and two co-authors from IIASA published a book on population and climate change that was mostly an assessment of the literature, what had been written, and what kind of research had been done up to that point in time. There was some analysis, but it was basically sort of relatively simple and back of the envelope.

So at that time, the three key messages that were, that one could get from looking at work in this area were number one, that probably on balance, if population growth were slowed, that would reduce greenhouse gas emissions significantly. Although those reductions in emissions would not really be - You wouldn't really feel them until the middle of the century and even more so, second half of the century. It's not a quick thing. And also, there were several stones left unturned. Not much work on the implications of aging or urbanization or other demographic things that might be happening along with a change in growth rates.

Second, that lower fertility and slower population growth would also, on balance, probably make adapting to the impacts of climate change easier; both at the household level, but also at the society-wide level. A caveat there, though, as well is that if you looked at any individual sector, health, agriculture, and so on, no single sector, in no single sector would you conclude that population policies would be the primary way to go about improving these areas. But, taken together, that set of conclusions, along with the fact that investments in fertility-related policies, reproductive health, family planning programs, are beneficial on their own, in their own right, for reasons that have nothing to do with the environment, that one could consider them win-win kind of policies with respect to climate change. That doesn't necessarily mean that's the thing you should do first or the most important climate policy or that it's going to solve the climate problem. But nonetheless, climate change is a big problem and this appeared to be an opportunity.

So what I'd like to do is give you an update on work since that time, including some that we've been doing ourselves. But I'm going to focus on the population and emissions. So that's bullet number one, where I spend most of my time. And I want to look at two things. First, some work on analyzing historical data, past experience, and then looking at some projections for the future. So let's start with historical analyses.

For quite some time and before we published the book, there were lots of, quite a number of analyses of historical emissions to look at well how much has population mattered to emissions growth in the past? And those were useful, but somewhat limited in that they assume that the effect of population on emissions was proportional, that if population were 20 percent higher or lower, emissions would be 20 percent higher or lower. Given that relationship, how much is population growth and emissions in the past?

What's happened that's been really, I think useful and kind of obvious, but for whatever reason took a while to do, is to not assume that population was proportional. Its effect on emissions was proportional, but to test it, to set up a statistical analysis to test has the effect been proportional or greater or less. And the bottom line there is that generally this work has supported a roughly proportional effect of changes in population size on emissions. It has also, in some analyses that considered it, supported the hypothesis that urbanization is also going to matter to emissions and also that age structure, changes in age structure, may as well.

Let me give you a little bit more detailed sense of what those results look like. This is a table of six or seven or eight studies that have done this kind of analysis testing the effect of population. And what it is is a table of elasticities. And elasticity means if you change population size by one percent, what percentage change will you get in emissions? That's what this column shows right here. And so you see, the results here range from about half a percent there at the top -- that was a study that only included countries from the EU. The rest of them are all around one, either just below or just above one, which means a proportional effect. Population size is one percent higher than all else equal controlling for different levels of income, different economic structures, different levels of technology in the country, that those things, controlling for those things, population had a roughly proportional effect.

These were studies, various kinds of data, some cross-sectional in just one year, some looking at over 20 or 30 years of data at the national level. You see from the rest of the table there that there are indications that urbanization and household size and the age structure also matter in different ways, but today I wanted to focus on population size. So that's not the end of the story. That doesn't mean that this is guaranteed to hold forever.

There are things that may be left out. Indirect effects, for example, of population on economic growth and then that affecting emissions. That does not show up in these types of analyses. But it is at least suggestive that when you look at historical data, the assumption that there's a roughly proportional relationship; it's not wildly off the mark.

I want to spend most of the time actually talking about, then, looking at future scenarios of emissions and what they tell us about the potential effects of different population paths on emissions. I think a good place to start is a set of scenarios that many of you are probably familiar with -- at least to some extent. And these are scenarios that were produced by the IPCC, or Intergovernmental Panel on Climate Change. These are sometimes referred to in the jargon as the SRES Scenarios, which stands for Special Reports on Emissions Scenarios, which was produced, published by the IPCC in the year 2000. And these have served as kind of a benchmark set of scenarios on which a lot of climate change analysis has been based and continues to be based since then.

The graph I'm showing you here is just to give you a flavor of what these look like. This is a set of, or a subset of the SRES scenarios that I'm showing the results for them for CO2 emissions from the year 2000 and these are 100]-year scenarios into the future. The way that these were produced is sketched here on the right-hand side. So roughly speaking, the methodology for doing this was first to develop -- this is stage one here -- four different just qualitative storylines about how development may occur globally in the future. Sort of fast, you know, a lot of globalization, fast economic growth, sort of regionalizing world and maybe economic growth is slowing down and so on. But dividing up the future into four sort of alternative pathways. Then within each of those pathways, defining quantitative driving forces: population growth, economic growth rates, technological process, that were judged to be consistent with those storylines, and then using a bunch of different models to model what the emissions outcomes would be based on those storylines and driving force assumptions. And here you see a subset of the 40 scenarios that you ended up with, just for CO2.

