CLIMATE CHANGE: A LITERATURE REVIEW

Evelyn R. Campiseño, Ed.D.[1]

Abstract

Climate change today is considered as the greatest environmental dilemma that confronts the entire globe and therefore it deserves solution on global level. Sample of climate change researches are reviewed. Although many of these studies significantly contributed in the fund of knowledge, solutions mitigating ill effects of the climatic shift have not yet been achieved generally. Researchers should shift focus from determining climate change indicators and its impacts to a more significant endeavor that will advocate mitigating measures and adaptation strategies. Technical knowledge should be maximized and resources should be utilized in implementing base programs that will help in mitigating the ill effects of climate change.

Keyword: *climate change, literature review, indicators, mitigation of, impact*

Introduction

Climate change today is considered as the greatest environmental dilemma that confronts the entire globe. Climate change is caused by global warming that is happening due to excessive emissions of anthropogenic GHGs i.e. CO_2, NH_4, O_3, and N_2O, and aerosols which end up in the atmosphere where they are strengthening greenhouse effect that changes atmospheric compositions of the globe. These changes are likely to alter precipitation patterns, sea level, temperatures, extreme events, and other factors of climate on which the human systems and natural environment depend.

According to the geologic evidences, a few billion years ago planet, Earth is a global snowball which gradually turns into a world so warm and hence scorching inch-by-inch. It may not seem that way it is but scientists still continue to claim that Earth is increasingly warming, and that climate change is very much a reality we live in.

We have been playing a critical role in Earth's climate as an actual driver of its change and as the recipient of the threats and perils it delivers. Human influence that result to excessive emission of GHGs and aerosols, have greatly increased the chance of having such warm years. Comparing observations with the expected response to man-made and natural drivers of climate change it is shown that global temperature could reach as high as 7 degrees temperature increase by the end of the century if greenhouse gases growth continues its current trend.

[1]*Vice President for Research Extension and Development,*
Jose Rizal Memorial State University – Main Campus, Dapitan City

The National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center provides that in April 2010, the combined global land and ocean average global surface temperature of 14.5°C (58.1°F) was the warmest on record which is 0.76°C (1.37°F) above the 20th century average of 13.7°C (56.7°F). For the year-to-date, the global combined land and ocean surface temperature of 13.3°C (56.0°F) was the warmest January-April period attained and is 0.69°C (1.24°F) above the 20th century average (Global Analysis, April 2010).

Polar meltdown

By far, the signs of climate change are increasingly visible each year with the Arctic as the most obvious evidence. Intensifying temperatures at Arctic causes ice melting and retreating at very fast pace. The Arctic ice, in the last 30 years, has shrunk by about 10% a decade which is around 28,000 square miles every year. Based on the most recent study of Masayo Ogi, a scientist with the Japan Agency for Marine-Earth Science and Technology in Yokohama, and her colleagues, both winter and summer winds and in particular, increased air and ocean temperatures could have been accountable for blowing ice out of the Arctic. If this trend continues in years to come, Arctic could become ice free by the end of this century, if not even before. Climate change that is happening at Arctic is an indicator of what will happen to our planet in years to come, unless we do something to stop this tumult which significantly changes conditions of our planet and creates global environmental disaster.

Climate change is global problem, and therefore it deserves solution on global level. All countries must work together in finding the optimum solution to save our planet from the worst what climate change can offer. This is really what makes climate change such a big challenge, namely the fact that world has to put aside all the differences and work together in order to have any chance against global warming.

Ten years whence, climate change has been increasingly the subject of studies among researchers from determining indicators to concerns about its likely impacts and prospective mitigating measures. Various studies related to climate change are published at prolific rates. In several reports, the figure of climate change publications is replicating every 11 years and approached 10,000 by the year 2000 (Stanhill G, 2001). Periodic reviews of recent literature, such as this one, serve

Since the end of the 19th century, the average temperature has risen 0.7 degrees C. To see the changes this rise in temperature has caused, compare the *before* and *after* photographs of glaciers.

to rescue those who do not always stay on top of the literature. The aim of this review is to catch up on climate change literature published in the last 3 years.

Climate change literature is assessed from 2007 to 2009 in considerable detail, with diverse searches over several search engines. After assembling a first set of publications that we considered as potentially significant, all are read through, sorted them into functional groupings, and discarded more trivial contributions. Contributions are classified as to indicators, impact and mitigation and adaptation.

The result is a view of the recent climate change literature that is somewhat eclectic, focusing in particular on assorted dimensions of climate change implications for biology and reviewing in somewhat less detail the burgeoning literature on ecosystem-level implications. Nonetheless, it is hope that this will be useful in providing an overview of recent activity and findings in climate change research.

Climate Change: Global Perspective

A relatively large number of studies have attempted to ascertain the impacts of climate change in specific areas utilizing different methodologies. These studies estimate static and physical impacts of climate change on "today' s world" mainly for modest increases in temperatures and cover a limited number of regions, often only the United States (Tol, 2002)

Extensive land areas showing a 20th-century warming trend in air temperature of was investigated by Serreze et al. (2000), Reilly *et al.*, (2000), and Comiso (1999). Over sea ice, there has been slight warming in the 1961–1990 period (Cavalieri *et al.,* 1997 and Michel & van Everdingen, 1994). Stewart (2000), Easterling *et al., (*2000) and Vaughan and Spouge (2000 studied the increasing precipitation. Vinje (2001) and Jacka and Budd (1998) noted that the sea-ice extent gradually decreasing over the last period

Carmack et al., 1995 in their study found that waters have warmed, and the surface layer has become thinner (Steele & Boyd, 1998, Carmack, 2000; Prowse and Flegg, 2000). The mixed layer in seas has become less saline (Bindoff & McDougall, 2000; Bromwich *et al.*, 1998; and, Wong *et al.,* 1999). Areas underlain by permafrost have been condensed in scale, and a general warming of ground temperatures has been observed in various areas as cited by Bockheim and Tarnocai, (1998) and Berger and Iams (1996). There has been a statistically significant decrease in spring snow extent over Eurasia since 1915 (Brown, 1997). Connolley and O'Farrell (1998) averred that many observations of environmental change in the Arctic showed a trend that is consistent with warming and similar to that predicted by general circulation models (GCMs).

