

Major Events, Scenarios and Risks to Civilization, Humans & Planet Earth



Deborah **Witcher**

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Chapter- 1

Famine

A **famine** is a widespread scarcity of food that may apply to any faunal species. This phenomenon is usually accompanied or followed by regional malnutrition, starvation, epidemic, and increased mortality.

Emergency measures in relieving famine primarily include providing deficient micronutrients, such as vitamins and minerals, through fortified sachet powders or directly through supplements. Aid groups have begun to use a famine relief model based on giving cash or cash vouchers to the hungry to pay local farmers, rather than buying food from donor countries as the latter distorts local food markets.

Long-term measures include investment in modern agriculture techniques, such as fertilizers and irrigation, which largely eradicated hunger in the developed world. World Bank strictures restrict government subsidies for farmers, and increasing use of fertilizers is opposed by some environmental groups because of its unintended consequences: adverse effects on water supplies and habitat.



Child victim of the Holodomor famine



ДИСТРОФИЯ АЛИМЕНТАРНАЯ (ГОЛОДНАЯ БОЛЕЗНЬ) – НАРУШЕНИЕ ОБЩЕГО ПИТАНИЯ ОРГАНИЗМА ВСЛЕДСТВИЕ ДЛИТЕЛЬНОГО НЕДОЕДАНИЯ, КОГДА ПИЩА СОДЕРЖИТ НЕДОСТАТОЧНОЕ КОЛИЧЕСТВО КАЛОРИЙ, СРАВНИТЕЛЬНО С ЗАТРАЧИВАЕМОЙ ЭНЕРГИЕЙ. ПОСЛЕ ВОЙНЫ У ДИСТРОФИИ ПОЯВИЛОСЬ ЕЩЕ ОДНО – НЕОФИЦИАЛЬНОЕ НАЗВАНИЕ – “ЛЕНИНГРАДСКАЯ БОЛЕЗНЬ”

A victim of starvation in besieged Leningrad suffering from dystrophia in 1941.

Causes of famine

Definitions of famines are based on three different categories – these include food supply based, food consumption based and mortality based definitions. Some definitions of famines are:

- Blix – Widespread food shortage leading to significant rise in regional death rates.
- Brown and Eckholm – Sudden, sharp reduction in food supply resulting in widespread hunger.
- Scrimshaw – Sudden collapse in level of food consumption of large numbers of people.
- Ravallion – Unusually high mortality with unusually severe threat to food intake of some segments of a population.
- Cuny – A set of conditions that occurs when large numbers of people in a region cannot obtain sufficient food, resulting in widespread, acute malnutrition.

Food shortages in a population are caused either by a lack of food or by difficulties in food distribution; it may be worsened by natural climate fluctuations and by extreme political conditions related to oppressive government or warfare. One of the proportionally largest historical famines was that of the Great Famine in Ireland. It began in 1845 because of potato disease and occurred even as food was being shipped *from* Ireland to England. Only the English could afford to pay higher prices. Recently historians have revised their assessments about how much control the English could have exercised in reducing the famine, finding they did more to try to help than is generally understood. The conventional explanation until 1981 for the cause of famines was the Food availability decline (FAD) hypothesis. The assumption was that the central cause of all famines was a decline in food availability. However, FAD could not explain why only a certain section of the population such as the agricultural laborer was affected by famines while others were insulated from famines. Based on the studies of some recent famines, the decisive role of FAD has been questioned and it has been suggested that the causal mechanism for precipitating starvation includes many variables other than just decline of food availability. According to this view, famines are a result of entitlements, the theory being proposed is called the "failure of exchange entitlements" or FEE. A person may own various commodities which can be exchanged in a market economy for the other commodities he or she needs. The exchange can happen via trading or production or through a combination of the two. These entitlements are called trade-based or production-based entitlements. Per this proposed view, famines are precipitated due to a break down in the ability of the person to exchange his entitlements. An example of famines due to FEE is the inability of an agricultural laborer to exchange his primary entitlement, i.e., labor for rice when his employment became erratic or was completely eliminated.

Some elements make a particular region more vulnerable to famine. These include:

- Poverty
- Inappropriate physical infrastructure
- Inappropriate social infrastructure
- A suppressive political regime
- A weak or under-prepared government

In certain cases, such as the Great Leap Forward in China (which produced the largest famine in absolute numbers), North Korea in the mid-1990s, or Zimbabwe in the early-2000s, famine can occur as an unintentional result of government policy. Malawi ended its famine by subsidizing farmers against the strictures of the World Bank. During the 1973 Wollo Famine in Ethiopia, food was shipped out of Wollo to the capital city of Addis Ababa, where it could command higher prices. In the late-1970s and early-1980s, residents of the dictatorships of Ethiopia and Sudan suffered massive famines, but the democracies of Botswana and Zimbabwe avoided them, despite also have severe drops in national food production. In Somalia, famine occurred because of a failed state.

Many famines are caused by imbalance of food production compared to the large populations of countries whose population exceeds the regional carrying capacity.

Historically, famines have occurred from agricultural problems such as drought, crop failure, or pestilence. Changing weather patterns, the ineffectiveness of medieval governments in dealing with crises, wars, and epidemic diseases such as the Black Death helped to cause hundreds of famines in Europe during the Middle Ages, including 95 in Britain and 75 in France. In France, the Hundred Years' War, crop failures and epidemics reduced the population by two-thirds.

The failure of a harvest or change in conditions, such as drought, can create a situation whereby large numbers of people continue to live where the carrying capacity of the land has temporarily dropped radically. Famine is often associated with subsistence agriculture. The total absence of agriculture in an economically strong area does not cause famine; Arizona and other wealthy regions import the vast majority of their food, since such regions produce sufficient economic goods for trade.

Famines have also been caused by volcanism. The 1815 eruption of the Mount Tambora volcano in Indonesia caused crop failures and famines worldwide and caused the worst famine of the 19th century. The current consensus of the scientific community is that the aerosols and dust released into the upper atmosphere causes cooler temperatures by preventing the sun's energy from reaching the ground. The same mechanism is theorized to be caused by very large meteorite impacts to the extent of causing mass extinctions.

Risk of future famine

The Guardian reports in in 2007 that approximately 40% of the world's agricultural land is seriously degraded. If current trends of soil degradation continue in Africa, the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana-based Institute for Natural Resources in Africa. As of late 2007, increased farming for use in biofuels, along with world oil prices at nearly \$100 a barrel, has pushed up the price of grain used to feed poultry and dairy cows and other cattle, causing higher prices of wheat (up 58%), soybean (up 32%), and maize (up 11%) over the year. In 2007 Food riots have taken place in many countries across the world. An epidemic of stem rust, which is destructive to wheat and is caused by race Ug99, has in 2007 spread across Africa and into Asia.

Beginning in the 20th century, nitrogen fertilizers, new pesticides, desert farming, and other agricultural technologies began to be used to increase food production, in part to combat famine. Between 1950 and 1984, as the Green Revolution influenced agriculture, world grain production increased by 250%. Much of this gain is non-sustainable. Such agricultural technologies temporarily increased crop yields, but as early as 1995, there were signs that they may be contributing to the decline of arable land (e.g. persistence of pesticides leading to soil contamination and decline of area available for farming). Developed nations have shared these technologies with developing nations with a famine problem, but there are ethical limits to pushing such technologies on lesser developed countries. This is often attributed to an association of inorganic fertilizers and pesticides with a lack of sustainability.

David Pimentel, professor of ecology and agriculture at Cornell University, and Mario Giampietro, senior researcher at the National Research Institute on Food and Nutrition (INRAN), place in their study *Food, Land, Population and the U.S. Economy* the maximum U.S. population for a sustainable economy at 200 million. To achieve a sustainable economy and avert disaster, the United States must reduce its population by at least one-third, and world population will have to be reduced by two-thirds, says study. The authors of this study believe that the mentioned agricultural crisis will only begin to impact us after 2020, and will not become critical until 2050. The oncoming peaking of global oil production (and subsequent decline of production), along with the peak of North American natural gas production will very likely precipitate this agricultural crisis much sooner than expected.

Geologist Dale Allen Pfeiffer claims that coming decades could see spiraling food prices without relief and massive starvation on a global level such as never experienced before. Water deficits, which are already spurring heavy grain imports in numerous smaller countries, may soon do the same in larger countries, such as China or India. The water tables are falling in scores of countries (including Northern China, the US, and India) due to widespread overpumping using powerful diesel and electric pumps. Other countries affected include Pakistan, Iran, and Mexico. This will eventually lead to water scarcity and cutbacks in grain harvest. Even with the overpumping of its aquifers, China has developed a grain deficit, contributing to the upward pressure on grain prices. Most of the three billion people projected to be added worldwide by mid-century will be born in countries already experiencing water shortages.

After China and India, there is a second tier of smaller countries with large water deficits — Algeria, Egypt, Iran, Mexico, and Pakistan. Four of these already import a large share of their grain. Only Pakistan remains marginally self-sufficient. But with a population expanding by 4 million a year, it will also soon turn to the world market for grain. According to a UN climate report, the Himalayan glaciers that are the principal dry-season water sources of Asia's biggest rivers - Ganges, Indus, Brahmaputra, Yangtze, Mekong, Salween and Yellow - could disappear by 2035 as temperatures rise and human demand rises. It was later revealed that the source used by the UN climate report actually stated 2350, not 2035. Approximately 2.4 billion people live in the drainage basin of the Himalayan rivers. India, China, Pakistan, Afghanistan, Bangladesh, Nepal and Myanmar could experience floods followed by severe droughts in coming decades. In India alone, the Ganges provides water for drinking and farming for more than 500 million people.

Characteristics of famine

Famine strikes Sub-Saharan African countries the hardest, but with exhaustion of food resources, overdrafting of groundwater, wars, internal struggles, and economic failure, famine continues to be a worldwide problem with hundreds of millions of people suffering. These famines cause widespread malnutrition and impoverishment; The famine in Ethiopia in the 1980s had an immense death toll, although Asian famines of the 20th century have also produced extensive death tolls. Modern African famines are

characterized by widespread destitution and malnutrition, with heightened mortality confined to young children.

Relief technologies including immunization, improved public health infrastructure, general food rations and supplementary feeding for vulnerable children, has provided temporary mitigation to the mortality impacts of famines, while leaving their economic consequences unchanged, and not solving the underlying issue of too large a regional population relative to food production capability. Humanitarian crises may also arise from genocide campaigns, civil wars, refugee flows and episodes of extreme violence and state collapse, creating famine conditions among the affected populations.

Despite repeated stated intentions by the world's leaders to end hunger and famine, famine remains a chronic threat in much of Africa and Asia. In July 2005, the Famine Early Warning Systems Network labelled Niger with emergency status, as well as Chad, Ethiopia, South Sudan, Somalia and Zimbabwe. In January 2006, the United Nations Food and Agriculture Organization warned that 11 million people in Somalia, Kenya, Djibouti and Ethiopia were in danger of starvation due to the combination of severe drought and military conflicts. In 2006, the most serious humanitarian crisis in Africa is in Sudan's region Darfur.

Some believed that the Green Revolution was an answer to famine in the 1970s and 1980s. The Green Revolution began in the 20th century with hybrid strains of high-yielding crops. Between 1950 and 1984, as the Green Revolution transformed agriculture around the globe, world grain production increased by 250%. Some criticize the process, stating that these new high-yielding crops require more chemical fertilizers and pesticides, which can harm the environment. However, it was an option for developing nations suffering from famine. These high-yielding crops make it technically possible to feed more people. However, there are indications that regional food production has peaked in many world sectors, due to certain strategies associated with intensive agriculture such as groundwater overdrafting and overuse of pesticides and other agricultural chemicals.

Frances Moore Lappé, later co-founder of the Institute for Food and Development Policy (Food First) argued in *Diet for a Small Planet* (1971) that vegetarian diets can provide food for larger populations, with the same resources, compared to omnivorous diets.

Noting that modern famines are sometimes aggravated by misguided economic policies, political design to impoverish or marginalize certain populations, or acts of war, political economists have investigated the political conditions under which famine is prevented. Amartya Sen states that the liberal institutions that exist in India, including competitive elections and a free press, have played a major role in preventing famine in that country since independence. Alex de Waal has developed this theory to focus on the "political contract" between rulers and people that ensures famine prevention, noting the rarity of such political contracts in Africa, and the danger that international relief agencies will undermine such contracts through removing the locus of accountability for famines from national governments.

Effects of famine

The demographic impacts of famine are sharp. Mortality is concentrated among children and the elderly. A consistent demographic fact is that in all recorded famines, male mortality exceeds female, even in those populations (such as northern India and Pakistan) where there is a normal times male longevity advantage. Reasons for this may include greater female resilience under the pressure of malnutrition, and the fact that women are more skilled at gathering and processing wild foods and other fall-back famine foods.

Famine is also accompanied by lower fertility. Famines therefore leave the reproductive core of a population—adult women—less affected compared to other population categories, and post-famine periods are often characterized a "rebound" with increased births. Even though the theories of Thomas Malthus would predict that famines reduce the size of the population commensurate with available food resources, in fact even the most severe famines have rarely dented population growth for more than a few years. The mortality in China in 1958–61, Bengal in 1943, and Ethiopia in 1983–85 was all made up by a growing population over just a few years. Of greater long-term demographic impact is emigration: Ireland was chiefly depopulated after the 1840s famines by waves of emigration.

Levels of food insecurity

In modern times, local and political governments and non-governmental organizations that deliver famine relief have limited resources with which to address the multiple situations of food insecurity that are occurring simultaneously. Various methods of categorizing the gradations of food security have thus been used in order to most efficiently allocate food relief. One of the earliest were the Indian Famine Codes devised by the British in the 1880s. The Codes listed three stages of food insecurity: near-scarcity, scarcity and famine, and were highly influential in the creation of subsequent famine warning or measurement systems. The early warning system developed to monitor the region inhabited by the Turkana people in northern Kenya also has three levels, but links each stage to a pre-planned response to mitigate the crisis and prevent its deterioration.

The experiences of famine relief organizations throughout the world over the 1980s and 1990s resulted in at least two major developments: the "livelihoods approach" and the increased use of nutrition indicators to determine the severity of a crisis. Individuals and groups in food stressful situations will attempt to cope by rationing consumption, finding alternative means to supplement income, etc. before taking desperate measures, such as selling off plots of agricultural land. When all means of self-support are exhausted, the affected population begins to migrate in search of food or fall victim to outright mass starvation. Famine may thus be viewed partially as a social phenomenon, involving markets, the price of food, and social support structures. A second lesson drawn was the increased use of rapid nutrition assessments, in particular of children, to give a quantitative measure of the famine's severity.

Since 2004, many of the most important organizations in famine relief, such as the World Food Programme and the U.S. Agency for International Development, have adopted a five-level scale measuring intensity and magnitude. The intensity scale uses both livelihoods' measures and measurements of mortality and child malnutrition to categorize a situation as food secure, food insecure, food crisis, famine, severe famine, and extreme famine. The number of deaths determines the magnitude designation, with under 1000 fatalities defining a "minor famine" and a "catastrophic famine" resulting in over 1,000,000 deaths.

Historical famine, by region

During the 20th century, an estimated 70 million people died from famines across the world, of whom an estimated 30 million died during the famine of 1958–61 in China. The other most notable famines of the century included the 1942–1945 disaster in Bengal, famines in China in 1928 and 1942, and a sequence of famines in the Soviet Union, including the Soviet famine of 1932-1933, Stalin's famine inflicted on USSR in 1932–33. A few of the great famines of the late 20th century were: the Biafran famine in the 1960s, the disaster in Cambodia in the 1970s, the Ethiopian famine of 1984–85 and the North Korean famine of the 1990s.

Famine in Africa



Malnourished children in Niger, during the 2005 famine.

In the mid-22nd century BC, a sudden and short-lived climatic change that caused reduced rainfall resulted in several decades of drought in Upper Egypt. The resulting famine and civil strife is believed to have been a major cause of the collapse of the Old Kingdom. An account from the First Intermediate Period states, "All of Upper Egypt was dying of hunger and people were eating their children." In 1680s, famine extended across the entire Sahel, and in 1738 half the population of Timbuktu died of famine. Egypt suffered six famines between 1687 and 1731. The famine that afflicted Egypt in 1784 cost it roughly one-sixth of its population. At the end of the 18th century, and even more at the beginning of the nineteenth, the Maghreb suffered from the deadly combination of plague and famine. Tripoli and Tunis were hard-hit by famine in 1784 and 1785 respectively.

Historians of African famine have documented repeated famines in Ethiopia. Possibly the worst episode occurred in 1888 and succeeding years, as the epizootic rinderpest, introduced into Eritrea by infected cattle, spread southwards reaching ultimately as far as South Africa. In Ethiopia it was estimated that as much as 90 percent of the national herd died, rendering rich farmers and herders destitute overnight. This coincided with drought associated with an el Nino oscillation, human epidemics of smallpox, and in several countries, intense war. The Ethiopian Great famine that afflicted Ethiopia from 1888 to 1892 cost it roughly one-third of its population. In Sudan the year 1888 is remembered as the worst famine in history, on account of these factors and also the exactions imposed by the Mahdist state. Colonial "pacification" efforts often caused severe famine, as for example with the repression of the Maji Maji revolt in Tanganyika in 1906. The introduction of cash crops such as cotton, and forcible measures to impel farmers to grow these crops, also impoverished the peasantry in many areas, such as northern Nigeria, contributing to greater vulnerability to famine when severe drought struck in 1913.

However, for the middle part of the 20th century, agriculturalists, economists and geographers did not consider Africa to be famine prone (they were much more concerned about Asia). There were notable counter-examples, such as the famine in Rwanda during World War II and the Malawi famine of 1949, but most famines were localized and brief food shortages. The specter of famine recurred only in the early 1970s, when Ethiopia and the west African Sahel suffered drought and famine. The Ethiopian famine of that time was closely linked to the crisis of feudalism in that country, and in due course helped to bring about the downfall of the Emperor Haile Selassie. The Sahelian famine was associated with the slowly growing crisis of pastoralism in Africa, which has seen livestock herding decline as a viable way of life over the last two generations.

Since then, African famines have become more frequent, more widespread and more severe. Many African countries are not self-sufficient in food production, relying on income from cash crops to import food. Agriculture in Africa is susceptible to climatic fluctuations, especially droughts which can reduce the amount of food produced locally. Other agricultural problems include soil infertility, land degradation and erosion, swarms of desert locusts, which can destroy whole crops, and livestock diseases. The Sahara reportedly spreads at a rate of up to 30 miles a year. The most serious famines have been caused by a combination of drought, misguided economic policies, and conflict. The 1983–85 famine in Ethiopia, for example, was the outcome of all these three factors, made worse by the Communist government's censorship of the emerging crisis. In Sudan at the same date, drought and economic crisis combined with denials of any food shortage by the then-government of President Gaafar Nimeiry, to create a crisis that killed perhaps 250,000 people—and helped bring about a popular uprising that overthrew Nimeiry.

Numerous factors make the food security situation in Africa tenuous, including political instability, armed conflict and civil war, corruption and mismanagement in handling food supplies, and trade policies that harm African agriculture. An example of a famine created by human rights abuses is the 1998 Sudan famine. AIDS is also having long-term economic effects on agriculture by reducing the available workforce, and is creating new

vulnerabilities to famine by overburdening poor households. On the other hand, in the modern history of Africa on quite a few occasions famines acted as a major source of acute political instability. In Africa, if current trends of population growth and soil degradation continue, the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana-based Institute for Natural Resources in Africa.

Recent examples include Sahel drought of the 1970s, Ethiopia in 1973 and mid-1980s, Sudan in the late-1970s and again in 1990 and 1998. The 1980 famine in Karamoja, Uganda was, in terms of mortality rates, one of the worst in history. 21% of the population died, including 60% of the infants.

In October 1984, television reports around the world carried footage of starving Ethiopians whose plight was centered around a feeding station near the town of Korem. BBC newsreader Michael Buerk gave moving commentary of the tragedy on 23 October 1984, which he described as a "biblical famine". This prompted the Band Aid single, which was organised by Bob Geldof and featured more than 20 other pop stars. The Live Aid concerts in London and Philadelphia raised further funds for the cause. An estimated 900,000 people die within one year as a result of the famine, but the tens of millions of pounds raised by Band Aid and Live Aid are widely believed to have saved the lives of around 6,000,000 more Ethiopians who were in danger of death. Essentially if Band Aid and Live Aid had never happened the death toll of the Ethiopian famine could have been as high as 7,000,000 or nearly a quarter of the population at the time.

Cases since 2000



Laure Souley holds her three-year-old daughter and an infant son at a MSF aide centre during the 2005 famine, Maradi Niger.

The 2005–06 Niger food crisis was a severe but localized food security crisis in the regions of northern Maradi, Tahoua, Tillabéri, and Zinder of Niger. It was caused by an early end to the 2004 rains, desert locust damage to some pasture lands, high food prices, and chronic poverty. In the affected area, 2.4 million of 3.6 million people are considered highly vulnerable to food insecurity. An international assessment stated that, of these, over 800,000 face extreme food insecurity and another 800,000 in moderately insecure food situations are in need of aid.

The **2010 Sahel famine** hit millions in Niger and across West Africa face food shortages after erratic rains hit farming in countries in the Sahel region south of the Sahara desert, the European Commission's aid group said Thursday. The erratic rains in the 2009/2010 agricultural season have resulted in an enormous deficit in food production in these countries," he said of nations such as Niger, Chad, northern Burkina Faso and northern Nigeria. He said strong leadership would be required from the United Nations and the rest of the international community to mobilise aid. "If we work fast enough, early enough, it won't be a famine. If we don't there is a strong risk."

July 6 saw the Methodist Relief and Development Fund (MRDF) aid experts say that more than 1,500,000 Nigerians were at risk of famine due to a month long heat wave that was hovering over Niger, Mali, Mauritania and Morocco. A fund of about £20,000 was distributed to the crisis-hit countries of Niger, Mali, Burkina Faso and Mauritania.

Initiatives to increase Food Security

Against a backdrop of conventional interventions through the state or markets, alternative initiatives have been pioneered to address the problem of food security. An example is the "Community Area-Based Development Approach" to agricultural development ("CABDA"), an NGO programme with the objective of providing an alternative approach to increasing food security in Africa. CABDA proceeds through specific areas of intervention such as the introduction of drought-resistant crops and new methods of food production such as agro-forestry. Piloted in Ethiopia in the 1990s it has spread to Malawi, Uganda, Eritrea and Kenya. In an analysis of the programme by the Overseas Development Institute, CABDA's focus on individual and community capacity-building is highlighted. This enables farmers to influence and drive their own development through community-run institutions, bringing food security to their household and region.

Famine in Asia

China



Chinese officials engaged in famine relief, 19th C. engraving

Chinese scholars had kept count of 1,828 instances of famine since 108 B.C. to 1911 in one province or another — an average of close to one famine per year. From 1333 to 1337 a terrible famine killed 6 million Chinese. The four famines of 1810, 1811, 1846, and 1849 are said to have killed no fewer than 45 million people. The period from 1850 to 1873 saw, as a result of the Taiping Rebellion, drought, and famine, the population of China drop by over 60 million people. China's Qing Dynasty bureaucracy, which devoted extensive attention to minimizing famines, is credited with averting a series of famines following El Niño-Southern Oscillation-linked droughts and floods. These events are comparable, though somewhat smaller in scale, to the ecological trigger events of China's vast 19th century famines. (Pierre-Etienne Will, *Bureaucracy and Famine*) Qing China carried out its relief efforts, which included vast shipments of food, a requirement that the rich open their storehouses to the poor, and price regulation, as part of a state guarantee of subsistence to the peasantry (known as *ming-sheng*).