Now what we want to do is at least start off and say, well, for this standard set, can we get anything out of these for what's the influence of population? The first thing to look at is what population assumptions did they actually use? This graph here shows, the yellow-shaded area is the range of assumptions for global population growth that were used in these IPPC scenarios. These are projections, again, from the year 2000 to 2100. And you see at the low end, the lowest SRES Scenario ends up with around 7 billion people by the end of the century, and the high one is around 15.

The other lines on here are the set of global projections of population that have been made since that time. So what we want to look at is, you know, are those assumptions in the IPCC scenario still up-to-date? And for a big part of the range, they are. But, you know, a big part of this yellow range is also occupied by scenarios that have been produced more recently that support the idea that those are plausible outcomes. There are two exceptions. One is that the high end is a bit high. It looks relatively unlikely compared to current outlooks, and also, I think more importantly, is that the low end is not well represented. These two lines down here, one is the U.N., the most recent long-term U.N. projection, U.N. low scenario, and the other one is the low end of the global projections done at IIASA.

So one thing that's important, I think, and known in the climate community is that the low end of the current demographic range is not well represented in the IPCC scenarios. Now, there's been a lot of additional scenarios done by the climate change community since these scenarios were produced, which were produced in the year 2000. Maybe they've done better. This shows about roughly the same thing. These are the population assumptions. And the blue is basically the range we looked at before. It's extended a bit at the high end, but the blue-shaded area is again basically the SRES range.

And all the individual lines are population assumptions used in emissions scenarios produced after the IPCC scenarios, so the more recent scenarios. And we see again, the more recent papers being written on emissions scenarios largely fall within the SRES range, and there's only one or two that are anywhere, you know, at the low end of the current range of demographic projections. So I think we can say it's largely still true. It was true in 2000, it's

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largely still true that that end of the range is not well represented, has not really been explored in emissions scenarios.

That being said, let's just take the set of SRES scenarios themselves and say, what's the relationship in these scenarios between population that's assumed as a driving force and the resulting emissions? And there's two stories here. And what I've plotted is on the horizontal axis here is the global population size in the IPCC scenarios in the year 2100, and you see these group basically into three groups because there were three, a low, a medium and a high scenario used. And on the vertical axis here is the cumulative emissions of carbon over the whole 100 years, which is a reasonable measure of kind of the total effect on the atmosphere from these emission scenarios.

So, you can see basically two kinds of relationships. The first is that if we take most of the scenarios -- and by the way, these labels here represent those four story lines I mentioned before. They were given rather creative names of A1, A2, B1 and B2. But neutral. That was the idea, they're neutral names. Not creative, but neutral. That's important, too. And if we consider three out of four storylines, there is, roughly speaking, a relationship that if you have higher emissions in the SRES scenarios, you end up with higher -- if you have a higher population, you also have higher emissions as a result.

At the same time, one can just look at these two storylines and the set of scenarios that were produced according to those two storylines, and in there, you see actually a larger range of emissions outcomes, all with the same population size. In fact, all with a low population scenario. The highest emissions scenarios in the IPCC set are these. And they actually have the lowest population assumptions. Now the reason that this happens is that this A1 storyline was used. It's a low population, high economic growth scenario that was used to do a kind of sensitivity analysis to make lots of different technology assumptions. So up here, there's an assumption that carbon-intensive energy sources remain dominant, and that there's a lot of technological progress, but it goes into producing better coal plants and so on. Whereas down here, there's a lot of technological development, but it's directed into renewables.

And so I think that the message here which is one that I will repeat later on is that, in general, one can associate lower population with lower emissions, but it's not going to guarantee a low emissions outcome on its own. And it doesn't in the SRES Scenarios.

Okay, last I would just like to show you some results of the modeling work that we've been doing, where our goal is to produce some of these kind of global emissions scenarios that we just looked at, but explicitly look at what's the effect when you more or less keep all else equal, but have a lower population rather than higher population. Now, I want to sort of lower your expectations here. I think I sound like the Clinton campaign at the moment, but I want to do that now because I don't actually -- nothing against Clinton supporters -- but we're on our way toward developing such a global scenario to look at the implications of lower population globally. But so far, what we have accomplished is some individual country case studies that we're in the process of linking. But I want to show you some preliminary, sort of intermediate results.

The model that we're using is called a population environment technology model. I won't go into any details. For economists in the audience, it's a multi-region general equilibrium model of the global economy. It's, you know, basically what goes on in the models, there's a household side that is making decisions on how much to save and how much and what to consume. There's a production side that's producing those goods to consume. That production side uses energy in order to produce those goods, and that energy production produces CO_2 emissions. So the model solves by making -- there's the assumptions in here are that producers maximize profits. Households maximize utility or consumption, and one solves the model and see what kind of CO_2 emissions result. This is a fairly typical standard kind of tool in the emissions scenario world.

