An essay on the ecological and socio-economic effects of the current and future global human population size

"The global human population is and will probably remain too large to allow for a sustainable use of the earth's resources and an acceptable distribution of welfare"

MSc Thesis

By Jasper A.J. Eikelboom

Supervised by dr. M. van Kuijk and prof. ir. N.D. van Egmond

Utrecht University

27-09-2013

Abstract

Since the dawn of civilization the world population has grown very slowly, but since the Industrial Revolution in 1750 and especially the Green Revolution around 1950 the growth rate increased dramatically. At the moment there are 7 billion people and in 2100 it is expected that there will be between 8.5 and 12 billion people. Currently we already overshoot the earth's carrying capacity and this problem will become even larger in the future. Because of the global overpopulation many negative ecological and socio-economic effects occur at the moment. Land-use change, climate change, biodiversity loss, risk of epidemics, poor welfare distribution, resource scarcity and subsequent indirect effects such as factory farming and armed struggles for resources are caused by overpopulation. All these effects are long-lasting and many are irreversible. The longer we overshoot the carrying capacity of the earth and the larger the human population becomes, the worse the effects will be. It can thus be concluded that the global human population is and will probably remain too large to allow for a sustainable use of the earth's resources and an equal distribution of the use of these resources. In order to achieve global sustainable use and an acceptable distribution of welfare, a world population of 2 billion people would be the maximum. Stabilization of the population is inevitable and therefore it is recommended to support policies to gradually reduce the population level in order to prevent self-regulatory mechanisms like catastrophic global food shortages, escalating armed conflicts about scarce resources or pandemic diseases, from happening.

1. Introduction

1.1. The history of population growth

At the dawn of civilization around 10,000 BC, a total of 1 to 5 million people inhabited the earth *(United States Census Bureau, 2012)*. After the Neolithic revolution, when the lifestyles of humans changed from hunter-gatherer to agriculture, the world population started to increase steadily and doubled approximately every 1000 years until 1000 BC *(Fig. 1)*. Then a rapid growth began until 1 AD when the world population was approximately 300 million *(United States Census Bureau, 2012)*. In the next millennium the world population did not increase much, mainly because of the Plague of Justinian, a multi-continental, bubonic plague which cost the lives of approximately 25 million people *(Rosen, 2007)*. After 1000 AD a steady growth of approximately 50 million people per century continued, only to be interrupted in 1350 by the Black Death which cost the lives of approximately 100 million people *(Friedrich & Hecker, 1835)*. From 1400 to 1750 the population doubled from 350 to 700 million people *(United States Census Bureau, 2012)*. This increase in growth speed can be partly contributed to the colonization of the Americas which yielded more agricultural space *(McNeill, 2008)*.

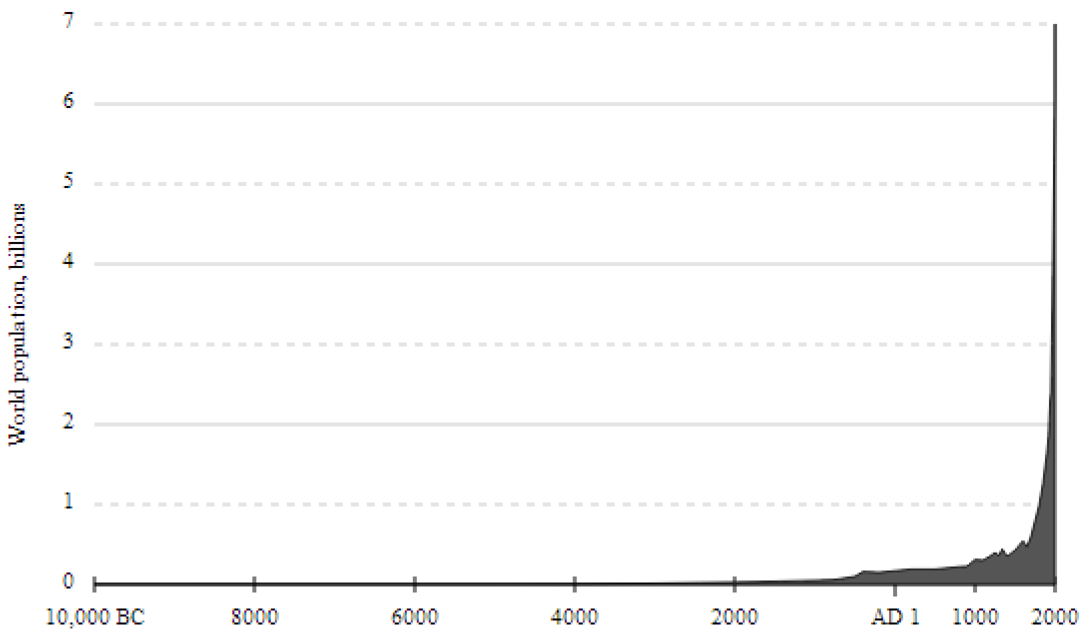

Figure 1: Estimated world population size (billions) from 10,000 BC to 2000 AD *(Worldometers, 2013)*.

Because of the Industrial Revolution in 1750 the growth rate of the world population started to increase rapidly *(Fig. 2)*. In 1800 the world population consisted of 1 billion people, as a consequence of the improvement of agricultural techniques and hygienic conditions, and in 1950 this number had already increased to 2.5 billion people *(United States Census Bureau, 2012)*. Because of the Green Revolution around 1950 the food production increased rapidly and this coincided with the largest growth rate in history of approximately 2 percent per year *(United Nations, 2012)*. In 1959 the world population was 3 billion and this doubled to 6 billion in 1999. From 1970 until present the relative growth rate has decreased from 2 to 1.15 percent per year *(United Nations, 2012)*.

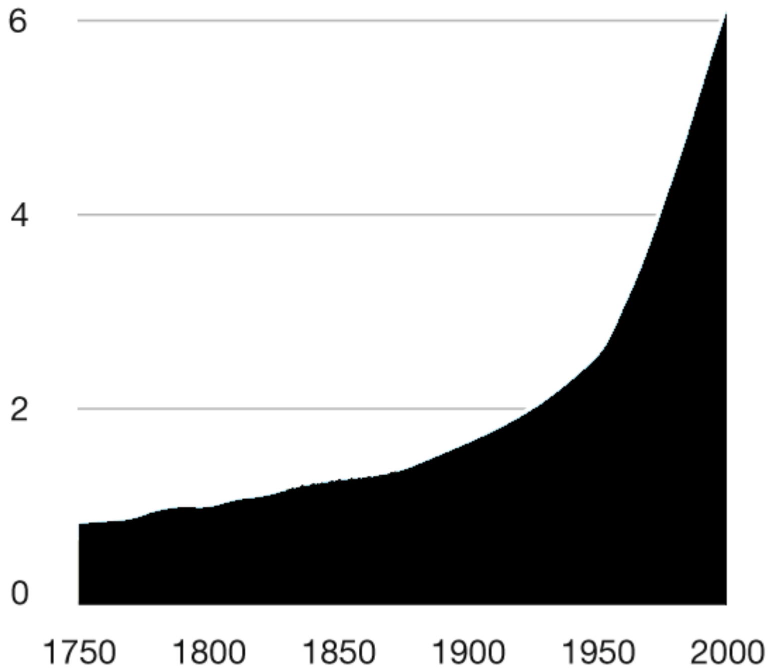

Figure 2: Estimated world population size (billions) from 1750 to 2000 *(Ahlenius, 2009)*.

It is projected that the world population will continue to grow until at least 2050 and probably longer *(Lutz et al., 2001)*. In 2100 there will most likely be between 8.5 and 12 billion people on earth *(United Nations, 2011)*.

1.2. Effects of overpopulation

Overpopulation occurs when the number of people exceeds the carrying capacity - the maximum population size that the environment can sustain indefinitely - of a region *(Turner II et al., 1990)*. This region can be a city, country or even the whole world. Overpopulation has negative effects on the environment and the society. Already in 18th century there were people who warned about the possible effects of overpopulation *(Malthus, 1798)*, but it wasn't until 1968 when the global awareness greatly increased *(Ehrlich, 1968)*. This essay will consider three major ecological effects and two major socio-economic effects caused by overpopulation. These effects are respectively land-use change, climate change, biodiversity loss, risk of epidemics and poor welfare distribution. The effects are discussed because of their present important influence on society and because they trigger many indirect effects (e.g., land-use change is a cause of soil erosion *(Turner II et al., 1990)*; biodiversity loss is the cause of ecosystem disruptions *(Vitousek et al., 1997)*; and poor welfare distribution is the cause of poverty and starvation *(Pimentel et al., 2010)*.

1.3. Ecological effects

Overpopulation started to have ecological effects early in history. Land-use change, especially deforestation, is a good example of this. This essay will cover the past deforestation of Europe and the present deforestation of the tropics. After the human population size started to increase during the Neolithic revolution, humans converted large areas of forest into farming land *(McGeough, 2013)*. In 1000 AD there were however still large amounts of forests in Western Europe, but because of the expanding human population a shortage of wood was already notable in 1500 *(Cantor, 1994)*. The need for food and wood continued through the Industrial era - when also large parts of the forests of the United States were cleared - until today. Nowadays tropical forests are cleared at an alarming rate to supply the large amount of people with wood and space for farming land. The deforestation of the tropics is a very critical problem at the moment, because it is the global hotspot for biodiversity loss and many other ecosystem services (e.g., carbon storage) are threatened *(Myers et al., 2000; Ruddiman, 2008)*. The production of meat and the required livestock feed is a large driver of deforestation, also when factory farming is performed *(Northoff, 2005; Turner, 2000)*. This problem is expected to become even larger in the near future, as the global meat consumption is expected to double from 2000 to 2050 because of the projected increase in welfare in countries with rising economies *(FAO, 2006; O'Neill et al., 2005)*.

Since the last couple of decades the entire system earth can be seen as an overpopulated area *(Turner II et al., 1990)*. Because of this global overpopulation, new problems have arisen that did not exist when there were only certain areas which suffered from regional overpopulation. For example: because of the anthropological emissions of greenhouse gasses the mean temperature on earth has started to increase, resulting in climate change *(Ruddiman, 2008)*. This essay will cover global warming, because nowadays the effects of climate change are increasingly becoming clear *(Ruddiman, 2008)*. Global warming is causing the animal and plant species extinction rate to increase *(Vitousek et al., 1997)*, but it has also other ecological effects. Some examples of these effects are the shrinking of polar and glacier ice masses, the mean sea level rise, the geographically shift of biomes, the expanding of deserts, and the acidification of oceans *(Ruddiman, 2008)*. And these ecological effects consequently affect agriculture, drinking water production and other sectors.

Partly because of this land-use change and climate change, the populations of many animal and plant species started to decline with the increase in human population size *(Vitousek et al., 1997)*. Because of the decline in animal population sizes, the extinction rate of animal species also increased drastically with an increase in human population size. This essay will focus on the animal biodiversity loss, because the extinction of animal species has been a large social concern during the past decades and extensive research about the problem is therefore vital. Nowadays the extinction rate of animal species is 100 to 1000 times higher than the mean extinction rate before the dawn of human civilization *(Lawton & May, 1995)*. This even caused some scientists to refer to these extinctions as the Anthropocene extinction, an extinction event caused by humans *(Crutzen & Stoermer, 2000; Wooldridge, 2008)*. Another cause of this decline of animal populations is overhunting/overfishing to supply the increasing size of the human population with enough food. Furthermore, another present cause of this problem is pollution of the environment in densely populated areas.

1.4. Socio-economic effects
The socio-economic effects of overpopulation already became clear around 1500 BC. During that period, probably the world's first epidemic occurred in Egypt *(Kozloff, 2006)*. The recent outbreak of SARS made epidemics also a large present global concern. From the time of the Roman Empire until now epidemics of smallpox, bubonic plague, influenza etc. have occurred on a regular basis. These epidemics have a higher chance to originate and a higher chance to spread in highly populated areas. Bad hygiene seems to have stimulated the occurrence of epidemic outbreaks. A recent example of this is the Haiti cholera outbreak, which originated after the Haitians started to drink untreated water from the Artibonite River after the country was hit by an earthquake *(NBC News, 2010)*. But epidemics also have a higher chance to arise in highly populated areas with a good hygiene

compared to low populated areas with the same level of hygiene, because the mutation of microbes goes faster as crowding makes genetic reassortment more likely *(Woolhouse & Gowtage-Sequeria, 2005; Garrett, 1996)*. A recent example of this is SARS, which originated in South Asia and could rapidly spread in the densely populated area of Hong Kong *(Smith, 2006)*.

In the past century, when the entire earth became overpopulated *(Turner II et al., 1990)*, new socio-economic problems arose. As the world population grew, the earth's resources became more and more insufficient to support humanity. More than 1 billion people are living in absolute poverty - deprived of basic human needs - as of 2008 *(World Bank, 2012)*. Because new international agreements to reduce poverty will probably be made in the coming future, it is critical to determine the cause of this poverty. Unequal welfare distributions were also a problem in former times (e.g., the Roman era) *(Turner II et al., 1990)*. However, this system of appropriation and distribution tends to become more skewed when resources become scarce *(Weld & Wright, 1996)*. So partly because of overpopulation, the welfare distribution on earth is far from equal as there are not enough resources to provide all people on earth with a 'sustainable European standard of living' *(Pimentel et al., 2010)*. Overconsumption by the rich countries worsens the poor welfare distribution on earth. Depleting natural resources have resulted in conflicts and an unequal distribution of these resources in the past *(Weld & Wright, 1996)*. If the carrying capacity of the earth was not exceeded, the overconsumption of some countries would not result in an increase of poverty in other countries. Furthermore, overpopulation can explain the increase in conflicts (e.g., terrorism and civil war) of the last decades *(Heinsohn, 2008; Weld & Wright, 1996)*. These conflicts are not only caused by depleting natural resources, but also in part because of a surplus of unemployed young men in for example the Arab World *(Heinsohn, 2008)*. Because of the massive population growth of the past decades, many young Arab men are now unemployed and/or unsatisfied and tend to more easily turn to a life of violence and terrorism.