When a stressed monarchy shifted from state management and direct shipments of grain to monetary charity in the mid-nineteenth century, the system broke down. Thus the 1867–68 famine under the Tongzhi Restoration was successfully relieved but the Great North China Famine of 1877–78, caused by drought across northern China, was a catastrophe. The province of Shanxi was substantially depopulated as grains ran out, and desperately starving people stripped forests, fields, and their very houses for food. Estimated mortality is 9.5 to 13 million people. (Mike Davis, *Late Victorian Holocausts*)

Great Leap Forward

The largest famine of the 20th century, and almost certainly of all time, was the 1958–61 Great Leap Forward famine in China. The immediate causes of this famine lay in Mao Zedong's ill-fated attempt to transform China from an agricultural nation to an industrial power in one huge leap. Communist Party cadres across China insisted that peasants abandon their farms for collective farms, and begin to produce steel in small foundries, often melting down their farm instruments in the process. Collectivisation undermined incentives for the investment of labor and resources in agriculture; unrealistic plans for decentralized metal production sapped needed labor; unfavorable weather conditions; and communal dining halls encouraged overconsumption of available food. Such was the centralized control of information and the intense pressure on party cadres to report only good news—such as production quotas met or exceeded—that information about the escalating disaster was effectively suppressed. When the leadership did become aware of the scale of the famine, it did little to respond, and continued to ban any discussion of the cataclysm. This blanket suppression of news was so effective that very few Chinese citizens were aware of the scale of the famine, and the greatest peacetime demographic disaster of the 20th century only became widely known twenty years later, when the veil of censorship began to lift.

The 1958–61 famine is estimated to have caused excess mortality of about 36 to 45 million, with a further 30 million cancelled or delayed births. It was only when the famine had wrought its worst that Mao was forced to reverse agricultural collectivisation policies, which were effectively dismantled in 1978. China has not experienced a famine

of the proportions of the Great Leap Forward since 1961, (Woo-Cummings, 2002) although there is widespread ongoing malnutrition in many rural areas of China in current times.

India

Owing to its almost entire dependence upon the monsoon rains, India is vulnerable to crop failures, which upon occasion deepen into famine. There were 14 famines in India between 11th and 17th century (Bhatia, 1985). For example, during the 1022–1033 Great famines in India entire provinces were depopulated. Famine in Deccan killed at least 2 million people in 1702-1704. B.M. Bhatia believes that the earlier famines were localised, and it was only after 1860, during the British rule, that famine came to signify general shortage of foodgrains in the country. There were approximately 25 major famines spread through states such as Tamil Nadu in the south, and Bihar and Bengal in the east during the latter half of the 19th century.



A child suffering extreme starvation in India, 1972.

Romesh Dutt argued as early as 1900, and present-day scholars such as Amartya Sen agree, that some historic famines were a product of both uneven rainfall and British economic and administrative policies, which since 1857 had led to the seizure and conversion of local farmland to foreign-owned plantations, restrictions on internal trade, heavy taxation of Indian citizens to support British expeditions in Afghanistan. Some British citizens, such as William Digby, agitated for policy reforms and famine relief, but Lord Lytton, the governing British viceroy in India, opposed such changes in the belief that they would stimulate shirking by Indian workers. The first, the Bengal famine of 1770, is estimated to have taken around 10 million lives — one-third of Bengal's population at the time. Other notable famines include the Great Famine of 1876–78, in which 6.1 million to 10.3 million people died and the Indian famine of 1899–1900, in which 1.25 to 10 million people died. The famines continued until independence in 1947, with the Bengal Famine of 1943–44— even though there were no crop failures —killing 1.5 million to 3 million Bengalis during World War II.

The observations of the Famine Commission of 1880 support the notion that food distribution is more to blame for famines than food scarcity. They observed that each province in British India, including Burma, had a surplus of foodgrains, and the annual surplus was 5.16 million tons (Bhatia, 1970). At that time, annual export of rice and other grains from India was approximately one million tons.

In 1966, there was a close call in Bihar, when the United States allocated 900,000 tons of grain to fight the famine. Three years of drought in India resulted in an estimated 1.5 million deaths from starvation and disease.

Middle East

Iraq, for example, had suffered famines in 1801, 1827 and 1831. In Anatolia, a great famine erupted in 1873-74 and killed tens of thousands.

The Great Persian Famine of 1870–1871 is believed to have caused the death of 1.5 million persons in Persia (present-day Iran), which would represent 20–25 percent of Persia's estimated total population of 6–7 million.

Lebanon became increasingly dependent on food imports from abroad, making the country extremely vulnerable to famine during World War I. By the end of the war, an estimated 100,000 of Lebanon's 450,000 population had died of famine.

North Korea

Famine struck North Korea in the mid-1990s, set off by unprecedented floods. This autarkic urban, industrial society had achieved food self-sufficiency in prior decades through a massive industrialization of agriculture. However, the economic system relied on massive concessionary inputs of fossil fuels, primarily from the Soviet Union and the People's Republic of China. When the Soviet collapse and China's marketization switched trade to a hard currency, full price basis, North Korea's economy collapsed. The

vulnerable agricultural sector experienced a massive failure in 1995–96, expanding to full-fledged famine by 1996–99. An estimated 600,000 died of starvation (other estimates range from 200,000 to 3.5 million). North Korea has not yet resumed its food self-sufficiency and relies on external food aid from China, Japan, South Korea and the United States. While Woo-Cumings have focused on the FAD side of the famine, Moon argues that FAD shifted the incentive structure of the authoritarian regime to react in a way that forced millions of disenfranchised people to starve to death (Moon, 2009).

Vietnam

Various famines have occurred in Vietnam. Japanese occupation during World War II caused the Vietnamese Famine of 1945, which caused 2 million deaths, or 10% of the population then. Following the unification of the country after the Vietnam War, Vietnam experienced a food shortage in the 1980s, which prompted many people to flee the country.

Japan

According to one authority, there were at least 130 famines during the Edo period from 1603 to 1868, of which 21 were particularly serious.

Famine in Europe

Western Europe

The Great Famine of 1315–1317 (or to 1322) was the first major food crisis that struck Europe in the 14th century. Millions in northern Europe would die over an extended number of years, marking a clear end to the earlier period of growth and prosperity during the 11th and 12th centuries. Starting with bad weather in the spring of 1315, widespread crop failures lasted until the summer of 1317, from which Europe did not fully recover until 1322. It was a period marked by extreme levels of criminal activity, disease and mass death, infanticide, and cannibalism. It had consequences for Church, State, European society and future calamities to follow in the 14th century. Medieval Britain was afflicted by 95 famines, and France suffered the effects of 75 or more in the same period. The famine of 1315–6 may have killed at least 10% of England's population, or at least 500,000 people.



De qué sirve una taza?

An engraving from Goya's *Disasters of War*, showing starving women, doubtless inspired by the terrible famine that struck Madrid in 1811-1812.

The 17th century was a period of change for the food producers of Europe. For centuries they had lived primarily as subsistence farmers in a feudal system. They had obligations to their lords, who had suzerainty over the land tilled by their peasants. The lord of a fief would take a portion of the crops and livestock produced during the year. Peasants generally tried to minimize the amount of work they had to put into agricultural food production. Their lords rarely pressured them to increase their food output, except when the population started to increase, at which time the peasants were likely to increase the production themselves. More land would be added to cultivation until there was no more available and the peasants were forced to take up more labour-intensive methods of production. Nonetheless, as long as they had enough to feed their families, they preferred to spend their time doing other things, such as hunting, fishing or relaxing. It was not necessary to produce more than they could eat or store themselves.

During the 17th century, continuing the trend of previous centuries, there was an increase in market-driven agriculture. Farmers, people who rented land in order to make a profit off of the product of the land, employing wage labour, became increasingly common, particularly in western Europe. It was in their interest to produce as much as possible on their land in order to sell it to areas that demanded that product. They produced guaranteed surpluses of their crop every year if they could. Farmers paid their labourers in money, increasing the commercialization of rural society. This commercialization had

a profound impact on the behaviour of peasants. Farmers were interested in increasing labour input into their lands, not decreasing it as subsistence peasants were.

Subsistence peasants were also increasingly forced to commercialize their activities because of increasing taxes. Taxes that had to be paid to central governments in money forced the peasants to produce crops to sell. Sometimes they produced industrial crops, but they would find ways to increase their production in order to meet both their subsistence requirements as well as their tax obligations. Peasants also used the new money to purchase manufactured goods. The agricultural and social developments encouraging increased food production were gradually taking place throughout the sixteenth century, but were spurred on more directly by the adverse conditions for food production that Europe found itself in the early seventeenth century — there was a general cooling trend in the Earth's temperature starting at the beginning end of the sixteenth century.

The 1590s saw the worst famines in centuries across all of Europe, except in certain areas, notably the Netherlands. Famine had been relatively rare during the 16th century. The economy and population had grown steadily as subsistence populations tend to when there is an extended period of relative peace (most of the time). Subsistence peasant populations will almost always increase when possible since the peasants will try to spread the work to as many hands as possible. Although peasants in areas of high population density, such as northern Italy, had learned to increase the yields of their lands through techniques such as promiscuous culture, they were still quite vulnerable to famines, forcing them to work their land even more intensively.

Famine is a very destabilizing and devastating occurrence. The prospect of starvation led people to take desperate measures. When scarcity of food became apparent to peasants, they would sacrifice long-term prosperity for short-term survival. They would kill their draught animals, leading to lowered production in subsequent years. They would eat their seed corn, sacrificing next year's crop in the hope that more seed could be found. Once those means had been exhausted, they would take to the road in search of food. They migrated to the cities where merchants from other areas would be more likely to sell their food, as cities had a stronger purchasing power than did rural areas. Cities also administered relief programs and bought grain for their populations so that they could keep order. With the confusion and desperation of the migrants, crime would often follow them. Many peasants resorted to banditry in order to acquire enough to eat.

One famine would often lead to difficulties in following years because of lack of seed stock or disruption of routine, or perhaps because of less-available labour. Famines were often interpreted as signs of God's displeasure. They were seen as the removal, by God, of His gifts to the people of the Earth. Elaborate religious processions and rituals were made to prevent God's wrath in the form of famine.

The great famine of the 1590s began the period of famine and decline in the 17th century. The price of grain, all over Europe was high, as was the population. Various types of people were vulnerable to the succession of bad harvests that occurred throughout the

1590s in different regions. The increasing number of wage labourers in the countryside were vulnerable because they had no food of their own, and their meager living was not enough to purchase the expensive grain of a bad-crop year. Town labourers were also at risk because their wages would be insufficient to cover the cost of grain, and, to make matters worse, they often received less money in bad-crop years since the disposable income of the wealthy was spent on grain. Often, unemployment would be the result of the increase in grain prices, leading to ever-increasing numbers of urban poor.

All areas of Europe were badly affected by the famine in these periods, especially rural areas. The Netherlands was able to escape most of the damaging effects of the famine, though the 1590s were still difficult years there. Actual famine did not occur, for the Amsterdam grain trade [with the Baltic] guaranteed that there would always be something to eat in the Netherlands although hunger was prevalent.

The Netherlands had the most commercialized agriculture in all of Europe at this time, growing many industrial crops, such as flax, hemp, and hops. Agriculture became increasingly specialized and efficient. As a result, productivity and wealth increased, allowing the Netherlands to maintain a steady food supply. By the 1620s, the economy was even more developed, so the country was able to avoid the hardships of that period of famine with even greater impunity.

The years around 1620 saw another period of famines sweep across Europe. These famines were generally less severe than the famines of twenty-five years earlier, but they were nonetheless quite serious in many areas. Perhaps the worst famine since 1600, the great famine in Finland in 1696, killed one-third of the population. PDF (589 KiB)

Two massive famines struck France between 1693 and 1710, killing over two million people. In both cases the impact of harvest failure was exacerbated by wartime demands on the food supply.

As late as the 1690s, Scotland experienced famine which reduced the population of parts of Scotland by at least 15%.

The famine of 1695–96 killed roughly 10% of Norway's population. At least nine severe harvest failures were recorded in the Scandinavian countries between 1740 and 1800, each resulting in a substantial rise of the death rate.

The period of 1740–43 saw frigid winters and summer droughts which led to famine across Europe leading to a major spike in mortality. (cited in Davis, *Late Victorian Holocausts*, 281) The freezing winter of 1740-41, which led to widespread famine in northern Europe, may owe its origins to a volcanic eruption.

The Great Famine, which lasted from 1770 until 1771, killed about one tenth of Czech lands' population, or 250,000 inhabitants, and radicalized countrysides leading to peasant uprisings.

Other areas of Europe have known famines much more recently. France saw famines as recently as the nineteenth century. Famine still occurred in eastern Europe during the 20th century.

The frequency of famine can vary with climate changes. For example, during the little ice age of the 15th century to the 18th century, European famines grew more frequent than they had been during previous centuries.

Because of the frequency of famine in many societies, it has long been a chief concern of governments and other authorities. In pre-industrial Europe, preventing famine, and ensuring timely food supplies, was one of the chief concerns of many governments, which employed various tools to alleviate famines, including price controls, purchasing stockpiles of food from other areas, rationing, and regulation of production. Most governments were concerned by famine because it could lead to revolt and other forms of social disruption.

Famine returned to the Netherlands during World War II in what was known as the *Hongerwinter*. It was the last famine of Europe, in which approximately 30,000 people died of starvation. Some other areas of Europe also experienced famine at the same time.

Italy

The harvest failures were devastating for the northern Italian economy. The economy of the area had recovered well from the previous famines, but the famines from 1618 to 1621 coincided because of a period of war in the area. The economy did not recover fully for centuries. There were serious famines in the late-1640s and less severe ones in the 1670s throughout northern Italy.

In northern Italy, a report of 1767 noted that there had been famine in 111 of the previous 316 years (i.e. the period 1451-1767) and only sixteen good harvests. During the terrible famine of 1680, some 80,000 persons, out of a total population of 250,000, are said to have died in Sardinia.

England

From 1536 England began legislating Poor Laws which put a legal responsibility on the rich, at a parish level, to maintain the poor of that parish. English agriculture lagged behind the Netherlands, but by 1650 their agricultural industry was commercialized on a wide scale. The last peace-time famine in England was in 1623–24. There were still periods of hunger, as in the Netherlands, but there were no more famines as such. Rising population levels continued to put a strain on food security, despite potatoes becoming increasingly important in the diet of the poor. On balance, potatoes increased food security in England where they never replaced bread as the staple of the poor. Climate conditions were never likely to simultaneously be catastrophic for both the wheat and potato crops.

Iceland

According to Bryson (1974), there were thirty-seven famine years in Iceland between 1500 and 1804.

In 1783 the volcano Laki in south-central Iceland erupted. The lava caused little direct damage, but ash and sulfur dioxide spewed out over most of the country, causing three-quarters of the island's livestock to perish. In the following famine, around ten thousand people died, one-fifth of the population of Iceland. [Asimov, 1984, 152-153]

Iceland was also hit by a potato famine between 1862 and 1864. Lesser known than the Irish potato famine, the Icelandic potato famine was caused by the same blight that ravaged most of Europe during the 1840s. About 5 percent of Iceland's population died during the famine.

Finland

The country suffered from severe famines, and that of 1696–1697 may have killed a third of the population. The Finnish famine of 1866–1868 killed 15% of the population.

Ireland



Depiction of victims of the Great Famine in Ireland, 1845-1849

The Great Famine in Ireland, 1845–1849, was in no small part the result of policies of the Whig government of the United Kingdom under Lord Russell. The land in Ireland was owned mostly by Anglican people of English descent, who did not identify culturally or ethnically with the Irish population. The landlords were known as the Anglo-Irish and felt no compunction to use their political clout to aid their tenants and in fact saw it as an opportunity to claim more land for high profit cattle grazing as the Irish died off or left. The British government's response to the food crisis in Ireland was to leave the matter solely to market forces to decide. In reality, since the British had forcefully taken the land from the native Irish over the centuries the Irish had little means to support themselves beyond the meager amount of land set aside for the potato crop. The potato had been grown by the Irish as it is a very high calorie per acre yield. Even if the Irish were able to

obtain other crops they would not have been enough to support the population on the small amount of land allocated to them, only a potato crop could do that. Ireland was a net food exporter during the famine with the British army guarding ports and food depots from the starving crowds. The immediate effect was 1,000,000 dead and another 1,000,000 refugees fleeing to Britain, Australia and the United States. After the famine passed, infertility caused by famine, diseases and emigration spurred by the landlord-run economy being so thoroughly undermined, caused the population to enter into a 100-year decline. It was not until the 1970s (half a century after most of Ireland became independent) that the population of Ireland, then at half of what it had been before the famine, began to rise again. This period of Irish population decline after the famine was at a time when the European population doubled and the English population increased fourfold. This left the country severely underpopulated. The population decline continued in parts of the country worst affected by the famine (the west coast) until the 1990s - 150 years after the famine and the British government's *laissez-faire* economic policy. Before the Hunger, Ireland's population was over half of England's. Today it is less than 10%. The population of Ireland is 5 million but there are over 80 million more people of Irish descent outside of Ireland. That is sixteen times the population of Ireland.

Russia and the USSR

Droughts and famines in Imperial Russia are known to have happened every 10 to 13 years, with average droughts happening every 5 to 7 years. Eleven major famines scourged Russia between 1845 and 1922, one of the worst being the famine of 1891–2. Famines continued in the Soviet era, the most notorious being the *Holodomor* in various parts of the country, especially the Volga, and the Ukrainian and northern Kazakh SSR's during the winter of 1932–1933. The Soviet famine of 1932–1933 is nowadays reckoned to have cost an estimated 6 million lives. The last major famine in the USSR happened in 1947 due to the severe drought and the mismanagement of grain reserves by the Soviet government.

The 872 days of the Siege of Leningrad (1941–1944) caused unparalleled famine in the Leningrad region through disruption of utilities, water, energy and food supplies. This resulted in the deaths of about one million people.

Famine in Latin America

It is clear that in pre-Columbian times some groups struggled to survive and often suffered food shortages and famines. The persistent drought around 850 AD coincided with the collapse of Classic Maya civilization, and the famine of One Rabbit (A.D. 1454) was a major catastrophe in Mexico.

Brazil's 1877–78 *Grande Seca* (Great Drought), the most severe ever recorded in Brazil, caused approximately half a million deaths. The one from 1915 was devastating too.

Chapter- 2

Poverty



An example of extreme poverty in a slum in Jakarta, Indonesia

Poverty is the lack of basic human needs, such as clean water, nutrition, health care, education, clothing and shelter, because of the inability to afford them. This is also referred to as absolute poverty or **destitution**. Relative poverty is the condition of having fewer resources or less income than others within a society or country, or compared to worldwide averages. About 1.7 billion people live in absolute poverty; before the industrial revolution, poverty had mostly been the norm.

Poverty reduction has historically been a result of economic growth as increased levels of production, such as modern industrial technology, made more wealth available for those who were otherwise too poor to afford them. Also, investments in modernizing agriculture and increasing yields is considered the core of the antipoverty effort, given three-quarters of the world's poor are rural farmers.

Today, economic liberalization includes extending property rights, especially to land, to the poor, and making financial services, notably savings, accessible. Inefficient institutions, corruption and political instability can also discourage investment. Aid and government support in health, education and infrastructure helps growth by increasing human and physical capital.

Causes

Scarcity of basic needs



Hardwood surgical tables are commonplace in rural Nigerian clinics.

Before the industrial revolution, poverty had been mostly accepted as inevitable as economies produced little, making wealth scarce. In Antwerp and Lyons, two of the largest cities in western Europe, by 1600 three-quarters of the total population were too poor to pay taxes. In 18th century England, half the population was at least occasionally dependent on charity for subsistence. In modern times, food shortages have been reduced

dramatically in the developed world, thanks to agricultural technologies such as nitrogen fertilizers, pesticides and new irrigation methods. Also, mass production of goods in places such as China has made what were once considered luxuries, such as vehicles or computers, inexpensive and thus accessible to many who were otherwise too poor to afford them.

Rises in the costs of living make poor people less able to afford items. Poor people spend a greater portion of their budgets on food than richer people. As a result, poor households and those near the poverty threshold can be particularly vulnerable to increases in food prices. For example, in late 2007 increases in the price of grains led to food riots in some countries. The World Bank warned that 100 million people were at risk of sinking deeper into poverty. Threats to the supply of food may also be caused by drought and the water crisis. Intensive farming often leads to a vicious cycle of exhaustion of soil fertility and decline of agricultural yields. Approximately 40% of the world's agricultural land is seriously degraded. In Africa, if current trends of soil degradation continue, the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana-based Institute for Natural Resources in Africa.

Health care can be widely unavailable to the poor. The loss of health care workers emigrating from impoverished countries has a damaging effect. For example, an estimated 100,000 Philippine nurses emigrated between 1994 and 2006. There are more Ethiopian doctors in Chicago than in Ethiopia.

Overpopulation and lack of access to birth control methods drive poverty. The world's population is expected to reach nearly 9 billion in 2040. However, the reverse is also true, that poverty causes overpopulation as it gives women little power to control giving birth, or to have educational attainment or a career.

Barriers to opportunities



Street children sleeping in Mulberry Street - Jacob Riis photo New York, United States (1890)



Homeless people living in cardboard boxes in Los Angeles, United States



Carrying water in a refugee camp in Ethiopia, 2008

The unwillingness of governments and feudal elites to give full-fledged property rights in land to their tenants is cited as the chief obstacle to development. This lack of economic freedom inhibits entrepreneurship among the poor. New enterprises and foreign investment can be driven away by the results of inefficient institutions, notably corruption, weak rule of law and excessive bureaucratic burdens. Lack of financial services, as a result of restrictive regulations, such as the requirements for banking licenses, makes it hard for even smaller microsavings programs to reach the poor.

Illiteracy

It takes two days, two bureaucratic procedures, and \$280 to open a business in Canada while an entrepreneur in Bolivia must pay \$2,696 in fees, wait 82 business days, and go through 20 procedures to do the same. Such costly barriers favor big firms at the expense of small enterprises, where most jobs are created. In India, before economic reforms, businesses had to bribe government officials even for routine activities, which was, in effect, a tax on business.

For example, in Nigeria, corruption led to an estimated \$400 billion of the country's oil revenue being stolen by Nigeria's leaders between 1960 and 1999. Lack of opportunities can further be caused by the failure of governments to provide essential infrastructure.

High competition
Higher cost of education
Lack of industrialization

For instance, in India, there is a lower rate of business establishment in various states like Bihar and Uttar Pradesh. With lower industrialization and infrastructural development in the state the provision of basic facilities like schools, colleges and hospitals tends to be below average. Education and healthcare does not reach the common people. Due to lack of jobs, people are forced to migrate to large cities for temporary work. For those unable to find jobs the result is impoverishment. Poor health and education severely affects productivity at work. Inadequate nutrition in childhood undermines the ability of individuals to develop their full physical mental capabilities. Lack of essential minerals such as iodine and iron can impair brain development. 2 billion people (one-third of the total global population) are thought to be affected by iodine deficiency. In developing countries, it is estimated that 40% of children aged 4 and younger suffer from anemia because of insufficient iron in their diets.