Increased melting is visible on glaciers and ice sheet, and they retreat and thin close to their margin (Whetton *et. al*., 1996 and Gordon and O'Farrell, 1997, Basher *et al*., 1998; and, Osterkamp *et al.*, 2000). According to Naganobu *et al (*2000), projected diminutions in sea-ice level alter under-ice biota and spring bloom in the sea-ice marginal zone and cause intense impacts at the entire levels in the food chain, from algae to krill to the great whales. A major impact would result from a flagging of the circulation of global thermohaline as an effect of a net increase in river flow and the ensuing increased flux of freshwater.

Warming increases biological production (IPCC, 2000); however, the effects of increased precipitation on biological production are unclear. As warming takes place, there are alterations in species compositions on land and in the sea, with a propensity for poleward shifts in species assemblages and loss of several polar species (IPCC, 2000; Everett and Fitzharris, 1998). According to Marchant *et al.* (1997 and Agrawala and van Aalst (2005), changes in sea ice alter the seasonal distributions, patterns of migration, nutritional status, reproductive success, geographic ranges and eventually the abundance and stability of species. Animals that are dependent on sea ice—such as seals, walrus, and polar bears are disadvantaged (Tynan and DeMaster, 1997). High arctic plants show a strong growth response to summer warming (Chapin *et al.*, 1997; Callaghan *et al.*, 1998). It is unlikely that elevated CO_2 levels increase carbon accumulation in plants, but they may be damaged by higher ultraviolet-B radiation (Davidson, 1998). Biological production in lakes and ponds will increase (Marsh and Hey, 1989; Prowse and Conly, 1998).

Flooding in the UK is on the increase due to climate change. (Source: Google)

In North America, there is little agreement across climate scenarios regarding changes in total annual runoff across (Harvell *et al.*, 1999). The only exemption is the HadCM2 transient scenario integrating IS92a sulfate aerosol emissions that suggests minor increases in lake levels and outflows (Mortsch and Quinn, 1996; Chao, 1999).

Canada and the United States have different loss profiles. The nature of weather-related exposures and losses is varied in both countries, arraying from property damages to business disturbances caused by communication system or electric power damage as in the 1998 ice storm (DeGaetano, 2000). Insurance programs of U.S. government for crops and floods have not been lucrative and in various cases have persuaded extra human activity in endangered areas. In the absence of related agendas in Canada, government calamity relief programs have remunerated approximately 86% of flood losses over the past 2 decades (Environment Canada, 1995; Anderson, 2000). There remains a significant pressure between the provision of such risks among public sector and the private insurers, and the effects of climate changes (e.g., coastal erosion) would increasingly stress government programs (Heinz Center, 2000).

Recent extreme events have led to several responses by insurers, including increased attention to building codes and disaster preparedness, limiting insurance availability or increasing prices, and establishment of new risk-spreading mechanisms (Maxwell, 1997). Insurers can play an important role in climate adaptation and mitigation (Ross, 2000). On the other hand, according to Chichilnisky and Heal (1998), the potential for surprise is real because their actuarial outlook is based on past climatic occurrence and forward-looking modeling studies are just now beginning to be used.

Studies conducted in Asia revealed that climate change is characterized by high population density (Xiao *et al.,* 1998; Safriel *et al*., 1993; Kark *et al*., 1999; Fryauff,et.al., 1997; and, Conway 2000) and relatively low rates of economic growth (Kane, 1991)

The impact of climate change, in combination with other stresses, affect human communities. The impacts are particularly disruptive for communities of indigenous peoples following traditional lifestyles (Langdon, 1995). Changes in sea ice, habitat and multiplicity of food species and seasonality of snow affect practices of hunting and gathering and coerce ancient traditions and ways of life (Wenzel, 1995). Communities that apply these lifestyles, on the other hand, are amply resilient to cope with these changes. According to Sabo (1991) and Odner (1992), augmented economic costs have an effect on infrastructure, in response to permafrost melting and condensed transportation capabilities across frozen ground and water. Even so, there are economic remunerations, including new opportunities for trade and shipping across the Arctic Ocean, easier access for ship-based tourism , lower heating costs and lower operational costs for the oil and gas industry (McKendrick, 1997; Nuttall, 1998).

Drought is one of the most threat to agriculture production. (Source: Google)

In its desire to incorporate mitigating measures to adaptation to climate change, some policies were put into practice. In the Netherland, the plan dubbed as “Room for Rivers” was introduced to prevent the country against river Rhine inundation in the coming years while slotting in climate change scenarios. This plan offered a combination of measures from dike enhancement to producing extra room for water discharge or preservation in river bed akin to obstacles removal, retention ponds construction, riverbed deepening, and dikes relocation (Verheem and Laeven, 2009). Considerations of climate change were incorporated when taking into account the high water levels to be estimated for 2020 and probable developments in the upstream regions of the river in other countries, for instance in Germany. Furthermore, Verheem and Laeven (2009) stated that, for the year 2100, the water levels in the Rhine were deliberated on the basis of the Intergovernmental Panel on Climate Change (IPCC) medium scenario that considers a 60 cm sea-level rise.

In Canada, to address to climate change impacts, numerous projects including water-retention or tailings-containment structures, bridges, as well as large buildings and linear infrastructure such as pipelines and roads are incorporated. Lee (2001) reviewed six Canadian projects that included climate change considerations, namely: the Cascade Power Park, the Confederation Bridge, Diavik mines, dredging in the St. Laurence River, the Little Bow reservoir, and decommissioning of Quirke and Panel mines. These projects were also selected because they could have longer-term environmental impacts.

The Confederation Bridge between New Brunswick and Prince Edward is a 27 km long bridge structure which was purposefully designed to permit the passage of vessels and stands approximately 40 m above sea level at the side spans and 60 m above sea level over the main navigational channel, considering a design life of 100 years over which the bridge could withstand all probable stresses, including from ice and wind (Bell et al., 2002). Simultaneously, studies were also undertaken to mull over the environmental conditions over a 100 year time frame (Bell et al., 2002). This assessment resulted in the construction of the bridge which is higher than currently required to accommodate projections of sea level rise. Moreover, monitoring programs such as monitoring of water temperatures, currents, coastal erosion, coastal sediment transport, and ice conditions affecting the bridge were established to provide early warning of unanticipated changes in order to allow adjustments (Bell et al., 2002).

The decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake which included, among others, the construction of permanent containment ponds for the radioactive tailings needed to remain permanently flooded in order to prevent the generation of acid that would result from exposure to air, is another project involved in Canada par climate change considerations.

