Let's look past today's political travails and think longer-range. What will things look like in 2050? There are more details below, but here's the general picture.

World population will probably grow by 2.5 billion people between now and 2050, with about half of the increase in Africa. Given historically weak economic growth in those areas with high population growth, water availability issues, and limits on agriculture, many of those areas will find it difficult to sustain the increased population. Large migration outflows seem very likely. In the meantime, climate change will have taken hold substantially more than it has today, with significant increases in heat waves, floods, and droughts. To keep climate change under control, a massive transformation of the global energy system will be needed.

At a more local level, U.S. population could grow by 25% or not much at all, depending on immigration. The U.S., too, will be impacted by climate change, especially on the coasts and in arid zones. Migration flows are also key to California, where population increase and climate change will stress water supply.

In short, challenges abound.

Here are more details.

**Global Population.** The world population will increase from about 7.3 billion today to 9.7 billion in 2050 (and 11.2 billion in 2100.) Half the growth will be in Africa, including some of the world's poorest countries. According to the UN,

"With the highest rate of population growth, Africa is expected to account for more than half of the world's population growth between 2015 and 2050."

"During this period, the populations of 28 African countries are projected to more than double, and by 2100, ten African countries are projected to have increased by at least a factor of five: Angola, Burundi, Democratic Republic of Congo, Malawi, Mali, Niger, Somalia, Uganda, United Republic of Tanzania and Zambia."

The exact population projections depend on birth rates. Projections have gone up because the birth rate in Africa has been higher than predicted. But even if all of Africa adopted a one-child policy, there would still be a lot of population growth. The reason is that the parents of those children have already been born—they are today's children and teenagers. Because Africa is already having a baby boom, children are a much larger share of the population than in more developed countries.

**Global Food.** According to the UN Food & Agricultural Organization (FAO), the world as a whole should be able to produce enough food for the increased population, at least assuming the effects of climate change aren't too severe. The problem is that much of the food will be grown in a small number of countries, whereas some of the countries that will have the greatest need for more food have little prospect of growing it themselves given poor land and water availability. For these reasons, the FAO says, "[s]ince they have to depend predominantly on their own production for food supplies, it is difficult to visualize a situation whereby they raise national average per capita food consumption to levels that ensure that no segment of their population will have per capita food below minimum requirements for good nutrition." In a report just last week, the FAO reemphasized these challenges, including the potential impact of climate change.

**Global Water**. Water will be an acute need in many places in 2050 for several reasons. First, economic growth entails greater water use for energy production and industry. Second, climate change will disrupt water supplies. Third, those extra 2.4 billion people are going to need more drinking water and water for irrigation, while many will be born in countries that are already water-stressed. Taking all these factors into account, The UN environmental agency projects a 55% increase in water demand by 2050. Putting these factors together, UNEP says the number of people living in river basins under severe water stress is "projected to more than double between 2000 -2050 , reaching 3.9 billion people."

**Global Climate Change.** The amount of climate change and its impacts in 2050 will depend on how much carbon we emit between now and then, on climate sensitivity, and on the nuances of regional climates. But the range of possibilities is pretty clear. According to the IPCC, $CO_2$ carbon concentrations will be 463-623 ppm, resulting in global average temperature increases of 0.8 to 2.6°F by 2050.

**Global Energy**. The Energy Information Agency projects a 50% increase in global energy consumption by 2040. In terms of the global energy mix, the EIA projects the following:

"Even though nonfossil fuels are expected to grow faster than fossil fuels (petroleum and other liquid fuels, natural gas, and coal), fossil fuels still account for more than three-quarters of world energy consumption through 2040. Natural gas, which has a lower carbon intensity than coal and petroleum, is the fastest-growing fossil fuel in the outlook, with global natural gas consumption increasing by 1.9% per year [partly due to fracking]."

To meet the 2 degree target to prevent dangerous climate change, the IPCC estimates that "greenhouse gas emissions in 2050 will have to be 40 to 70 percent lower than what they were in 2010." That's obviously incompatible with business-as-usual trends in fossil fuel

use, so major changes in the global energy system will be needed — because otherwise, based on current trends, emissions will instead steadily climb.

**The U.S.** According to the Census Bureau, the U.S. population in 2050 depends mostly on immigration levels. With zero immigration, the population would barely budge. Continuation of current immigration rates would push the population to about 400 million, and a really high immigration rate could boost that to 450 million. Food shouldn't be a problem, but depending on where the growth takes place, there could be water availability issues in high-growth areas. At the same time as the population is increasing, climate change will be taking hold. According to EPA, "Climate models project that if global emissions of greenhouse gases continue to grow, summertime temperatures in the United States that ranked among the hottest 5% in 1950-1979 will occur at least 70% of the time by 2035-2064." (Note, this EPA document may or may not be available by the time you read this.) We could expect to see about a foot of sea level rise, which translates into different heights depending on localities, with Galveston, TX and the Tidewater area of VA being examples of places with higher than average effects. Precipitation will probably increase in wet areas and decrease in arid ones. Extreme events (floods, droughts, heat waves) will intensify, causing more problems than the shifts in average conditions.

In terms of energy, EIA projects that "U.S. petroleum and other liquid fuels production, which in addition to crude oil…includes natural gas plant liquids derived from natural gas processing…is projected to grow from 14.8 million barrels/day (b/d) in 2015 to 18.6 million b/d in 2040." Natural gas use is expected to increase 1% a year through 2040 (so about 23% between now and then). In its final days, the Obama Administration sketched out a strategy "to reduce the nation's greenhouse gas emissions by at least 80 percent below 2005 levels by 2050." Whether that plan will ever be implemented is unknown, given Trump's election.

**California.** Population growth is even harder to predict on the state level. The estimates range from somewhat above 40 million (no immigration) up to 60 million (high inflows); the Public Policy Institute of California's estimate of 50 million seems reasonable. Southern California is likely to experience high growth because of its significance as a port area and proximity to the border. Obviously, the huge uncertainties about the magnitude of growth make it hard to plan infrastructure over the next three-and-a-half decades, but there's likely to be heavy stress on the water system. We can expect escalating battles between cities and farmers over how to divide up the available supply of water. On the energy side, California's goal is to cut carbon emissions 80% below 1990 levels. Researchers say that California may need new energy technologies to meet this goal, particularly given expected increases in the state's population.

As I said, challenges will abound. It’s not too early to be thinking about how we’re going to meet them.