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WESTERN HEMISPHERE
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EXECUTIVE SUMMARY

Climate change has been a security issue for mankind since Homo sapiens first emerged on the planet, driving him to find new and better food, water, shelter, and basic resources for survival and the advancement of civilization. Only recently, however, has the rate of climate change coupled with man's knowledge of his own role in that change accelerated, perhaps profoundly, changing the security paradigm. If we take a "decades" look at the security issue, we see competition for natural resources giving way to Cold War ideological containment and deterrence, itself giving way to non-state terrorism and extremism. While we continue to defend against these threats, we are faced with even greater security challenges that inextricably tie economic, food and human security together and where the flash points may not provide clearly discernable causes, as they will be intrinsically tied to climate change.

Several scientific reports have revealed that the modest development gains that can be realized by some regions could be reversed by climate change. This means that climate change is not just a long-term environmental threat as was widely believed, but an economic and developmental disaster that is unfolding. As such, addressing climate change has become central to the development and poverty reduction by the World Bank and other financial institutions. In Latin America, poorer countries and communities, such as those found in Central America, will suffer the hardest because of weaker resilience and greater reliance on climate-sensitive sectors such as agriculture. The US should attempt to deliver capability to assist these states to deal with the effects of climate change.

INTRODUCTION

In the past, the common symptoms of human environmental impact have been urban-industrial air pollution, chemically polluted waterways and the manifestations of urban squalor in both rich and poor countries. These local hazards are now being supplemented with those due to changes in some of the planet's great biophysical and ecological systems, and hence there are additional and larger-scale impacts. This impact, due significantly to climate change, has influenced the functioning of many ecosystems, the seasonal cycles, and geographic range of plants and creatures[1], thus affecting food production and water availability. These "at risk" ecosystems provide society with a number of goods (e.g., food, fiber, fuel, pharmaceutical products) and services that are essential to human health and well-being, and form the basis of our modern economies. Climate change is, therefore, seen not just as an environmental threat, but a threat that is cross-cutting and can affect all of the key economic sectors.[2]

Climate change will, in many countries result in large scale starvation, as previously productive agricultural areas dry up or become inundated by flooding. This could in turn lead to mass migrations and deaths of a scale never before seen. In fact, it would be much larger than the Irish migration due to the potato blight in the 1840s, where nearly two million people—a quarter of Ireland's population then-- migrated to the U.S. Additionally, diseases will become more prevalent in many areas and, due to the global interconnectedness of modern society, will spread rapidly from nation to nation. As countries fight to control disease and migration, others will

[1] Susan Hassol, *Impacts of a warming Arctic: Arctic Climate Impact Assessment*, (Cambridge, U.K.: Cambridge University Press) 2004.
[2] Anthony Nyong, "Climate-Related Conflicts in West Africa," *Environmental Change and Security Program Report*, Issue 12, (Washington, DC: US Agency for International Development) 2006-2007.

be seeking to relieve the pressure through exploitation of new areas of natural resources, causing increased border incursions/disputes and conflict.

Addressing climate change through stand-alone projects will not achieve the desired outcomes because of its cross-cutting nature. Therefore, the optimum strategy calls for a mainstreaming approach, where climate change concerns are integrated into programs and projects of development banks and other international institutions, as well as into governmental developmental planning and security processes. Additionally, military and national security experts must understand climate change and its root causes in order to identify potential routes to conflict and those interagency development programs that mitigate that threat.

In a 2007 publication titled, "National Security and the *Threat of Climate Change,"* the CNA Corporation's Military Advisory Board set the stage for future military studies in climate change, by stating the following:

> *Carbon dioxide levels in the atmosphere are greater now than at any time in the past 650,000 years, and the average global temperature has continued a steady rise. This rise presents the prospect of significant climate change, and while uncertainty exists, and debate continues regarding the science and future extent of projected climate changes, the trends are clear.*
>
> *The nature and pace at which climate change is being observed today and the consequences projected by the consensus scientific opinion are grave and pose equally grave implications for our national security. Moving beyond the arguments of cause-and-effect, it is important that the US military begin planning to address these potentially devastating effects. The consequences of climate change can affect the organization, in terms of training,*

equipping, and planning of the military services. The US military has a clear obligation to determine the potential impacts of climate change on its ability to execute its mission in support of national security objectives.