More recently, Byer and Yeomas (2007) assessed a number of current EIA reports in Canada and concluded that climate change and the qualms about climate change have not been sufficiently attended to and they found discrepancies between comparable types of projects. These concerns are the product of the novelty of this practice area and are likely to be better addressed once practitioners have expanded skills and experience to address adaptation to climate change as component of an EIA. A further recent report from the same country also affirmed that stakeholders in the private sector have recommended that information gaps such as climate change projections and alterations in other environmental circumstances pose challenges to meeting climate change considerations in EIA as an officially authorized requirement (National Round Table on the Environment and the Economy, 2009).

In Oceania, the East Lakes electrical infrastructure project located on the banks of Lake Burley Griffin are positioned approximately 2 m above the probable maximum flood level to avoid potential future flood risks (AECOM/Purdon Associates, 2009. The Mount Franklin Road, Cotter Hut Road and Smokers Trail contribute to reduce the climate change vulnerability of the Canberra region with regards to wildfire hazard (Aurecon, 2009).

The Murrumbidgee to Googong Water Transfer project in New South Wales, which is a part of the Australian Capital Territory (ACT) Government Water Security Program was established to improve security to the ACT's water supply. This involves pumping water from the ACT Murrumbidgee river and relocating it via a pipeline to the Googong Reservoir through Burra Creek (NSW) which provides water treated to drinking quality standards.

DISAPPEARING LAKE. **Talk about a sea change: From 2006 (bottom) to 2009, Central Asia's vast Aral Sea dramatically retreated, with its eastern section losing about 80 percent of its water in just four years, as seen in satellite imagery. (Source: Google)**

A number of studies have also focused on how environmental policies, particularly with regard to climate change linked to innovation, affect the incentives for both the creation and adoption of environmental technology. Innovations generated by environmental guidelines that institute a GHG emission price come from businesses presently connected in the development and utilization of energy producing and consuming technologies, particularly in the electricity provision and transportation services as well as come from the agro-biotech sector that manufacture and consume other non-CO2 GHGs like chemical companies, and from less evident sectors such as the information technology trade such as the framework of energy management and conservation (Newell, 2008). Estimates suggest that investments in Research and Development (R & D) energy, have fallen significantly in real terms in tandem with declines in energy prices and public energy R&D spending (Newell, 2008).

In 2006, the R&D expenditures for the 1,250 companies top producers of transportation technologies such as - Ford, DaimlerChrysler, Toyota, Boeing, and Rolls-Royce which have individual company R&D budgets measured in billions of dollars per year and which together contribute to a global R&D budget for the automotive sector of $80 billion annually shows that globally have the highest levels of R&D investment (U.K. Department for Innovation, Universities and Skills 2007). In 2006, electronic and electrical equipment companies spent over $35 billion in R&D, with companies like Siemens and Samsung, as well as general industrial companies, like Mitsubishi Heavy Industries and General Electric, which have yearly R&D budgets of over $11 billion internationally.

Empirical studies like that of Lanjouw and Mody (1996), Hascic et al. (2008), also examined pollution abatement control expenditures (PACE) to proxy for environmental regulatory stringency. Experimental studies of the links amid environmental guidelines and innovation were originally restricted by a lack of data; in recent times, however, empirical economists have begun to estimate the effects that prices and environmental policies have on environmentally friendly innovation, as procedures of innovative movement such as patents have become more readily accessible.

To classify numerous key environmental patent classes, Lanjouw and Mody (1996) utilized the International Patent Classification (IPC). By means of patent data from the US, Germany, Japan and 14 low-and middle-income countries, they discover that as PACE in the country increase, environmentally friendly innovation increases.

Hascic et al. (2008) study the effect of environmental policy stringency on patenting activity for five different types of environmental technology – air pollution, water pollution, waste disposal, noise protection, and environmental monitoring. They find that private expenditures on pollution control lead to larger environmental innovation, but not government expenditures on pollution control utilizing both PACE expenditures and a World Economic Forum survey of top management business executives as alternative measures of environmental stringency. However, higher levels of government environmental R&D led to more environmental patents.

Significant increases in patents pertaining to sulfur dioxide (SO2) and nitrogen oxides (NOX) emissions reduction are found in response to the passage of environmental regulations in the United States, Japan, and Germany (Popp, 2006). Baker and Adu-Bonnah (2008) asserted that the way in which technological change affects the shape of the marginal abatement cost curve also affects R&D decisions made under uncertainty. Their model considers both qualms regarding future climate damages and about probability of success for a variety of energy research projects, hence the optimal level of abatement desired.

There are a few studies conducted to compare innovation under different policy types. Popp (2003) combined patent data with plant-level data on flue gas desulfurization (FGD) units, or scrubbers to judge against innovation before and after passage of CO_2 permit trading, the 1990 Clean Air Act of United States and accordingly found out that the innovation level for FGD units was in fact higher prior to tradable CO_2 permits were pioneered by the 1990 Clean Air Act (CAA). Taylor et al. (2003) also distinguished that the scrubber requirement led to a decline in patents on pre-combustion techniques for dropping CO_2 emissions, such as cleaner coal. Bosetti et al. (2009) similarly found out that R&D alone is insufficient to stabilize CO_2 levels without an accompanying carbon tax.

In the investigated of Lange and Bellas (2005) which utilized a survey of firms to examine the effect of various environmental policy instruments on environmental R&D, respondents were asked to describe both the type of environmental policies faced, as well as the stringency of such policies and found that greater stringency does induce a firm to perform more environmental R&D. Similar study of Johnstone and Hascic (2008) revealed that flexible environmental regulations lead to higher quality innovation. The result of different policy instruments on innovation were also scrutinized comparing price-based policies such as feed-in tariffs and tax credits to quantity-based policies such as renewable energy mandates and discerned significant differences across technologies. Of the various alternative energy technologies, wind has the lowest cost and is closest to being competitive with traditional energy sources.

Numerous researchers assessing the effectiveness of different environmental polices revealed that environmental and technology policies worked best jointly. Whilst technology policy aid in facilitating the formation of new environment-friendly technologies, it offers small spur in adopting these technologies. Fischer and Newell (2008) created a theoretical model introducing government support for emissions control. Using a computable general equilibrium model to study the potential effects of energy R&D for climate change mitigation, Goulder and Mathai (200) averred that policies to address knowledge spillovers are more effective if they address all knowledge spillovers, rather than focusing exclusively on R&D pertaining to alternative energy.