Similarly substance abuse, including for example alcoholism and drug abuse can consign people to vicious poverty cycles. Infectious diseases such as malaria and tuberculosis can perpetuate poverty by diverting health and economic resources from investment and productivity; malaria decreases GDP growth by up to 1.3% in some developing nations and AIDS decreases African growth by 0.3-1.5% annually.

War, political instability and crime, including violent gangs and drug cartels, also discourage investment. Civil wars and conflicts in Africa cost the continent some \$300 billion between 1990 and 2005. Eritrea and Ethiopia spent hundreds of millions of dollars on the war that resulted in minor border changes. Shocks in the business cycle affect poverty rates, increasing in recessions and declining in booms. Cultural factors, such as discrimination of various kinds, can negatively affect productivity such as age discrimination, stereotyping, gender discrimination, racial discrimination, and caste discrimination.

Max Weber and the modernization theory suggest that cultural values could affect economic success. However, researchers have gathered evidence that suggest that values are not as deeply ingrained and that changing economic opportunities explain most of the movement into and out of poverty, as opposed to shifts in values.

Effects of poverty



Again in a developed nation council houses in Seacroft, Leeds, UK have been deserted due to poverty and high crime.

The effects of poverty may also be causes, as listed above, thus creating a "poverty cycle" operating across multiple levels, individual, local, national and global.

Health

Hunger, disease, and less education describe a person in poverty. One third of deaths - some 18 million people a year or 50,000 per day - are due to poverty-related causes: in total 270 million people, most of them women and children, have died as a result of poverty since 1990. Those living in poverty suffer disproportionately from hunger or even starvation and disease. Those living in poverty suffer lower life expectancy. According to the World Health Organization, hunger and malnutrition are the single gravest threats to the world's public health and malnutrition is by far the biggest contributor to child mortality, present in half of all cases.

Every year nearly 11 million children living in poverty die before their fifth birthday. 1.02 billion people go to bed hungry every night. Poverty increases the risk of

homelessness. There are over 100 million street children worldwide. Increased risk of drug abuse may also be associated with poverty.

According to the Global Hunger Index, South Asia has the highest child malnutrition rate of the world's regions. Nearly half of all Indian children are undernourished, one of the highest rates in the world and nearly double the rate of Sub-Saharan Africa. Every year, more than half a million women die in pregnancy or childbirth. Almost 90% of maternal deaths occur in Asia and sub-Saharan Africa, compared to less than 1% in the developed world.

Women who have born children into poverty may not be able to nourish the children efficiently and provide adequate care in infancy. The children may also suffer from disease that has been passed down to the child through birth. Asthma and rickets are common problems children acquire when born into poverty.

Education



Great Depression: man lying down on pier, New York City docks, 1935.

Research has found that there is a high risk of educational underachievement for children who are from low-income housing circumstances. This often is a process that begins in primary school for some less fortunate children. In the US educational system, these children are at a higher risk than other children for retention in their grade, special

placements during the school's hours and even not completing their high school education. There are indeed many explanations for why students tend to drop out of school. For children with low resources, the risk factors are similar to excuses such as juvenile delinquency rates, higher levels of teenage pregnancy, and the economic dependency upon their low income parent or parents.

Families and society who submit low levels of investment in the education and development of less fortunate children end up with less favorable results for the children who see a life of parental employment reduction and low wages. Higher rates of early childbearing with all the connected risks to family, health and well-being are majorly important issues to address since education from preschool to high school are both identifiably meaningful in a life.

Poverty often drastically affects children's success in school. A child's "home activities, preferences, mannerisms" must align with the world and in the cases that they do not these students are at a disadvantage in the school and most importantly the classroom. Therefore, it is safe to state that children who live at or below the poverty level will have far less success educationally than children who live above the poverty line. Poor children have a great deal less healthcare and this ultimately results in many absences from the academic year. Additionally, poor children are much more likely to suffer from hunger, fatigue, irritability, headaches, ear infections, flu, and colds. These illnesses could potentially restrict a child or student's focus and concentration.

Housing



Afghan girl begging in Kabul

Slum-dwellers, who make up a third of the world's urban population, live in a poverty no better, if not worse, than rural people, who are the traditional focus of the poverty in the developing world, according to a report by the United Nations.

Most of the children living in institutions around the world have a surviving parent or close relative, and they most commonly entered orphanages because of poverty. Experts and child advocates maintain that orphanages are expensive and often harm children's development by separating them from their families. It is speculated that, flush with money, orphanages are increasing and push for children to join even though demographic data show that even the poorest extended families usually take in children whose parents have died.

Violence

According to a UN report on modern slavery, the most common form of human trafficking is for prostitution, which is largely fueled by poverty. In Zimbabwe, a number of girls are turning to prostitution for food to survive because of the increasing poverty. In one survey, 67% of children from disadvantaged inner cities said they had witnessed a serious assault, and 33% reported witnessing a homicide. 51% of fifth graders from New Orleans (median income for a household: \$27,133) have been found to be victims of violence, compared to 32% in Washington, DC (mean income for a household: \$40,127).

Drug abuse

Poverty reduction

Historically, poverty reduction has been largely a result of economic growth. The industrial revolution led to high economic growth and eliminated mass poverty in what is now considered the developed world. In 1820, 75% of humanity lived on less than a dollar a day, while in 2001, only about 20% do. As three quarters of the world's poor live in the country side, the World Bank cites helping small farmers as the heart of the fight against poverty. Economic growth in agriculture is, on average, at least twice as effective in benefiting the poorest half of a country's population as growth generated in non-agricultural sectors. However, aid is essential in providing better lives for those who are already poor and in sponsoring medical and scientific efforts such as the Green Revolution and the eradication of smallpox.

Voluntary poverty

Among some individuals, such as ascetics, poverty is considered a necessary or desirable condition, which must be embraced to reach certain spiritual, moral, or intellectual states. Poverty is often understood to be an essential element of renunciation in religions such as

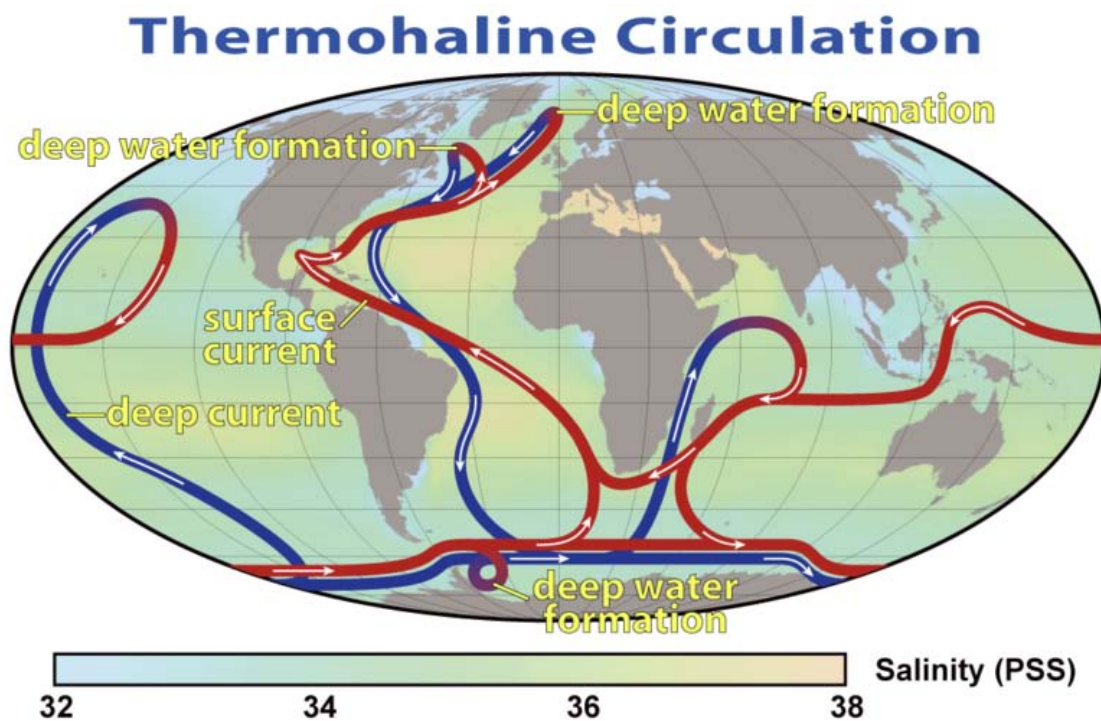
Buddhism (only for monks, not for lay persons) and Jainism, whilst in Roman Catholicism it is one of the evangelical counsels.

Certain religious orders also take a vow of extreme poverty. For example, the Franciscan orders have traditionally foregone all individual and corporate forms of ownership. While individual ownership of goods and wealth is forbidden for Benedictines, following the Rule of St. Benedict, the monastery itself may possess both goods and money, and throughout history some monasteries have become very rich.

In this context of religious vows, poverty may be understood as a means of self-denial to place oneself at the service of others; Pope Honorius III wrote in 1217 that the Dominicans "lived a life of voluntary poverty, exposing themselves to innumerable dangers and sufferings, for the salvation of others".

Chapter- 3

Shutdown of Thermohaline Circulation



A summary of the path of the thermohaline circulation. Blue paths represent deep-water currents, while red paths represent surface currents

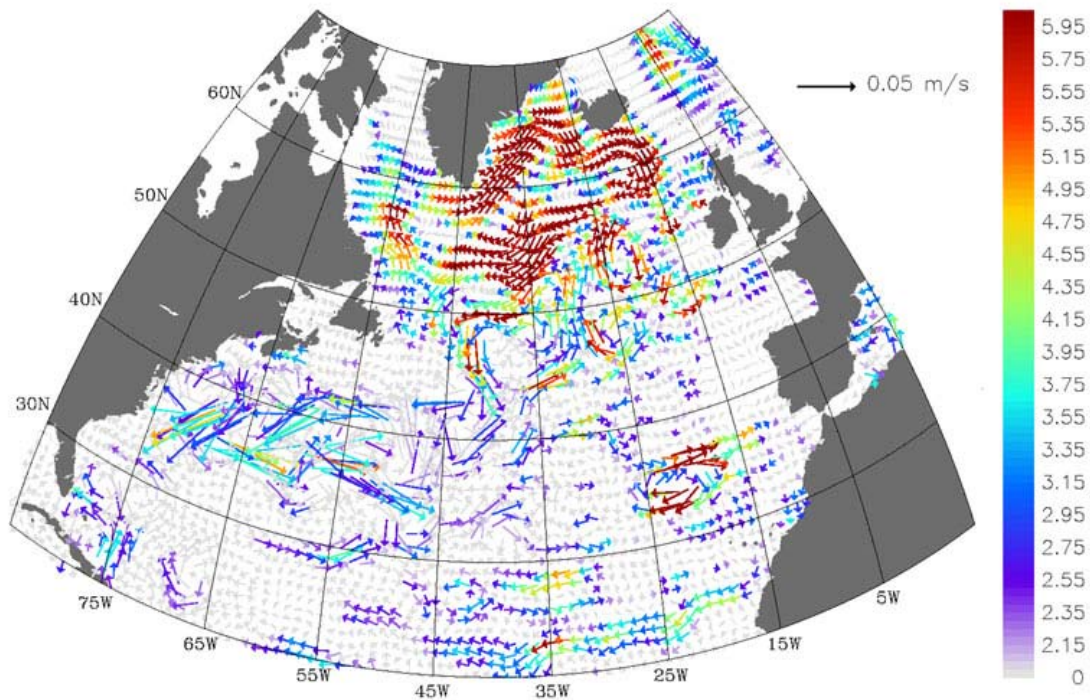
Shutdown or slowdown of the thermohaline circulation is a postulated effect of global warming.

There is some speculation that global warming could, via a shutdown or slowdown of the thermohaline circulation, trigger localised cooling in the North Atlantic and lead to cooling, or lesser warming, in that region. This would particularly affect the areas of the British Isles and the Nordic countries that are warmed by the North Atlantic drift. The chances of this occurring are unclear; there is some evidence for the stability of the Gulf Stream but a possible weakening of the North Atlantic drift; and there is evidence of

warming in northern Europe and nearby seas, rather than the reverse. The future is undecided, as studies of the Florida Current suggest that the Gulf Stream weakens with cooling and strengthens with warming, being weakest (by ~10%) during the Little Ice Age and strongest during 1,000–1,100 years BP (Before Present), the Medieval Warm Period.

Thermohaline circulation and fresh water

Heat is transported from the equator polewards mostly by the atmosphere but also by ocean currents, with warm water near the surface and cold water at deeper levels. The best known segment of this circulation is the Gulf Stream, a wind-driven gyre, which transports warm water from the Caribbean northwards. A northwards branch of the Gulf Stream, the North Atlantic Drift, is part of the thermohaline circulation (THC), transporting warmth further north to the North Atlantic, where its effect in warming the atmosphere contributes to warming Europe. Other factors are also important, such as atmospheric waves that bring subtropical air further north, which have been suggested to influence the Climate of the British Isles more than the Gulf Stream. The evaporation of ocean water in the North Atlantic increases the salinity of the water as well as cooling it, both actions increasing the density of water at the surface. The formation of sea ice further increases the salinity. This dense water then sinks and the circulation stream continues in a southerly direction. Global warming could lead to an increase in freshwater in the northern oceans, by melting glaciers in Greenland and by increasing precipitation, especially through Siberian rivers. It is by no means clear that sufficient freshwater could be provided to interrupt thermohaline circulation – climate models indicate not, but research continues.



The red end of the spectrum indicates slowing in this presentation of the trend of velocities derived from NASA Pathfinder altimeter data from May 1992 to June 2002. Source: NASA.

Some even fear that global warming may be able to trigger the type of abrupt massive temperature shifts which occurred during the last glacial period: a series of Dansgaard-Oeschger events – rapid climate fluctuations – may be attributed to freshwater forcing at high latitude interrupting the THC. The Younger Dryas event may have been of this sort, too. However, these events are believed to have been triggered by massive freshwater discharges from the Laurentide ice sheet, rather than from the melting of polar sea-ice and precipitation changes associated with the increased open water in global warming. Meltwater events aside, the climate deterioration into the last ice age appears to have taken about 5,000 years. Also, in coupled Atmosphere-Ocean General Circulation Models the THC tends to weaken somewhat rather than stop, and the warming effects outweigh the cooling, even locally: the IPCC Third Assessment Report notes that "even in models where the THC weakens, there is still a warming over Europe". Model runs in which the THC is forced to shut down do show cooling – locally up to 8 °C (14 °F) — although the largest anomalies occur over the North Atlantic, not over land. However, climate models are not sufficiently sophisticated at present to include climatic factors which give these predictions veracity; e.g., the recent return of deep convection to the subpolar gyre in both the Labrador and Irminger seas and the growing ice mass of Greenland.

Measurements in 2004, 2005, 2008 and 2010

In April 2004, the hypothesis that the Gulf Stream is switching off received a boost when a retrospective analysis of U.S. satellite data seemed to show a slowing of the North Atlantic Gyre, the northern swirl of the Gulf Stream.

In May 2005, Peter Wadhams reported to *The Times* about the results of investigations in a submarine under the Arctic ice sheet measuring the giant chimneys of cold dense water, in which the cold dense water normally sinks down to the sea bed and is replaced by warm water, forming one of the engines of the North Atlantic Drift. He and his team found the chimneys to have virtually disappeared. Normally there are seven to twelve giant columns, but Wadhams found only two giant columns, both extremely weak.

In 2008, Vage et al. reported "the return of deep convection to the subpolar gyre in both the Labrador and Irminger seas in the winter of 2007–2008," employing "profiling float data from the Argo program to document deep mixing," and "a variety of in situ, satellite and reanalysis data" to set the context for the phenomenon. This might have a lot to do with the observations of variations in cold water chimney behaviour.

In January 2010, the Gulf Stream briefly connected with the West Greenland Current after fluctuating for a few weeks due to an extreme negative phase of the Arctic oscillation, temporarily diverting it west of Greenland.

Bryden measurements reported late 2005

The NewScientist.com news service reported on 30 November 2005 that the National Oceanography Centre in the UK found a 30% reduction in the warm currents that carry water north from the Gulf Stream from the last such measurement in 1992. The authors note that currently the observed changes are "uncomfortably close" to the uncertainties in the measurements. However, the North Atlantic is currently warmer than in the earlier measurements. This suggests that either the circulation is not weakening, or that, even if it is weakening, the weakening is not having the hypothesised cooling effect, or that other factors are able to overwhelm any cooling.

The New Scientist article was based on an article in *Nature*. In *News and Views* in the same issue, Detlef Quadfasel reinforces the point that the uncertainty of the estimates of Bryden *et al.* is high, but says other factors and observations do support their results. Quadfasel continues by pointing out the significance of the possible implications, with palaeoclimate records showing drops of air temperature up to 10 °C within decades, linked to abrupt switches of ocean circulation when a certain threshold is reached. He concludes that further observations and modelling are crucial for providing early warning of a possible devastating breakdown of the circulation.

On 19 January 2006, a News Feature *Climate change: A sea change* by Quirin Schiermeier appeared in *Nature*, detailing reactions to the Bryden results. Points made by Schiermeier include the following:

- The results are a surprise to scientists in the field.
- Modelling suggests that increase of fresh water flows large enough to shut down the thermohaline circulation would be an order of magnitude greater than currently estimated to be occurring, and such increases are unlikely to become critical within the next hundred years; this is hard to reconcile with the Bryden measurements.
- The Bryden results could be caused by natural variation, or "noise", that is, coincidence.
- If the results are correct, perhaps thermohaline circulation reductions will not have the drastic effects that have been predicted on European cooling.
- While previous shutdowns (e.g. the Younger Dryas) have caused cooling, the current overall climate is different; in particular sea-ice formation is less because of overall global warming.
- However, a thermohaline circulation shutdown could have other major consequences apart from cooling of Europe, such as an increase in major floods and storms, a collapse of plankton stocks, warming or rainfall changes in the tropics or Alaska and Antarctica (including those from intensified El Niño effect), more frequent and intense El Niño events, or an oceanic anoxic event (oxygen (O₂) below surface levels of the stagnant oceans becomes completely depleted - a probable cause of past mass extinction events).

Further measurements support the interpretation of natural variation.

Chapter- 4

Mutual Assured Destruction

Mutually assured destruction (M.A.D.) is a doctrine of military strategy and national security policy in which a full-scale use of nuclear weapons by two opposing sides would effectively result in the destruction of both the attacker and the defender, becoming thus a war that has no victory nor any armistice but only total destruction. It is based on the theory of deterrence according to which the deployment of strong weapons is essential to threaten the enemy in order to prevent the use of the same weapons. The strategy is effectively a form of Nash equilibrium in which neither side, once armed, has any incentive to disarm.

Theory

The MAD doctrine assumes that each side has enough nuclear weaponry to destroy the other side and that either side, if attacked for any reason by the other, would retaliate with equal or greater force. The expected result is an immediate escalation resulting in both combatants' total and assured destruction. It is now generally hypothesized that the nuclear fallout or nuclear winter resulting from a large scale nuclear war would bring about worldwide devastation, though this was not a critical assumption to the theory of MAD.

The doctrine further assumes that neither side will dare to launch a first strike because the other side will launch on warning (also called fail-deadly) or with secondary forces (second strike) resulting in the destruction of both parties. The payoff of this doctrine is expected to be a tense but stable peace.

The primary application of this doctrine started during the Cold War (1940s to 1990s) in which MAD was seen as helping to prevent any direct full-scale conflicts between the United States and the Soviet Union while they engaged in smaller proxy wars around the world. It was also responsible for the arms race, as both nations struggled to keep nuclear parity, or at least retain second-strike capability. Although the Cold War ended in the early 1990s, the doctrine of Mutually Assured Destruction certainly continues to be in force.

Proponents of MAD as part of U.S. and USSR strategic doctrine believed that nuclear war could best be prevented if neither side could expect to survive a full scale nuclear

exchange as a functioning state. Since the credibility of the threat is critical to such assurance, each side had to invest substantial capital in their nuclear arsenals even if they were not intended for use. In addition, neither side could be expected or allowed to adequately defend itself against the other's nuclear missiles. This led both to the hardening and diversification of nuclear delivery systems (such as nuclear missile silos, ballistic missile submarines and nuclear bombers kept at fail-safe points) and to the Anti-Ballistic Missile Treaty.

This MAD scenario is often referred to as **nuclear deterrence**. The term deterrence was first used in this context after World War II; prior to that time, its use was limited to legal terminology.

History

Pre-1945



Wilkie Collins.

Perhaps the earliest reference to the concept comes from the English author Wilkie Collins, writing at the time of the Franco-Prussian War in 1870: "I begin to believe in only one civilising influence—the discovery one of these days of a destructive agent so terrible that War shall mean annihilation and men's fears will force them to keep the peace".

Echoes of the doctrine can be found in the first document which outlined how the atomic bomb was a practical proposition. In March 1940, the Frisch-Peierls memorandum anticipated deterrence as the principal means of combating an enemy with nuclear weapons.

In practice during World War II, utter annihilation from the air had already been visited upon the enemies of the Allied forces, both in Europe and Japan, well before use of the Atomic Bomb, and with perhaps even deadlier results. The incendiary attacks on Dresden in Germany, e.g., and Tokyo in efforts to finally force surrender and end both the European and Pacific Wars, set the stage for the concepts of Total War and MAD.

Early Cold War

In August 1945, the United States accepted the surrender of Japan after the nuclear attacks on Hiroshima and Nagasaki. Four years later, on August 29, 1949, the Soviet Union detonated its own nuclear weapon. At the time, both sides lacked the means to effectively use nuclear devices against each other. However, with the development of aircraft like the Convair B-36, both sides were gaining a greater ability to deliver nuclear weapons into the interior of the opposing country. The official nuclear policy of the United States was one of "massive retaliation", as coined by President Dwight D. Eisenhower's Secretary of State John Foster Dulles, which called for massive attack against the Soviet Union if they were to invade Europe, regardless of whether it was a conventional or a nuclear attack.

During the Cuban Missile Crisis, the Soviet Union truly developed an understanding of the effectiveness of the U.S. ballistic missile submarine forces, and work on Soviet ballistic missile submarines began in earnest. For the remainder of the Cold War, although official positions on MAD changed in the United States, the consequences of the second strike from ballistic missile submarines was never in doubt.



A time exposure of eight MIRVs from Peacekeeper missile passing through clouds.

The multiple independently targetable re-entry vehicle (MIRV) was another weapons system designed specifically to aid with the MAD nuclear deterrence doctrine. With a MIRV payload, one ICBM could hold many separate warheads. MIRVs were first created by the United States in order to counterbalance Soviet anti-ballistic missile systems around Moscow. Since each defensive missile could only be counted on to destroy one offensive missile, making each offensive missile have, for example, three warheads (as with early MIRV systems) meant that three times as many defensive missiles were needed for each offensive missile. This made defending against missile attacks more costly and difficult. One of the largest U.S. MIRVed missiles, the LGM-118A Peacekeeper, could hold up to 10 warheads, each with a yield of around 300 kilotons—all together, an explosive payload equivalent to 230 Hiroshima-type bombs. The multiple

warheads made defense untenable with the technology available, leaving only the threat of retaliatory attack as a viable defensive option. MIRVed land-based ICBMs are considered destabilizing because they tend to put a premium on striking first. It is because of this that this type of weapon was banned under the START II agreement.