Our contribution to this has been to take this household sector and break it up into different types of households. So you can differentiate the old from the young, large households from small, urban from rural, and see whether these changes make a difference.

I want to first show you some results from a study of the U.S., emissions scenarios from the U.S., where we focused on aging, substantial impacts of aging, and also of changes in household size. Now, just why might this matter, if the U.S. gets older, why might this affect emissions? Well, it's because, as we know, households that are older versus those that are younger behave different economically. This is true both on the income side and on the consumption side.

So here's some data for the U.S. that shows -- let's just look at small households. In here, that means households with three people or less in them. And older households have lower income, more of the income is from capital than from labor. Younger households, of course, have higher income and so that there's a large difference. There's a substantial difference in per capita income between small households and large households. The main reason is that most of the large households are large because there's children in them who are not earning money, but they're part of consumption. They do what's called dilute the income stream. And I have two daughters and I have some data on that. So, it's a plausible explanation for what's going on here. And the idea, in general, is that if the U.S. is going to, and is expected to shift more toward older households that look like the 65 plus category, how is that going to affect growth and income?

Now it's true that households also differ on the consumption side. I won't go through that, but households of different age and size have different patterns of consumption, different goods that may have different demands for energy to produce those goods and shift in towards consuming more of what older households consume and less of what younger households consume may also matter. And we try to account for that in the model as well.

So what do we get? Here's a set of results for the effect of aging on CO_2 emissions in 2100, it means in the long-term, the second half of the century, at least after 50 years. This is the percent difference in emissions that you get for scenarios that are equal in all ways except for whether or not we've accounted for aging. So we run a set of scenarios in which everyone in the U.S. is treated as identical. Every household is identical. And then we run a second set in which we differentiate by age and include projections, demographic projections with plausible scenarios of aging. And we've done this for three demographic scenarios, one in which households turn out to be smaller and older, a medium one, and one where they're larger and younger. And this is the effect.

The aging effect is more than a third. Your emissions are reduced by more than a third when you simply account for the fact that the U.S. will be getting older. Of course, the biggest effect is in this small, low population growth scenario, because low population growth is also associated with more rapid aging.

So, it's worth, you know, number one, noting that it's important to account for aging. That's one message. The other is that if you're interested in what would be the difference between a medium population path and a low population path, not just due to aging, but due to the difference in population size. By including aging, that is going to magnify the effect, the reduction in emissions that you would get from a lower population size. Because you're going to get lower emissions, number one, because your population size is lower, and you're

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also going to get them even a little bit extra lower because that population is going to be older, as well.

Last, I want to show you just results for a study we did of China where we took into account aging and household size changes, but also urbanization. Urbanization, I think it's obvious that there's difference between households that are urban or rural that are at least as large or larger than differences across age. Households, urban households have higher per capita income. What this graph shows is energy consumption. All of these colors of energy consumption in cities and towns in China are commercial energy use. The blue one is biomass energy. So you see, the population is shifting from these kinds of households to these kinds, fairly rapidly over time. And this is not typically explicitly accounted for in the kind of scenarios that are in the climate change literature, and we wanted to see if this makes a big difference.

And here's the result. This is just presented in a slightly different way than the U.S., but this is a projected emissions path for China from the year 2000 to 2100. The assumptions behind it are patterned after one of the IPCC story lines, the B2 scenario. And this red line shows a scenario where we treat everybody in China as identical and run this into the future, and the economy grows and population changes, and these are the carbon emissions you get. So it about doubles over the course of the century.

When we include the fact of aging, we see a significant, detectable, but not overwhelming effect lowering emissions due to aging, same as in the U.S. When we then add on top of that urbanization, we go from this yellow line up to this blue one. The implications there are -- and we haven't looked at differences between two different population size scenarios yet, but we just wanted to look at how important is urbanization by itself, and it looks pretty big. It's a big effect. In these scenarios, instead of doubling emissions by the end of the century, we triple them. And these effects are mostly felt by the middle of the century, by 2050, because much of the urbanization happens by the middle of the century.

So my conclusions based on the work since 2000 is that -- there's three basically. One is that looking at historical analyses of past experience supports a roughly proportional effect of population size on emissions. Future scenarios have not really yet explicitly looked at the implications of slower population growth. Work that we've done so far indicates that we're going to need to take into account aging and urbanization. Probably not everywhere in the world, but in the areas where it's likely to matter the most.

I mentioned we are working towards global scenario analysis this year to look at the effects of lower population growth where we can take into account coincident effects of aging and urbanization and other things where it's relevant. And the kind of thing that we want to do is look at how much emissions reduction could you get from a lower population path that more aggressively pursued the kind of policies that Joe was talking about. Another way to look at it is, say that you've got a fixed long-term policy goal for climate change, preventing a doubling of concentrations in the atmosphere or something like that. How much less costly would it be, how much less would you have to spend on changing the energy system, for example, to reach that goal, if you had a lower population path rather than a medium one? So I hope that maybe I'll be back here again in the future with at least some bottom line to these answers. Thanks.