Climate change can act as a threat multiplier for instability in some of the most volatile regions of the world, and it presents significant national security challenges for the United States. Accordingly, it is appropriate to start now to help mitigate the severity of some of these emerging challenges. The decision to act should be made soon in order to plan prudently for the nation's security. [3]

This paper identifies the current issues in climate change and focuses on Central American countries that are most at risk of developing profound security challenges. It looks first at the scientific basics of greenhouse gases, and their effects and consequences. It then documents current agreements and protocols that in and of themselves may spawn international conflict. Finally, it identifies some emerging policies and economic incentives for potential mitigation of challenges that countries in Central America will face as a result of climate change.

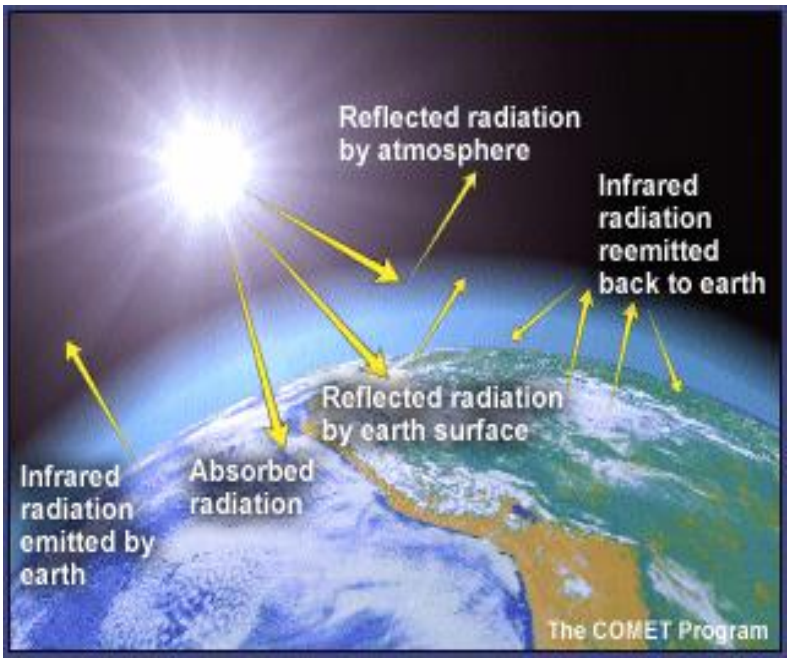
GREENHOUSE EFFECT

Since the earth's natural "Greenhouse effect" was first described in 1824 by the French physicist, Joseph Fourier, scientists have documented that fossil fuel burning and other industrial activities have been emitting billions of tons of global warming emissions. Most of the short wavelength radiation (high energy) coming from the sun are absorbed by the earth's surface. However, some of this radiation is re-emitted as long wavelength (infrared) radiation, (Heat).

[3] Military Advisory Board, *National Security and the Threat of Climate Change*, (Alexandria, Va.: CNA, April 2007).

Greenhouse gases (GHGs) in the atmosphere allow short wavelength radiation to pass through to the earth's surface, but trap much of the reflected long wavelength radiation causing what is called the "Greenhouse effect" or global warming.

Figure 1: A Schematic Illustration of the Greenhouse Effect[4]



The potential cause and focus in recent years has been on "global warming" but more recently the terminology has shifted to "climate change." Scientist disagree on whether "manmade" global warming has set off the current global warming trend, or whether we are really on the verge of the

[4] "The Greenhouse Effect & Greenhouse Gases," *Windows to the Universe,* http://www.windows2universe.org/earth/climate/greenhouse_effect_gases.html.