In the event of a Soviet conventional attack on Western Europe, NATO planned to use tactical nuclear weapons. The Soviet Union countered this threat by issuing a statement that any use of nuclear weapons against Soviet forces, tactical or otherwise, was grounds for a full-scale Soviet retaliatory strike. Thus it was generally assumed that any combat in Europe would end with apocalyptic conclusions. The quote "I know not with what weapons World War III will be fought, but World War IV will be fought with sticks and stones" is generally attributed to Albert Einstein.

Second strike capability

It was only with the advent of ballistic missile submarines, starting with the *George Washington* class in 1959, that a survivable nuclear force became possible and second strike capability credible. This was not fully understood until the 1960s when the strategy of mutually assured destruction was first fully described, largely by United States Secretary of Defense Robert McNamara.

In McNamara's formulation, MAD meant that nuclear nations either had first strike or second strike capability. A nation with first strike capability would be able to destroy the entire nuclear arsenal of another nation and thus prevent any nuclear retaliation. Second strike capability indicated that a nation could uphold a promise to respond to a nuclear attack with enough force to make such a first attack highly undesirable. According to McNamara, the arms race was in part an attempt to make sure that no nation gained first strike capability.

An early form of second strike capability had already been provided by the use of continual patrols of nuclear-equipped bombers, with a fixed number of planes always in the air (and therefore untouchable by a first strike) at any given time. The use of this tactic was reduced however, by the high logistic difficulty of keeping enough planes active at all times, and the increasing priority given to ICBMs over bombers (which might be shot down by air defenses before reaching their targets).

Ballistic missile submarines established a second strike capability through their stealth and by the number fielded by each Cold War adversary—it was highly unlikely that all of them could be targeted and preemptively destroyed (in contrast to, for example, a missile bunker with a fixed location that could be targeted during a first strike). Given their long range, high survivability and ability to carry many medium- and long-range nuclear missiles, submarines were credible and effective means for full-scale retaliation even after a massive first strike.

Late Cold War

The original doctrine of U.S. MAD was modified on July 25, 1980, with U.S. President Jimmy Carter's adoption of *countervailing strategy* with Presidential Directive 59. According to its architect, Secretary of Defense Harold Brown, "countervailing strategy" stressed that the planned response to a Soviet attack was no longer to bomb Russian population centers and cities primarily, but first to kill the Soviet leadership, then attack military targets, in the hope of a Russian surrender before total destruction of the USSR (and the United States). This modified version of MAD was seen as a winnable nuclear war, while still maintaining the possibility of assured destruction for at least one party. This policy was further developed by the Reagan Administration with the announcement of the Strategic Defense Initiative (nicknamed "Star Wars"), the goal of which was to develop space-based technology to destroy Soviet missiles before they reached the U.S.

SDI was criticized by both the Soviets and many of America's allies (including Prime Minister of the United Kingdom Margaret Thatcher) because, were it ever operational and effective, it would have undermined the "assured destruction" required for MAD. If America had a guarantee against Soviet nuclear attacks, its critics argued, it would have first strike capability which would have been a politically and militarily destabilizing position. Critics further argued that it could trigger a new arms race, this time to develop countermeasures for SDI. Despite its promise of nuclear safety, SDI was described by many of its critics (including Soviet nuclear physicist and later peace activist Andrei Sakharov) as being even more dangerous than MAD because of these political implications. Supporters also argued that SDI could trigger a new arms race, forcing the USSR to spend an increasing proportion of GDP on defense - something which has been claimed to have been an indirect cause of the eventual collapse of the Soviet Union.

Proponents of Ballistic Missile Defense (BMD) argue that MAD is exceptionally dangerous in that it essentially offers a single course of action in the event of nuclear attack: full retaliatory response. The fact that nuclear proliferation has led to an increase in the number of nations in the "nuclear club", including nations of questionable stability (Pakistan and North Korea, e.g.), and that a nuclear nation might be hijacked by a despot or other person or persons who might use nuclear weapons without sane regard for the consequences, presents a strong case for proponents of BMD who seek a policy which both protects against attack, but also does not require an escalation into what might become global nuclear war. Russia continues to have a strong public distaste for Western BMD initiatives, presumably because proprietary operative BMD systems could exceed their technical and financial resources, and therefore degrade their larger military standing and sense of security in a post-MAD environment. Russian refusal to accept invitations to participate in NATO BMD may be indicative of the lack of an alternative to MAD in current Russian nuclear-war-fighting strategy and capability.



A payload launch vehicle carrying a prototype exoatmospheric kill vehicle is launched from Meck Island at the Kwajalein Missile Range on December 3, 2001, for an intercept of a ballistic missile target over the central Pacific Ocean.

Post Cold War

After the fall of the Soviet Union, the Russian Federation emerged as a sovereign entity encompassing most of the territory of the former USSR. Relations between the U.S. and this new power have been less tense than they had been with its predecessor. Tensions also decreased between the U.S and China.

The administration of U.S. President George W. Bush withdrew from the Anti-Ballistic Missile Treaty in June 2002, claiming that the limited national missile defense system

which they propose to build is designed only to prevent nuclear blackmail by a state with limited nuclear capability and is not planned to alter the nuclear posture between Russia and the United States.

While relations have improved and an intentional nuclear exchange is increasingly unlikely, the decay in Russian nuclear capability in the post Cold War era has had an effect on the continued viability of the MAD doctrine. An article by Keir Lieber and Daryl Press stated that the United States could carry out a nuclear first strike on Russia and would "have a good chance of destroying every Russian bomber base, submarine, and ICBM." This was attributed to reductions in Russian nuclear stockpiles and the increasing inefficiency and age of that which remains. Lieber and Press argued that the MAD era is coming to an end and that U.S. is on the cusp of global nuclear primacy.

However, in a follow up article in the same publication, others criticized the analysis, including Peter Flory, the U.S. Assistant Secretary of Defense for International Security Policy, who began by writing "The essay by Keir Lieber and Daryl Press contains so many errors, on a topic of such gravity, that a Department of Defense response is required to correct the record." Regarding reductions in Russian stockpiles, another response stated that "a similarly one-sided examination of [reductions in] U.S. forces would have painted a similarly dire portrait".

A situation in which the United States might actually be expected to carry out a "successful" attack is perceived as a disadvantage for both countries. The strategic balance between the United States and Russia is becoming less stable, and the objective, technical possibility of a first strike by the United States is increasing. At a time of crisis, this instability could lead to an accidental nuclear war. For example, if Russia feared a U.S. nuclear attack, Moscow might make rash moves (such as putting its forces on alert) that would provoke a U.S. preemptive strike. An outline of current United States nuclear strategy toward both Russia and other nations was published as the document "Essentials of Post-Cold War Deterrence" in 1995.

Official policy

Whether MAD was the officially accepted doctrine of the United States military during the Cold War is largely a matter of interpretation. The term MAD was not coined by the military but was, however, based on the policy of "Assured Destruction" advocated by U.S. Secretary of Defense Robert McNamara during the 1960s. The United States Air Force, for example, has retrospectively contended that it never advocated MAD as a sole strategy, and that this form of deterrence was seen as one of numerous options in U.S. nuclear policy. Former officers have emphasized that they never felt as limited by the logic of MAD (and were prepared to use nuclear weapons in smaller scale situations than "Assured Destruction" allowed), and did not deliberately target civilian cities (though they acknowledge that the result of a "purely military" attack would certainly devastate the cities as well). MAD was implied in several U.S. policies and used in the political rhetoric of leaders in both the U.S. and the USSR during many periods of the Cold War.

To continue to deter in an era of strategic nuclear equivalence, it is necessary to have nuclear (as well as conventional) forces such that in considering aggression against our interests any adversary would recognize that no plausible outcome would represent a victory or any plausible definition of victory. To this end and so as to preserve the possibility of bargaining effectively to terminate the war on acceptable terms that are as favorable as practical, if deterrence fails initially, we must be capable of fighting successfully so that the adversary would not achieve his war aims and would suffer costs that are unacceptable, or in any event greater than his gains, from having initiated an attack.

– *President Jimmy Carter in 1980, Presidential Directive 59, Nuclear Weapons Employment Policy*

Criticism



Nuclear weapon test Apache (yield 1.85 Mt).

Critics of the MAD doctrine frequently played on the similarity between the acronym and the common word for mental illness. The doctrine of nuclear deterrence depends on several challengeable assumptions:

Second-strike capability

- A first strike must not be capable of preventing a retaliatory second strike or else mutual destruction is not assured. In this case, a state would have nothing to lose with a first strike; or might try to preempt the development of an opponent's second-strike capability with a first strike (i.e., decapitation strike). To avoid this, countries may design their nuclear forces to make decapitation strike almost impossible, by dispersing launchers over wide areas and using a combination of sea-based, air-based, underground, and mobile land-based launchers.

Perfect detection

- No false positives (errors) in the equipment and/or procedures that must identify a launch by the other side. The implication of this is that an accident could lead to a full nuclear exchange. During the Cold War there were several instances of false positives, as in the case of Stanislav Petrov.
- No possibility of camouflaging a launch. The use of stealth technology in aircraft such as the B-2 bomber makes this assumption less likely to be fulfilled.
- No means of delivery that does not have the characteristics of a long range missile delivery, i.e. detectable far ahead of detonation. Again this assumption is challengeable with for instance stealth aircraft but also with other means, such as smuggling weapons to the target undetected. A close range missile attack from a submarine would also negate this assumption, as would positioning the weapons close to the intended target (exemplified in the Cuban Missile Crisis).
- Perfect attribution. If there is a launch from the Sino-Russian border, it could be difficult to distinguish which nation is responsible and, hence, against which nation retaliation should occur.

Perfect rationality

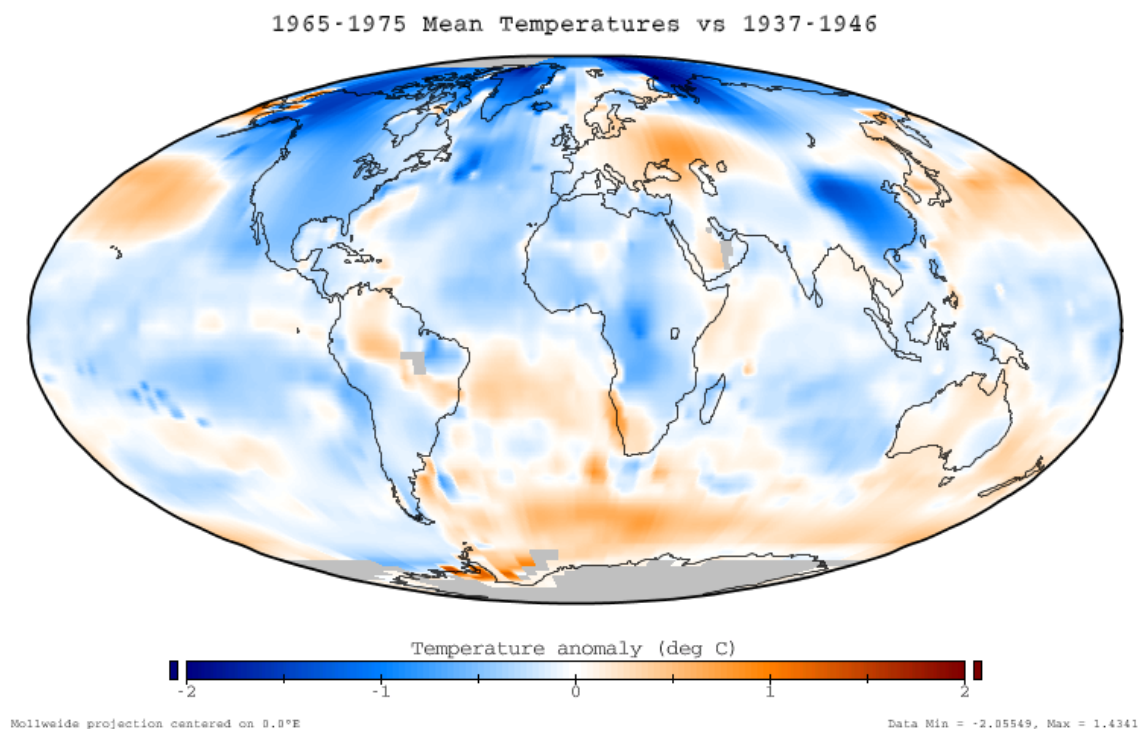
- No "rogue states" will develop nuclear weapons. Or, if they do, they will stop behaving as rogue states and subject themselves to the logic of MAD.
- No rogue commanders will have the ability to corrupt the launch decision process (this is demonstrated with *Dr. Strangelove*).
- All leaders with launch capability care about the survival of their subjects (for example, a leader with religious ideas about the end of the world might launch regardless).
- No leader with launch capability would strike first and gamble that the opponent's response system would fail.

Inability to defend

- No shelters sufficient to protect population and/or industry.
- No development of anti-missile technology or deployment of remedial protective gear.

Chapter- 5

Global Cooling



Mean temperature anomalies during the period 1965 to 1975 with respect to the average temperatures from 1937 to 1946. This dataset was not available at the time.

Global cooling was a conjecture during the 1970s of imminent cooling of the Earth's surface and atmosphere along with a posited commencement of glaciation. This hypothesis had mixed support in the scientific community, but gained temporary popular attention due to a combination of press reports that did not accurately reflect the scientific understanding of ice age cycles, and a slight downward trend of temperatures from the 1940s to the early 1970s. In contrast to the global cooling conjecture, the current scientific opinion on climate change is that the Earth has not durably cooled, but undergone global warming throughout the twentieth century.

Introduction: general awareness and concern

In the 1970s there was increasing awareness that estimates of global temperatures showed cooling since 1945. Of those scientific papers considering climate trends over the 21st century, only 10% inclined towards future cooling, while most papers predicted future warming. The general public had little awareness of carbon dioxide's effects on climate, but Science News in May 1959 forecast a 25% increase in atmospheric carbon dioxide in the 150 years from 1850 to 2000, with a consequent warming trend. The actual increase in this period was 29%. Paul R. Ehrlich mentioned climate change from greenhouse gases in 1968. By the time the idea of global cooling reached the public press in the mid-1970s temperatures had stopped falling, and there was concern in the climatological community about carbon dioxide's warming effects. In response to such reports, the World Meteorological Organization issued a warning in June 1976 that *a very significant warming of global climate* was probable.

Currently there are some concerns about the possible cooling effects of a slowdown or shutdown of thermohaline circulation, which might be provoked by an increase of fresh water mixing into the North Atlantic due to glacial melting. The probability of this occurring is generally considered to be very low, and the IPCC notes, "even in models where the THC weakens, there is still a warming over Europe. For example, in all AOGCM integrations where the radiative forcing is increasing, the sign of the temperature change over north-west Europe is positive."

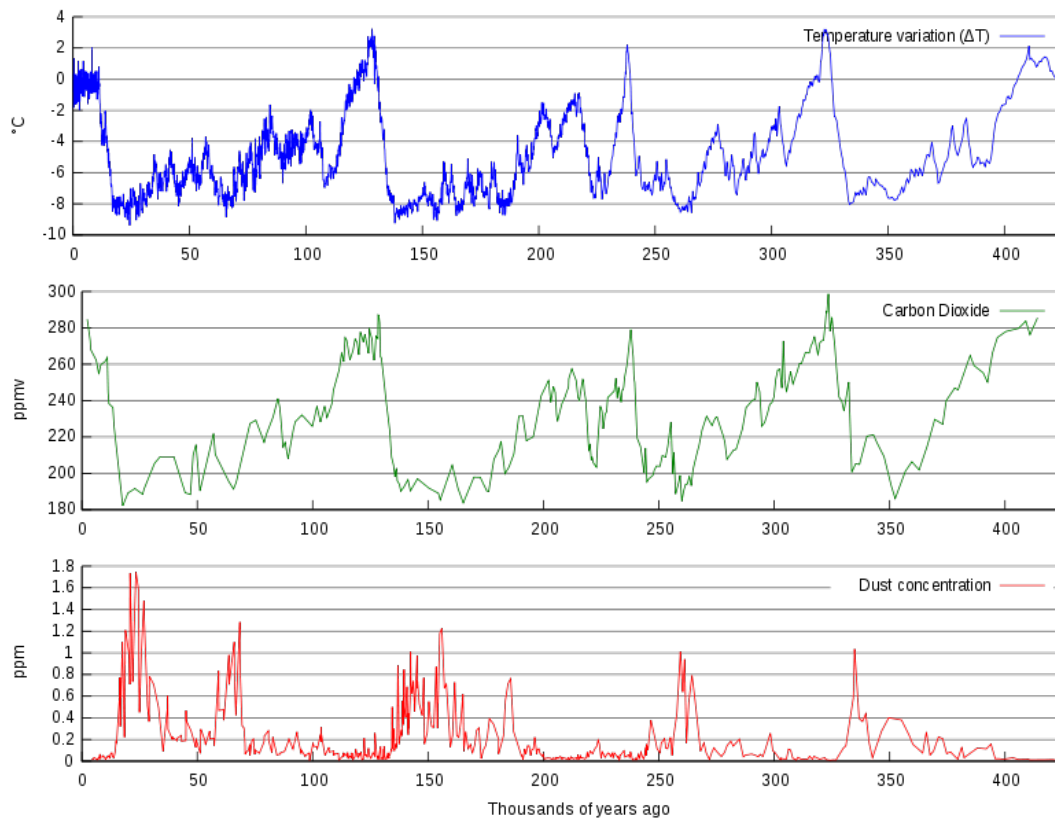
Physical mechanisms

The cooling period is well reproduced by current (1999 on) global climate models (GCMs) that include the physical effects of sulphate aerosols, and there is now general agreement that aerosol effects were the dominant cause of the mid-20th century cooling. However, at the time there were two physical mechanisms that were most frequently advanced to cause cooling: aerosols and orbital forcing.

Aerosols

Human activity — mostly as a by-product of fossil fuel combustion, partly by land use changes — increases the number of tiny particles (aerosols) in the atmosphere. These have a *direct effect*: they effectively increase the planetary albedo, thus cooling the planet by reducing the solar radiation reaching the surface; and an *indirect effect*: they affect the properties of clouds by acting as cloud condensation nuclei. In the early 1970s some speculated that this cooling effect might dominate over the warming effect of the CO₂ release. As a result of observations and a switch to cleaner fuel burning, this no longer seems likely; current scientific work indicates that global warming is far more likely. Although the temperature drops foreseen by this mechanism have now been discarded in light of better theory and the observed warming, aerosols are believed to have contributed a cooling tendency (outweighed by increases in greenhouse gases) and also have contributed to "Global Dimming."

Orbital forcing



CO₂, temperature, and dust concentration measured by Petit et al. from Vostok ice core at Antarctica.

Orbital forcing refers to the slow, cyclical changes in the tilt of Earth's axis and shape of its orbit. These cycles alter the total amount of sunlight reaching the earth by a small amount and affect the timing and intensity of the seasons. This mechanism is believed to be responsible for the timing of the ice age cycles, and understanding of the mechanism was increasing rapidly in the mid-1970s.

The seminal paper of Hays, Imbrie and Shackleton *Variations in the earth's orbit: pacemaker of the ice ages* qualified its predictions with "forecasts must be qualified in two ways. First, they apply only to the natural component of future climatic trends - and not to anthropogenic effects such as those due to the burning of fossil fuels. Second, they describe only the long-term trends, because they are linked to orbital variations with periods of 20,000 years and longer. Climatic oscillations at higher frequencies are not predicted... the results indicate that the long-term trend over the next 20,000 years is towards extensive Northern Hemisphere glaciation and cooler climate".

The idea that ice ages cycles were predictable appears to have become conflated with the idea that another one was due "soon" - perhaps because much of this study was done by geologists, who are accustomed to dealing with very long time scales and use "soon" to refer to periods of thousands of years. A strict application of the Milankovitch theory

does not allow the prediction of a "rapid" ice age onset (i.e., less than a century or two) since the fastest orbital period is about 20,000 years. Some creative ways around this were found, notably one championed by Nigel Calder under the name of "snowblitz", but these ideas did not gain wide acceptance.

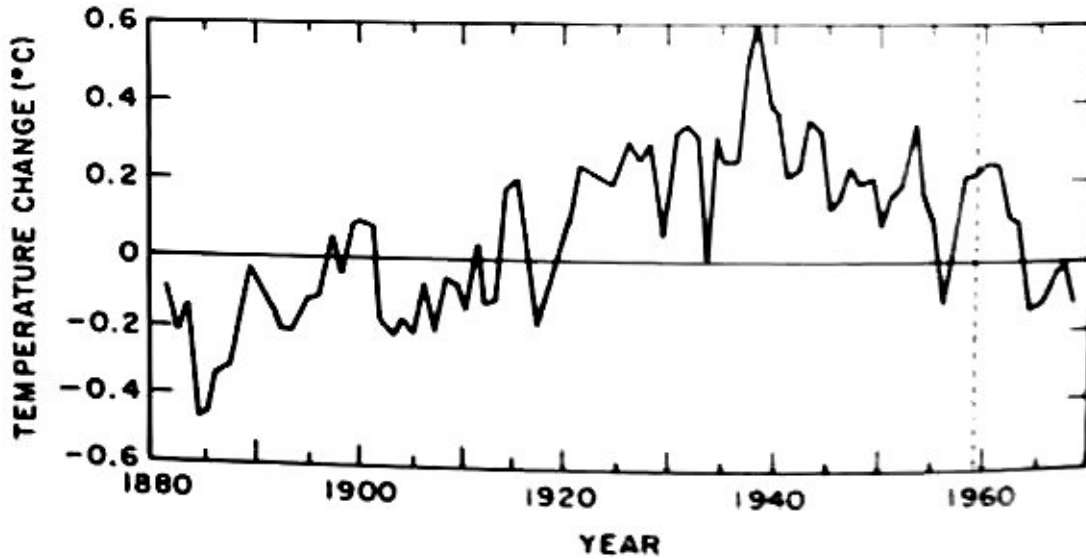
It is common to see it asserted that the length of the current interglacial temperature peak is similar to the length of the preceding interglacial peak (Sangamon/Eem), and from this conclude that we might be nearing the end of this warm period. This conclusion is supported by the fact that the lengths of previous interglacials were regular; see appended figure. Petit et al. note that "Interglacials 5.5 and 9.3 are different from the Holocene, but similar to each other in duration, shape and amplitude." During each of these two events, there is a warm period of 4 kyr followed by a relatively rapid cooling. *As an objection, the future orbital variations will not closely resemble those of the past.*

Concern in the mid-twentieth century

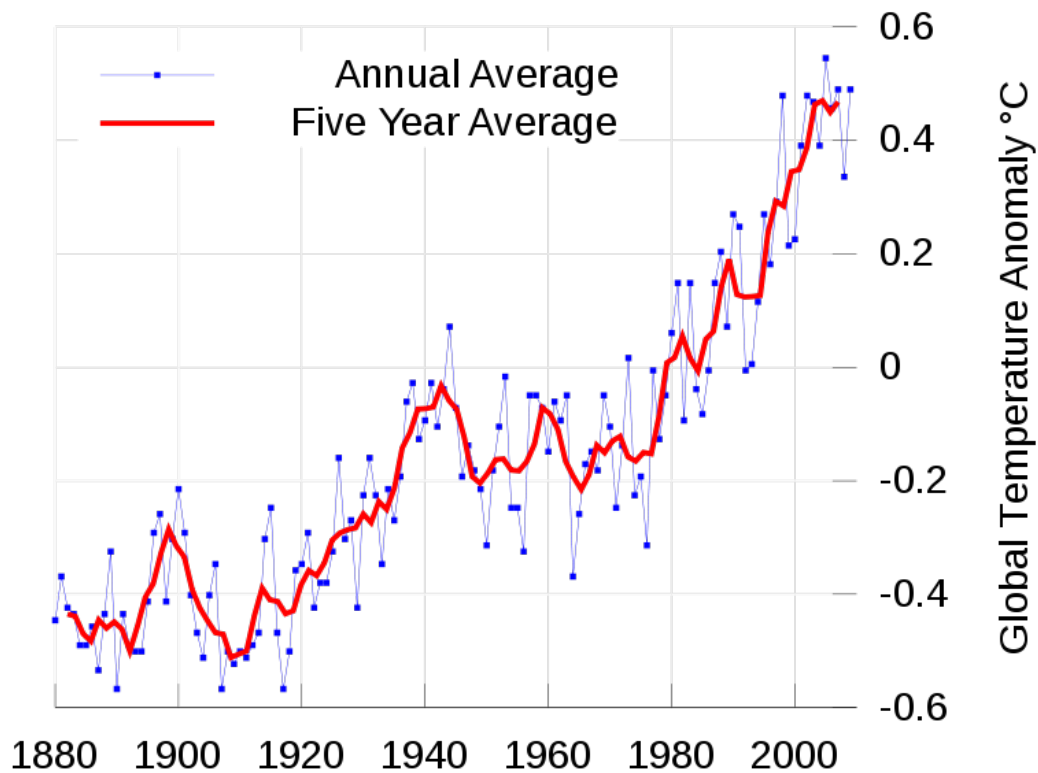
Pre-1970s

At a conference on climate change held in Boulder, Colorado in 1965, evidence supporting Milankovitch cycles triggered speculation on how the calculated small changes in sunlight might somehow trigger ice ages. In 1966 Cesare Emiliani predicted that "a new glaciation will begin within a few thousand years." In his 1968 book *The Population Bomb*, Paul R. Ehrlich wrote "The greenhouse effect is being enhanced now by the greatly increased level of carbon dioxide... [this] is being countered by low-level clouds generated by contrails, dust, and other contaminants... At the moment we cannot predict what the overall climatic results will be of our using the atmosphere as a garbage dump."