Climate Change: National Concern

At no other time has the science of climate change been more robust than today. The distinguishable signals of climate change are among its robust findings, i.e. that the earth is certainly warming; the 1990s was the warmest decade globally; and in the instrumental record (1861-2000), 1998 was the warmest year; that over the 20th century, the global average surface temperature has augmented by about 0.6°C; that global average sea level rose between 0.1 and 0.2 meters during the same period; and that rainfall may have increased by 0.2% to 0.3% per decade over the tropical (10°N to 10°S) land areas. Such indicators of a shifting climate are already apparent in the Philippines as our restricted data (1960 to present) explain that the escalating trends in temperature, severe climate event occurrences and sea level rise are consistent with the above global trends.

As reported by the IPCC-TAR, extreme climate events/ variability, such as, forest fires, droughts, floods and tropical cyclones have increased in temperate and tropical Asia. Compared with the previous 100 years, the warm episodes of the El Niño-Southern Oscillation (ENSO) phenomena have been more frequent, persevering and forceful since the mid-1970s.

The impacts of climate change turn out to be more apparent and fatal, predominantly for susceptible and developing countries such as the Philippines. Because of its being an archipelago, the United Nation-organized Intergovernmental Panel on Climate Change (IPCC) regard Philippines as one of the countries most prone to the effects of climate change.

As an archipelago which has the 2nd largest coral reef cover in the world (BFAR) and a coastline which is roughly the equivalent of the earth's circumference (Anemuller, et. al, 2006), the Philippines is at threat from large-scale impacts of climate change on the ocean. There is a threat of a recurrence of colossal bleaching of corals comparable to the one experienced by conservation priority sites and marine protected regions in the provinces of Pangasinan, Puerto Galera, Negros, Dumaguete and Palawan last 1998 which were associated to the increase in temperature of ocean surface that was brought about by the El Niňo Phenomenon (Arceo, et. al, 2001). Sea level increase due to thermal expansion, melting of glaciers, ice sheets and ice caps threatens coastal areas, low-lying communities and island ecosystems that are already experiencing subsidence and chaotic coastal improvement.

Moreover, due to increasing human population and resource demand, habitat destruction and unsustainable development (Heaney, 2004), Philippines deemed one of the top mega-diversity countries in the world, constitute an additional pressure that could exacerbate the high rate of species extinction and current degradation of the Philippines' ecosystem.

The sector most affected by climate change, so far, is agriculture and food security. During strong El Niño events and after the occurrence of stern tropical cyclones, the sharpest fall in agricultural productions is experienced. Increases in rice and corn productions during La Nina years, however, are credited to favorable rainfall conditions. The highest typhoon damage was 1.17% of GDP and 4.21% of agriculture.

According to Arceo, H.O. et al. (2001), the climate change impacts on marine ecosystems and coastal zones observed in 1998 were immense coral bleaching in various reefs all over the Philippines caused by the elevated sea temperature during the severe 1997-98 ENSO episode. Fish kills and high mortality of cultured giant clams in ocean nurseries were also observed. Severe red tide outbreaks also occurred after the strong El Niño periods. The worst incidence of red tide in Manila Bay occurred in 1992, another El Niño period.

Based on the findings of IPCC, climate change has manifested itself in the Philippines through the extreme incidence of severe El Niño and La Niña episodes, as well as, fatal and destructive typhoons and other severe storms; floods, flash floods, drought, landslides, forest fires, etc. There were 5 La Niña and 7 El Niño events commencing 1970 to 2000 compared to only 3 La Niña and 2 El Niño occurrences as of 1950 to 1970. The strong warm (El Niño) episodes were in 1972-73, 1982-83, 1997-98, whereas the strong cold (La Niña) events were within 1973-74, 1988-89 and 1998-99 (CAB T.P. No. 2001-7).

The country runs the threat of being distressed by further recurrent and intense El Niño and La Niña occurrences resulting in droughts and floods, correspondingly. Other extreme precipitation episodes due to the increase in southwest monsoon activities and severe storm events have been arising lately, which caused immense flash floods and landslides. Coastal shrinking is also visible. The University of the Philippines' National Institute of Geological Sciences asserted that low coastal areas at the Manila Bay, such as Caloocan, Malabon, Navotas, Valenzuela and some towns in Bulacan, Bataan and Pampanga have submerged one meter in the past 30 years or ten times than the pace of the global sea level increase in the last century.

In their paper "Flooding in Pampanga, Bataan, Bulacan and Camanava: Causes, Trends and Possible Solutions", geologists blamed the fast rise of water level at the Manila Bay to too much extraction of groundwater by a growing population and economic activities. There are about 23 million people living around the Manila Bay, who experience flood during the rainy season. The resulting fatalities and damage to property aggravate the misery and dilemma of already over-burdened masses. Classified by the Manila Observatory as areas that are most at risk to climate and weather related changes, provinces and regions, such as Albay, Biliran, Ifugao and Sorsogon (Manila Observatory, 2005), are evidently areas with an elevated Poverty Incidence Rating (NSCB, 200).

Flooding in the Philippines (Source: Google)

In October 1995, typhoon Angela carried storm surges, mudslides and a dam failure that caused slam to a thousand deaths. In September 1993, Typhoon Flo leaves nearly 600 dead. Typhoons Zeb and Babs hit virtually one after another in July 2000, leaving about 300 dead and ravaging agriculture.

On July 12, 2000, one of the world's most horrible images of social catastrophe in history was witnessed by the Philippines. Under tons of garbage in Payatas dumpsite, Quezon City, almost 500 garbage scavengers who were living literally at the site were buried alive when a 50-foot garbage mountain collapsed on their makeshift houses at the altitude of torrential rains. It was a tragic commentary on poverty in the Philippines, yet the lesson remains to be learned to this day.

Rains generated by tropical storms succession cause a giant mountain of trash to collapse in the Payatas open dump in Manila in July 2000, which buried hundreds of people who reckoned such garbage as source of livelihood. More than 200 dead bodies were recovered but many more are believed to have died.

In February 2006, after days of a minor earthquake and heavy rains, a landslide buried the village of Guinsaugon in the central Philippines which killed more than a thousand. Almost 200 deaths was marked when Typhoon Xangsane hit Manila in September 2006, toppling billboards, trees and power lines consequently knocking out electrical service for days. In November 2006, Typhoon Durian lashed the Philippines, letting loose of the volcanic mudslides around Mayon Volcano slopes leaving roughly a thousand dead or missing. Typhoon Fengshen, in June 2008, sinked a ferry killing about

800 people, claims nearly 500 other lives on land and leaves more than one million others homeless.