1.5. Outline of this essay

This essay will first discuss multiple projections of the population growth. After that the carrying capacity of the earth will be described. Then the following direct effects of overpopulation will be discussed in different paragraphs: land-use change, climate change, biodiversity loss, epidemics, and welfare distribution. These effects are unfortunately not all the problems caused by overpopulation as they also have many indirect effects *(Holdren & Ehrlich, 1974)*. These indirect effects will be explained together with the associated direct effect. In the summary and conclusion of this essay the projections of the population growth, the carrying capacity of the earth and the effects of overpopulation will be summarized and evaluated to support the conclusion that the global human population is and remains too large to allow for a sustainable use of the earth's resources and an equal distribution of the use of these resources.

2. Projection of the population size

According to the United Nations and the IIASA the world population will continue to grow until at least 2050 and probably longer *(Appendix: Projection of the population size)*. Different scenarios yield different projections for the population size, but in 2100 the population size will very likely be larger than today and probably between 8.5 and 12 billion people *(Fig. 3)*. The only projection after 2100 puts the population size for the medium scenario around 8 billion people in 2300 *(United Nations, 2011)*. These projections are mainly determined by a decrease in fertility, but also by a decrease in mortality and an increase in life expectancy *(United Nations, 2011)*. These trends are mainly caused by the improving social-economic stability of most countries and women emancipation *(United Nations, 2011; Malthus, 1798; Thompson, 2003; Montgomery, 2000; Hilderink et al., 1996; Shorter, 1973)*. Broadening of the view of conservative religious societies, mainly the Islam, is very important in the determining the projection of fertility *(Hilderink et al., 1996)*. The total result is the slowing down of the population growth, but the population will continue to grow for almost one-hundred years after replacement level (i.e., the mean number of children that women have to bear to ensure that every woman ever born is replaced by only one daughter) is reached *(Preston et al., 2000)*. However, the improving social-economic stability - mainly of the countries with the so-called "rising economies" - increases the pressure on the environment per person drastically *(Turner II et al., 1990)*.

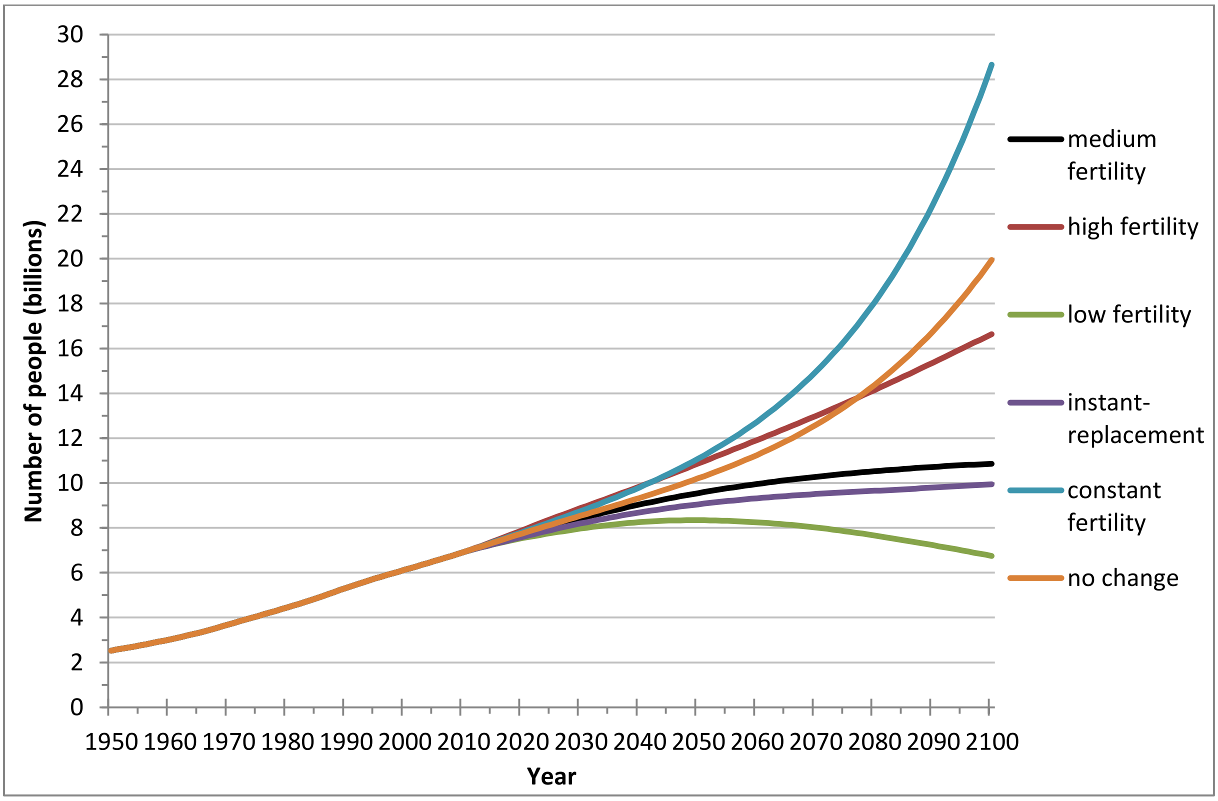

Figure 3: Projected world population according to different United Nations projection scenarios, 1950-2100 *(data from United Nations, 2012)*.

3. Carrying capacity of the earth

3.1. Ecological Footprint

The earth's renewable resources (e.g., water, agricultural products, timber etc.) are not infinite and need not to be overexploited to function sustainably *(Turner II et al., 1990)*. Of course non-renewable resources (e.g., earth oil) can never be exploited sustainably, because their gross growth rate is almost zero *(Ruddiman, 2008)*. At the moment the total population of more than 7 billion people is overexploiting the earth's resources. To quantify the amount of resources people are using, the Ecological Footprint is often used *(WWF, 2012)*. This is the total amount of biologically productive land and sea area necessary to supply the resources that a person consumes, and to assimilate associated waste. In this method the area needed for all different types of resources (e.g., land used by crops, water used by fish and area needed for livestock and livestock feed) and waste deposit (e.g., area needed to sustainably process sewage, agricultural and industrial waste and area with biomass needed to take up carbon) is summed up. During any given time period in a year we consume more than 50 percent more resources than the earth produces *(Meadows et al., 2005; WWF, 2012; World Population Balance, 2013)*. This means that it takes the earth eighteen months to produce (or re-uptake in the case of carbon) what we consume in twelve months *(World Population Balance, 2013)*. Already in 1970 the carrying capacity of the earth was overshot for the first time with a population size of 3.7 billion people *(Fig. 6; United Nations, 2012)*.

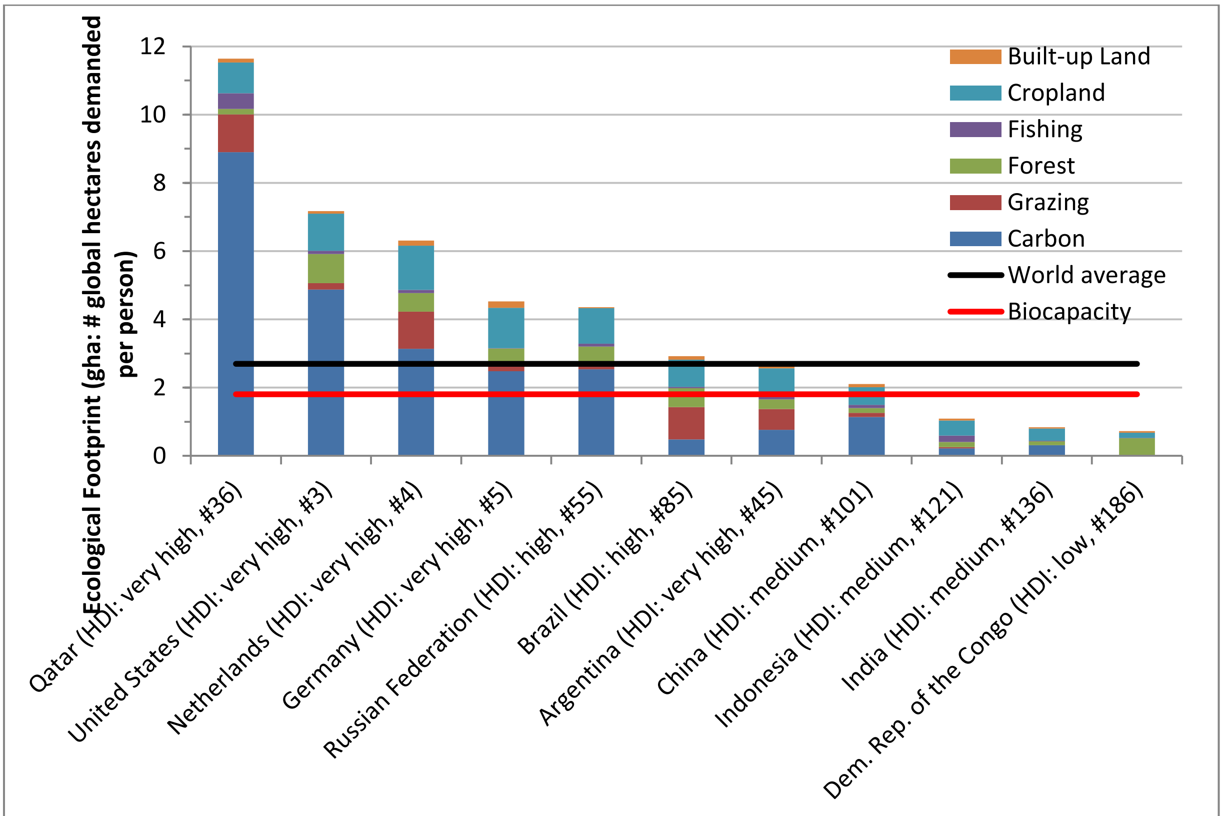

Figure 4: Ecological Footprint - the total amount of biologically productive land and sea area necessary to supply the resources a person consumes, and to assimilate associated waste - per country in 2008 *(data from: WWF, 2012)*. The Human Development Index (HDI) category and rank - a weighted combination of life expectancy, education and income - is also indicated for each country. The biocapacity is the amount of hectares available per person.

In 2008 there were 6.7 billion people and 12 billion hectares of biologically productive land and water on earth *(Global Footprint Network, 2010)*. When assuming that no land is set aside for other species that consume the same biological material as humans, there were 1.8 global hectares per person available in 2008 (the biocapacity). The world average global hectares demanded per person was however 2.7 in 2008 *(Fig. 4)*. This world average obviously includes all countries, so also the developing countries. The most developed countries (with a 'very high' Human Development Index) have a much larger Ecological Footprint than the world average *(Fig. 4-5; United Nations, 2013a)*. For example, in 2008 a citizen of the United States had an average Ecological Footprint of 7.17 gha. Comparing this to the biocapacity, if everyone on earth had the same Ecological Footprint as a citizen of the United States, four planet earths are needed to sustain these people *(WWF, 2012)*. The mean Ecological Footprint of the European Union in 2003 was 4.7 gha, about two-third of the amount of the American Ecological Footprint in 2008 *(Global Footprint Network, 2007)*. So more than 2.5 planet earths are needed if everyone shares the European standard of living. Furthermore, on average also the people in the lowest category of the Human Development Index are unsustainably overshooting and depleting their resource biocapacity (which is lower than the world average) - by over 10 percent *(World Population Balance, 2013; Global Footprint Network, 2008)*. The sustainability criteria for a country, proposed in the Living Planet Report, makes use of the Ecological Footprint and Inequality-Adjusted Human Development Index (IHDI), a weighted combination of life expectancy, education, income and inequality *(WWF, 2012; Fig. 5)*. The IHDI is used as a criterion instead of the HDI, because the IHDI is the actual level of human development, whilst the HDI can be viewed as an index of "potential" human development in a country *(UNDP, 2010)*. According to the Living Planet Report there is no country in the world that meets the minimum criteria for sustainability, meaning there is not a single country with a 'very high' - or even 'high' - IHDI that also has an Ecological Footprint below the world average biocapacity *(Fig. 5)*.