1970s awareness



The temperature record as seen in 1975; compare with the next figure.



Instrumental record of global average temperatures.

Concern peaked in the early 1970s, partly because of the cooling trend then apparent (a cooling period began in 1945, and two decades of a cooling trend suggested a trough had

been reached after several decades of warming), and partly because much less was then known about world climate and causes of ice ages. Although there was a cooling trend then, climate scientists were aware that predictions based on this trend were not possible - because the trend was poorly studied and not understood. However in the popular press the possibility of cooling was reported generally without the caveats present in the scientific reports.

In the 1970s the compilation of records to produce hemispheric, or global, temperature records had just begun.

A history of the discovery of global warming states that: *While neither scientists nor the public could be sure in the 1970s whether the world was warming or cooling, people were increasingly inclined to believe that global climate was on the move, and in no small way.*

In 1972 Emiliani warned "Man's activity may either precipitate this new ice age or lead to substantial or even total melting of the ice caps..." By 1972 a group of glacial-epoch experts at a conference agreed that "the natural end of our warm epoch is undoubtedly near"; but the volume of Quaternary Research reporting on the meeting said that "the basic conclusion to be drawn from the discussions here is that the knowledge necessary for understanding the mechanism of climate change is still lamentably inadequate". Unless there were impacts from future human activity, they thought that serious cooling "must be expected within the next few millennia or even centuries"; but many other scientists doubted these conclusions.

In 1972, George Kukla and Robert Matthews, in a Science write-up of a conference, asked when and how the current interglacial would end; concluding that "Global cooling and related rapid changes of environment, substantially exceeding the fluctuations experienced by man in historical times, must be expected within the next few millennia or even centuries."

1970 SCEP report

The 1970 "Study of Critical Environmental Problems" reported the possibility of warming from increased carbon dioxide, but no concerns about cooling, setting a lower bound on the beginning of interest in "global cooling".

1971 paper on warming and cooling factors

There was a paper by S. Ichtiaque Rasool and Stephen H. Schneider, published in the journal *Science* in July 1971. Titled "Atmospheric Carbon Dioxide and Aerosols: Effects of Large Increases on Global Climate," the paper examined the possible future effects of two types of human environmental emissions:

1. greenhouse gases such as carbon dioxide;

2. particulate pollution such as smog, some of which remains suspended in the atmosphere in aerosol form for years.

Greenhouse gases were regarded as likely factors that could promote global warming, while particulate pollution blocks sunlight and contributes to cooling. In their paper, Rasool and Schneider theorized that aerosols were more likely to contribute to climate change in the foreseeable future than greenhouse gases, stating that quadrupling aerosols could decrease the mean surface temperature (of Earth) by as much as 3.5 C. If sustained over a period of several years, they calculated, such a temperature decrease could be sufficient to trigger an ice age.

1972 and 1974 National Science Board

The National Science Board's *Patterns and Perspectives in Environmental Science* report of 1972 discussed the cyclical behavior of climate, and the understanding at the time that the planet was entering a phase of cooling after a warm period. "Judging from the record of the past interglacial ages, the present time of high temperatures should be drawing to an end, to be followed by a long period of considerably colder temperatures leading into the next glacial age some 20,000 years from now." But it also continued; "However, it is possible, or even likely, that human interference has already altered the environment so much that the climatic pattern of the near future will follow a different path."

The Board's report of 1974, *Science And The Challenges Ahead*, continued on this theme. "During the last 20-30 years, world temperature has fallen, irregularly at first but more sharply over the last decade." However discussion of cyclic glacial periods does not feature in this report. Instead it is the role of man that is central to the report's analysis. "The cause of the cooling trend is not known with certainty. But there is increasing concern that man himself may be implicated, not only in the recent cooling trend but also in the warming temperatures over the last century". The report can not conclude whether carbon dioxide in warming, or agricultural and industrial pollution in cooling, are factors in the recent climatic changes, noting; "Before such questions as these can be resolved, major advances must be made in understanding the chemistry and physics of the atmosphere and oceans, and in measuring and tracing particulates through the system."

1975 National Academy of Sciences report

There also was a study by the U.S. National Academy of Sciences about issues that needed more research. This heightened interest in the fact that climate can change. The 1975 NAS report titled "Understanding Climate Change: A Program for Action" did not make predictions, stating in fact that "we do not have a good quantitative understanding of our climate machine and what determines its course. Without the fundamental understanding, it does not seem possible to predict climate." Its "program for action" consisted simply of a call for further research, because "it is only through the use of adequately calibrated numerical models that we can hope to acquire the information necessary for a quantitative assessment of the climatic impacts."

The report further stated:

The climates of the earth have always been changing, and they will doubtless continue to do so in the future. How large these future changes will be, and where and how rapidly they will occur, we do not know..

This is not consistent with claims like those of Science & Environmental Policy Project (SEPP) that "the NAS "experts" exhibited ... hysterical fears" in the 1975 report.

1974 Time Magazine article

While these discussions were ongoing in scientific circles, other accounts appeared in the popular media. In their June 24, 1974 issue, Time presented an article titled *Another Ice Age?* that noted "the atmosphere has been growing gradually cooler for the past three decades" but noted that "Some scientists... think that the cooling trend may be only temporary"

1975 Newsweek article

An April 28, 1975 article in *Newsweek* magazine was titled "The Cooling World", it pointed to "ominous signs that the Earth's weather patterns have begun to change" and pointed to "a drop of half a degree [Fahrenheit] in average ground temperatures in the Northern Hemisphere between 1945 and 1968." Here we, claimed "The evidence in support of these predictions [of global cooling] has now begun to accumulate so massively that meteorologists are hard-pressed to keep up with it." The *Newsweek* article did not state the cause of cooling; it stated that "what causes the onset of major and minor ice ages remains a mystery" and cited the NAS conclusion that "not only are the basic scientific questions largely unanswered, but in many cases we do not yet know enough to pose the key questions."

Here mentioned the alternative solutions of "melting the Arctic ice cap by covering it with black soot or diverting Arctic rivers" but conceded these were not feasible. The *Newsweek* article concluded by criticizing government leaders: "But the scientists see few signs that government leaders anywhere are even prepared to take the simple measures of stockpiling food or of introducing the variables of climatic uncertainty into economic projections of future food supplies...The longer the planners (politicians) delay, the more difficult will they find it to cope with climatic change once the results become grim reality." Emphasized sensational and largely unsourced consequences - "resulting famines could be catastrophic", "drought and desolation," "the most devastating outbreak of tornadoes ever recorded", "droughts, floods, extended dry spells, long freezes, delayed monsoons," "impossible for starving peoples to migrate," "the present decline has taken the planet about a sixth of the way toward the Ice Age."

On October 23, 2006, Newsweek issued a correction, over 31 years after the original article, stating that it had been "so spectacularly wrong about the near-term future"

(though editor Jerry Adler claimed that 'the story wasn't "wrong" in the journalistic sense of "inaccurate."').

Other 1970s sources

In the late 1970s there were several popular books on the topic, including *The Weather Conspiracy: The Coming of the New Ice Age*.

1979 WMO conference

Later in the decade, at a WMO conference in 1979, F K Hare reported that:

Fig 8 shows [...] 1938 the warmest year. They [temperatures] have since fallen by about 0.4 °C. At the end there is a suggestion that the fall ceased in about 1964, and may even have reversed.

Figure 9 challenges the view that the fall of temperature has ceased [...] the weight of evidence clearly favours cooling to the present date [...] The striking point, however, is that interannual variability of world temperatures is much larger than the trend [...] it is difficult to detect a genuine trend [...]

It is questionable, moreover, whether the trend is truly global. Calculated variations in the 5-year mean air temperature over the southern hemisphere chiefly with respect to land areas show that temperatures generally rose between 1943 and 1975. Since the 1960-64 period this rise has been strong [...] the scattered SH data fail to support a hypothesis of continued global cooling since 1938. [p 65]

More recent climate cooling predictions

1980s

Concerns about nuclear winter arose in the early 1980s from several reports. Similar speculations have appeared over effects due to catastrophes such as asteroid impacts and massive volcanic eruptions. A prediction that massive oil well fires in Kuwait would cause significant effects on climate was quite incorrect.

1990s

The idea of a global cooling as the result of global warming was already proposed in the 1990s. In 2003, the Office of Net Assessment at the United States Department of Defense was commissioned to produce a study on the likely and potential effects of a modern climate change, especially of a shutdown of thermohaline circulation. The study, conducted under ONA head Andrew Marshall, modelled its prospective climate change on the 8.2 kiloyear event, precisely because it was the middle alternative between the Younger Dryas and the Little Ice Age. The study caused controversy in the media when it was made public in 2004. However, scientists acknowledge that “abrupt climate change initiated by GIS melting is not a realistic scenario for the 21st century.”.

Present level of knowledge

Currently, the concern that cooler temperatures would continue, and perhaps at a faster rate, has been observed to be incorrect by the IPCC. More has to be learned about climate, but the growing records have shown that the cooling concerns of 1975 have not been borne out.

As for the prospects of the end of the current interglacial (again, valid only in the absence of human perturbations) : it isn't true that interglacials have previously only lasted about 10,000 years; and Milankovitch-type calculations indicate that the present interglacial would probably continue for tens of thousands of years naturally. Other estimates (Loutre and Berger, based on orbital calculations) put the unperturbed length of the present interglacial at 50,000 years. Berger (EGU 2005 presentation) believes that the present CO₂ perturbation will last long enough to suppress the next glacial cycle entirely.

As the NAS report indicates, scientific knowledge regarding climate change was more uncertain than it is today. At the time that Rasool and Schneider wrote their 1971 paper, climatologists had not yet recognized the significance of greenhouse gases other than water vapor and carbon dioxide, such as methane, nitrous oxide, and chlorofluorocarbons. Early in that decade, carbon dioxide was the only widely studied human-influenced greenhouse gas. The attention drawn to atmospheric gases in the 1970s stimulated many discoveries in future decades. As the temperature pattern changed, global cooling was of waning interest by 1979.

Chapter- 6

Global Dimming

Global dimming is the gradual reduction in the amount of global direct irradiance at the Earth's surface that was observed for several decades after the start of systematic measurements in the 1950s. The effect varies by location, but worldwide it has been estimated to be of the order of a 4% reduction over the three decades from 1960–1990. However, after discounting an anomaly caused by the eruption of Mount Pinatubo in 1991, a very slight reversal in the overall trend has been observed.

It is thought to have been caused by an increase in particulates such as sulfate aerosols in the atmosphere due to human action. The switch from a "global dimming" trend to a "brightening" trend in 1990 happened just as global aerosol levels started to decline.

Global dimming has interfered with the hydrological cycle by reducing evaporation and may have reduced rainfall in some areas. Global dimming also creates a cooling effect that may have partially masked the effect of greenhouse gases on global warming.

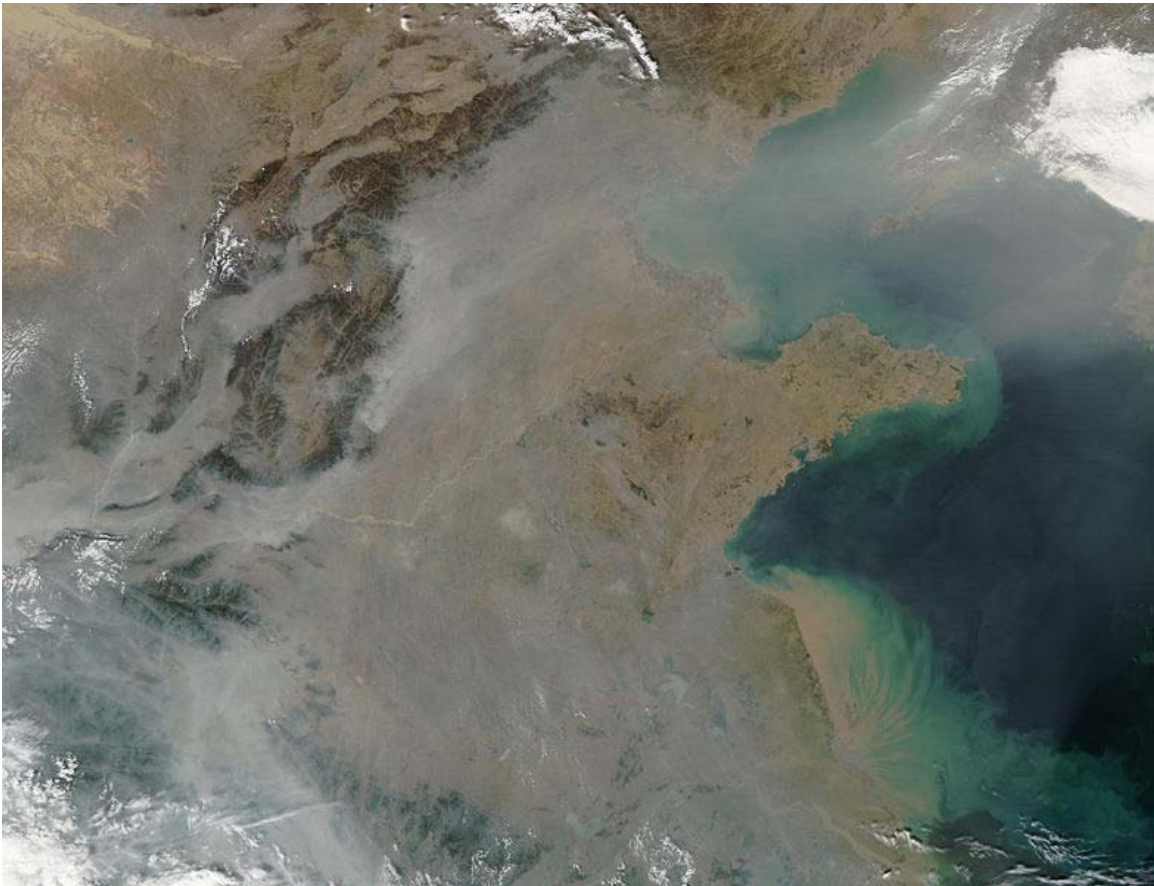
Deliberate manipulation of this dimming effect is now being considered as a geoengineering technique to reduce the impact of global warming.

Causes and effects

It is thought that global dimming is probably due to the increased presence of aerosol particles in the atmosphere caused by human action. Aerosols and other particulates absorb solar energy and reflect sunlight back into space. The pollutants can also become nuclei for cloud droplets. Water droplets in clouds coalesce around the particles. Increased pollution causes more particulates and thereby creates clouds consisting of a greater number of smaller droplets (that is, the same amount of water is spread over more droplets). The smaller droplets make clouds more reflective, so that more incoming sunlight is reflected back into space and less reaches the Earth's surface. In models, these smaller droplets also decrease rainfall.

Clouds intercept both heat from the sun and heat radiated from the Earth. Their effects are complex and vary in time, location, and altitude. Usually during the daytime the interception of sunlight predominates, giving a cooling effect; however, at night the re-radiation of heat to the Earth slows the Earth's heat loss.

Research



Eastern China. Dozens of fires burning on the surface (red dots) and a thick pall of smoke and haze (greyish pixels) filling the skies overhead. Photo taken by MODIS aboard

In the late-1960s, Mikhail Ivanovich Budyko worked with simple two-dimensional energy-balance climate models to investigate the reflectivity of ice. He found that the ice-albedo feedback created a positive feedback loop in the Earth's climate system. The more snow and ice, the more solar radiation is reflected back into space and hence the colder Earth grows and the more it snows. Other studies found that pollution or a volcano eruption could provoke the onset of an ice age.

In the mid-1980s, Atsumu Ohmura, a geography researcher at the Swiss Federal Institute of Technology, found that solar radiation striking the Earth's surface had declined by more than 10% over the three previous decades. His findings appeared to contradict global warming—the global temperature had been generally rising since the 70s. Less light reaching the earth seemed to mean that it should cool. Ohmura published his findings "Secular variation of global radiation in Europe" in 1989. This was soon followed by others: Viivi Russak in 1990 "Trends of solar radiation, cloudiness and atmospheric transparency during recent decades in Estonia", and Beate Liepert in 1994

"Solar radiation in Germany — Observed trends and an assessment of their causes". Dimming has also been observed in sites all over the former Soviet Union. Gerry Stanhill who studied these declines worldwide in many papers coined the term "global dimming".

Independent research in Israel and the Netherlands in the late 1980s showed an apparent reduction in the amount of sunlight, despite widespread evidence that the climate was actually becoming hotter. The rate of dimming varies around the world but is on average estimated at around 2–3% per decade. The trend reversed in the early 1990s. It is difficult to make a precise measurement, due to the difficulty in accurately calibrating the instruments used, and the problem of spatial coverage. Nonetheless, the effect is almost certainly present.

The effect (2–3%, as above) is due to changes within the Earth's atmosphere; the value of the solar radiation at the top of the atmosphere has not changed by more than a fraction of this amount.



Smog at the Golden Gate Bridge. Smog is a likely contributor to global dimming.

The effect varies greatly over the planet, but estimates of the terrestrial surface average value are:

- 5.3% (9 W/m²); over 1958–85 (Stanhill and Moreshet, 1992)
- 2%/decade over 1964–93 (Gilgen *et al.*, 1998)
- 2.7%/decade (total 20 W/m²); up to 2000 (Stanhill and Cohen, 2001)
- 4% over 1961–90 (Liepert 2002)

Note that these numbers are for the terrestrial surface and not really a global average. Whether dimming (or brightening) occurred over the ocean has been a bit of an unknown though a specific measurement measured effects some 400 miles (643.7 km) from India over the Indian Ocean towards the Maldives Islands. Regional effects probably dominate but are not strictly confined to the land area, and the effects will be driven by regional air circulation. A 2009 review by Wild *et al.* found that widespread variation in regional and time effects. There was solar brightening beyond 2000 at numerous stations in Europe, the United States, and Korea. The brightening seen at sites in Antarctica during the 1990s, influenced by recovering from the Mount Pinatubo volcanic eruption in 1991, fades after 2000. The brightening tendency also seems to level off at sites in Japan. In China there is some indication for a renewed dimming, after the stabilization in the

1990s. A continuation of the long-lasting dimming is also noted at the sites in India. Overall, the available data suggest continuation of the brightening beyond the year 2000 at numerous locations, yet less pronounced and coherent than during the 1990s, with more regions with no clear changes or declines. Therefore, globally, greenhouse warming after 2000 may be less modulated by surface solar variations than in prior decades. The largest reductions are found in the northern hemisphere mid-latitudes. Visible light and infrared radiation seem to be most affected rather than the ultraviolet part of the spectrum.

Pan evaporation data

Over the last 50 or so years, pan evaporation has been carefully monitored. For decades, nobody took much notice of the pan evaporation measurements. But in the 1990s in Europe, Israel, and North America, scientists spotted something that at the time was considered very strange: the rate of evaporation was falling although they had expected it to increase due to global warming. The same trend has been observed in China over a similar period. A decrease in solar irradiance is cited as the driving force. However, unlike in other areas of the world, in China the decrease in solar irradiance was not always accompanied by an increase in cloud cover and precipitation. It is believed that aerosols may play a critical role in the decrease of solar irradiance in China.

BBC Horizon producer David Sington believes that many climate scientists regard the pan-evaporation data as the most convincing evidence of solar dimming. Pan evaporation experiments are easy to reproduce with low-cost equipment, there are many pans used for agriculture all over the world and in many instances the data has been collected for nearly a half century. However, pan evaporation depends on some additional factors besides net radiation from the sun. The other two major factors are vapor pressure deficit and wind speed. The ambient temperature turns out to be a negligible factor. The pan evaporation data corroborates the data gathered by radiometer and fills in the gaps in the data obtained using pyranometers. With adjustments to these factors, pan evaporation data has been compared to results of climate simulations.

Probable causes



NASA photograph showing aircraft contrails and natural clouds. The temporary disappearance of contrails over North America due to plane groundings after the September 11, 2001 attacks, and the resulting increase in diurnal temperature range gave empirical evidence of the effect of thin ice clouds at the Earth's surface.

The incomplete combustion of fossil fuels (such as diesel) and wood releases black carbon into the air. Though black carbon, most of which is soot, is an extremely small component of air pollution at land surface levels, the phenomenon has a significant heating effect on the atmosphere at altitudes above two kilometers (6,562 ft). Also, it dims the surface of the ocean by absorbing solar radiation.

Experiments in the Maldives (comparing the atmosphere over the northern and southern islands) in the 1990s showed that the effect of macroscopic pollutants in the atmosphere at that time (blown south from India) caused about a 10% reduction in sunlight reaching the surface in the area under the pollution cloud — a much greater reduction than expected from the presence of the particles themselves. Prior to the research being undertaken, predictions were of a 0.5–1% effect from particulate matter; the variation from prediction may be explained by cloud formation with the particles acting as the focus for droplet creation. Clouds are very effective at reflecting light back out into space.