And just recently, in September 2009, flooding spawned by Typhoon "Ondoy" in the Philippines is just the newest in a phase of natural catastrophes that grieve the archipelago, trapped in both the Pacific typhoon belt and its volcanic "Ring of Fire." Storms, landslides or earthquakes -- and sometimes a combination of all three at once -- are an almost monthly event, displacing as many as eight million people every year, according to an Asian Development Bank study released in 2008. These tremendous events have one thing in common – persistent torrential rains, rooting flash floods and landslides, killing people and demolishing properties and the environment along its path.

In parts of the Philippines, farmers have had to stop growing rice completely during the droughts caused by the 'El Nino' years, and river delta and coastal rice production has already suffered badly across South-East Asia because of storms that overwhelm sea defenses and salt-water intrusion into paddy fields. (Source: Google)

These severe weather incidences linked with climate change, and the tragedy these have wrought, have resulted to losses amounting to billions of pesos. From 1975 to 2002, tropical cyclones have caused losses of 4.578 billion pesos due to damage to property, including damage to agriculture worth 3.047 billion pesos. In 1998, the 2nd hottest year on record, crop losses amounting to 828 million pesos was incurred when a drought in Southern Mindanao transpired. Also damages owed to four succeeding tropical cyclones towards the end of 2004 outlay the nation an estimated 7,615.98 million pesos.

Climate change also intensifies the various socio-economic saddles already shouldered by Filipino families, such as water scarcity and hunger. In the health region, several of the biological organisms related to the spread of infectious diseases are mainly influenced by the oscillation in climate variables. Among other factors, dengue fever and malaria are sensitive to such climate parameters as temperature, relative humidity and rainfall. Based on Relox, N.A. (1998) findings, further climate-related diseases like cholera have been allied with extremes of precipitation, floods and droughts. Moreover, Flavier (2001) affirmed that risks related with the projected spread of vector-based insect-borne infection, such as malaria and dengue, due to warming temperatures are escalating even as health care budgetary support in the Philippines continues to deflate.

The threat of climate change impacts will also further marginalize indigenous peoples such as the T'boli of Mindanao and the Badjao of the Sulu Seas whose customs and livelihood are deeply rooted in the well-being of the environment, devaluing their "contribution to the conservation and protection of biological diversity and ecosystems which is crucial for the prevention of climate change" (The Bonn Declaration, 2000).

November 2009 during typhoon season by Sir Berong (Source: Google) March 2010 during El Niño season by Crimson

Climate change in the Philippines is really real; that is the overwhelming scientific consensus, as is the conclusion that this change is human-induced. The reality can be seen in rising sea levels, changing ecosystems, prolonged and more severe droughts. Storm surges and riverine flooding is aggravated by the increasing frequency and intensities of tropical cyclones and other types of environmental degradation. Low lying areas are severely affected and high economic losses result from the damages caused by typhoons. Sea-level rise exacerbates the already flooded areas.

This problem requires not only the local and national government offices to exert more efforts deepening the understanding of people on climate change and the adaptive capacity and vulnerability of nature and human dimensions to climate change, but also to any educational institutions to deliver it to its final end or if not, at least alleviate it.

It is scary to even imagine what will happen to the country should sea levels rise beyond one meter. We have witnessed its effects in the unprecedented strength and number of super-typhoons in recent years. Millions of Filipinos are now at risk. We need to take action now, before our national becomes damaged beyond repair. If we fail to act quickly, decisively, and with great vigor, there will soon be nowhere to run and nowhere to hide.

The Philippines' critical vulnerability to the grave impacts of climate change will be among the country's major challenges in the years, and even decades, to come. And although the effects of this catastrophe—stronger typhoons, rising sea levels, and corresponding effects on Filipinos, the national economy and the environment—are not inescapable, they are projected to continue and worsen, especially if strong solutions are not implemented.

A girl standing amid the ruins of homes destroyed by a freak twister that hit the Baseco compound in Tondo, Manila. (Source: Google)

But while it is true that the Philippine government has taken a step forward in addressing this global threat, the risks our country faces are too great and call for much greater leaps toward proactive and lasting solutions.

In the Philippines, present climate change studies were primarily that of Lasco and company such as the rate of sequestration by vegetation and approximation of the existing stored carbon (C) that can potentially serve as a sink for the carbon dioxide derived from eight geothermal plants in Leyte Geothermal Reservation, Philippines, appraisal of potential forestry mitigation options in the Philippines via the Comprehensive Mitigation Assessment Process (COMAP) model supposing that recent trends persist up to the year 2030, among others (Lasco et. al, 2005; Lasco et. al, 2002; Lasco & Pulhin, 2001; Lasco et. al, 2000' Lasco & Pulhin, 1999; Lasco & Pulhin, 1998; Lasco, 1998, etc.)

Conclusion and Recommendation

Climate change researches are reviewed herein. Majority of these studies are presenting observations as well as correlations and experimental in nature. Only a few focused on policy recommendations. Prospective climate change researchers need to shift focus from determining climate change indicators and its impacts to a more significant endeavor that will advocate mitigating measures and adaptation strategies. Technical knowledge should be maximized and resources should be utilized in implementing base programs that will help in mitigating the ill effects of climate change.

References

Agrawala, S. and M. van Aalst (2005). "Bridging the gap between climate change and development", Bridge Over Troubled Waters: Linking Climate Change and Development. OECD, Paris, pp. 133-146.

Anderson, D.R., (2000): Catastrophe insurance and compensation: remembering basic principles. CPCU Journal, 53(2), 76–89.

Arceo, Hazel Miledel Quibilan, Porfirio Alino, Goldee Lim and Wilfredo Licuanan (2001). Coral bleaching in Philippine reefs: Coincident evidences with mesoscale thermal anomalies, Proceedings of the International Conference on Scientific Aspects of Coral Reef Assessment, Monitoring, and Restoration,. See: http://cat. inist.fr/?aModele=affiche N&cpsidt=13403144

Aurecon (2009). Mount Franklin Road, Cotter Hut Road and Smokers Trail, Namadgi National Park: Draft Environmental Impact Statement, Canberra, Australia.

Baker, E. and K. Adu-Bonnah (2008). Investment in risky R&D programs in the face of climate uncertainty, Energy Economics 30(2):465-486.