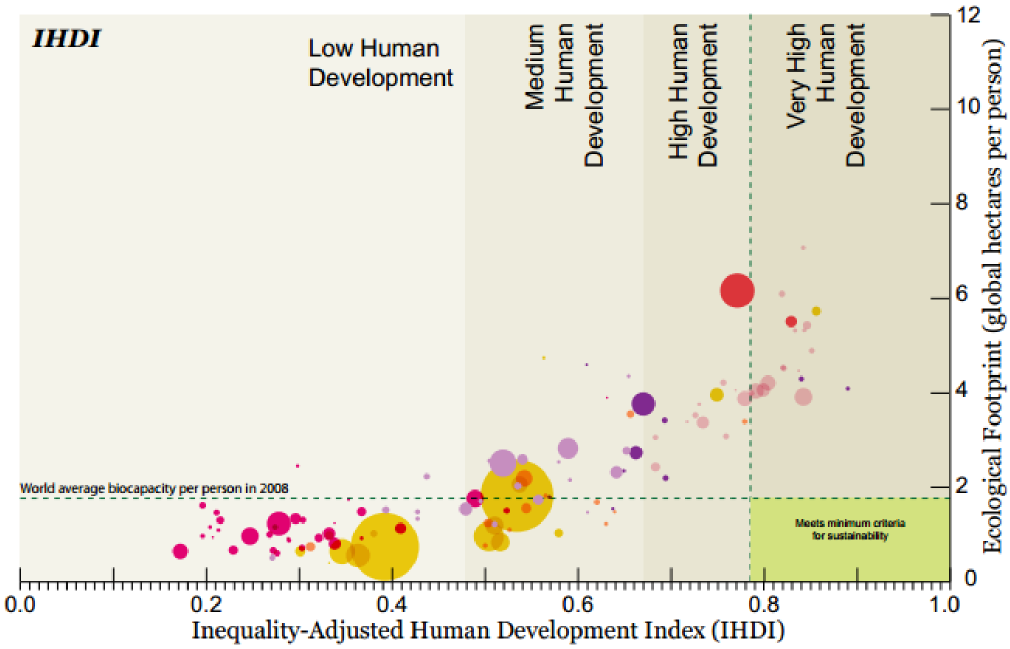

Figure 5: The Ecological Footprint - the total amount of biologically productive land and sea area necessary to supply the resources a person consumes, and to assimilate associated waste - for each country (in 2008) versus the Inequaliy-Adjusted Human Development Index (in 2011) - a weighted combination of life expectancy, education, income and inequality - *(WWF, 2012)*.

3.2. Carrying capacity

In response to these facts several recent studies indicate that the earth's resources are enough to sustain only about 2 billion people at a European standard of living *(Pimentel et al., 2010; World Population Balance, 2013)*. This number is deliberately not calculated by comparing the world average Ecological Footprint with the world average biocapacity, which would result in approximately 4 billion people. This calculation would be unethical, because nowadays the (I)HDI in many countries is still low. By using the world average Ecological Footprint in the calculation the countries with a low (I)HDI would not get the chance to increase their (I)HDI, because this would automatically increase their Ecological Footprint *(WWF, 2012)*. So the number of 2 billion people is calculated by comparing the average European Ecological Footprint with the world average biocapacity. With this number of people there are theoretically still enough resources available for poor countries to increase their (I)HDI to a European standard of living. The average European Ecological Footprint is expected to be a feasible Ecological Footprint for countries with a 'very high' (I)HDI *(Pimentel et al., 2010)*, but critics say it could be even lower. An example of this is Argentina: a country with a 'very high' HDI and an Ecological Footprint of 2.67, comparable with the world average *(Fig. 4)*. But this comparison is not fair, because of the great inequality between citizens of Argentina resulting in only a 'medium' IHDI *(UNDP, 2013)*. So the 44 countries with a higher HDI than Argentina would most likely have to lower their HDI and/or equality to reach the same Ecological Footprint as Argentina, which is of course undesirable *(Fig. 4-5)*.

The carrying capacity of 2 billion people still implies that many countries have to limit overconsumption, especially some rich Middle-Eastern countries, the United States and a large number of West European countries, in order to reduce their Ecological Footprint to approximately the same as the Ecological Footprint of Germany in 2008 *(Fig. 4)*. In the Netherlands for example this can be achieved by reducing the meat and dairy consumption by half *(Planbureau voor de Leefomgeving, 2013)*.

3.3. Population, consumption and technology

The Ecological Footprint is not only determined by the population size, but also by the mean consumption per person and by technology - the efficiency with which natural resources are converted into goods and services *(Ehrlich, 1968; WWF, 2012)*. Not only overpopulation is therefore important, but overconsumption is actually the key concept. Overconsumption is a situation where resource use has outpaced the sustainable capacity of the ecosystem. The three most heard arguments against the proposed carrying capacity as a political target to be met, is that people in developing countries can reduce their high fertility level, people in developed countries can reduce their consumption level, and that improved technology will allow a more efficient use of resources *(Weld & Wright, 1996)*. Unfortunately, past trends show the opposite.

It is wrong to assume that only the people in the developing countries should be concerned with reducing their fertility level and population size. The fertility level in most developed countries is nowadays indeed at or below replacement level *(United Nations, 2011)*, but the developed countries are still overshooting the carrying capacity and can therefore still be considered overpopulated *(Fig. 4)*. Furthermore, if the population in the developing countries would stop growing, then the total population size would still be far above the earth's carrying capacity. The projections of the population size show that this carrying capacity will most probably not be reached within the next

300 years, which is the maximum projection period, if the fertility level of the developing countries would reach replacement level or just below *(Appendix: Projection of the population size)*. So also the population in the developed countries should be concerned with the earth's carrying capacity of 2 billion people *(Pimentel et al., 2010)*.

To assess the consumption level of people in a developed country, the United Kingdom WWF Footprint Calculator can be used *(WWF, 2013)*. When the most sustainable answer is chosen at every question, then there are still 1.36 planet earths needed to supply 7 billion people this way (this means never travel by public transport, car or plane; only eat organic and local vegan food; separate all your waste; living with 5 people in one flat apartment; owning no pets; never heat your house above 15 °C; never buy a television or mobile phone etc.). It would be really difficult to reduce consumption even more. Actually, in a developed country it would already be very hard to live in this way, as it is doubtful for everyone to be able to function properly in these societies whilst not being able to use motorized transport, television or mobile phones. Governmental actions could also further decrease the consumption rate, especially the carbon footprint, but it is reasonably impossible for a country with a 'very high' HDI to get an Ecological Footprint at or under the biocapacity with the present 7 billion people on earth. With the expected population size in 2100 it would be far from realistic to assume that these countries can have an Ecological Footprint at or under the biocapacity whilst maintaining their same welfare and equality.

The consumption levels of humans are increasing more rapidly than improvements in the efficiency of resource production *(WWF, 2012)*. The population is also growing faster than the biosphere's capacity is growing *(WWF, 2012)*. This implies that the (technology-driven) increase in the earth's productivity is not enough to compensate for the demands of the growing population *(Fig. 5)*. Therefore it is also unlikely that the improving technology will allow unlimited human population growth. A good example regarding this issue is the following. Since 1968 to 1990 many technological breakthroughs - for example the information technology - improved the efficiency with which natural resources were converted into goods and services. In 1968 there were about 1 billion people with a decent standard of living and 2.5 billion people who lived in relative poverty. In 1990 there were 1.2 billion people with a decent standard of living and 4.1 billion people who lived in relative poverty *(Weld & Wright, 1996)*. This example illustrates the inability of technology to keep up with the population growth to allow everyone a decent standard of living. Critics also often point to the environmental Kuznets curve (EKC) to explain that technology will solve the issue of overpopulation *(Shafik, 1994)*. The theory is that when the economy evolves, environmental degradation will first increase because of an increase in consumption and then the environmental degradation will decrease after a certain threshold GDP is reached, because of technological development. But after this it is most likely that the environmental degradation will increase again, with a slower rate however, after the economic grow continues beyond a threshold GDP *(Levinson, 2000)*. The EKC has been proven for certain pollutants in some countries, but until today there has been no reduction in Ecological Footprint observed with increasing economy *(New York Times, 2009)*. Furthermore, new problems keep arising with technological-optimistic scaling of the population size and consumption. An example of this is "peak phosphorus" - the point in time at which the maximum global phosphorus production rate is reached - which is caused by the depletion of the scarce and finite phosphorus resources *(Cordell et al., 2009)*. Phosphorous is a key ingredient of fertilizers and 30 to 50 percent of the global crop supply is nowadays attributed to fertilizers *(Stewart et al., 2005)*. There is debate about the timescale in which this phosphorus shortage will start, ranging from approximately 50 to 300 years, but it will have serious consequences for the food supply *(Cordell et al., 2009; IFDC, 2010; Stewart et al., 2005)*.

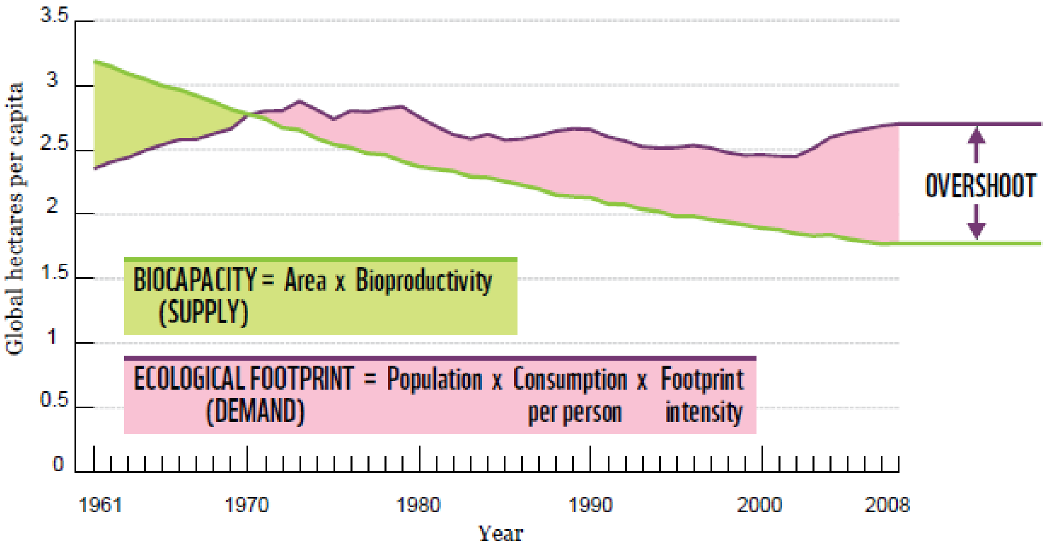

Figure 6: Trends in Ecological Footprint and biocapacity per person between 1961 and 2008 *(WWF, 2012)*. The formula for Ecological Footprint (demand) is based on Ehrlich's formula: Impact = Population x Affluence / Technology *(Ehrlich, 1968)*.

3.4. Summary of the paragraph

It is certainly not possible to sustain 7 billion people on earth by reducing the Ecological Footprint to the biocapacity without severe loss of welfare. On top of that, the human population is expected to grow over the coming decades, probably to a total between 8.5 and 12 billion by 2100 *(United Nations, 2012; Lutz et al., 2001)*. The longer we overexploit the earth's resources, the more the world average biocapacity declines as for example fossil resources become depleted and fertile land becomes desertified *(World Population Balance, 2013)*. The ideas about when we will run out of food differ between scientists and some past projections have failed, leading some people to believe the earth has no boundaries *(Ehrlich, 1968)*. Recently a book was released in which it is forecast that catastrophic global food shortage will hit by mid-century *(Cribb, 2010)*. Whether this will become reality or not, it is certain that it is not possible to consume this way indefinitely. Therefore we will need more and more planet earths to supply us with enough resources *(Fig. 7)*, unfortunately there is only one. A population size of about 2 billion people at a European standard of living would be the maximum to achieve global sustainable use of the earth *(Pimentel et al., 2010; World Population Balance, 2013)*.

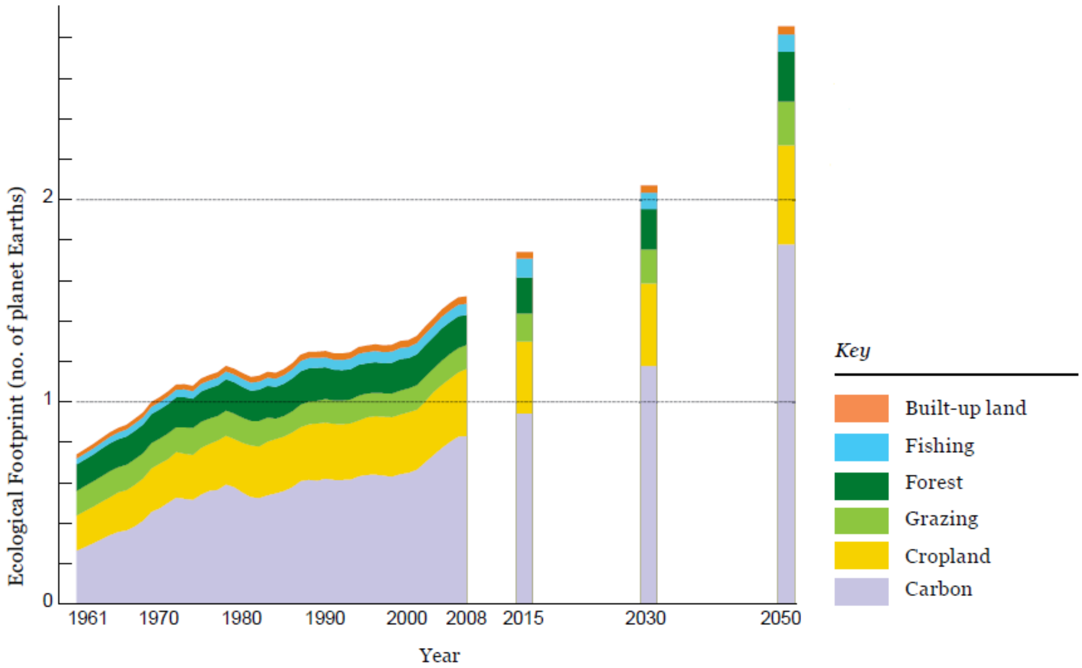

Figure 7: "Business as usual" scenario of the Ecological Footprint from 2009 to 2050 *(WWF, 2012)*.