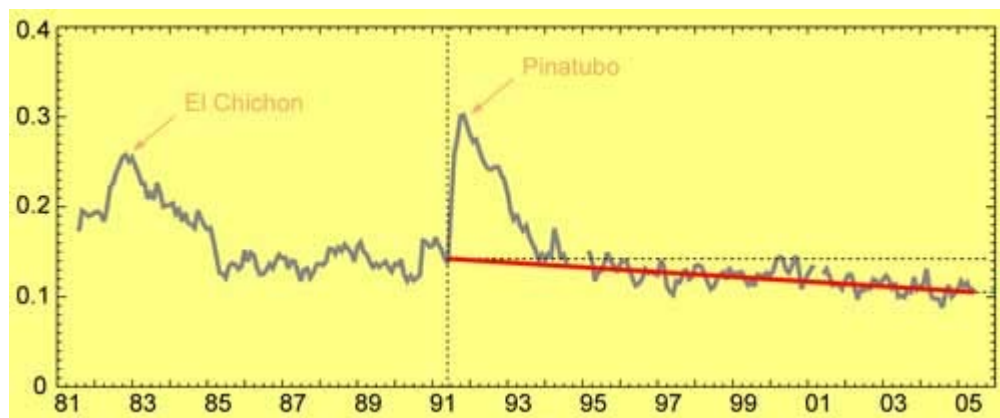
The phenomenon underlying global dimming may also have regional effects. While most of the earth has warmed, the regions that are downwind from major sources of air pollution (specifically sulfur dioxide emissions) have generally cooled. This may explain the cooling of the eastern United States relative to the warming western part.

However some research shows that black carbon will actually increase global warming, being second only to CO₂. They believe that soot will absorb solar energy and transport it to other areas such as the Himalayas where glacial melting occurs. It can also darken Arctic ice reducing reflectivity and increasing absorption of solar radiation.

Some climate scientists have theorized that aircraft contrails (also called vapor trails) are implicated in global dimming, but the constant flow of air traffic previously meant that this could not be tested. The near-total shutdown of civil air traffic during the three days following the September 11, 2001 attacks afforded a unique opportunity in which to observe the climate of the United States absent from the effect of contrails. During this period, an increase in diurnal temperature variation of over 1 °C (1.8 °F) was observed in some parts of the U.S., i.e. aircraft contrails may have been raising nighttime temperatures and/or lowering daytime temperatures by much more than previously thought.

Airborne volcanic ash can reflect the Sun's rays back into space and thereby contribute to cooling the planet. Dips in earth temperatures have been observed after large volcano eruptions such as Mount Agung in Bali that erupted in 1963, El Chichon (Mexico) 1983, Ruiz (Colombia) 1985, and Pinatubo (Philippines) 1991. But even for major eruptions, the ash clouds remain only for relatively short periods.

Recent reversal of the trend



Sun-blocking aerosols around the world steadily declined (red line) since the 1991 eruption of Mount Pinatubo, according to satellite estimates.

Wild *et al.*, using measurements over land, report brightening since 1990, and Pinker *et al.* found that slight dimming continued over land while brightening occurred over the ocean. Hence, over the land surface, Wild *et al.* and Pinker *et al.* disagree. A 2007 NASA sponsored satellite-based study sheds light on the puzzling observations by other

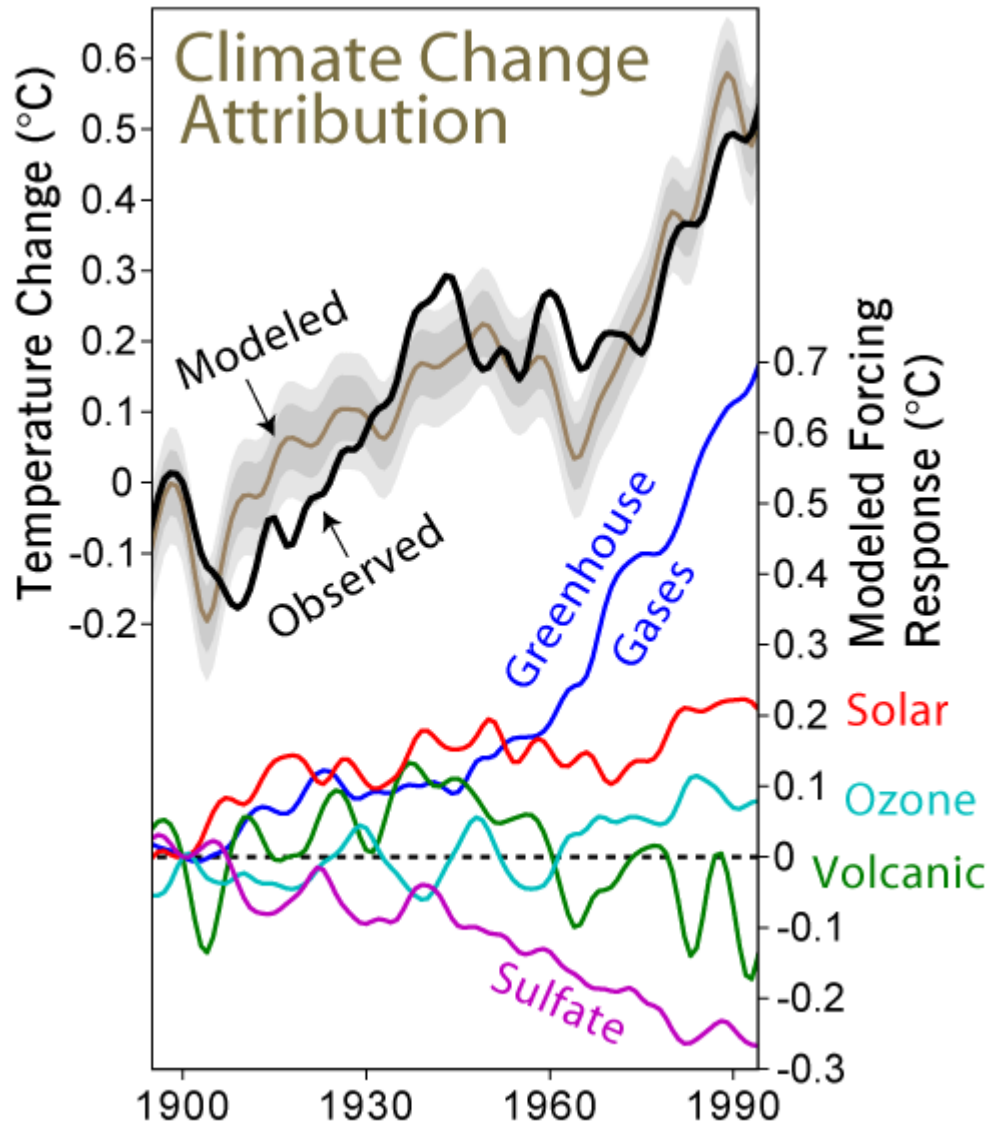
scientists that the amount of sunlight reaching Earth's surface had been steadily declining in recent decades, began to reverse around 1990. This switch from a "global dimming" trend to a "brightening" trend happened just as global aerosol levels started to decline.

It is likely that at least some of this change, particularly over Europe, is due to decreases in airborne pollution. Most governments of developed nations have taken steps to reduce aerosols released into the atmosphere, which helps reduce global dimming.

Sulfate aerosols have declined significantly since 1970 with the Clean Air Act in the United States and similar policies in Europe. The Clean Air Act was strengthened in 1977 and 1990. According to the EPA, from 1970 to 2005, total emissions of the six principal air pollutants, including PM's, dropped by 53% in the US. In 1975, the masked effects of trapped greenhouse gases finally started to emerge and have dominated ever since.

The Baseline Surface Radiation Network (BSRN) has been collecting surface measurements. BSRN was started in the early 1990s and updated the archives in this time. Analysis of recent data reveals that the surface of the planet has brightened by about 4% in the past decade. The brightening trend is corroborated by other data, including satellite analyses.

Relationship to hydrological cycle



This figure shows the level of agreement between a climate model driven by five factors and the historical temperature record. The negative component identified as "sulfate" is associated with the aerosol emissions blamed for global dimming.

Pollution produced by humans may be seriously weakening the Earth's water cycle — reducing rainfall and threatening fresh water supplies. A 2001 study by researchers at the Scripps Institution of Oceanography suggests that tiny particles of soot and other pollutants have a significant effect on the hydrological cycle. According to Veerabhadran Ramanathan, "the energy for the hydrological cycle comes from sunlight. As sunlight heats the ocean, water escapes into the atmosphere and falls out as rain. So as aerosols cut down sunlight by large amounts, they may be spinning down the hydrological cycle of the planet."

Large scale changes in weather patterns may also have been caused by global dimming. Climate modelers speculatively suggest that this reduction in solar radiation at the surface may have led to the failure of the monsoon in sub-Saharan Africa during the 1970s and 1980s, together with the associated famines such as the Sahel drought, caused by Northern hemisphere pollution cooling the Atlantic. Because of this, the Tropical rain belt may not have risen to its northern latitudes, thus causing an absence of seasonal rains. This claim is not universally accepted and is very difficult to test. However a 2009 Chinese study of 50 years of continuous data found that though most parts of eastern China saw no significant change in the amount of water held by the atmosphere but light rains had decreased. In addition, where the atmosphere transported water vapor didn't coincide with light rain frequency. The researchers then modeled the effect of aerosols and also concluded the overall effect was that water drops in polluted cases are up to 50 percent smaller than in pristine skies. They concluded smaller size impedes the formation of rain clouds and the falling of light rain beneficial for agriculture; a different effect than reducing solar irradiance, but still a direct result from the presence of aerosols.

The 2001 study by researchers at the Scripps Institution of Oceanography concluded that the imbalance between global dimming and global warming at the surface leads to weaker turbulent heat fluxes to the atmosphere. This means globally reduced evaporation and hence precipitation occur in a dimmer and warmer world, which could ultimately lead to a more humid atmosphere in which it rains less.

A natural form of large scale environmental shading/dimming has been identified that affected the 2006 northern hemisphere hurricane season. The NASA study found that several major dust storms in June and July in the Sahara desert sent dust drifting over the Atlantic Ocean and through several effects caused cooling of the waters — and thus dampening the development of hurricanes.

Relationship to global warming

Some scientists now consider that the effects of global dimming have masked the effect of global warming to some extent and that resolving global dimming may therefore lead to increases in predictions of future temperature rise. According to Beate Liepert, "We lived in a global warming plus a global dimming world and now we are taking out global dimming. So we end up with the global warming world, which will be much worse than we thought it will be, much hotter." The magnitude of this masking effect is one of the central problems in climate change with significant implications for future climate changes and policy responses to global warming.

Interactions between the two theories for climate modification have also been studied, as global warming and global dimming are neither mutually exclusive nor contradictory. In a paper published on March 8, 2005 in the American Geophysical Union's Geophysical Research Letters, a research team led by Anastasia Romanou of Columbia University's Department of Applied Physics and Mathematics, New York, also showed that the apparently opposing forces of global warming and global dimming can occur at the same time. Global dimming interacts with global warming by blocking sunlight that would

otherwise cause evaporation and the particulates bind to water droplets. Water vapor is the major greenhouse gas. On the other hand, global dimming is affected by evaporation and rain. Rain has the effect of clearing out polluted skies.

Brown clouds have been found to amplify global warming according to Veerabhadran Ramanathan, an atmospheric chemist at the Scripps Institution of Oceanography in La Jolla, CA. "The conventional thinking is that brown clouds have masked as much as 50 percent of global warming by greenhouse gases through so-called global dimming... While this is true globally, this study reveals that over southern and eastern Asia, the soot particles in the brown clouds are in fact amplifying the atmospheric warming trend caused by greenhouse gases by as much as 50 percent."

Possible use to mitigate global warming

Some scientists have suggested using aerosols to stave off the effects of global warming as an emergency geoengineering measure. In 1974, Mikhail Budyko suggested that if global warming became a problem, the planet could be cooled by burning sulfur in the stratosphere, which would create a haze. An increase in planetary albedo of just 0.5 percent is sufficient to halve the effect of a CO₂ doubling.

The simplest solution would be to simply emit more sulfates, which would end up in troposphere - the lowest part of the atmosphere. If this was done, Earth would still face many problems, such as:

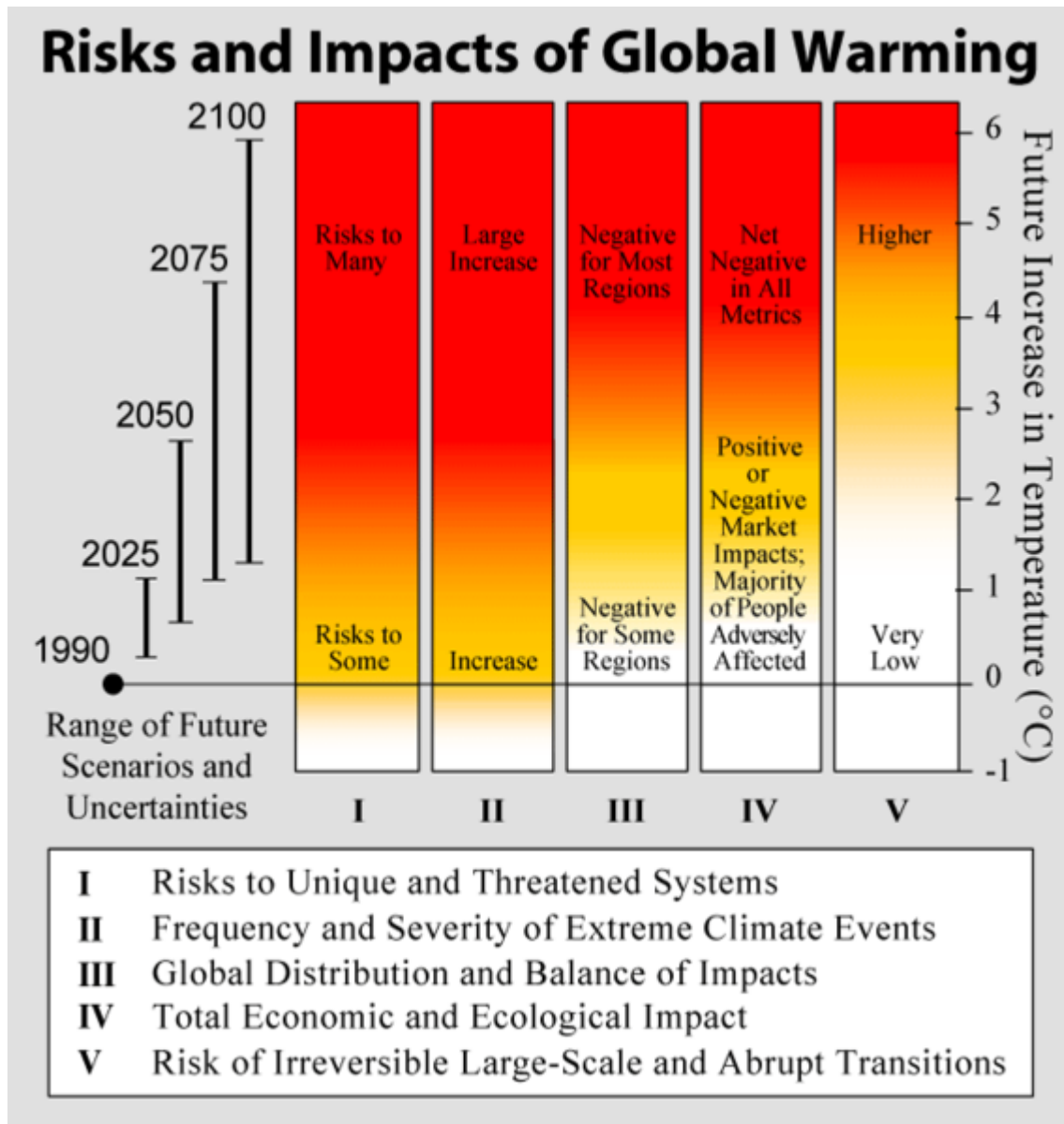
- Using sulfates causes environmental problems such as acid rain
- Using carbon black causes human health problems
- Dimming causes ecological problems such as changes in evaporation and rainfall patterns
- Droughts and/or increased rainfall cause problems for agriculture
- Aerosol has a relatively short lifetime

The solution actually advocated is transporting sulfates into the next higher layer of the atmosphere - stratosphere. Aerosols in the stratosphere last years instead of weeks - so only a relatively smaller (though still large) amount of sulfate emissions would be necessary, and side effects would be less. This would require developing an efficient way to transport large amounts of gases into stratosphere, many of which have been proposed though none are known to be effective or economically viable.

In a blog post, Gavin Schmidt stated that "Ideas that we should increase aerosol emissions to counteract global warming have been described as a 'Faustian bargain' because that would imply an ever increasing amount of emissions in order to match the accumulated greenhouse gas in the atmosphere, with ever increasing monetary and health costs."

Chapter- 7

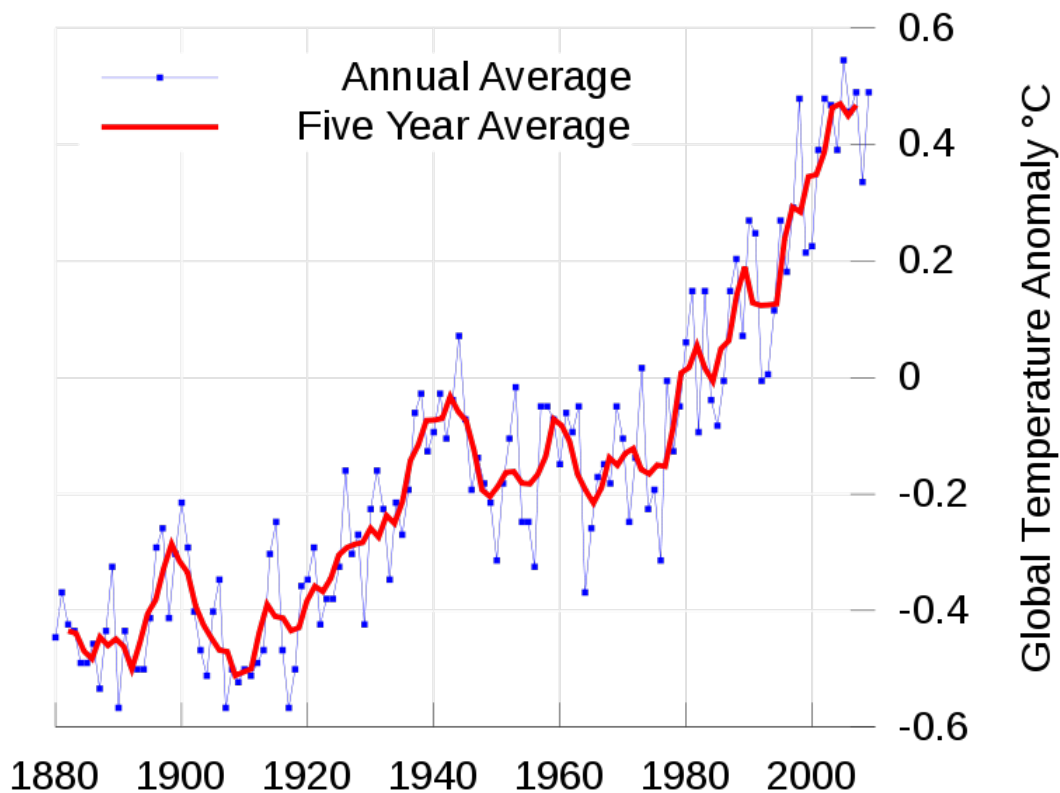
Effects of Global Warming



Graphical description of risks and impacts of climate change by IPCC (2001). A revision of this figure by Smith *et al.* (2009) shows increased risks.

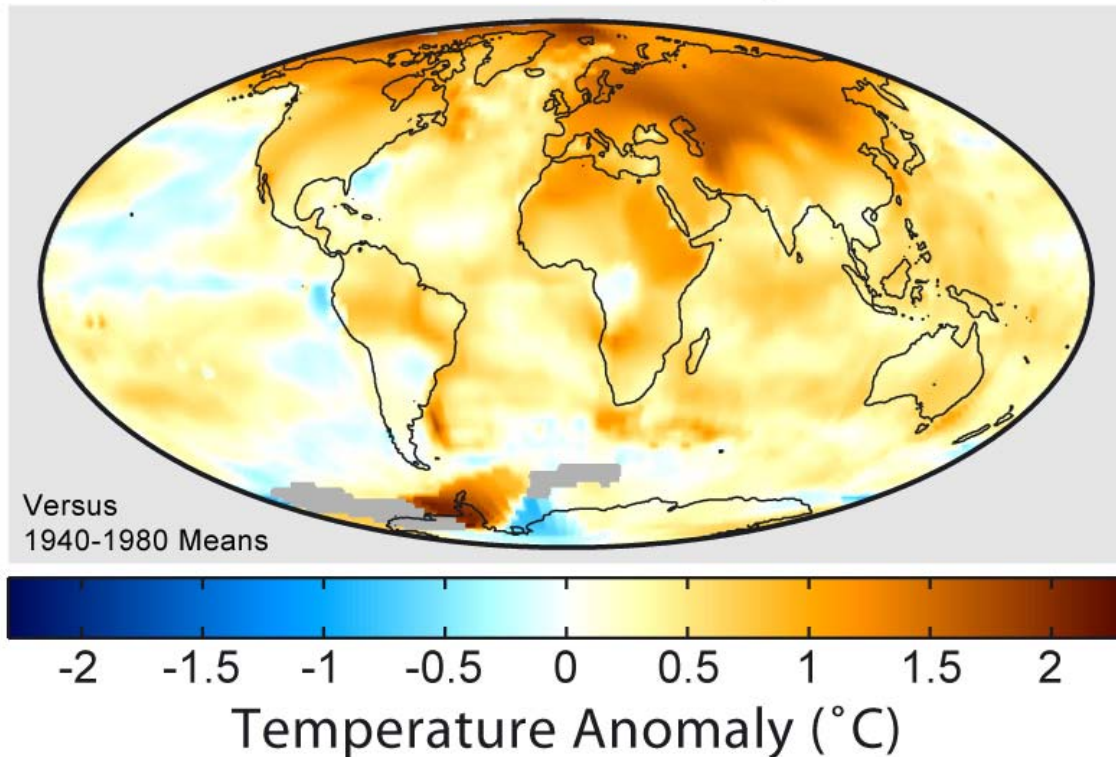
Here we, explain about the **effects of global warming** and climate change. The effects, or impacts, of climate change may be physical, ecological, social or economic. Evidence of observed climate change includes the instrumental temperature record, rising sea levels, and decreased snow cover in the Northern Hemisphere. According to IPCC (2007a:10), "[most] of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in [human greenhouse gas] concentrations". It is predicted that future climate changes will include further global warming (i.e., an upward trend in global mean temperature), sea level rise, and a probable increase in the frequency of some extreme weather events. Signatories of the United Nations Framework Convention on Climate Change have agreed to implement policies designed to reduce their emissions of greenhouse gases.

Overview



Global mean surface temperature difference from the average for 1880-2009

1999-2008 Mean Temperatures



Mean surface temperature change for the period 1999 to 2008 relative to the average temperatures from 1940 to 1980

Over the last hundred years or so, the instrumental temperature record has shown a trend in climate of increased global mean temperature, i.e., global warming. Other observed changes include Arctic shrinkage, Arctic methane release, releases of terrestrial carbon from permafrost regions and Arctic methane release in coastal sediments, and sea level rise. Global average temperature is predicted to increase over this century, with a probable increase in frequency of some extreme weather events, and changes in rainfall patterns. Moving from global to regional scales, there is increased uncertainty over how climate will change. The probability of warming having unforeseen consequences increases with the rate, magnitude, and duration of climate change. Some of the physical impacts of climate change are irreversible at continental and global scales. With medium confidence, IPCC (2007b:17) concluded that with a global average temperature increase of 1–4°C, (relative to 1990–2000) partial deglaciation of the Greenland ice sheet would occur over a period of centuries to millennia. Including the possible contribution of partial deglaciation of the West Antarctic Ice Sheet, sea level would rise by 4–6 m or more.