Basher, R.E., A.B. Pittock, B. Bates, T. Done, R.M. Gifford, S.M. Howden, R. Sutherst, R. Warrick, P. Whetton, D. Whitehead, J.E. Williams, and A. Woodward, 1998: Australasia. In: The Regional Impacts of Climate Change. An Assessment of Vulnerability. A Special Report of IPCC Working Group II for the Intergovernmental Panel of Climate Change [Watson, R.T, M.C. Zinyowera, R.H. Moss, and D.J. Dokken (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 878 pp. Netherlands Journal of Geosciences / Geologie en Mijnbouw 82 (1): 19-30 (2003)

Bell, A., N. Collins, C. Ells, G. de Romily, A. Rossiter and R. Young (2002). Evaluation of the ClimAdapt Guide to Incorporating Climate Change into the Environmental Impact Assessment Process, Research and Development Monograph Series, ClimAdapt - Nova Scotia's Climate Change Adaptation Initiative, Canada.

Berger, A.R. and W.J. Iams, 1996: Geoindicators: Assessing Rapid Environmental Change in EarthSystems. A.A. Balkema, Rotterdam, The Netherlands, 466 pp. Available online at http//www. gcrio.org/geo/title.html.

BFAR: See: http://www.bfar.da.gov.ph/infocorner/fast_facts.htm

Bindoff, N.L. and T.J. McDougall, 2000: Decadal changes along an Indian Ocean section at 32ºS and their interpretation. Journal of Physical Oceanography, 30(6), 1207–1222.

Bockheim, J.G, and C. Tarnocai, 1998: Recognition of cryoturbation for classifying permafrost-affected soils. Geoderma, 81, 281–293.

Bosetti, V., C. Carraro, M. Galeotti and E. Massetti (2006). A World Induced Technical Change Hybrid Model‖, The Energy Journal, Hybrid Modeling of Energy Environment Policies: Reconciling Bottom-up and Top-down, Special Issue.

Bromwich, D., L. Zhong, and A.N. Rogers, 1998: Winter atmospheric forcing of the Ross Sea polynya. In: Ocean, Ice and Atmosphere, Interactions at the Antarctic Continental Margin [Jacobs, S.S. and R.F. Weiss (eds.)]. American Geophysical Union, Antarctic Research Series, 75, 101–133.

Brown, J., 1997: Circumpolar active layer monitoring program. Frozen Ground, 22–23.

Byer, P.H. and J.S. Yeomas (2007). "Methods for addressing climate change uncertainties in project environmental impact assessments", Impact Assessment and Project Appraisal, Vol. 25, No. 2, pp. 85-99.

Callaghan, T. V., C. Körner, S.E. Lee, and J.H.C. Cornelison, (1998): Part 1: scenarios for ecosystem responses to global change. In: Global Change in Europe's Cold Regions [Heal, O.W., T. V. Callaghan, J.H.C.s

Carmack, E.C., (2000): Review of the Arctic Oceans freshwater budget: sources, storage and export. In: The Freshwater Budget of the Arctic Ocean [Lewis, E.L, E.P. Jones, P. Lemke, T.D. Prowse, and P. Wadhams (eds.)]. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 91–126.

Cavalieri, D.J., P. Gloersen, C.L. Parkinson, J.C. Comiso, and H.J. Zwally, (1997): Observed hemispheric asymmetry in global sea ice changes. Science, 278, 1104–1106.

Chao, P.T., B.F. Hobbs, and B.N. Venkatesh, (1999): How climate uncertainty should be included in Great Lakes management: Modeling workshop results. Journal of the American Water Resources Association, 35(6) , 1485–1497 .

Chapin , F.S. III, J.P. McFadden, and S.E. Hobbie, (1997): The role of arctic vegetation in ecosystem and global processes. In: Ecology of Arctic Environments [Woodin, S.J. and M. Marquiss (eds.)]. Blackwell Science, Oxford, United Kingdom, pp. 97–112.

Chichilnisky, G. and G. Heal, 1998: Managing unknown risks: the future of global reinsurance. Journal of Portfolio Management, Summer, 85–91.

Comiso, J.C., (1999): Variability and trends in Antarctic surface temperatures from in situ and satellite infrared measurements. Journal of Climate, 13(10), 1674–1696.

Connolley, W.M. and S.P. O'Farrell, (1998): Comparison of warming trends over the last century around Antarctica from three couple models. Annals of Glaciology, 27, 565–570.

Conway, D., K. Bhattarai, and N.R. Shrestha, (2000): Population-environment relations at the forested frontier of Nepal. Applied Geography, 20, 221–242.

Davidson, A.T, (1998): The impact of UVB radiation on marine plankton. Mutation Research—Fundamental and Molecular Mechanisms of Mutagenesis, 422, 119–129.

DeGaetano ,A . T., (2000): Climatic perspective and impacts of the 1998 northern New York and new England ice storm. Bulletin of the American Meterological Society, 81(2), 237–254.

Easterling, D.R., H.F. Diaz, A.V. Douglas, W.D. Hogg, K.E. Kunkel, J.C. Rogers and J.F.Wilkinson, (2000): Long-term observations for monitoringextremes in the Americas. Climatic Change, 42(1), 285–308.

Environment Canada, (1995): Climate Change Impacts: An Ontario Perspective. Smith and Lavendar Environmental Consultants, Sustainable Futures, and Environment Canada, Toronto, ON, Canada, 76 pp.

Epstein, P.R., H.F. Díaz, S. Elias, G. Grabherr, N.E. Graham, W.J.M. Martens, E. Mosley-Thompson, and J. Susskind, 1998: Biological and physical signs of climate change: focus on mosquito-borne diseases. Bulletin of the American Meteorological Society, 79(3), 409–417.

Everett, J.T and B.B. Fitzharris, (1998): The Arctic and the Antarctic. In: The Regional Impacts of Climate Change. An Assessment of Vulnerability. A Special Report of IPCC Working Group II for the Intergovernmental Panel of Climate Change [Watson, R.T, M.C. Zinyowera, R.H. Moss, and D.J. Dokken (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 85–103.

Fischer, C. and R. Newell (2008). Environmental and technology policies for climate mitigation‖, Journal of Environmental Economics and Management 55(2):142-162.

Fryauff, D.J., E. Gomez-Saladin, Purnomo, I. Sumawinata, M.A. Sutamihardja, S. Tuti, B. Subianto, and T.L. Richie, 1997: Comparative performance of the Parasite F test for detection of plasmodium falciparum in malaria-immune and non-immune populations in Irian Jaya,

GAO, (2000): Insurers' Ability to Pay Catastrophe Claims. U.S. General Accounting Office, Washington, DC, USA, 32 pp. Available online at http://www.gao.gov/ corresp/gg.pdf.