4. Ecological effects

4.1. Land-use change

Humankind has radically changed the face of the earth and has been the species with the largest influence on the environment in the entire history of the earth *(Turner II et al., 1990)*. Their population explosions have made the human presence on earth a forceful environmental factor *(Turner II et al., 1990; Ehrlich, 1968)*. Due to the ability of humans to consciously change the earth's landscape to make it most beneficial to them, they undertook and triggered many forms of land-use change.

When the human population increased, the pressure on the environment increased as well. Using four regional case studies from the past - Tigris-Euphrates lowland in 1900-1600 BC, Egypt in 100-743 AD, central Maya lowlands in 600-1000 AD, and Basin of Mexico during multiple population growth phases - Turner II et al. *(1990)* determined that the regional-scale transformations occurred during times of relatively rapid population growth. In some cases the population even declined because of these land-use changes and in almost all cases the environment could not recover until the present day after this driver seized to exist. The authors concluded that the projected global-scale population "leveling-out" need not diminish the scale and profundity of global environmental change *(Turner II et al., 1990)*. They added that brutal regional population declines are likely to occur in the future because of these land-use changes, even with a global population growth rate of zero.

As explained in the introduction, the expanding and growing of the human population in Medieval Europe caused massive deforestation for wood and agricultural space *(Cantor, 1994)*. Before the rise of human civilization, Europe consisted primarily of temperate forests. Nowadays only thirty percent of its area is covered with forests. This forest cover is largely of human creation, through the heavy reforestation of the last 150 years following the extensive exploitation of forests over previous centuries in this densely populated continent *(FAO, 1995)*. It has been estimated that a total of 497,000 km^2 of forest has been cleared in Europe alone *(Turner II et al., 1990)*.

The consequences of this European land-use change were immense and manifold. Water regulating effects by forests were diminished and soil erosion increased *(Turner II et al., 1990)*. But most notably, the habitats of many animal and plant species were utterly devastated and fragmented. The ecosystem suffered severely because of this and the numbers and distribution of species dropped significantly *(Lawton & May, 1995; Turner II et al., 1990)*. The face of the landscape in Europe changed so much because of this that if a (satellite) image could have been taken of the landscape in the year 1000, people nowadays would not recognize it as the same area they live in and vice versa *(Richards, 1986)*. Metaphorically, the landscape can nowadays be most accurately described as a "patchwork quilt".

Nowadays the tropical forests are cleared at an alarming rate *(Myers et al., 2000)*. The main cause of this is the tripled population size of the developing - often tropical - countries since the 1950s and the demand of the developed countries for wood, food and livestock feed *(Turner II et al., 1990)*. The forests became one of the last sources of new land for the extension of agriculture and for wood. With the drastically increased population and wood as one of the largest sources of income, the agricultural land is in great demand because the wood can be exported to other countries. Changes in technology also have had an enormous effect on forest exploitation as the chain-saw and the truck made deforestation much easier and quicker *(Turner II et al., 1990)*.

The tropical forests have a number of important functions on a regional and global scale. They function as the habitat for the majority of the animal and plant species on earth *(Myers et al., 2000)*. They also have trapped a lot of carbon in its biomass and continue to trap atmospheric carbon *(Ruddiman, 2008)*. The forests also regulate the water flows and prevent the (surrounding) area from becoming drier and desertificating *(Turner II et al., 1990)*. Furthermore, the tropical forests produce about 30 percent of our planet's fresh water *(Field, 2006)*. There are therefore many negative effects of the rapid and extensive tropical deforestation *(Eden, 1978)*. Biodiversity is declining rapidly and many animal and plant species are going extinct *(Turner II et al., 1990; Myers et al., 2000)*, which will be discussed in more detail in the chapter "Biodiversity loss". Tropical deforestation is also responsible for 20 percent of the greenhouse gas emissions and once cleared, it cannot uptake the atmospheric carbon dioxide anymore *(Fondation Chirac, 2006)*. This makes tropical deforestation the second largest cause of global warming and this will be discussed further in the chapter "Climate change". The climate of deforested areas and the climate of areas that are sometimes thousands of kilometers away have become much drier *(Turner II et al., 1990)*. Many of the soils in tropical areas are unsuitable for agriculture and after being opened up they become degraded irreversibly through chemical weathering, oxidization and erosion *(Sanchez et al., 1982; Tosi & Voertman, 1964; Tosi & Voertman, 1975)*. This way the likelihood of severe flooding and siltation of reservoirs also increases *(Daniel & Kulasingam, 1974; Salati & Vose, 1984)*. The function of tropical forests to produce fresh water is also very important in the present and coming global water shortage and this shortage will be much worse if the tropical deforestation continues *(Field, 2006)*.

As the need for agricultural space is the largest pressure for the past and present land-use change (i.e., 60 to 80 percent of all cleared tropical rainforest will be used as pasture) *(Northoff, 2005)*, special attention has to be given to the largest driver of this need for agricultural space: the meat production *(FAO, 2006; Turner II et al., 1990)*. The meat and fodder - livestock feed - production together make up for the main part of the total global agricultural area. Twenty-six percent of all ice-free land is used for livestock grazing and about another 20 percent is used as cropland *(FAO, 2012)*. Of this cropland 33 percent is used for fodder production *(FAO, 2012)*, so a total of 33 percent of the earth's land is used for the sole purpose of meat, dairy and wool production. In the year 1700 only 7 percent of the land was used for livestock grazing and cropland *(The Guardian, 2005)*, indicating the magnitude of this driver of land-use change. This problem is expected to become even larger in the near future, as the global meat consumption is expected to double from 2000 to 2050 *(FAO, 2006)*.

The main issue with this is the huge inefficiency of using livestock to acquire calories and proteins. Only 12 percent of crop calories used for fodder end up as calories consumed by humans *(University of Minnesota News, 2013)*. Only 55 percent of crop calories worldwide directly nourish people, as cropland is also used - apart from fodder - for biofuel *(University of Minnesota News, 2013)*. Humans can completely meet protein needs with plant-based diets if the crop systems would shift and it is expected that *in vitro* meat can replace real meat in the future *(University of Minnesota News, 2013; AD, 2013)*. This way the earth could feed four billion people more or, which would be much wiser, make up for the present overshoot in the carbon footprint *(University of Minnesota News, 2013; WWF, 2012)*. However, just using a shift in crop systems to allow for four billion more people on earth to be fed would not solve the other problems caused by the human overpopulation. Therefore it would not be recommended to let the population size increase further by a shift in food production and/or technology, because this will still result in problems for other resource areas. Limiting the meat and dairy consumption by half in the developed countries would already reduce the area needed per person with a quarter *(Planbureau voor de Leefomgeving, 2013)*. Furthermore, livestock contribute to seven percent of the total greenhouse gas emissions themselves *(FAO, 2012)*. So reducing the use of livestock to acquire calories and proteins has more advantages then only solving the global food problem.

The trend of the past decades was the shift to factory farming in which animals were confined to small spaces in large farms, often under barren and unnatural conditions *(Turner, 2000)*. Apart from the ethical problems of this method, this will not solve the food problem in the future *(Turner, 2000)*. There is still space required to produce fodder and this will also increase significantly because more fodder needs to be given to the animals to make up for the lack in calories acquired from grazing. The global meat consumption is expected to double from 2000 to 2050, so this will further increase the area needed to produce fodder *(FAO, 2006)*. An example is that over 90 percent of the world soybean production is used for fodder and many of the tropical forests are nowadays converted in soybean plantations *(Turner, 2000)*. Intensive animal farming is also highly water-intensive as 87 percent of fresh water is consumed for agriculture *(Turner, 2000)*. With the knowledge that in the next 10 years there will be 40 countries suffering from extreme or absolute water shortages, the meat and dairy production becomes even more controversial *(Turner, 2000)*. Other consequences of factory farming and the intensification of farming in general is the damaged soil fertility and the pollution of land, water and air. Agriculture is by far the number one driver of ammonia and nitrate pollution in Europe *(Turner, 2000)*.

4.2. Climate change

Human activity caused the mean global temperature to increase and is continuously doing so *(Ruddiman, 2008)*. By emitting unsustainable amounts of greenhouse gasses - primarily carbon dioxide (CO_2), but also water vapor (H_2O), methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) and more - the atmospheric composition changed *(IPCC, 2000)*. These greenhouse gasses absorb thermal infrared radiation and trap it for a large part in the atmosphere, causing the greenhouse effect *(Ruddiman, 2008)*. This is a natural process and without it the mean temperature on earth would be approximately -20 °C *(Ruddiman, 2008)*. However, because of the anthropologic greenhouse emission the atmospheric concentration of the greenhouse gasses increases faster than ever before and subsequently causes an increase in mean global temperature and the accompanied climate changes *(Turner II et al., 1990)*.

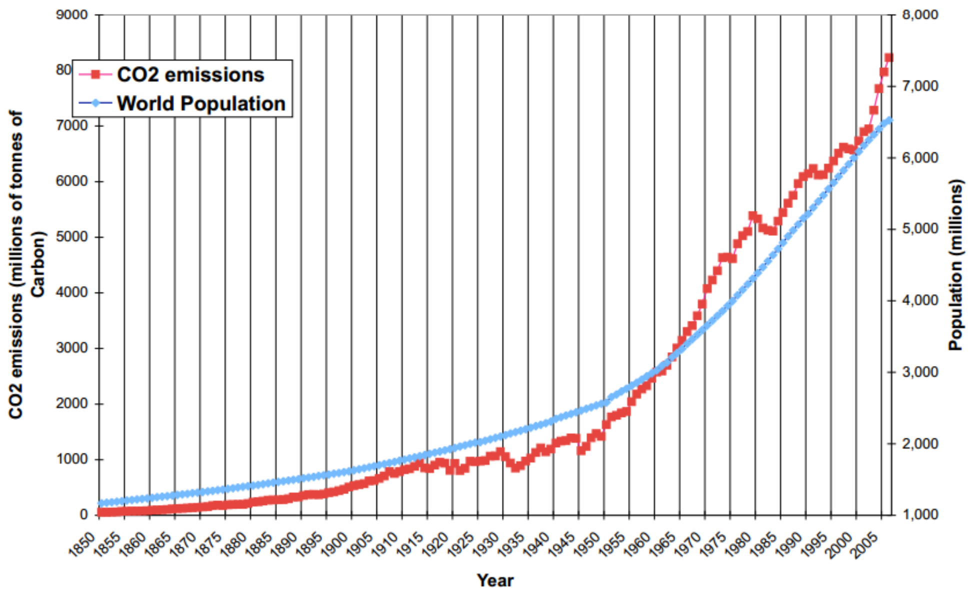

Figure 8: World population vs. CO_2 emissions, 1850-2006 *(Easterbrook, 2009)*.

Since the end of the Industrial Revolution around 1850, the population and CO_2 emissions increased approximately with the same order of magnitude *(Fig. 8)*. This means that the CO_2 emissions per person remained roughly constant and the CO_2 emissions increased only with an increase in population size. Since the Green Revolution around 1950 the situation even worsened. The emissions grew much more sharply than the population from 1950 onwards, with the only exceptions being during the economic recessions of the early 1980's, early 1990's, and around 2000. This happened partly because of the intensified agriculture, but probably also because of the increase in industrial production, materialistic consumption and energy use. Since 2000, emissions have been growing at about double the population growth rate *(Easterbrook, 2009)*. This means that after the Green Revolution the CO_2 emissions still increased with population size, but not with the same order of magnitude because the CO_2 emissions per person have increased.

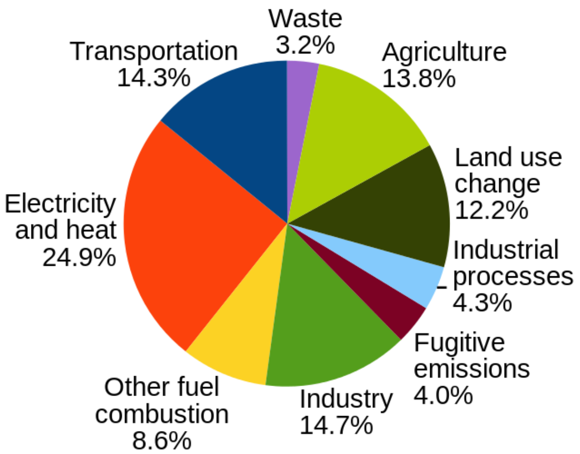

Figure 9: Annual world greenhouse gas emissions by sector, 2005 *(Herzog, 2009)*.

There are multiple causes of the anthropological emissions of greenhouse gasses *(Fig. 9)*. Fossil fuel burning has produced about three-quarters of the increase in CO_2 from human activity over the past 20 years. The rest of this increase is caused mostly by land-use change, particularly deforestation

(IPCC, 2001). The effects of global warming are even a lot more numerous than its causes. Not only does the mean global temperature increase, but because of the temperature increase many indirect effects occur or are very likely to occur in the future *(Bergman, 2011; NASA, 2013)*:

- Arctic sea ice, glaciers and permafrost are melting;
- Sea level is rising;
- Sea-surface and lake temperatures are rising;
- Sea water is acidifying;
- Heavier rainfall and flooding's in some areas, particularly high latitudes;
- Extreme drought is increasing in some areas, particularly subtropical land regions;
- Increase in strength and frequency of hurricanes;
- More frequent heat waves;
- Negative human health impact;
- Increase in withering of crops;
- Ecosystems are geographically shifting;
- Increase of the species extinction rate.

