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Global change scenarios from the perspective of the past

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Abstract

Global change projections are discussed. Anthropogenic pressures have been on the rise and their manifestations, such as changes in population, water footprint, land use and land cover and production output (of energy, food, and any other goods and services) are expected to grow further in future, with serious unwelcome side effects. Climate change has been unabated and unequivocal and is projected to go on until the end of this century and beyond. In order to restrict global warming to below the goal of 2°C, major concerted mitigation efforts, particularly control of atmospheric concentrations of greenhouse gases (GHGs), are necessary, but the probability of adequate efforts being undertaken sufficiently early is not high, and keeps decreasing.

Key words: Global change, climate change, anthropogenic pressure, projections, water footprint.

1. Introduction

There is no doubt that in order to project the possible future, it is necessary to examine past records. However, since, under conditions of global change, it is not possible to find direct analogies of present and future situations in the past, the statement that the past holds a key to the future is valid to a limited extent only. As stated by Milly *et al.* (2008), "stationarity is dead". The convenient assumption of stationarity (that stochastic properties of past processes will remain valid in the future) is simply not acceptable. This means that, for instance, the notion of a 100-year flood being conveniently used in the design of flood defences (e.g., levees) has a limited validity. The 100-year flood is changing with time, in line with changing climatic and terrestrial systems. Hence a 100-year flood can be understood as corresponding to a moving data window, rather than an absolute and unchangeable notion.

Consequently, there are different attempts to develop projections for the future, i.e. by studying analogies, using mathematical model-driven simulations, sensitivity analyses or artificial experiments, which all should lead to plausible scenarios. In some cases, the range in uncertainty can be assessed. This paper reviews various aspects of anthropogenic pressures and their consequences, and then proceeds to illustrate these by reference to climate change projections.

2. Anthropogenic pressure

In the last decades, the global system has been loaded with increasing human impacts called by the common name: anthropogenic pressure. There has been strong growth in the global population, production (of energy, food, and any other goods and services), and – as an unwelcome side effect – greenhouse gas (GHG) emissions. The rate of increase in the loads of GHG emissions over the last two centuries and projections of future increases are illustrated in Table I.

2.1. Population growth

In 2011, the global population surpassed 7 billion. The rate of global population growth has been quasi-linear for over two dozen years. It took 12 years for the population to grow from 5 billion in 1987 to 6 billion in 1999 and again 12 years to grow to 7 billion in 2011. However, until quite recently, the rate has been accelerating with time. Over a period of 100 years, from 1850 to 1950, the global population doubled, from 1.25 to 2.5 billion. But the next doubling, from 2.5 to 5 billion has taken 37 years only.

The majority of the global population lives in Asia. In each of two large Asian countries, China and India, populations exceed 1 billion (over 1.3 and over 1.1 billion, respectively), and keep growing. It is expected that around 2030 the population of India will overtake that of China.

On top of population growth, structural changes in populations are very important. Urban dwellers constitute a gradually increasing part of the global human population, from 13% in 1900, to 29% in 1950 and 49% in 2005. Now, more than half of the global population lives in cities. Each year, world's urban population grows by 67 million people; i.e. 1.3 million per week. In 1800 only one city in the world (London) had a population in excess of 1 million. Now, the numbers of cities with more than 1 million inhabitants approach 500; i.e. the numbers have grown by more than two orders of magnitude. Improved urban infrastructure (including water infrastructure) has played a major role in driving the urbanization trend. Undoubtedly, life in large cities has advantages. There are 26 and 63 metropolitan areas with populations in excess of 10 million and 5 million, respectively. There are approximately 1 billion slum dwellers today but their numbers grow fast and are projected to reach 1.4 billion in 2020. Water use in slums is very low, of the order of 5-10 l (capita) day, and available water is frequently unsafe.

Even if the Earth's population is envisaged to grow, projections of European populations qualitatively differ from the global demographic trend. The numbers of inhabitants of Europe are not expected to grow over the coming decades. The fertility rate is not high, especially in Central and Eastern Europe and in Russia, and the total population is expected to decline despite the migration balance (net influx of immigrants) and a higher fertility rate amongst migrant populations. Life expectancies should increase as a result of advances in the public health system. One clearly notes ageing of the population and increases in the percentage of the population living in urbanized areas in Europe (cf. Table II). During the 40-year interval from 1965 to 2005, the population of Europe increased only by 15.2% (from 634.8 million to 731.1 million), but the population aged over 65 and over 80 years of age increased by 94.4% (from 59.8 million to 116.2 million) and by 179.6% (from 9.2 million to 25.7 million), respectively. This tendency is going to be even stronger in the future.

The numbers of inhabitants of Poland have been declining and will continue to decline in the foreseeable future. However, the absolute and relative fraction of old people (over 65 and over 80 years of age) has been dramatically growing and further growth is foreseen. Only in 2020-2025 will the expected growth of population of 80+ be influenced by the effects of the decline in birth rates during the World War II (Szwed *et al.* 2010).

2.2. The water footprint

Growing populations demand increasing food production. Moreover, over the last decades, diet has been changing towards increased meat consumption. The water footprint of meat is much higher than that of vegetables. Hoekstra (2010) evaluated the water footprints of lettuce and cabbage, i.e. vegetables whose green parts are being consumed,

Table I. Facets of anthropogenic pressure (source: Kajfez-Bogataj, personal communication).

	Estimate for 1800	**Estimate for 2000**	**Growth 1800-2000**	**Forecast for 2050**
Population [billion]	1	6	6 ×	9-10 ?
Production of primary energy [EJ]	13	420	32 ×	600-1000
Global domestic product [trillion US$]	0.3	30	100 ×	85-110
Emissions of carbon dioxide [Gt C]	0.3	6.4	21 ×	5-15
Daily travel (except walking and running) [km]	0.04	40	1000 ×	120-160 ?