The impacts of climate change across world population will not be distributed evenly (Smith *et al.*, 2001:957). Some regions and sectors are expected to experience benefits while others will experience costs. With greater levels of warming (greater than 2–3°C by 2100, relative to 1990 temperature levels), it is very likely that benefits will decline and

costs increase (IPCC, 2007b:17). Low-latitude and less-developed areas are probably at the greatest risk from climate change (Schneider *et al.*, 2007:781). With human systems, adaptation potential for climate change impacts is considerable, although the costs of adaptation are largely unknown and potentially large. In a literature assessment, Schneider *et al.* (2007:792) concluded, with high confidence, that climate change would likely result in reduced diversity of ecosystems and the extinction of many species.

Definition of climate change

Here we refer to reports produced by the IPCC. In their usage, "climate change" refers to a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties, and that persists for extended periods, typically decades or longer (IPCC, 2007d:30). The climate change referred to may be due to natural causes or the result of human activity.

Effects on weather

Increasing temperature is likely to lead to increasing precipitation but the effects on storms are less clear. Extratropical storms partly depend on the temperature gradient, which is predicted to weaken in the northern hemisphere as the polar region warms more than the rest of the hemisphere.

Extreme weather

IPCC (2007a:8) predicted that in the future, over most land areas, the frequency of warm spells or heat waves would very likely increase. Other likely changes are listed below:

- Increased areas will be affected by drought
- There will be increased intense tropical cyclone activity
- There will be increased incidences of extreme high sea level (excluding tsunamis)

Increased freshwater flow

Research based on satellite observations, published in October, 2010, shows an increase in the flow of freshwater into the world's oceans, partly from melting ice and partly from increased precipitation driven by an increase in global ocean evaporation. The increase in global freshwater flow, based on data from 1994 to 2006, was about 18%. Much of the increase is in areas which already experience high rainfall. One effect, as perhaps experienced in the 2010 Pakistan floods, is to overwhelm flood control infrastructure.

Local climate change



The first recorded South Atlantic hurricane, "Catarina", which hit Brazil in March 2004

Regional effects of global warming vary in nature. Some are the result of a generalised global change, such as rising temperature, resulting in local effects, such as melting ice. In other cases, a change may be related to a change in a particular ocean current or weather system. In such cases, the regional effect may be disproportionate and will not necessarily follow the global trend.

There are three major ways in which global warming will make changes to regional climate: melting or forming ice, changing the hydrological cycle (of evaporation and precipitation) and changing currents in the oceans and air flows in the atmosphere. The coast can also be considered a region, and will suffer severe impacts from sea level rise.

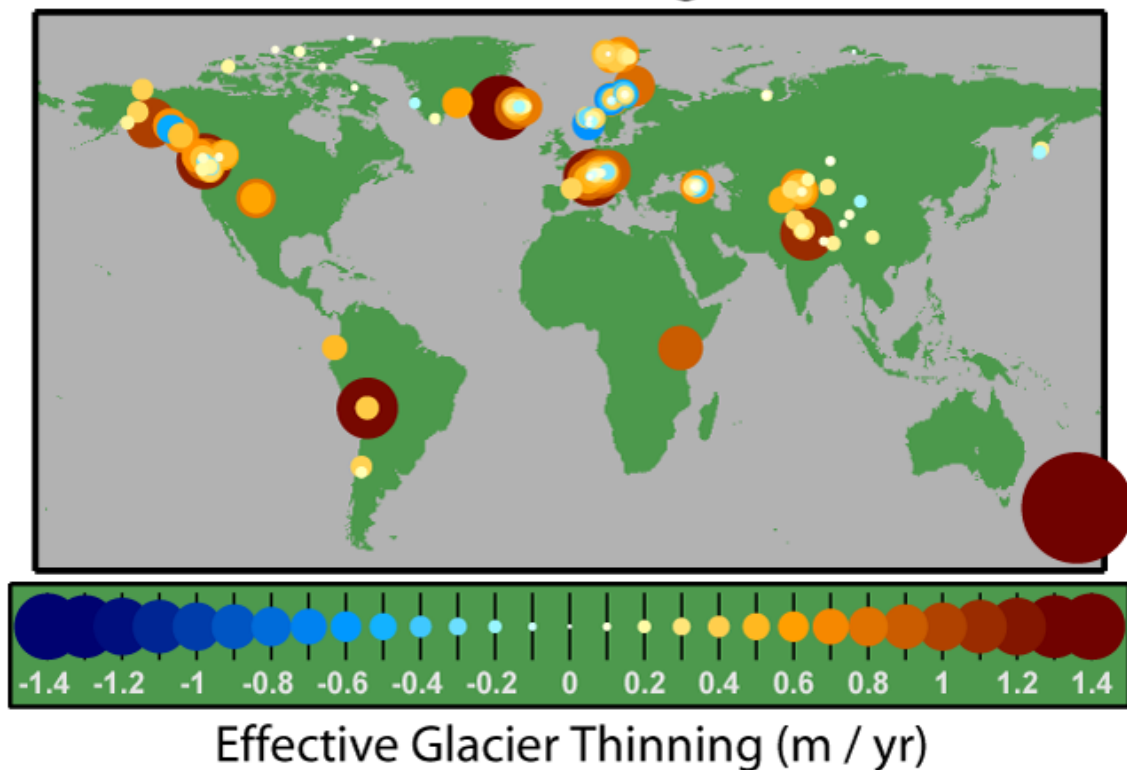
Biogeochemical cycles

Climate change may have an effect on the carbon cycle in an interactive "feedback" process. A feedback exists where an initial process triggers changes in a second process that in turn influences the initial process. A positive feedback intensifies the original process, and a negative feedback reduces it (IPCC, 2007d:78). Models suggest that the interaction of the climate system and the carbon cycle is one where the feedback effect is positive (Schneider *et al.*, 2007:792).

Using the A2 SRES emissions scenario, Schneider *et al.* (2007:789) found that this effect led to additional warming by 2100, relative to the 1990-2000 period, of 0.1 to 1.5 °C. This estimate was made with high confidence. The climate projections made in the IPCC Fourth Assessment Report of 1.1 to 6.4 °C account for this feedback effect. On the other hand, with medium confidence, Schneider *et al.* (2007) commented that additional releases of GHGs were possible from permafrost, peat lands, wetlands, and large stores of marine hydrates at high latitudes.

Glacier retreat and disappearance

Mountain Glacier Changes Since 1970



A map of the change in thickness of mountain glaciers since 1970. Thinning in orange and red, thickening in blue.

IPCC (2007a:5) found that, on average, mountain glaciers and snow cover had decreased in both the northern and southern hemispheres. This widespread decrease in glaciers and ice caps has contributed to observed sea level rise. With very high or high confidence, IPCC (2007d:11) made a number of predictions relating to future changes in glaciers:

- Mountainous areas in Europe will face glacier retreat
- In Latin America, changes in precipitation patterns and the disappearance of glaciers will significantly affect water availability for human consumption, agriculture, and energy production
- In Polar regions, there will be reductions in glacier extent and the thickness of glaciers.

Oceans

The role of the oceans in global warming is a complex one. The oceans serve as a sink for carbon dioxide, taking up much that would otherwise remain in the atmosphere, but increased levels of CO₂ have led to ocean acidification. Furthermore, as the temperature of the oceans increases, they become less able to absorb excess CO₂. Global warming is projected to have a number of effects on the oceans. Ongoing effects include rising sea levels due to thermal expansion and melting of glaciers and ice sheets, and warming of the ocean surface, leading to increased temperature stratification. Other possible effects include large-scale changes in ocean circulation.

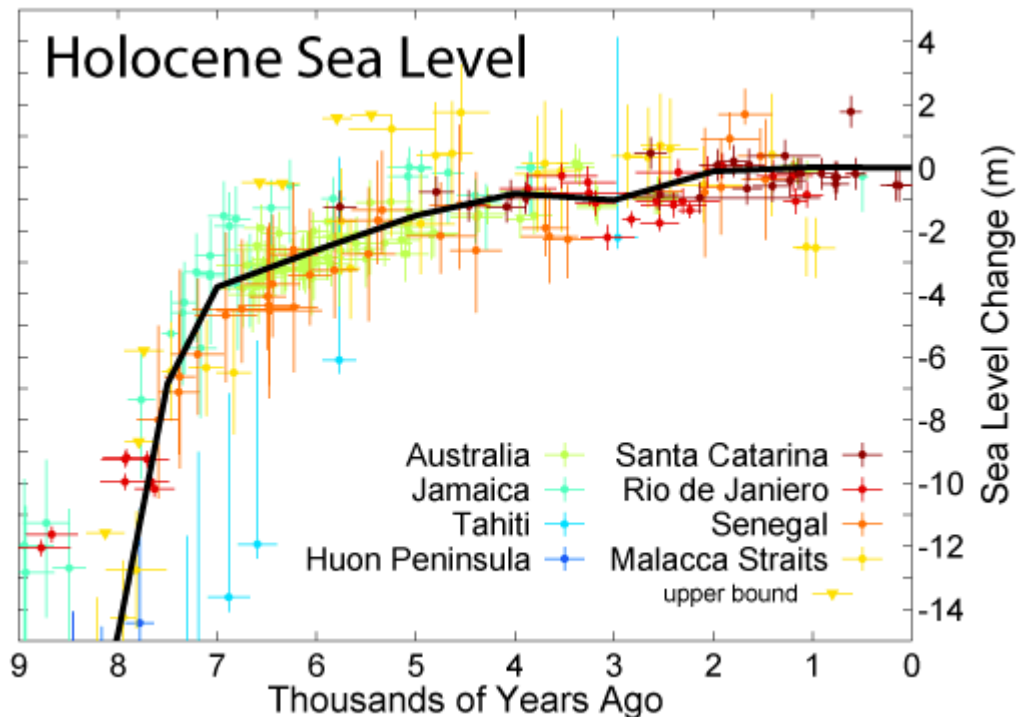
Acidification

Dissolving CO₂ in seawater increases the hydrogen ion (H⁺) concentration in the ocean, and thus decreases ocean pH. Caldeira and Wickett (2003) placed the rate and magnitude of modern ocean acidification changes in the context of probable historical changes during the last 300 million years. Since the industrial revolution began, it is estimated that surface ocean pH has dropped by slightly more than 0.1 units (on the logarithmic scale of pH; approximately a 30% increase in H⁺), and it is estimated that it will drop by a further 0.3 to 0.5 units (more than doubling ocean H⁺ concentrations) by 2100 as the oceans absorb more anthropogenic CO₂.

Oxygen depletion

The amount of oxygen dissolved in the oceans may decline, with adverse consequences for ocean life.

Sea level rise



IPCC (2007a:5) reported that since 1961, global average sea level had risen at an average rate of 1.8 [1.3 to 2.3] mm/yr. Between 1993 and 2003, the rate increased above the previous period to 3.1 [2.4 to 3.8] mm/yr. IPCC (2007a) were uncertain whether the increase in rate from 1993 to 2003 was due to natural variations in sea level over the time period, or whether it reflected an increase in the underlying long-term trend.

IPCC (2007a:13, 14) projected sea level rise to the end of the 21st century using the SRES emission scenarios. Across the six SRES marker scenarios, sea level was projected to rise by 18 to 59 cm (7.1 to 23.2 inches). This projection was for the time period 2090-2099, with the increase in level relative to average sea levels over the 1980-1999 period. Due to a lack of scientific understanding, this sea level rise estimate does not include all of the possible contributions of ice sheets.

Temperature rise

From 1961 to 2003, the global ocean temperature has risen by 0.10 °C from the surface to a depth of 700 m. There is variability both year-to-year and over longer time scales, with global ocean heat content observations showing high rates of warming for 1991 to 2003, but some cooling from 2003 to 2007. The temperature of the Antarctic Southern Ocean rose by 0.17 °C (0.31 °F) between the 1950s and the 1980s, nearly twice the rate for the world's oceans as a whole. As well as having effects on ecosystems (e.g. by melting sea ice, affecting algae that grow on its underside), warming reduces the ocean's ability to absorb CO₂.

Social systems

Food supply

Climate change will impact agriculture and food production around the world due to: the effects of elevated CO₂ in the atmosphere, higher temperatures, altered precipitation and transpiration regimes, increased frequency of extreme events, and modified weed, pest, and pathogen pressure (Easterling *et al.*, 2007:282). In general, low-latitude areas are at most risk of having decreased crop yields (Schneider *et al.*, 2007:790). With low to medium confidence, Schneider *et al.* (2007:787) concluded that for about a 1 to 3°C global mean temperature increase (by 2100, relative to the 1990-2000 average level) there would be productivity decreases for some cereals in low latitudes, and productivity increases in high latitudes. With medium confidence, global production potential was predicted to:

- increase up to around 3°C,
- very likely decrease above about 3 to 4°C.

Most of the studies on global agriculture assessed by Schneider *et al.* (2007:790) had not incorporated a number of critical factors, including changes in extreme events, or the spread of pests and diseases. Studies had also not considered the development of specific practices or technologies to aid adaptation.

Health

Human beings are exposed to climate change through changing weather patterns (temperature, precipitation, sea-level rise and more frequent extreme events) and indirectly through changes in water, air and food quality and changes in ecosystems, agriculture, industry and settlements and the economy (Confalonieri *et al.*, 2007:393). According to a literature assessment by Confalonieri *et al.* (2007:393), the effects of climate change to date have been small, but are projected to progressively increase in all countries and regions.

With high confidence, Confalonieri *et al.* (2007:393) concluded that climate change had altered the seasonal distribution of some allergenic pollen species. With medium confidence, they concluded that climate change had:

- altered the distribution of some infectious disease vectors
- increased heatwave-related deaths

With high confidence, IPCC (2007d:48) projected that:

- the health status of millions of people would be affected through, for example, increases in malnutrition; increased deaths, diseases and injury due to extreme weather events; increased burden of diarrhoeal diseases; increased frequency of cardio-respiratory diseases due to high concentrations of ground-level ozone in

- urban areas related to climate change; and altered spatial distribution of some infectious diseases.
- climate change would bring some benefits in temperate areas, such as fewer deaths from cold exposure, and some mixed effects such as changes in range and transmission potential of malaria in Africa. Overall, IPCC (2007d:48) expected that benefits would be outweighed by negative health effects of rising temperatures, especially in developing countries.

With very high confidence, Confalonieri *et al.* (2007:393) concluded that economic development was an important component of possible adaptation to climate change. Economic growth on its own, however, was not judged to be sufficient to insulate the world's population from disease and injury due to climate change. The manner in which economic growth occurs was judged to be important, along with how the benefits of growth are distributed in society. Examples of other important factors in determining the health of populations were listed as: education, health care, and public-health infrastructure.

Specific health impacts

Malnutrition

With high confidence, Confalonieri *et al.* (2007) projected that malnutrition would increase due to climate change. This link is associated with climate variability and change (Confalonieri *et al.*, 2007). Drought reduces variety in diets and reduces overall consumption. This can lead to micronutrient deficiencies.

The World Health Organization (WHO) (referred to by Confalonieri *et al.*, 2007) conducted a regional and global assessment to quantify the amount of premature morbidity and mortality due to a range of factors, including climate change. Projections were made over future climate change impacts. Limited adjustments for adaptation were included in the estimates based on these projections. Projected relative risks attributable to climate change in 2030 varied by health outcome and region. Risks were largely negative, with most of the projected disease burden due to increases in diarrhoeal disease and malnutrition. These increases were primarily in low-income populations already experiencing a large burden of disease.

Extreme events

With high confidence, Confalonieri *et al.* (2007) projected that climate change would increase the number of people suffering from death, disease and injury from heatwaves, floods, storms, fires and droughts.

Floods and weather disasters

Floods are low-probability, high-impact events that can overwhelm physical infrastructure and human communities (Confalonieri *et al.*, 2007). Major storm and flood disasters have occurred in the last two decades.

The impacts of weather disasters is considerable and unequally distributed. For example, natural disasters have been shown to result in increased domestic violence against - and post-traumatic stress disorders in – women. In terms of deaths and populations affected, floods and tropical cyclones have the greatest impact in South Asia and Latin America. Vulnerability to weather disasters depends on the attributes of the person at risk, including where they live and their age, as well as other social and environmental factors. High-density populations in low-lying coastal regions experience a high health burden from weather disasters.

Heatwaves

Hot days, hot nights and heatwaves have become more frequent (Confalonieri *et al.*, 2007). Heatwaves are associated with marked short-term increases in mortality. For example, in August 2003, a heatwave in Europe resulted in excess mortality in the range of 35,000 total deaths.

Heat-related morbidity and mortality is projected to increase (Confalonieri *et al.*, 2007). The health burden could be relatively small for moderate heatwaves in temperate regions, because deaths occur primarily in susceptible persons.

Drought

The effects of drought on health include deaths, malnutrition, infectious diseases and respiratory diseases (Confalonieri *et al.*, 2007). Countries within the "Meningitis Belt" in semi-arid sub-Saharan Africa experience the highest endemicity and epidemic frequency of meningococcal meningitis in Africa, although other areas in the Rift Valley, the Great Lakes, and southern Africa are also affected (Confalonieri *et al.*, 2007). The spatial distribution, intensity, and seasonality of meningococcal (epidemic) meningitis appear to be strongly linked to climate and environmental factors, particularly drought. The cause of this link is not fully understood.

Fires

In some regions, changes in temperature and precipitation are projected to increase the frequency and severity of fire events (Confalonieri *et al.*, 2007). Forest and bush fires cause burns, damage from smoke inhalation and other injuries.

Infectious disease vectors

With high confidence, Confalonieri *et al.* (2007) projected that climate change would continue to change the range of some infectious disease vectors. Vector-borne diseases (VBD) are infections transmitted by the bite of infected arthropod species, such as

mosquitoes, ticks, triatomine bugs, sandflies, and blackflies (Confalonieri *et al.*, 2007). There is some evidence of climate-change-related shifts in the distribution of tick vectors of disease, of some (non-malarial) mosquito vectors in Europe and North America. Climate change has also been implicated in changes in the breeding and migration dates of several bird species. Several species of wild bird can act as carriers of human pathogens as well as of vectors of infectious agents.

Dengue

It is possible^d that climate change will increase the number of people at risk of dengue (Confalonieri *et al.*, 2007). Based on the expert judgement of Confalonieri *et al.* (2007), this projection had about a two-in-ten chance of being correct. Dengue is the world's most important vector-borne viral disease (Confalonieri *et al.*, 2007). Several studies have reported associations between dengue and climate, however, these associations are not entirely consistent.

Malaria

The spatial distribution, intensity of transmission, and seasonality of malaria is influenced by climate in Sub-saharan Africa (Confalonieri *et al.*, 2007). Rainfall can be a limiting factor for mosquito populations and there is some evidence of reductions in transmission associated with decadal decreases in rainfall. The effects of observed climate change on the geographical distribution of malaria and its transmission intensity in highland regions remains controversial. There is no clear evidence that malaria has been affected by climate change in South America or in continental regions of the Russian Federation. There is still much uncertainty about the potential impact of climate change on malaria at local and global scales.

A paper by researchers from the University of Oxford and the University of Florida published in Nature in May 2010 concluded that claims that a warming climate has led to more widespread disease and death due to malaria are largely at odds with the evidence, and that "*predictions of an intensification of malaria in a warmer world, based on extrapolated empirical relationships or biological mechanisms, must be set against a context of a century of warming that has seen marked global declines in the disease and a substantial weakening of the global correlation between malaria endemicity and climate.*"

Other infectious diseases

There is good evidence that diseases transmitted by rodents sometimes increase during heavy rainfall and flooding because of altered patterns of human-pathogen-rodent contact (Confalonieri *et al.*, 2007).

Projections

With very high confidence, Confalonieri *et al.* (2007) concluded that climate change would have mixed effects on malaria. Malaria is a complex disease to model and all of the published models assessed by Confalonieri *et al.* (2007) had limited parameterization of some key factors. Parameterization is used in climate models because the resolution of models is insufficient to resolve some physical processes (Randall *et al.*, 2007). Given this limitation, models assessed by Confalonieri *et al.* (2007) projected that, particularly in Africa, climate change would be associated with geographical expansions of the areas suitable for *Plasmodium falciparum* malaria in some regions, and contractions in other regions. Projections also suggested that some regions would experience a longer season of transmission. Projections suggested expansions in vector species that carry dengue for parts of Australia and New Zealand.

Diarrhoeal diseases

With medium confidence, Confalonieri *et al.* (2007) concluded that climate change would increase the burden of diarrhoeal diseases. Childhood mortality due to diarrhoea in low-income countries, especially in Sub-Saharan Africa, remains high (Confalonieri *et al.*, 2007). This is despite improvements in care. Several studies have shown that transmission of enteric pathogens is higher during the rainy season. Some studies have found that higher temperature was strongly associated with increased episodes of diarrhoeal disease in adults and children in Peru. The WHO study, referred to earlier, projected that climate change would increase the burden of diarrhoeal diseases in low-income regions by approximately 2 to 5% in 2020 (Confalonieri *et al.*, 2007).

Ground-level ozone

With high confidence, Confalonieri *et al.* (2007) projected that climate change would increase cardio-respiratory morbidity and mortality associated with ground-level ozone. Ground-level ozone is both naturally occurring and is the primary constituent of urban smog (Confalonieri *et al.*, 2007). Ozone in smog is formed through chemical reactions involving nitrogen oxides and other compounds. The reaction is a photochemical reaction, meaning that it involves electromagnetic radiation, and occurs in the presence of bright sunshine and high temperatures. Exposure to elevated concentrations of ozone is associated with increased hospital admissions for pneumonia, chronic obstructive pulmonary disease, asthma, allergic rhinitis and other respiratory diseases, and with premature mortality.

Background levels of ground-level ozone have risen since pre-industrial times because of increasing emissions of methane, carbon monoxide and nitrogen oxides (Confalonieri *et al.*, 2007). This trend is expected to continue into the mid-21st century.

Cold-waves

It is expected that^b climate change will bring some health benefits (Confalonieri *et al.*, 2007). It is expected that these benefits will be outweighed by negative climate change effects.

Cold-waves continue to be a problem in northern latitudes, where very low temperatures can be reached in a few hours and extend over long periods (Confalonieri *et al.*, 2007). Reductions in cold-deaths due to climate change are projected to be greater than increases in heat-related deaths in the UK (Confalonieri *et al.*, 2007).

Water resources

In a literature assessment, Kundzewicz *et al.*. (2007:175) concluded, with high confidence, that:

- the negative impacts of climate change on freshwater systems outweigh the benefits. All of the regions assessed in the IPCC Fourth Assessment Report (Africa, Asia, Australia and New Zealand, Europe, Latin America, North America, Polar regions (Arctic and Antarctic), and small islands) showed an overall net negative impact of climate change on water resources and freshwater ecosystems.
- Semi-arid and arid areas are particularly exposed to the impacts of climate change on freshwater. With very high confidence, it was judged that many of these areas, e.g., the Mediterranean basin, western USA, southern Africa, and north-eastern Brazil, would suffer a decrease in water resources due to climate change.