The anthropological greenhouse gas emissions are expected to increase until at least 2040 and will continue to increase without a global moral and policy change *(IPCC, 2000)*. Even with a decrease in greenhouse gas emissions, the atmospheric concentration of greenhouse gasses will continue to increase until at least 2100 *(Ruddiman, 2008)*. Lagging behind even further is the mean global temperature increase, which is expected to increase even after the end of this century *(Fig. 10; Ruddiman, 2008)*. The IPCC estimates that the earth will warm between 2 and 6 °C in the 21st century *(Fig. 10)*.

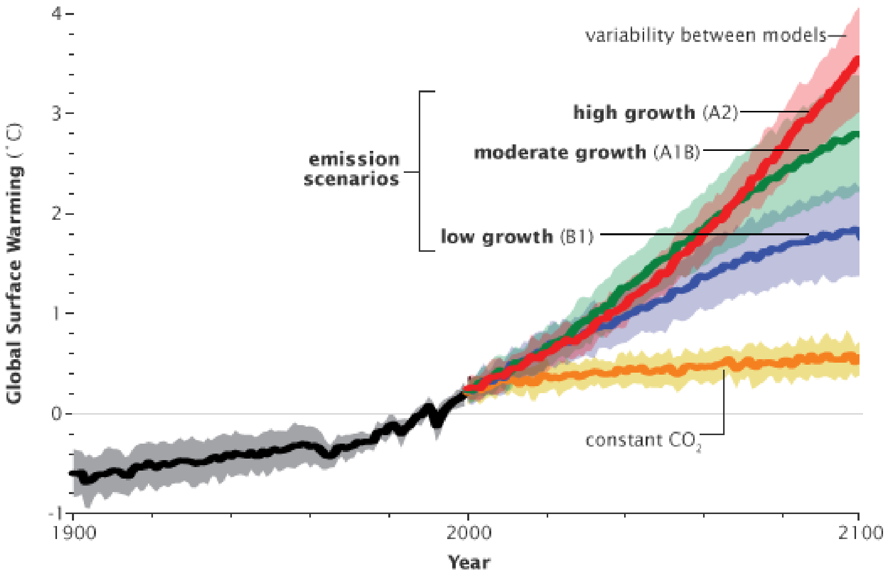

Figure 10: Global warming model simulations, with three different scenarios depending on how fast carbon dioxide emissions grow and one fictional scenario if the atmospheric concentration of greenhouse gasses stayed at the same level as in 2000 *(IPCC, 2007)*.

Because population growth is a direct cause of the ongoing climate change *(Easterbrook, 2009)*, an increase in population size would accelerate the climate change and its effects. Furthermore, as the population increases, less space is available for forests. But with an increase in population, more forests are needed to store the anthropological atmospheric carbon successfully *(WWF, 2012)*. The Carbon Footprint takes up more than a half of the total Ecological Footprint and it is expected that between 2015 and 2020 one entire planet earth - completely covered with forests - is needed just to store the anthropological carbon dioxide emissions *(Fig. 7)*. So without a decrease in population size the irreversible effects will be worse.

4.3. Biodiversity loss

The populations of many animal and plant species started to decline with the increase in human population size *(Vitousek et al., 1997)*. As a consequence, the extinction rate of animal species is also 100 to 1000 times higher than the mean extinction rate before the dawn of human civilization *(Lawton & May, 1995)*. As many as 44 percent of all species of vascular plants and 35 percent of all species in four vertebrate groups are confined to areas comprising only 1.4 percent of the land surface of the Earth, particularly in the tropics, which are threatened enormously by loss of habitat *(Myers et al., 2000)*. Furthermore, the global Living Planet Index (LPI) - which is used to reflect changes in the health of the planet's ecosystems by tracking population trends of over 2500 vertebrate species - declined by 28 percent between 1970 and 2008 *(WWF, 2012)*. In the tropical regions alone, in which the majority of the animal and plant species on earth live, the LPI declined with 61 percent between 1970 and 2008 *(WWF, 2012)*.

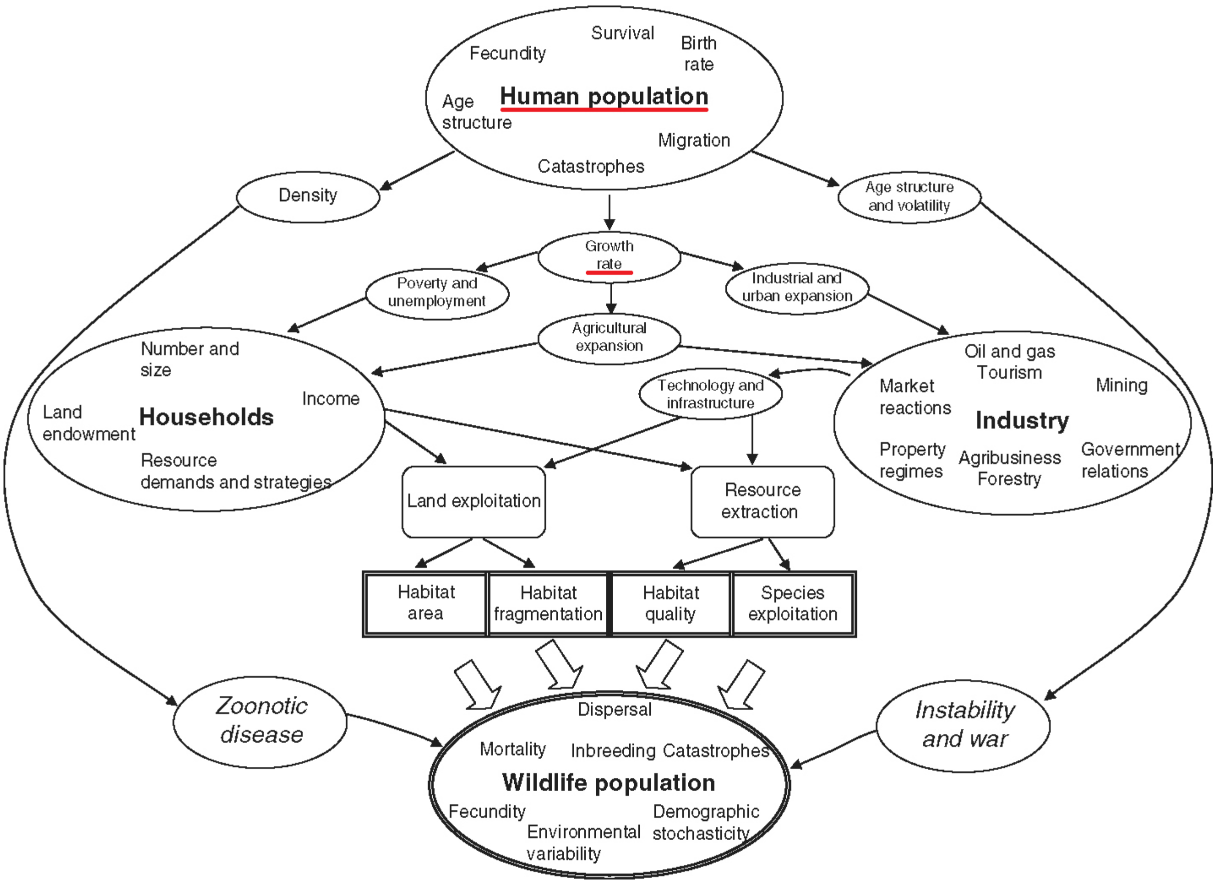

Figure 11: Extinction Vortex, showing the causes of the reduction of animal species populations *(Perenboom, 2012)*.

There are multiple direct causes of biodiversity loss for which overpopulation is an indirect cause *(Fig. 11; Vitousek et al., 1997)*. The massive growth in the human population through the 20th century has had more impact on biodiversity than any other single factor and at least until the middle of the 21st century, worldwide losses of pristine diverse land will probably depend much on the worldwide human birth rate *(Scientific American, 2008; Dumont, 2012)*. The following three phenomena are the major drivers of biodiversity loss and they all relate to overpopulation:

- Habitat destruction, especially tropical deforestation but also pollution *(Ehrlich & Ehrlich, 1981)*;
- Overexploitation (e.g., overhunting, overfishing, excessive logging and poor soil conservation) *(Turner II et al., 1990)*;
- Climate change, causing the disappearance and geographically shifting of ecosystems - and this is causing the migration of invasive species and possible hybridization -, droughts, habitat destruction etc. *(IPCC, 2002)*.

Biodiversity loss results in many secondary effects for the ecosystems, of which many are hard to predict and have a far more enduring impact than any other environmental problem *(Cardinale et al., 2012; Myers et al., 2000)*. The stability of ecosystems functions through time decreases as biodiversity is lost and this impact is non-linear and saturating, such that change accelerates as biodiversity loss increases *(Cardinale et al., 2012)*. Furthermore, biodiversity loss reduces the productivity - the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients - of communities *(Cardinale et al., 2012)*.

While the drivers of biodiversity loss still exist - which are caused by the global human overpopulation - people are trying to save species from extinction. However, people are far from able to assist all species under threat, if only for lack of funding *(Myers et al., 2000)*. Trying to protect these species and their habitats without reducing the impact of the cause of this problem, being overpopulation, can be considered as “shutting the stable door after the horse has bolted”. It could still be successful in many cases for a certain amount of decades or centuries, but the solutions to biodiversity loss would be far more durable and successful if people focused on the cause of the problem. Overpopulation still exists and therefore many people are still dependent on for example the tropical rainforest clearing for their own survival, are also still dependent on the (over)hunting of (endangered) species, and are still dependent on the burning of fossil fuels etc. Until at least the middle of the 21st century, worldwide losses of pristine biodiverse land will still depend much on the worldwide human birth rate *(Dumont, 2012)*. Furthermore, saving species from extinction is not enough to prevent a loss in genetic diversity and this will reduce the stability and productivity of ecosystems *(Cardinale et al., 2012)*. Therefore the most sustainable way to reduce biodiversity loss and to preserve the stability and productivity of ecosystems would be a reduced global human population size, because this eliminates the number one driver of biodiversity loss *(Ehrlich & Ehrlich, 1981)*. According to evidence from mass extinctions in the prehistoric past, evolutionary processes would not generate a replacement stock of species within less than several million years. Meaning that what we do (or do not do) within the next few decades will determine the long-term future - lasting many times longer than we (*Homo sapiens*) have been a species - of a vital feature of the biosphere, its abundance and diversity of species *(Myers et al., 2000)*.

5. Socio-economic effects

5.1. Risk of epidemics

The risk of diseases (and possibly epidemics) to originate and spread are higher in highly populated areas *(Woolhouse & Gowtage-Sequeria, 2005)*. Epidemic outbreaks relate to, but are not limited to, bad hygiene *(NBC News 2010; Woolhouse & Gowtage-Sequeria, 2005)*. A recent example of this is SARS *(Smith, 2006)*. Other than bad hygiene, overpopulation seems to be the major driving force behind the increased risk of epidemics *(Hamlett, 2011)*. Furthermore, bad hygiene often occurs in highly populated areas, but it is possible to have a highly populated area with a good hygiene. So in this case overpopulation is not regarded as the cause of bad hygiene.

Not only does the population increase, urbanization also increases as a consequence of overpopulation *(Hamlett, 2011)*. As of 2007 half of the world's population lives in urban areas, and it is predicted that by 2025 approximately two thirds of the population will live in an urban environment *(Hamlett, 2011)*. Because of urbanization there will be not only more humans, but they will also be living closer together than before. This increases the risk of epidemics to originate and spread *(Woolhouse & Gowtage-Sequeria, 2005)*. Because of urbanization the mutation of microbes also goes faster - as crowding makes genetic reassortment more likely - and as a result of these mutations researchers are currently having difficulties making new and effective antibiotics *(Garrett, 1996)*. Furthermore, with an increase in urbanization it will become a larger challenge to maintain a proper hygiene in these areas *(Garrett, 1996)*.

The globalized society also increases the speed and area for diseases to spread, because human mobility affords microbes greatly increased opportunities for movement *(Garrett, 1996)*. Even before commercial air travel, swine flu in 1918 and 1919 managed to circumnavigate the planet five times in 18 months killing 22 million people *(Garrett, 1996)*. With the present globalization the effects would be even far more devastating. A good example of this is again SARS *(Smith, 2006)*. The SARS outbreak began in Hong Kong in November of 2002 and spread worldwide - to Taiwan, Canada, the United States etc. - claiming over 900 lives by July of 2003. SARS moved through regions of the world where the microbe could not have managed without the increase of human travel *(Ali & Keil, 2006)*. The metropolises were also the breeding grounds of the pathogen *(Ali & Keil, 2006)*. Researchers concluded that the travel speed and area of SARS was increased because of globalization *(Ali & Keil, 2006)*.

Not only does the population size and density of humans increase, but the same is happing for the livestock. Especially since the introduction of factory farming in the 1950s animals are kept under crowded conditions *(Turner, 2000)*. As a consequence animal diseases are also more likely to evolve and spread under these conditions. These diseases can further genetically reassert, because of the many interactions between different bacteria and viruses, to be potentially harmful for humans. Examples of this are the pandemic flu outbreaks of 1957, 1968 and 2009 *(New Scientist, 2009)*.