Global Analysis (April, 2010). State of the Climate. National Oceanic and Atmospheric Administration National Climatic Data Center.

Gordon, H.B. and S.P. O'Farrell, (1997): Transient climate change in the CSIRO coupled model with dynamic sea ice. Monthly Weather Review, 25, 875–907.

Goulder, L.H. and K. Mathai (2000), "Optimal CO2 abatement in the presence of induced technological change", Journal of Environmental Economics and Management 39:1-38.

Hagemann, S. and L. Dümenil, (1998): A parameterization of the lateral waterflow for the global scale. Climate Dynamics, 14, 17–31.

Harvell, C., K. Kim, J. Burkholder, R. Colwell, P. Epstein, D. Brimes, E. Hofmann, E. Lipp, A. Osterhaus, and R. Overstreet, (1999): Emerging marine diseases: climate links and anthropogenic factors. Science, 285, 1505–1510

Heinz Center, (2000): Evaluation of Erosion Hazards. Federal Emergency Management Agency,Washington, DC, USA, 252 pp. Available online at http://www.fema.gov/erosion.htm.

Hulme, M. and T.R. Carter, (2000). The changing climate of Europe. In: Assessment of Potential Effects and Adaptations for Climate Change in Europe: The Europe ACACIA Project [Parry, M.L. (ed.)]. Jackson Environment Institute, University of East Anglia, Norwich, United Kingdom, 324 pp.

IPCC (1998). The Regional Impacts of Climate Change: An Assessment of Vulnerability. Special Report of IPCC Working Group II [Watson, R.T., M.C. Zinyowera, and R.H. Moss (eds.)]. Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 517 pp.

IPCC, (2000): Emissions Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change [Nakicenovic, N., J. Alcamo, G. Davis, B. de Vries, J. Fenham, S. Gaffin, K. Gregory, A. Grubler, T.Y. Jung, T. Kram, E.L. La Rovere, L. Michaelis, S. Mori, T. Morita, W. Pepper, H. Pitcher, L. Price, K. Raihi, A. Roehrl, H.-H. Rogner, A. Sankovski, M. Schlesinger, P. Shukla, S. Smith, R. Swart, S. van Rooijen, N. Victor, and Z. Dadi (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 599 pp.

IPCC, 2001: Climate Change (2001): The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp.

Jacka, T.H. and W.F. Budd, (1998): Detection of temperature and seaiceextent changes in the Antarctic and Southern Ocean, 1949–96. Annals of Glaciology, 27, 553–559. de la Mare, W.K., 1997: Abrupt mid-twentieth century decline in Antarctic sea ice extent from whaling records. Nature, 389, 57–61.

Johnstone, N. , Hascic, I., , and C. Michel (2008). Environmental policy stringency and technological innovation: Evidence from patent counts, paper presented at the European Association of Environmental and Resource Economists 16th Annual Conference, Gothenburg, Sweden, June 26, 2008.

Kane, S., J. Reilly, and J. To b e y, 1991: Climate Change: Economic Implication for World Agriculture. AER-No. 647, U.S. Department of Agriculture, Economic Research Service, Washington, DC, USA, 21 pp.

Kark, S., U. Alkon, E. Randi, and U.N. Safriel, 1999: Conservation priorities for chukar partridge in Israel based on genetic diversity across an ecological gradient. Conservation Biology, 13, 542–552.

Langdon, S.J., (1995): Increments, ranges and thresholds: human population responses to climate change in northern Alaska. In: Human Ecology and Climate Change [Peterson, D.L. and D.R. Johnson (eds.)]. Taylor & Francis, Washington, DC, USA, pp. 139–154.

Lange, I. and Allen Bellas (2005). Technological change for sulfur dioxide scrubbers under market-based regulation, Land Economics 81 :546-556.

Lasco, R.D. and F.B. Pulhin (1998). In: Proceedings of the Consultation Meeting for the International Conference on Tropical Forests and Climate Change: Status, Issues and Challenges. Sponsored by University of the Philippines Los Baños, Integrated Environmental Assessment for Sustainable Development - Department of Environment and Natural Resources, United Nations Development Programme. November 25, 1997. Makati, Philippines.

Lasco, R.D. (1998). World Resource Review 10:410-418.

Lasco, R.D. and F.B. Pulhin (1998). Paper presented at the GCTE-LUCC Open Science Conference on Global Change. 16 March 1998. Barcelona, Spain.

Lasco, R.D. and F. B. Pulhin. (1999). In: Proc. Of the International Conference on Tropical Forests and Climate Change, CFNR, UPLB, Philippines.

Lasco, R. D., Ravindranath, N.H., and P. Sudha (2000). Mitigation and Adaptation to Global Change Journal 00:1-22.

Lasco, R.D., J.S. Lales, M.T. Arnuevo, I.Q. Guillermo, A.C. de Jesus, R. Medrano, O. F. Bajar and C.V. Mendoza (2002). J of Renewable Energy 25:307-315.

Lasco, R.D. and F.B. Pulhin (2001). J of Mitigation and Adaptation Strategies for Global Change 6:313-334.

Lasco, R.D.L., Espaldon, M.V.O., Tapia, M.A. (2005). The Philippine Millennium Ecosystem Assessment (MA) Sub Global Assessment. Environmental Forestry Programme, College of Forestry and Natural Resources, UPLB.

Lee, R.J. (2001), Climate Change and Environmental Assessment: Part 1- Review of Climate Change Considerations in Selected Past Environmental Assessments, Report to the Canadian Environmental Assessment Agency, Research and Development Monograph Series.

MacIver, D.C. (ed.), (1998): Workshop summary. In: IPCC Workshop on Adaptation to Climate Variability and Change, San Jose, Costa Rica, 29 March–1 April, 1998. Atmospheric Environment Service, Environment Canada, Ottowa, ON, Canada, 55 pp.Marchant, H.J, (1997): The effects of enhanced UV-B irradiance on Antarctic organisms. In: Antarctic Communities: Species, Structure and Survival [Battaglia, B., J. Valencia, and D.W.H. Walton (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 367–374.

McKendrick, J.D., (1997): Long-term tundra recovery in northern Alaska. In: Disturbance and Recovery in Arctic Lands [Crawford, R.M.M. (ed.)]. NATO ASI Series 2: Environment, Vol. 25, J. Kluwer Academic Publishers, Dordrecht, The Netherlands, The Netherlands, pp. 503–518.