Migration and conflict

An argument can be made that rising ethnic conflicts may be linked to competition over natural resources that are increasingly scarce as a result of climate change (Wilbanks *et al.*, 2007:365). According to a literature assessment by Wilbanks *et al.*. (2007:365), other factors need to be taken into account. It was suggested that major environmentally influenced conflicts in Africa have more to do with the relative abundance of resources, e.g., oil and diamonds, than with resource scarcity. On this basis, Wilbanks *et al.*. (2007:365) suggested that predictions of future conflicts due climate change should be viewed with caution.

With high confidence, Schneider *et al.*. (2007:787) predicted that stresses such as increased drought, water shortages, and riverine and coastal flooding would affect many local and regional populations. With medium confidence, it was predicted that these stresses would lead, in some cases, to relocation within or between countries. This might have the effect of exacerbating conflicts, and possibly impose migration pressures.

Zhang *et al* also concluded that climate change drives conflict.

Aggregate impacts

Aggregating impacts adds up the total impact of climate change across sectors and/or regions (IPCC, 2007d:76). The impacts of climate change across world population will not be distributed evenly (Smith *et al.*, 2001:957). IPCC (2007b:17) found that for increases in global mean temperature of less than 1-3 °C above 1990 levels, some

impacts were projected to produce benefits in some places and sectors, and produce costs in other places and sectors. For some low-latitude and polar regions, net costs were projected for small increases in temperature. According to IPCC (2007b:17), a temperature increase of greater than about 2-3 °C would very likely result in all regions either experiencing reductions in net benefits or increases in net costs.

Regions

Some regions are likely to be especially affected by climate change (IPCC, 2007d:9):

- The Arctic, because of high rates of projected warming.
- Africa, especially in the sub-Saharan region. This is due to the continent's low capacity to adapt to climate change and projected impacts.
- Small islands, due to high exposure of population and infrastructure at risk to sea-level rise and increased storm surge.
- Asian megadeltas, due to large populations and high exposure to sea-level rise, storm surge and river flooding.

Within other areas, some people are particularly at risk, such as the poor, young children and the elderly.

Biological systems

With very high confidence, Schneider *et al.* (2007:792) concluded that regional temperature trends were already affecting species and ecosystems around the world. In a literature assessment, Rosenzweig *et al.* (2007:81) concluded that over the last three decades, human-induced warming had likely had a discernable influence on many physical and biological systems.

Schneider *et al.* (2007:792) concluded, with high confidence, that climate change would result in the extinction of many species and a reduction in the diversity of ecosystems.

- **Terrestrial ecosystems and biodiversity:** With a warming of 3°C, relative to 1990 levels, it is likely that global terrestrial vegetation would become a net source of carbon (Schneider *et al.*, 2007:792). With high confidence, Schneider *et al.* (2007:788) concluded that a global mean temperature increase of around 4°C (above the 1990-2000 level) by 2100 would lead to major extinctions around the globe.
- **Marine ecosystems and biodiversity:** With very high confidence, Schneider *et al.* (2007:792) concluded that a warming of 2°C above 1990 levels would result in mass mortality of coral reefs globally.
- **Freshwater ecosystems:** Above about a 4°C increase in global mean temperature by 2100 (relative to 1990-2000), Schneider *et al.* (2007:789) concluded, with high confidence, that many freshwater species would become extinct.

Abrupt or irreversible changes

Abrupt climate change

Abrupt climate change is defined as a large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems (CCSP, 2008a). There is the possibility of a rapid change in glaciers, ice sheets, and hence sea level. Predictions of such a change are highly uncertain due to a lack of scientific understanding. Modeling of the processes associated with a rapid ice sheet and glacier change could potentially increase future projections of sea level rise.

The Atlantic Meridional Overturning Circulation

The Atlantic Meridional Overturning Circulation (AMOC) is an important component of the Earth's climate system, characterized by a northward flow of warm, salty water in the upper layers of the Atlantic and a southward flow of colder water in the deep Atlantic (CCSP, 2008b, p. 5). Potential impacts associated with MOC changes include reduced warming or (in the case of abrupt change) absolute cooling of northern high-latitude areas near Greenland and north-western Europe, an increased warming of Southern Hemisphere high-latitudes, tropical drying, as well as changes to marine ecosystems, terrestrial vegetation, oceanic CO₂ uptake, oceanic oxygen concentrations, and shifts in fisheries (Schneider *et al.*, 2007). According to an assessment by the US Climate Change Science Program (CCSP, 2008b, p. 5), it is very likely that the strength of the AMOC will decrease over the course of the 21st century. Warming is still expected to occur over most of the European region downstream of the North Atlantic Current in response to increasing greenhouse gases, as well as over North America. Although it is very unlikely that the AMOC will collapse in the 21st century, the potential consequences of such a collapse could be severe.

Irreversibilities

An irreversible change is one where that change, once set in motion, cannot be reversed, at least over some specified timescale, e.g., centuries to millennia (Goldemberg *et al.*, 1996, p. 22). Climate change is likely to lead to some irreversible impacts (IPCC, 2007d). One example of a potentially irreversible impact of climate change is damage to ecosystems.

Footnotes

The IPCC report that is referred here uses specific and quantitative language to describe uncertainty (Ahmad *et al.*, 2001). This language is intended to provide an indication of the level of confidence that IPCC authors have about a particular finding. The qualitative language used to describe uncertainty has a quantitative scale associated with it. The quantitative values for qualitative terms are intended to ensure that confidence levels are

interpreted correctly. This is because qualitative statements, e.g., using the word "likely," can be interpreted differently in quantitative terms.

Quantitative values for confidence statements made in the IPCC Fourth Assessment Report are listed below (IPCC, 2007). These quantitative values are subjective probabilities that reflect the expert judgement of IPCC authors:

- ^a Very high confidence: At least 9 out of 10 chance of being correct
- ^b High confidence: About 8 out of 10 chance
- ^c Medium confidence: About 5 out of 10 chance
- ^d Low confidence: About 2 out of 10 chance
- ^e Very low confidence: Less than a 1 out of 10 chance

Chapter- 8

Overpopulation

Overpopulation is a condition where an organism's numbers exceed the carrying capacity of its habitat. The term often refers to the relationship between the human population and its environment, the Earth. Steve Jones, head of the biology department at University College London, has said, "Humans are 10,000 times more common than we should be, according to the rules of the animal kingdom, and we have agriculture to thank for that. Without farming, the world population would probably have reached half a million by now." The world's population has significantly increased in the last 50 years, mainly due to medical advancements and substantial increases in agricultural productivity.

The recent rapid increase in human population over the past two centuries has raised concerns that humans are beginning to overpopulate the Earth, and that the planet may not be able to sustain present or larger numbers of inhabitants. The population has been growing continuously since the end of the Black Death, around the year 1400; at the beginning of the 19th century, it had reached roughly 1,000,000,000 (1 billion). Increases in life expectancy and resource availability during the industrial and green revolutions led to rapid population growth on a worldwide level. By 1960, the world population had reached 3 billion; it doubled to 6 billion over the next four decades. As of 2009, the estimated annual growth rate was 1.10%, down from a peak of 2.2% in 1963, and the world population stood at roughly 6.7 billion. Current projections show a steady decline in the population growth rate, with the population expected to reach between 8 and 10.5 billion between the year 2040 and 2050.

The scientific consensus is that the current population expansion and accompanying increase in usage of resources is linked to threats to the ecosystem. The InterAcademy Panel Statement on Population Growth, which was ratified by 58 member national academies in 1994, called the growth in human numbers "unprecedented", and stated that many environmental problems, such as rising levels of atmospheric carbon dioxide, global warming, and pollution, were aggravated by the population expansion. At the time, the world population stood at 5.5 billion, and optimistic scenarios predicted a peak of 7.8 billion by 2050, a number that current estimates show will be reached around 2030.

History of concern

Concern about overpopulation is relatively recent in origin. Throughout history, populations have grown slowly despite high birth rates, due to the population-reducing effects of war, plagues and high infant mortality. During the 750 years before the Industrial Revolution, the world's population hardly increased, remaining under 250 million.

By the beginning of the 19th century, the world population had grown to a billion individuals, and intellectuals such as Thomas Malthus and physiocratic economists predicted that mankind would outgrow its available resources, since a finite amount of land was incapable of supporting an endlessly increasing population. Mercantilists argued that a large population was a form of wealth, which made it possible to create bigger markets and armies.

Projections of population growth

According to projections, the world population will continue to grow until at least 2050, with the population reaching 9 billion in 2040, and some predictions putting the population in 2050 as high as 11 billion.

According to the United Nations' World Population Prospects report:

- The world population is currently growing by approximately 74 million people per year. Current United Nations predictions estimate that the world population will reach 9.0 billion around 2050, assuming a decrease in average fertility rate from 2.5 down to 2.0.
- Almost all growth will take place in the less developed regions, where today's 5.3 billion population of underdeveloped countries is expected to increase to 7.8 billion in 2050. By contrast, the population of the more developed regions will remain mostly unchanged, at 1.2 billion. An exception is the United States population, which is expected to increase 44% from 305 million in 2008 to 439 million in 2050.
- In 2000-2005, the average world fertility was 2.65 children per woman, about half the level in 1950-1955 (5 children per woman). In the medium variant, global fertility is projected to decline further to 2.05 children per woman.
- During 2005-2050, nine countries are expected to account for half of the world's projected population increase: India, Pakistan, Nigeria, Democratic Republic of the Congo, Bangladesh, Uganda, United States, Ethiopia, and China, listed according to the size of their contribution to population growth. China would be higher still in this list were it not for its One Child Policy.
- Global life expectancy at birth, which is estimated to have risen from 46 years in 1950-1955 to 65 years in 2000-2005, is expected to keep rising to reach 75 years in 2045-2050. In the more developed regions, the projected increase is from 75 years today to 82 years by mid-century. Among the least developed countries,

where life expectancy today is just under 50 years, it is expected to be 66 years in 2045-2050.

- The population of 51 countries or areas, including Germany, Italy, Japan and most of the successor States of the former Soviet Union, is expected to be lower in 2050 than in 2005.
- During 2005-2050, the net number of international migrants to more developed regions is projected to be 98 million. Because deaths are projected to exceed births in the more developed regions by 73 million during 2005-2050, population growth in those regions will largely be due to international migration.
- In 2000-2005, net migration in 28 countries either prevented population decline or doubled at least the contribution of natural increase (births minus deaths) to population growth. These countries include Austria, Canada, Croatia, Denmark, Germany, Italy, Portugal, Qatar, Singapore, Spain, Sweden, United Arab Emirates and United Kingdom.
- Birth rates are now falling in a small percentage of developing countries, while the actual populations in many developed countries would fall without immigration.
- By 2050 (Medium variant), India will have 1.6 billion people, China 1.4 billion, United States 439 million, Pakistan 309 million, Indonesia 280 million, Nigeria 259 million, Bangladesh 258 million, Brazil 245 million, Democratic Republic of the Congo 189 million, Ethiopia 185 million, Philippines 141 million, Mexico 132 million, Egypt 125 million, Vietnam 120 million, Russia 109 million, Japan 103 million, Iran 100 million, Turkey 99 million, Uganda 93 million, Tanzania 85 million, Kenya 85 million and United Kingdom 80 million.

2050

- Africa - 1.9 billion
- Asia - 5.2 billion
- Europe - 674 million
- Latin America & Caribbean - 765 million
- North America - 448 million

Fresh water

Fresh water supplies, on which agriculture depends, are running low worldwide. This water crisis is only expected to worsen as the population increases. Lester R. Brown of the Earth Policy Institute argues that declining water supplies will have future disastrous consequences for agriculture.

Potential problems with dependence on desalination are reviewed below, however, the majority of the world's freshwater supply is contained in the polar icecaps, and underground river systems accessible through springs and wells.

Fresh water can be obtained from salt water by desalination. For example, Malta derives two thirds of its freshwater by desalination. A number of nuclear powered desalination

plants exist; these could continuously provide drinking water with few limitations, if the development of breeder reactors results in nuclear fuel becoming a renewable resource. However, the high costs of desalination, especially for poor countries, make impractical the transport of large amounts of desalinated seawater to interiors of large countries. The cost of desalinization varies; Israel is now desalinating water for a cost of 53 cents per cubic meter, Singapore at 49 cents per cubic meter. In the United States, the cost is 81 cents per cubic meter (\$3.06 for 1,000 gallons).

According to a 2004 study by Zhoua and Tolb, "one needs to lift the water by 2000 m, or transport it over more than 1600 km to get transport costs equal to the desalination costs. Desalinated water is expensive in places that are both somewhat far from the sea and somewhat high, such as Riyadh and Harare. In other places, the dominant cost is desalination, not transport. This leads to somewhat lower costs in places like Beijing, Bangkok, Zaragoza, Phoenix, and, of course, coastal cities like Tripoli." Thus while the study is generally positive about the technology for affluent areas that are proximate to oceans, it concludes that "Desalinated water may be a solution for some water-stress regions, but not for places that are poor, deep in the interior of a continent, or at high elevation. Unfortunately, that includes some of the places with biggest water problems." Another potential problem with desalination is the byproduction of saline brine, which can be a major cause of marine pollution when dumped back into the oceans at high temperatures."

The world's largest desalination plant is the Jebel Ali Desalination Plant (Phase 2) in the United Arab Emirates, which can produce 300 million cubic meters of water per year, or about 2500 gallons per second. The largest desalination plant in the US is the one at Tampa Bay, Florida, which began desalinizing 25 million gallons (95000 m³) of water per day in December 2007. A January 17, 2008, article in the *Wall Street Journal* states, "Worldwide, 13,080 desalination plants produce more than 12 billion gallons of water a day, according to the International Desalination Association." After being desalinated at Jubail, Saudi Arabia, water is pumped 200 miles (320 km) inland through a pipeline to the capital city of Riyadh.

Food

Studies agree that there is enough food to support the world population, but critics dispute this, particularly if sustainability is taken into account.

More than 100 countries now import wheat and 40 countries import rice. Egypt and Iran rely on imports for 40% of their grain supply. Algeria, Japan, South Korea and Taiwan import 70% or more. Yemen and Israel import more than 90%. And just 6 countries - Argentina, Australia, Canada, France, Thailand and the USA - supply 90% of grain exports. In recent decades the US alone supplied almost half of world grain exports.

A 2001 United Nations report says population growth is "the main force driving increases in agricultural demand" but "most recent expert assessments are cautiously optimistic about the ability of global food production to keep up with demand for the foreseeable

future (that is to say, until approximately 2030 or 2050)", assuming declining population growth rates.

However, the observed figures for 2007 show an actual increase in absolute numbers of undernourished people in the world, 923 million in 2007 versus 832 million in 1995.; the more recent FAO estimates point out to an even more dramatic increase, to 1.02 billion in 2009.

Population as a function of food availability

Thinkers such as David Pimentel, a professor from Cornell University, Virginia Abernethy, Alan Thornhill, Russell Hopffenberg and author Daniel Quinn propose that like all other animals, human populations predictably grow and shrink according to their available food supply – populations grow in an abundance of food, and shrink in times of scarcity.

Proponents of this theory argue that every time food production is increased, the population grows. Some human populations throughout history support this theory. Populations of hunter-gatherers fluctuate in accordance with the amount of available food. Population increased after the Neolithic Revolution and an increased food supply. This was followed by subsequent population growth after subsequent agricultural revolutions.

Critics of this idea point out that birth rates are lowest in the developed nations, which also have the highest access to food. In fact, some developed countries have both a diminishing population and an abundant food supply. The United Nations projects that the population of 51 countries or areas, including Germany, Italy, Japan and most of the states of the former Soviet Union, is expected to be lower in 2050 than in 2005. This shows that when one limits their scope to the population living within a given political boundary, human populations do not always grow to match the available food supply. Additionally, many of these countries are major *exporters* of food.

Nevertheless, on the global scale the world population is increasing, as is the net quantity of human food produced - a pattern that has been true for roughly 10,000 years, since the human development of agriculture. That some countries demonstrate negative population growth fails to discredit the theory. Food moves across borders from areas of abundance to areas of scarcity. Additionally, this hypothesis is not so simplistic as to be rejected by a single case study, as in Germany's recent population trends - clearly other factors are at work: contraceptive access, cultural norms and most importantly economic realities differ from nation to nation.

As a result of water deficits

Water deficits, which are already spurring heavy grain imports in numerous smaller countries, may soon do the same in larger countries, such as China or India, if technology is not used. The water tables are falling in scores of countries (including Northern China,

the US, and India) owing to widespread overdrafting beyond sustainable yields. Other countries affected include Pakistan, Iran, and Mexico. This overdrafting is already leading to water scarcity and cutbacks in grain harvest. Even with the overpumping of its aquifers, China has developed a grain deficit. This effect has contributed in driving grain prices upward. Most of the 3 billion people projected to be added worldwide by mid-century will be born in countries already experiencing water shortages. One suggested solution is for population growth to be slowed quickly by investing heavily in female literacy and family planning services. Desalination is also considered a viable and effective solution to the problem of water shortages.

After China and India, there is a second tier of smaller countries with large water deficits — Algeria, Egypt, Iran, Mexico, and Pakistan. Four of these already import a large share of their grain. Only Pakistan remains self-sufficient. But with a population expanding by 4 million a year, it will also soon turn to the world market for grain.

Environment

Overpopulation has substantially adversely impacted the environment of Earth starting at least as early as the 20th century. There are also economic consequences of this environmental degradation in the form of ecosystem services attrition. Beyond the scientifically verifiable harm to the environment, some assert the moral right of other species to simply exist rather than become extinct. Environmental author Jeremy Rifkin has said that "our burgeoning population and urban way of life have been purchased at the expense of vast ecosystems and habitats. ... It's no accident that as we celebrate the urbanization of the world, we are quickly approaching another historic watershed: the disappearance of the wild."

Says Peter Raven, former President of the American Association for the Advancement of Science (AAAS) in their seminal work AAAS Atlas of Population & Environment, "Where do we stand in our efforts to achieve a sustainable world? Clearly, the past half century has been a traumatic one, as the collective impact of human numbers, affluence (consumption per individual) and our choices of technology continue to exploit rapidly an increasing proportion of the world's resources at an unsustainable rate. ... During a remarkably short period of time, we have lost a quarter of the world's topsoil and a fifth of its agricultural land, altered the composition of the atmosphere profoundly, and destroyed a major proportion of our forests and other natural habitats without replacing them. Worst of all, we have driven the rate of biological extinction, the permanent loss of species, up several hundred times beyond its historical levels, and are threatened with the loss of a majority of all species by the end of the 21st century."

Further, even in countries which have both large population growth and major ecological problems, it is not necessarily true that curbing the population growth will make a major contribution towards resolving all environmental problems. However, as developing countries with high populations become more industrialized, pollution and consumption will invariably increase.

The Worldwatch Institute said the booming economies of China and India are planetary powers that are shaping the global biosphere. The report states:

The world's ecological capacity is simply insufficient to satisfy the ambitions of China, India, Japan, Europe and the United States as well as the aspirations of the rest of the world in a sustainable way

It said that if China and India were to consume as much resources per capita as United States or Japan in 2030 together they would require a full planet Earth to meet their needs. In the longterm these effects can lead to increased conflict over dwindling resources and in the worst case a Malthusian catastrophe.

Many studies link population growth with emissions and the effect of climate change.

Effects of human overpopulation

Some problems associated with or exacerbated by human overpopulation:

- **Inadequate fresh water** for drinking water use as well as sewage treatment and effluent discharge. Some countries, like Saudi Arabia, use energy-expensive desalination to solve the problem of water shortages.
- **Depletion of natural resources**, especially fossil fuels
- Increased levels of **air pollution, water pollution, soil contamination and noise pollution**. Once a country has industrialized and become wealthy, a combination of government regulation and technological innovation causes pollution to decline substantially, even as the population continues to grow.
- **Deforestation and loss of ecosystems** that sustain global atmospheric oxygen and carbon dioxide balance; about eight million hectares of forest are lost each year.
- **Changes in atmospheric composition and consequent** global warming
- Irreversible **loss of arable land** and increases in **desertification** Deforestation and desertification can be reversed by adopting property rights, and this policy is successful even while the human population continues to grow.
- **Mass species extinctions**. from reduced habitat in tropical forests due to slash-and-burn techniques that sometimes are practiced by shifting cultivators, especially in countries with rapidly expanding rural populations; present extinction rates may be as high as 140,000 species lost per year. As of 2008, the IUCN Red List lists a total of 717 animal species having gone extinct during recorded human history.
- **High infant and child mortality**. High rates of infant mortality are caused by poverty. Rich countries with high population densities have low rates of infant mortality.
- **Intensive factory farming** to support large populations. It results in human threats including the evolution and spread of antibiotic resistant bacteria diseases, excessive air and water pollution, and new virus that infect humans.

- Increased chance of the emergence of **new epidemics and pandemics** For many environmental and social reasons, including overcrowded living conditions, malnutrition and inadequate, inaccessible, or non-existent health care, the poor are more likely to be exposed to infectious diseases.
- **Starvation, malnutrition** or poor diet with ill health and diet-deficiency diseases (e.g. rickets). However, rich countries with high population densities do not have famine.
- Poverty coupled with **inflation** in some regions and a resulting low level of capital formation. Poverty and inflation are aggravated by bad government and bad economic policies. Many countries with high population densities have eliminated absolute poverty and keep their inflation rates very low.
- **Low life expectancy** in countries with fastest growing populations
- **Unhygienic living conditions** for many based upon water resource depletion, discharge of raw sewage and solid waste disposal. However, this problem can be reduced with the adoption of sewers. For example, after Karachi, Pakistan installed sewers, its infant mortality rate fell substantially.
- **Elevated crime rate** due to drug cartels and increased theft by people stealing resources to survive
- Conflict over scarce resources and crowding, leading to **increased levels of warfare**
- **Less Personal Freedom / More Restrictive Laws.** Laws regulate interactions between humans. Law "serves as a primary social mediator of relations between people." The higher the population density, the more frequent such interactions become, and thus there develops a need for more laws and/or more restrictive laws to regulate these interactions. It is even speculated that democracy is threatened due to overpopulation, and could give rise to totalitarian style governments.

Some economists, such as Thomas Sowell and Walter E. Williams argue that third world poverty and famine are caused in part by bad government and bad economic policies. Most biologists and sociologists see overpopulation as a serious threat to the quality of human life.

Overpopulation and warfare

The hypothesis that population pressure causes increased warfare has been recently criticized on the empirical grounds. Both studies focusing on specific historical societies and analyses of cross-cultural data have failed to find positive correlation between population density and incidence of warfare. Andrey Korotayev, in collaboration with Peter Turchin, has shown that such negative results do not falsify the population-warfare hypothesis. Population and warfare are dynamical variables, and if their interaction causes sustained oscillations, then we do not in general expect to find strong correlation between the two variables measured at the same time (that is, unlagged). Korotayev and Turchin have explored mathematically what the dynamical patterns of interaction between population and warfare (focusing on internal warfare) might be in both stateless and state societies. Next, they have tested the model predictions in several empirical case

studies: early modern England, Han and Tang China, and the Roman Empire. Their empirical results have supported the population-warfare theory: Korotayev and Turchin have found that there is a tendency for population numbers and internal warfare intensity to oscillate with the same period but shifted in phase (with warfare peaks following population peaks). Furthermore, they have demonstrated that in the agrarian societies the rates of change of the two variables behave precisely as predicted by the theory: population rate of change is negatively affected by warfare intensity, while warfare rate of change is positively affected by population density.