Apart from the increased risk of epidemics in highly populated areas, the present overpopulation - the human population exceeds the maximum population the earth can sustain indefinitely, given habitat, water, food, and other necessities *(Hamlett, 2011)* - also increases the risk of diseases. Overpopulation causes environmental degradation which consequently produces an increase in disease prevalence *(Pimentel et al., 2007)*. There are several examples of this interplay between environmental degradation and diseases. Deforestation has created breeding pools for malaria-transmitting mosquitoes and have subsequently increased the already high prevalence of malaria in Africa *(Pimentel et al., 2007)*. These cleared areas have also shown an increased amount of helminthes infections, the world total reaching over 2 billion people effected in 2007 *(Pimentel et al., 2007)*. Additionally, vehicle exhaust and industrial fumes have polluted the air in China making respiratory disease the leading cause of death in this country *(Pimentel et al., 2007)*. Also, chemical toxins have been charged with the increased rates of cancer and birth defects in America *(Pimentel et al., 2007)*.

It can be concluded that the risk of diseases and epidemics in highly populated areas is higher. In the future these risks will increase even further, because of population growth, urbanization and globalization. The present and future overpopulation also increases the disease prevalence through the increased risk of diseases in livestock used in factory farming and through environmental degradation. Therefore it will become more dangerous for humans and the human population if the population is allowed to grow further. It is suggested that this phenomenon is in fact a self-regulatory mechanism that in time will bring human populations down to a level compatible with the survival of other species *(Ashford, 2007)*. In the article of Ashford *(2007)* it is asserted that disease limits populations, however only under exceptional circumstances. Due to technological and agricultural innovation humanity has increased the earth's carrying capacity. Ashford *(2007)* asserts that these advances have lead some people to believe that the earth has no carrying capacity. However, this kind of thinking proves to be a result of lethal myopia, because population has already surpassed the planets carrying capacity *(WWF, 2012)*. During the wait until a pandemic disease strikes, populations will continue to grow and the world will be in a kind of "supersaturated state". So the disease, when it arrives, will not only halt further growth, but will bring the population back down to, or even well below equilibrium level *(Ashford, 2007; Hamlett, 2011)*.

5.2. Poor welfare distribution

Because the 7 billion people on earth are consuming more than the earth's average biocapacity, resources are limited *(WWF, 2012)*. Only a part of the countries with a medium or low IHDI are consuming below the earth's average biocapacity *(Fig. 5)*, but on average the people in the lowest category of the Human Development Index are also unsustainably overshooting and depleting their resource biocapacity (which is lower than the world average) - by over 10 percent *(World Population Balance, 2013; Global Footprint Network, 2008)*. This overshoot in Ecological Footprint is causing the inability to solve the unequal division of resources and welfare across countries and not the other way around, because at the moment there are simply not enough resources to supply everyone with a decent standard of living as on average everyone is already consuming above the average biocapacity - global and/or regional *(WWF, 2012; World Population Balance, 2013; Global Footprint Network, 2008)*. The argument that overconsumption of the developed countries is the cause of poverty in the developing countries is false, because overconsumption - a situation where resource use has outpaced the sustainable capacity of the ecosystem - is also happening in the average country with the lowest category of the Human Development Index *(World Population Balance, 2013; Global Footprint Network, 2008)*. Therefore, even an equal division of a good standard of living across all humans on earth would still result in overconsumption, because people who live in the most sustainable way in a country with a very high HDI, still consume too much *(WWF, 2013)*. Of course it would be positive if the developed countries would reduce their Ecological Footprint so the developing countries could improve their standard of living, but this would not solve the global problem of overconsumption and poverty.

In the case of scarcity it is more likely that this will result in conflict instead of the equal distribution of resources *(Weld & Wright, 1996)*. Examples of this are the Turbot War in 1995 between Canada and Spain about overfishing, the Cod Wars in 1958, 1972 and 1975 between Iceland and the United Kingdom also about fishing rights, and the 86 armed civil wars between 1989 and 1994 in the developing countries of which many were in fact about resources *(Weld & Wright, 1996)*. Furthermore, foreign aid spending is declining in the vast majority of donor countries even as the need in the poorest countries is rising, because the developed countries want to prevent their standards of living from falling further especially with the rising economies like China in mind *(Weld & Wright, 1996)*. These conflicts are probably in the nature of men and in the spirit of capitalism, as most people would first choose for their own country. However, this problem would not exist if every country was to consume below its own biocapacity.

Overpopulation by itself is also a factor contributing to conflicts *(Heinsohn, 2008)*. Because of the massive population growth in the Arab World in the last couple of decades, there is a surplus of young, unemployed Arab men *(Heinsohn, 2008)*. Heinsohn *(2008)* explains that this surplus of young men is the actual cause of the present unrest, terrorism and war. If it wasn't for the massive population growth, this problem would probably not exist or be much less. Unequal societies in general are also performing significantly worse in regard to social and health problems (e.g., violence, drug abuse and mental health) *(Wilkinson & Pickett, 2009)*.

It can be concluded that overpopulation is the cause of the inability to solve the poor welfare distribution on earth *(Weld & Wright, 1996)*. The problem of poverty and low standards of living will increase with an increase in population size in the future if nothing is radically changed. If the population size would be lower - with every country consuming below its own biocapacity - this problem would not exist.

6. Summary and conclusion

With 7 billion people on earth, we are consuming far more resources than the earth can produce. In 2100 there will probably be between 8.5 and 12 billion people on earth, most likely making the total consumption even more unsustainable. Individual problems, like food shortages, could theoretically be solved without a reduction in human population by changes in diet, land-use change and/or technological advancements. It will however be impossible to solve all problems caused by overpopulation, like carbon storage and biodiversity conservation, without a smaller human population size.

Overpopulation is the cause of land-use change, climate change, biodiversity loss, risk of epidemics, poor welfare distribution and all indirect effects caused by these phenomena, in particular armed conflicts. These effects will be long-lasting, in many cases longer than humans themselves have lived on earth, and many will be irreversible. The longer and the more overshoot the earth's capacity, the worse these effects will become.

It can be concluded that the global human population is and will probably remain too large to allow for a sustainable use of the earth's resources and an acceptable distribution of welfare. Immediate global action is recommended to minimize further environmental degradation and social-economic problems, and to prevent possible future scenarios like a catastrophic global food shortage, escalating armed conflicts about scarce resources or a pandemic disease that will bring the population back to or below carrying capacity level. Therefore it would be favored to prevent these scenarios from happening by regulating the inevitable stabilization of the population in a humane way by supporting policies to gradually reduce the population level. In order to achieve global sustainable use and an acceptable distribution of welfare, a world population of 2 billion people would be the maximum. This can be done most importantly by a reduction in fertility - which can partly be achieved by the emancipation of women by broadening the view of conservative religious societies -, adjusting the consumption levels and ongoing technological advancements.

References

AD, 2013. Eerste reageerbuishamburger klaar om gegeten te worden. Retrieved August 5, 2013. Available on the world wide web: http://www.ad.nl/ad/nl/5596/Planet/article/detail/3483423/2013/07/29/Eerste-reageerbuishamburger-klaar-om-gegeten-te-worden.dhtml

Ahlenius H., 2009. Trends in population, developed and developing countries, 1750-2050 (estimates and projections). Retrieved July 5, 2013. Available on the world wide web: http://www.grida.no/graphicslib/detail/trends-in-population-developed-and-developing-countries-1750-2050-estimates-and-projections_1616

Ali S.H. & Keil R., 2006. Global Cities and the Spread of Infectious Disease: The Case of Severe Acute Respiratory Syndrome (SARS) in Toronto, Canada. Urban Studies, 43(3): 491-509.

Ashford R.W., 2007. Disease as a Stabilizing Factor in the Protection of Landscape: The Leishmaniases as Models. EcoHealth, 4: 99-103.

Bergman J., 2011. Effects of Climate Change Today. Retrieved August 5, 2013. Available on the world wide web: http://www.windows2universe.org/earth/climate/cli_effects.html

Bongaarts J. & Bulatao R.A., 2000. Beyond Six Billion: Forecasting the World's Population. National Academy Press, Washington DC.

Cantor N.F., 1994. The civilization of the Middle Ages: a completely revised and expanded edition of Medieval history. HarperCollins.

Cardinale B.J., Duffy J.E., Gonzalez A. et al., 2012. Biodiversity loss and its impact on humanity. Nature, 486: 59-67.

Cordell D., Drangert J.O. & White S., 2009. The story of phosphorus: Global food security and food for thought. Global Environmental Change, 19(2): 292-305.

Cribb J., 2010. The Coming Famine: The Global Food Crisis and What We Can Do to Avoid It. University of California Press.

Crutzen P.J. & Stoermer E.F., 2000. The 'Anthropocene'. Global Change Newsletter, 41: 17-18.

Daniel J.G. & Kulasingam A., 1974. Problems arising from large-scale forest clearing for agricultural use - the Malaysian experience. Malaysian Forester, 37: 152-160.

Dumont E., 2012. Estimated impact of global population growth on future wilderness extent. Earth System Dynamics Discussions, 3: 433-452.

Easterbrook S.M., 2009. Population growth vs. emissions growth. Retrieved August 5, 2013. Available on the world wide web: http://www.easterbrook.ca/steve/2009/06/population-growth-vs-emissions-growth/

Eberstadt N., 2013. Sharp decline in Muslim fertility rates. Retrieved September 27, 2013. Available on the world wide web: http://www.yalibnan.com/2013/02/11/sharp-decline-in-muslim-fertility-rates/

Eden M.J., 1978. Ecology and land development: the case of Amazonian rainforest. Transactions, Institute of British Geographers, 3: 444-463.

Ehrlich P.R., 1968. The Population Bomb. Buccaneer Books.

Ehrlich P.R. & Ehrlich A.H., 1981. Extinction. Random House, New York.

FAO, 1995. State of the World's Forests. Retrieved August 2, 2013. Available on the world wide web: http://www.fao.org/docrep/003/x6953e/X6953E00.htm

FAO, 2006. World agriculture: towards 2030/2050. Prospects for food, nutrition, agriculture and major commodity groups. Interim report: Global Perspectives Unit, United Nations Food and Agriculture Organization.

FAO, 2012. Livestock and landscapes. Retrieved August 2, 2013. Available on the world wide web: http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Factsheet_LIVESTOCK_and_LANDSCAPES.pdf

Field F., 2006. How can you save the rainforest. Retrieved August 3, 2013. The Times, London.

Fondation Chirac, 2006. Access to land resources. Retrieved August 3, 2013. Available on the world wide web: http://www.fondationchirac.eu/en/deforestation/

Friedrich J. & Hecker C., 1835. The epidemics of the middle ages. Sherwood, Gilbert and Piper.

Garrett L., 1996. The Return of Infectious Disease. Foreign Affairs, 75(1): 66-79.

Global Footprint Network, 2007. Europe 2007: Gross Domestic Product and Ecological Footprint. Retrieved July 31, 2013. Available on the world wide web: http://www.footprintnetwork.org/en/index.php/gfn/page/national_assessments/

Global Footprint Network, 2008. Africa: Ecological Footprint and human well-being. Retrieved July 31, 2013. Available on the world wide web: http://www.footprintnetwork.org/en/index.php/gfn/page/national_assessments/

Global Footprint Network, 2010. Ecological Wealth of Nations: Earth's Biocapacity as a new framework for International Cooperation. Retrieved July 31, 2013. Available on the world wide web: http://www.footprintnetwork.org/en/index.php/GFN/page/ecological_wealth_of_nations_en

Hamlett E., 2011. Overpopulation: Disease Prevalence. Retrieved August 8, 2013. Available on the world wide web: http://blogs.cornell.edu/bioee1610/2011/11/29/overpopulation-disease-prevalence/

Heinsohn G., 2003. Söhne und Weltmacht: Terror im Aufstieg und Fall der Nationen. Orell Füssli, Bern.

Herzog T., 2009. World Greenhouse Gas Emissions in 2005. WRI Working Paper. Retrieved August 5, 2013. Available on the world wide web: http://www.wri.org/publication/navigating-the-numbers

Hilderink H.B.M., Niessen L.W., Hutter I. et al., 1996. Fertility change in India. Retrieved September 27, 2013. Available on the world wide web: http://hdl.handle.net/10029/258361

Holdren J.P. & Ehrlich P.R., 1974. Human Population and the Global Environment. American Scientist, 62: 282-292.

IFDC, 2010. New IFDC Report Indicates World Reserves of Rock Phosphate Are Adequate to Meet Demand. Retrieved September 27, 2013. Available on the world wide web: http://www.ifdc.org/Media_Center/IFDC_in_the_News/October_2010/New_IFDC_Report_Indicates_World_Reserves_of_Rock_P/

IIASA, 2013. World Population Program: IIASA. Retrieved July 22, 2013. Available on the world wide web: http://www.iiasa.ac.at/web/home/research/researchPrograms/WorldPopulation/news.html

IPCC, 2000. Emissions Scenarios. Cambridge University Press. Retrieved August 5, 2013. Available on the world wide web: http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=0

IPCC, 2001. IPCC Third Assessment Report: Climate Change 2001. Retrieved August 5, 2013. Available on the world wide web: http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/006.htm

IPCC, 2002. Climate Change and Biodiversity. Retrieved August 6, 2013. Available on the world wide web: http://www.ipcc.ch/pdf/technical-papers/climate-changes-biodiversity-en.pdf

IPCC, 2007. IPCC Fourth Assessment Report: Climate Change 2007. Retrieved August 5, 2013. Available on the world wide web: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

Kozloff A., 2006. Bubonic Plague in the Reign of Amenhotep III? KMT, 17(3): 36-46.