Maxwell, B. (ed.), (1997): Responding to Global Climate Change in Canada’s Arctic. Volume II of the Canada Country Study: Climate Impacts and Adaptation. Environment Canada, Toronto, ON, Canada, 82 pp.

Michel, F.A. and R.O. van Everdingen, 1994: Changes in hydrogeologic regimes in permafrost regions due to climate change. Permafrost and Periglacial Processes, 5, 191–195.

Mortsch, L. and F. Quinn, (1996): Climate change scenarios for Great Lakes Basin ecosystem studies. Limnology and Oceanography, 41(5), 903–911.

National Round Table on the Environment and the Economy (2009), True North: Adapting Infrastructure to Climate Change in Northern Canada, NRTEE, Ottawa, Canada.

Newell, R.G. (2008). A U.S. Innovation Strategy for Climate Change Mitigation. Hamilton Project Discussion Paper 2008-15, Brookings Institution, Washington, DC.

Nuttall, M., (1998): Protecting the Arctic: Indigenous Peoples and Cultural Survival. Harwood Academic Publishers, Amsterdam, The Netherlands, 195 pp.

Odner, K., (1992): The Varanger Saami: Habitation and Economy A D 1200–1900. Scandinavian University Press, Oslo, Norway, 320 pp.

Parry, M.L. (ed.), 2000: Assessment of Potential Effects and Adaptations for Climate Change in Europe: The Europe ACACIA Project. Jackson Environment Institute, University of East Anglia, Norwich, United Kingdom, 324 pp.

Popp, D. (2003), ―Pollution control innovations and the Clean Air Act of 1990, Journal of Policy Analysis and Management 22:641-660.

Popp, D. (2006), ―International innovation and diffusion of air pollution control technologies: The effects of NOX and SO2 regulation in the U.S., Japan, and Germany, Journal of Environmental Economics and Management 51(1):46-71.

Prowse , T.D. and M. Conly, (1998): Impacts of climatic variability and flow r e gulation on ice jam flooding of a northern delta. Hydrological Processes, 12, 1589–1610.

Prowse, T.D. and P.O. Flegg, (2000): Arctic river flow: a review of contributing areas. In: The Freshwater Budget of the Arctic Ocean [Lewis, E.L., E.P.Jones, P. Lemke, T.D. Prowse, and P. Wadhams (eds.)]. NATO Science Series, No. 2, Environmental Security, J. Kluwer Academic Publishers, Dordrecht, The Netherlands, Vol. 70, pp. 269–280.

Reilly, J., F. Tubiello, B. McCarl, and J. Melillo, (2000): Climate change and agriculture in the United States. In: Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and C hange. Report for the U.S. Global Change Research Program. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 379–403.

Ross, A., (2000): Reflections on the Future: Climate Change and its Impacts on the Insurance Industry. Paper No. 8, University of Western Ontario and Institute for Catastrophic Loss Reduction, Toronto, ON, Canada, 9 pp.

Sabo, G. III., (1991): Long-Term Adaptations Among Arctic Hunter-Gatherers. Garland Publishing, London, United Kingdom, 403 pp.

Safriel, U.N., 1993: Climate change and the Israeli biota: little is known but much can be done. In: Regional Implications of Future Climate Change [Graber, M., A. Cohen, and M. Magaritz (eds.)]. The Israeli Academy of Sciences and Humanities, Jerusalem, Israel, pp. 252–260.

Serreze, M.C., J.E. Walsh, F.S. Chapin III, T. Osterkamp, M. Dyurgerov, V. Romanovsky,W.C. Oechel, J. Morison, T. Zhang, and R.G. Barry, (2000): Observational evidence of recent change in the northern high latitude environment. Climatic Change, 46, 159–207.

Steele, M. and T. Boyd (1998): Retreat of the cold halocline layer in the Arctic Ocean. Journal of Geophysical Research, 103, 10419–10435.

Stewart, R.E., (2000): The variable climate of the Mackenzie River Basin: Its water cycle, feedbacks and fresh water discharge. In: The Freshwater Budget of the Arctic Ocean [Lewis, E.L., E.P. Jones, P. Lemke, T.D. Prowse, and P. Wadhams (eds.)]. NATO Science Series, No. 2, Environmental Security, J. Kluwer Academic Publishers, Dordrecht, The Netherlands, Vol. 70, pp. 367–381.

Taylor M.S. and B.R. Copeland (2003), Trade and the Environment: Theory and Evidence (Princeton University Press, Princeton, NJ).

Tynan, C.T. and D.P. DeMaster, (1997): Observations and predictions of Arctic climatic change: potential effects on marine mammals. Arctic, 50,308–322 .

Tol, R.S.J. (2006) The Stern Review of the Economics of Climate Change: A Comment. Mimeo, October 30. Economic and Social Research Institute, Vrije University, and Carnegie Mellon University.Verheem, R. and M. Laeven (2009), "SEA for flood protection in the Netherlands: A Case Study".

Vaughan, D.G. and J.R. Spouge, (2000): Risk estimation of the collapse of the West Antarctic ice sheet. Climatic Change (in press).

Vinje, T., (2001): Anomalies and trends of sea ice extent and atmosphere circulation in the Nordic Seas during the period 1864–1998. Journal of Climate, 14, 255–267.

Whetton, P.H., M.H. England, S.P. O'Farrell, I.G. Watterson, and A.B. Pittock, (1996): Global comparisons of the regional rainfall results of enhanced greenhouse coupled and mixed layer experiments: implications for climate change scenario development for Australia. Climatic Change, 33, 497–519.

Wenzel, G.W., (1995): Warming the Arctic: environmentalism and the Canadian Inuit. In: Human Ecology and Climate Change [Peterson, D.L. and D.R. Johnson (eds.)]. Taylor & Francis, Washington, DC, USA, pp. 169–184.

Wong, A.P.S., N.L. Bindoff, and J.A. Church, 1999: Large-scale freshening of intermediate waters in the Pacific and Indian Oceans. Nature, 400, 440–443.

Xiao, X.M., J.M. Melillo, D.W. Kicklighter, Y. Pan, A.D. McGuire, and J.Helirich, 1998: Net primary production of terrestrial ecosystems in China and its equilibrium responses to changes in climate and atmospheric CO_2 concentration. Acta Phytoecologica Sinica, 22(2), 97–118.