Lawton J.H. & May R.M., 1995. Extinction Rates. Oxford University Press.

Levinson A., 2000. The Ups and Downs of the Environmental Kuznets Curve. Retrieved September 27, 2013. Available on the world wide web: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.92.2062&rep=rep1&type=pdf

Lutz W., Sanderson W.C. & Scherbov S., 2001. The end of world population growth. Nature, 412(6846): 543-545.

Malthus T.R., 1798. An Essay on the Principle of Population. Joseph Johnson, London.

McGeough J.A., 2013. Neolithic tools. Retrieved June 30, 2013. Available on the world wide web: http://www.britannica.com/EBchecked/topic/254115/hand-tool/39205/Neolithic-tools

McNeill J.R., 2008. The Columbian Exchange. In: Two worlds: Prehistory, contact, and the Lost Colony, ed. Walbert D.: 5.1. The University of North Carolina.

Meadows D., Randers J. & Meadows D., 2005. Limits to Growth: The 30-Year Update. Earthscan.

Montgomery K., 2000. The Demographic Transition. Retrieved September 27, 2013. Available on the world wide web: http://www.uwmc.uwc.edu/geography/Demotrans/demtran.htm

Myers N., Mittermeier R.A., Mittermeier C.G. et al., 2000. Biodiversity hotspots for conservation priorities. Nature, 403: 853-858.

NASA, 2013. The current and future consequences of global change. Retrieved August 5, 2013. Available on the world wide web: http://climate.nasa.gov/effects

NBC News, 2010. Cholera cases found in Haiti capital. Retrieved June 30, 2013. Available on the world wide web: http://www.msnbc.msn.com/id/39787756/ns/health-infectious_diseases/

New Scientist, 2009. Deadly new flu virus in US and Mexico may go pandemic. Retrieved August 8, 2013. Available on the world wide web: http://www.newscientist.com/article/dn17025-deadly-new-flu-virus-in-us-and-mexico-may-go-pandemic.html#.UgPCn9LIbXs

New York Times, 2009. The Richer-Is-Greener Curve. Retrieved September 27, 2013. Available on the world wide web: http://tierneylab.blogs.nytimes.com/2009/04/20/the-richer-is-greener-curve/

Northoff E., 2005. Cattle ranching is encroaching on forests in Latin America. Retrieved July 18, 2013. Available on the world wide web: http://www.fao.org/newsroom/en/news/2005/102924/

O'Neill J., Wilson D., Purushothaman R. et al., 2005. Global Economics Paper No: 134. Retrieved July 29, 2013. Available on the world wide web: http://www.sdnbd.org/sdi/issues/economy/BRICs_3_12-1-05.pdf

Perenboom Z., 2012. An introduction to Zoo Conservation Biology. Lecture attended on October 15, 2012. Utrecht University, the Netherlands.

Pimentel D., Cooperstein S., Randell H. et al., 2007. Ecology of Increasing Disease: Population Growth and Environmental Degradation. Human Ecology, 35: 653-668.

Pimentel D., Whitecraft M., Scott Z.R. et al., 2010. Will Limited Land, Water, and Energy Control Human Population Numbers in the Future? Human Ecology, 38: 599-611.

Planbureau voor de Leefomgeving, 2013. Voetafdruk Nederlandse voedselconsumptie kan een kwart dalen. Retrieved July 31, 2013. Available on the world wide web: http://www.pbl.nl/nieuws/nieuwsberichten/2013/voetafdruk-nederlandse-voedselconsumptie-kan-een-kwart-dalen

Preston S., Heuveline P. & Guillot M., 2000. Demography: Measuring and Modeling Population Processes. Wiley-Blackwell.

Rees T.J., 2012. Why are religious people so fertile? Retrieved September 27, 2013. Available on the world wide web: http://epiphenom.fieldofscience.com/2012/10/why-are-religious-people-so-fertile.html

Richards J.F., 1986. World environment history and economic development. In: Sustainable Development of the Biosphere, ed. Clark W.C. & Munn R.E.: 53-71. Cambridge University Press.

Rosen W., 2007. Justinian's flea: plague, empire, and the birth of Europe. Penguin.

Ruddiman W.F., 2008. Earth's Climate: Past and Future (2nd Ed.). W.H. Freeman and Company.

Salati E. & Vose P.B., 1984. Amazon Brazil: a system in equilibrium. Science, 225(4658): 129-137.

Sanchez P.A., Bandy D.E., Villachica J.H. et al., 1982. Amazon basin soils: management for continuous crop production. Science, 216: 821-827.

Scientific American, 2008. Population Bomb Author's Fix For Next Extinction: Educate Women. Retrieved August 6, 2013. Available on the world wide web: http://www.scientificamerican.com/article.cfm?id=sixth-extinction

Shafik N., 1994. Economic development and environmental quality: an econometric analysis. Oxford Economic Papers, 46(Oct.): 757-773.

Shorter E., 1973. Female Emancipation, Birth Control, and Fertility in European History. The American Historical Review, 78(3): 605-640.

Smith R.D., 2006. Responding to global infectious disease outbreaks: Lessons from SARS on the role of risk perception, communication and management. Social Science and Medicine, 63(12): 3113-3123.

Stewart W.M., Dibb D.W., Johnston A.E. et al., 2005. The Contribution of Commercial Fertilizer Nutrients to Food Production. Agronomy Journal, 97: 1-6.

The Guardian, 2005. Earth is all out of new farmland. Retrieved August 2, 2013. Available on the world wide web: http://www.taipeitimes.com/News/world/archives/2005/12/07/2003283384

Thompson W., 2003. Encyclopedia of Population 2. Macmillan Reference. 2003.

Tosi J.A. & Voertman R.F., 1964. Some environmental factors in the economic development of the tropics. Economic Geography, 40: 189-205.

Tosi J.A. & Voertman R.F., 1975. Making the best use of the tropics. Unasylva, 27: 269-283.

Turner II B.L., Clark W.C., Kates R.W. et al., 1990. The earth as transformed by human action: global and regional changes in the biosphere over the past 300 years. Cambridge University Press.

Turner J., 2000. Factory farming and the environment. Retrieved June 30, 2013. Available on the world wide web: http://www.unsystem.org/SCN/archives/scnnews21/ch04.htm

UNDP, 2010. Human Development Report 2010, The Real Wealth of Nations: Pathways to Human Development. Retrieved September 26, 2013. Available on the world wide web: http://hdr.undp.org/en/media/HDR_2010_EN_Complete_reprint.pdf

UNDP, 2013. Human Development Report 2013, The Rise of the South: Human Progress in a Diverse World. Retrieved September 26, 2013. Available on the world wide web: http://hdr.undp.org/en/media/HDR2013_EN_Statistics.pdf

United Nations, 1998. World Population Prospects: The 1998 Revision. Retrieved June 30, 2013. Available on the world wide web: http://www.un.org/esa/population/pubsarchive/catalogue/catrpt1.htm

United Nations, 2011. World demographic trends. Report of the Secretary-General.

United Nations, 2012. World Population Prospects: The 2012 Revision. Retrieved June 30, 2013. Available on the world wide web: http://esa.un.org/unpd/wpp/index.htm

United Nations, 2013a. Human Development Report 2013, The Rise of the South: Human Progress in a Diverse World. Retrieved July 29, 2013. Available on the world wide web: http://hdr.undp.org/en/reports/global/hdr2013/

United Nations, 2013b. United Nations Population Division: Department of Economic and Social Affairs. Retrieved July 22, 2013. Available on the world wide web: http://www.un.org/en/development/desa/population/

United States Census Bureau, 2012. World Population: Historical Estimates of World Population. Retrieved June 30, 2013. Available on the world wide web: http://www.census.gov/population/international/data/worldpop/table_history.php

University of Minnesota News, 2013. Existing Cropland Could Feed 4 Billion More. Retrieved August 2, 2013. Available on the world wide web: http://www1.umn.edu/news/news-releases/2013/UR_CONTENT_451697.html

Vitousek P. M., Mooney H. A., Lubchenco J. et al., 1997. Human Domination of Earth's Ecosystems. Science, 277(5325): 494-499.

Weld M. & Wright W., 1996. Confronting the Population Crisis: Responses to the Twenty-One Most Commonly Used Arguments to Confound the Issue. Retrieved June 30, 2013. Available on the world wide web: http://www.aldridgeshs.eq.edu.au/sose/modrespg/populate/pop/index.htm

Wilkinson R.G. & Pickett K., 2009. The Spirit Level: Why More Equal Societies Almost Always Do Better. Allen Lane, United Kingdom.

Wooldridge S.A., 2008. Mass extinctions past and present: a unifying hypothesis. Biogeosciences Discuss (Copernicus), 5(3): 2401-2423.

Woolhouse M.E.J. & Gowtage-Sequeria S., 2005. Host Range and Emerging and Reemerging Pathogens. Emerging Infectious Diseases, 11(12): 1842-1847.

World Bank, 2012. World Bank Sees Progress Against Extreme Poverty, But Flags Vulnerabilities. Retrieved July 5, 2013. Available on the world wide web:http://www.worldbank.org/en/news/press-release/2012/02/29/world-bank-sees-progress-against-extreme-poverty-but-flags-vulnerabilities

World Population Balance, 2013. Current Population is Three Times the Sustainable Level. Retrieved July 31, 2013. Available on the world wide web: http://www.worldpopulationbalance.org/3_times_sustainable

WWF, 2012. Living Planet Report. Retrieved July 31, 2013. Available on the world wide web: http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/2012_lpr/

WWF, 2013. Footprint Calculator. Retrieved July 31, 2013. Available on the world wide web: http://footprint.wwf.org.uk/

Worldometers, 2013. World Population. Retrieved June 30, 2013. Available on the world wide web: http://www.worldometers.info/world-population/

Appendix: Projection of the population size

A.1. World population

Two major bureaus have made long-range projections about the world population size until the end of this century: The Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat *(United Nations, 2013b)* and the World Population Program of the International Institute for Applied Systems Analysis *(IIASA, 2013)*. According to all the different scenarios of the United Nations the world population will continue to grow until at least 2050 *(United Nations, 2012)*. The IIASA also indicates that there is an 80 percent chance that the population will continue to grow until 2050 *(Fig. 12)*. Furthermore, there is an 85 percent chance that the world population will start to decline before the end of this century because of a decrease in mean fertility.

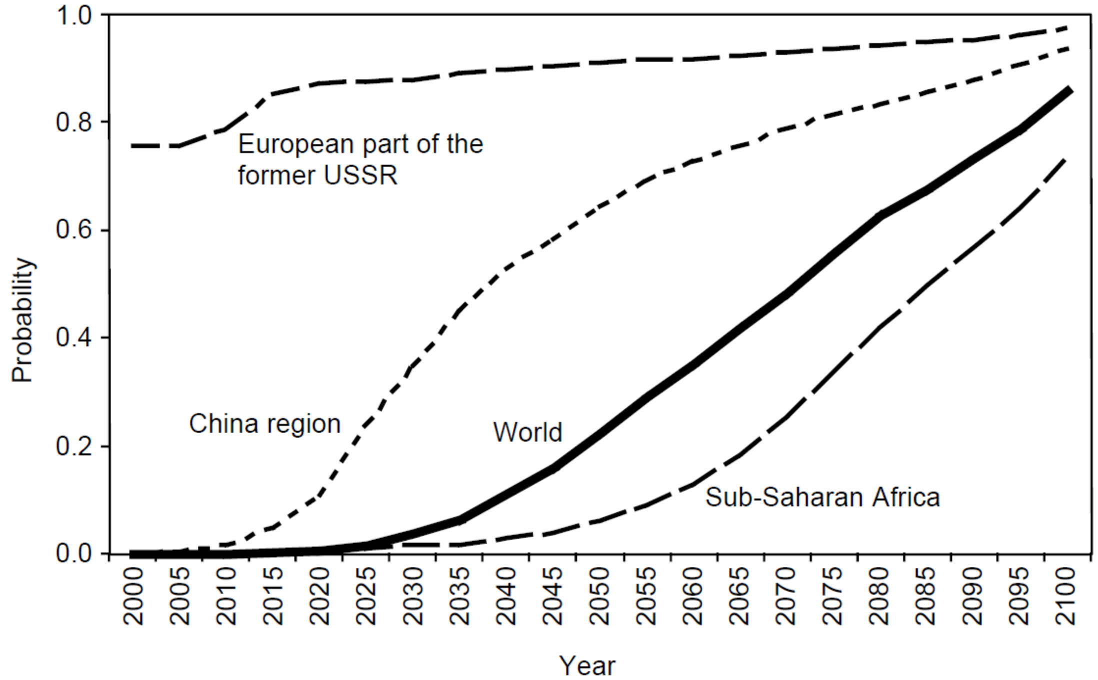

Figure 12: Forecast probability that the population will start to decline at or before the indicated date *(Lutz et al., 2001)*.

The medium scenario of the United Nations forecasts a world population of 9.5 billion people in 2050 and just below 11 billion people in 2100 *(United Nations, 2012)*. According to the median scenario of the IIASA the world population in 2050 will be just below 9 billion people and will drop to 8.5 billion people in 2100 *(Fig. 13)*. Long-term projections of the United Nations indicate that in 2300, with a medium fertility scenario, the world population will likely have dropped to a slowly rising population of 8.3 billion people *(United Nations, 2011)*. But if the high fertility scenario is used this will result in a fast growing population of 29.6 billion people in 2300 and with a low fertility scenario it will result in a population slowly shrinking to 1.6 billion people.

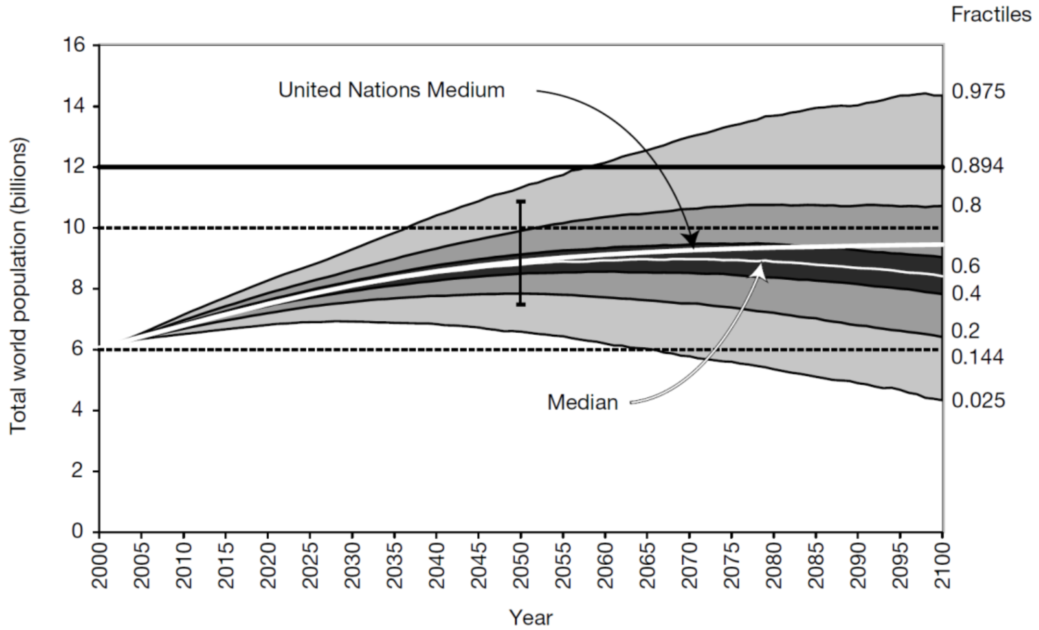

Figure 13: Forecast distributions of world population sizes (fractiles). For comparison, the United Nations medium scenario (white line) *(United Nations, 1998)*, and 95 percent interval as given by the National Research Council *(Bongaarts & Bulatao, 2000)* on the basis of an ex post error analysis (vertical line in 2050) are also given *(Lutz et al., 2001)*. N.B. The United Nations medium scenario in this graph is based on the data from the 1998 Revision of the World Population Projections and is out of date compared to the data of the United Nations used in the rest of this essay.

A.2. Different scenarios

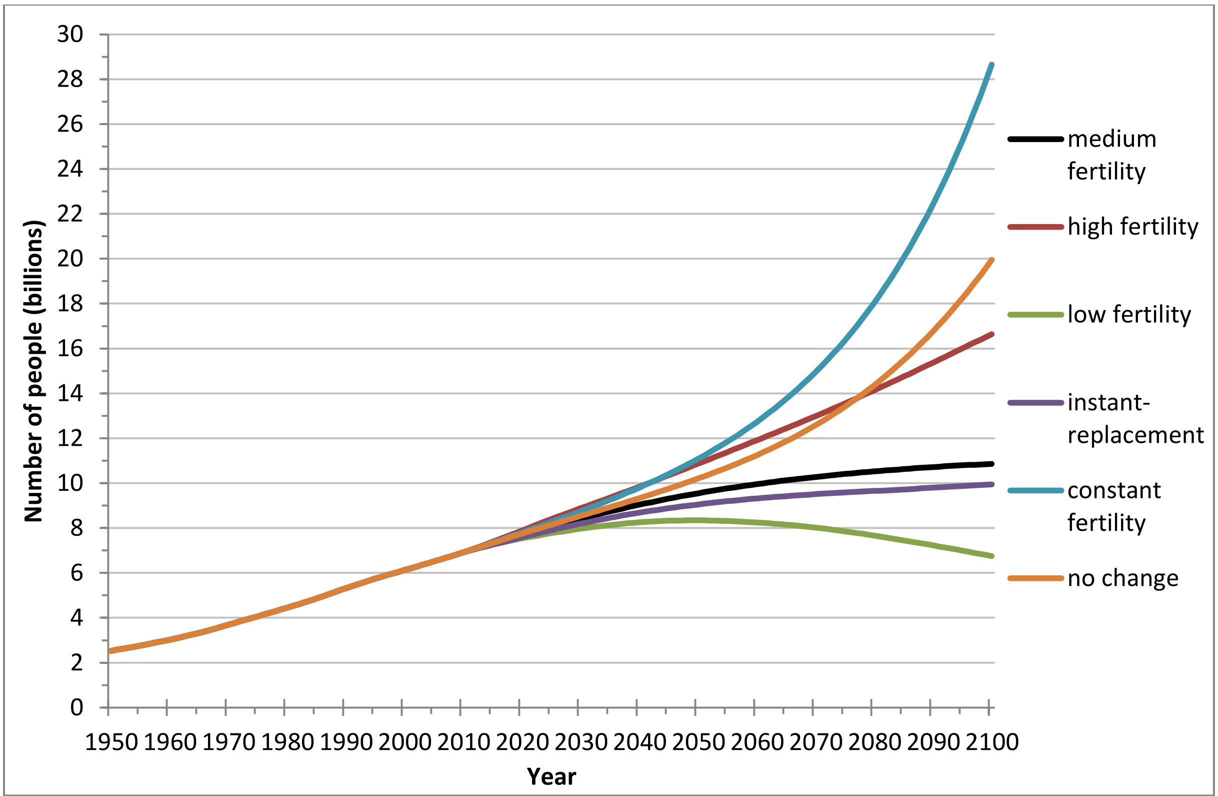

Figure 14: Projected world population according to different United Nations projection scenarios, 1950-2100 *(data from United Nations, 2012)*.

The United Nations has made several projection scenarios of which six are most commonly published *(Fig. 14; United Nations, 2011)*. The IIASA has built one model with probabilistic world population projections *(Fig. 13; Lutz et al., 2001)*. These projections are made on a national level and based on the age-specific fertility rate (mean number of children born to a woman during the year she is of the specific age), the age-specific mortality rate (number of deaths per 1000 individuals of a specific age per year), the age-specific net migration rate (difference of immigrants and emigrants per 1000 individuals of a specific age per year) and the life expectancy or longevity (mean length of life).

Three observed changes in global demographic characteristics since the 1950s are key to forecasting the world population distribution: decrease in fertility, decrease in mortality and increase in life expectancy *(United Nations, 2011)*. The decrease in mortality and the increase in life expectancy are positive reinforcements for population growth and the decrease in fertility is a negative reinforcement. From these three variables fertility is by far the most important in determining the world population projections. The mortality in the developing countries already dropped significantly. The decrease in fertility is lagging behind, but these values are expected to decrease to replacement level (the mean number of children that women have to bear to ensure that every woman ever born is replaced by only one daughter). In the developed countries the mean fertility is already below replacement level. The mortality is expected to decrease for all countries until the end of the projections (the year 2300 in case of the projections of the United Nations) and the life expectancy is expected to keep increasing until the end of the projections.

The different projection scenarios of the United Nations are: medium fertility, high fertility, low fertility, instant-replacement, constant fertility and no change. Five of these scenarios differ only with respect to the path that future fertility is assumed to take. The no change scenario differs from the others with respect to both the path of future fertility and the path of future mortality *(United Nations, 2011)*.

The medium fertility scenario has a widespread acceptance as the definitive word regarding future population trends *(United Nations, 2011)*. It assumes that future fertility follows a path informed by the past experience of countries at different stages of development. The fertility rate of countries with a fertility above 1.85 children per woman is assumed to decrease slowly (at a pace derived from the experience of developing countries since the 1970s) to a level of 1.85 children per woman. Once that level is reached it remains at that level for 100 years. After that period, fertility increases slowly until it reaches replacement level and is then maintained at replacement level from that point until 2300. For countries with current fertility below 1.85 children per woman, fertility is projected to increase, usually slowly, to reach 1.85 children per woman. After that it follows the same trajectory as the countries with an original fertility above 1.85 children per woman do *(United Nations, 2011)*.

The low and high fertility scenario are constructed to test the sensitivity of future population growth to small changes in fertility trends *(United Nations, 2011)*. Respectively, these changes can for example be a population control policy or a large increase in influence of the Catholic Church. In the high fertility scenario, fertility remains half a child above the fertility of the medium scenario until 2050 and then falls to about a quarter of a child higher than the fertility of that scenario until 2300. In the low fertility scenario, fertility is at first set to be half a child below the fertility of the medium scenario but after 2050 it rises to about a quarter of a child below the fertility of that scenario and maintains the difference until 2300 *(United Nations, 2011)*.

For the instant-replacement scenario the fertility is set at its actual replacement level for each country *(United Nations, 2011)*. Because the life expectancy is increasing until the end of the projections for all the United Nations scenarios, the population does not achieve a stationary state in this scenario either.

The constant fertility and the no change scenario are produced to assess the sustainability of current levels of the components of population growth *(United Nations, 2011)*. The constant fertility scenario keeps the actual fertility rate constant per country for the entire projection period. The no change scenario does the same, but in this scenario the actual mortality rate per country is also constant for the entire projection period.

The large difference between the projections of the United Nations *(Fig. 14; United Nations, 2011)* and the projection of the IIASA *(Fig. 13; Lutz et al., 2001)* is the assumption of universal replacement-level fertility that the United Nations made for the end of the projection period for the medium fertility scenario. The IIASA did not make this assumption and has set the fertility to range between 1.5 and 2.0 children per woman for the year 2080-2084. The United Nations claims that increases in fertility have been recorded recently in some developed countries and have been predicted by studying trends in the postponement of childbearing. But they also admit that the universal replacement-level fertility is uncertain and they write about the increase of the fertility of all developed countries to replacement level: “Whether and when it may do so is an unanswered question” *(United Nations, 2011)*. However, these different assumptions cause the difference in outcome of the projections of the United Nations and the IIASA. And because of this, the United Nations concluded that the world population of the medium fertility scenario will always be slowly growing, while the IIASA concluded that the world population will start to decline.

A.3. Decrease in fertility

The decrease in fertility is mainly caused by the improving social-economic stability of most of the developed and developing countries in the last couple of decades *(United Nations, 2011)*. Also urbanization, education and emancipation of women has a negative influence on fertility and these phenomena often coincide with improving social-economic stability. This effect is called the demographic-economic paradox: the inverse correlation between wealth and fertility *(Malthus, 1798)*.

Mortality also tends to decrease with an increase in wealth and this effect, together with the decrease in fertility, is called demographic transition *(Thompson, 2003)*. Typically the mortality starts to decrease before the fertility starts to decrease and fertility keeps “lagging behind” until replacement level is reached (also typically some time after the mortality stopped decreasing significantly). This results in rapid population growth as the fertility is much higher than the mortality in this transition period *(Thompson, 2003)*. Even after replacement level is reached (or below replacement level) the population will keep increasing for almost one-hundred years until it stabilizes or decreases *(Preston et al., 2000)*. This process is called population momentum and is caused by the large proportion of the population entering its reproductive years compared to the older people of the population. Therefore, even with the low fertility, many babies will still be born and population growth will continue for some time after reaching replacement level *(Preston et al., 2000)*.

The emancipation of women is an important factor in determining the fertility decline *(Montgomery, 2000; Hilderink et al., 1996; Shorter, 1973)*. For example, in the European history the decline in fertility seems to have coincided with the rise of feminism *(Shorter, 1973)*. Nowadays the population growth is still largest in conservative religious societies where the position of women is still subordinate to the position of men *(Rees, 2012)*. These societies often have conservative family values and women are less influential in childbearing decisions *(Rees, 2012; Montgomery, 2000)*. Furthermore, with an increased women emancipation the female labor and education also increases, subsequently lowering the fertility *(Montgomery, 2000)*. In fertility projection scenarios the ideologies and values of societies are very important in determining the outcome *(Hilderink et al., 1996)*. Conservative religions are therefore very important in the coming fertility decline. Most important is the development of the Islam. If the position of women is continued to be looked upon as subordinate, then the fertility will not decline in these societies, but will possibly even increase *(Hilderink et al., 1996; Eberstadt, 2013)*.

Even though the fertility decreases because of an increase in social-economic stability, the pressure on the environment and resources per person increases *(Turner II et al., 1990)*. Therefore, this increase in standard of living has major negative effects on the environment in the near future and these effects won't significantly decrease until the population starts to decrease. At the moment, the highest standards of living are found in the United States, Canada, Western Europe, Japan, Australia, New Zealand, Japan, Argentina, Chile and some other relatively low-populated countries *(United Nations, 2013a)*. The total population size of these developed countries is approximately one billion as of 2010 *(United Nations, 2012)*. However, poverty is decreasing globally and there are numerous countries classified as rising economies which have the possible prospect of reaching high standards of living, comparable with Western Europe and the United States, in the near future *(World Bank, 2012)*. These rising economies are mainly the BRICS (Brazil, Russia, India, China and South Africa) and the Next Eleven (Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, Turkey, South Korea and Vietnam) *(O'Neill et al., 2005)*. As of 2010, these countries have a total population size of more than four billion people *(United Nations, 2012)*. If all these countries would get the highest standard of living then the pressure on the environment would increase dramatically.