next great Ice Age. Rather than enter the political and philosophical debates, this paper assumes that greenhouse gases are significantly impacting the environment and causing rapid variations in the climate. The Intergovernmental Panel on Climate Change (IPCC) has projected a globally averaged warming of about 0.3 to 0.4°F per decade for a range of scenarios of GHG emissions over the next 20 years. The total temperature increase between 1850–1899 and 2001–2005 reached 0.76 °C. In fact, 5 of 21 IPCC models projected that the average warming will exceed 7.2°F by the end of the century with the largest warming in the US expected to occur during winter over northern Alaska. These warming trends vary geographically and further play into the dramatic climate discourse. The temperature of the world's oceans has also been rising, and mountain glaciers and snow cover have declined in both hemispheres. All these phenomena contribute to an average global sea level rise of 1.8 mm per year from 1961 to 2003, and at a faster rate – about 3.1 mm from 1993 to 2003. The scientists[5] have agreed that emissions have to be limited to 44 Gtonne CO_2e by 2020 to stay on a 2 degree limitation course. Based on the Copenhagen Accord pledges, the emissions in 2020 could be 49 Gtonne under a good scenario, but as high as 53 Gtonne (almost like business-as-usual) in the bad scenario.[6]

GHGs, as defined in the Kyoto Protocol, consist primarily of six gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). Since pre-industrial times, the atmospheric concentration of GHGs has grown significantly with carbon dioxide concentration increasing by about 31%, methane by about 150% and nitrous oxide by

[5] Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis,* Island Press, Washington, DC.
[6] World Bank, "Climate Change by the Numbers" 2003, http://siteresources.worldbank.org/DATASTATISTICS/Resources/WDI08_section3_intro.pdf.

about 16%.[7] The fluorinated compounds, although present in relatively much lower concentrations in the global atmosphere when compared with carbon dioxide and methane, have significantly larger global warming potentials (GWP) of up to 22,000 times greater than that of carbon dioxide and methane, which have GWPs of 1 and 23 respectively. GWP is a basis for comparing each gas's ability to trap heat. Furthermore, hydro-fluorocarbons have seen the highest percentage increase in concentration since 1998.[8] Table 1 shows the sources of greenhouse gases and the global warming potential of each gas.

[7] Luis M. Galindo, Carlos de Miguel, and Jimy Ferrer, "Vital Climate Change Graphics for Latin America and the Caribbean (2010) - Maps and Graphics at UNEP/GRID-Arendal," *Maps and Graphics at UNEP/GRID-Arendal,* June 2010, http://www.grida.no/_res/site/file/publications/LAC_Web_eng_2011-01-03.pdf.

[8] Lenny Bernstein, et al., *Climate Change 2007:Synthesis Report*, IPCC, November 2007.

Table 1: Source of Greenhouse Gases and their Global Warming Potential

Name	Symbol	Common Sources	GWP
Carbon Dioxide	CO_2	Fossil Fuel Combustion	1
		Forest Clearing	
		Industrial Production Processes	
Methane	CH_4	Landfills	25
		Natural Gas Production	
		Fermentation From Livestock	
Nitrous Oxide	N_2O	Soil Management	298
		Fossil Fuel Combustion	
		Fertilizers (production and application)	
Hydro-fluorocarbons	HFCs	Refrigeration Gases	140-11,700
		Semiconductor Manufacturing	
Perfluorocarbon	PFCs	Aluminum Production	7,850
		Semiconductor Industry	
Sulfur Hexafluoride	SF_6	Electrical Transmission Systems	23,900
		Magnesium Production	

GLOBAL CLIMATE CHANGE POLICY

Predictions by climate models of the GHGs influence on global temperature increase and various other environmental indicators prompted the formation of the Intergovernmental Panel on Climate Change (IPCC) in 1988.[9] The Kyoto Protocol was adopted by the United Nations Framework Convention on Climate Change (UNFCCCC) in 1997 to reduce emissions by an average of 5% by the period 2008-2012. To date, 186 countries have ratified the convention. The U.S. did not choose to become a signatory to the protocol although it is a signatory to the UNFCCC, placing the U.S. outside of the international norm.[10]

The Kyoto Protocol was outlined to make the convention operational in 1997, whereby 39 developed countries (Annex 1 countries) made legally binding commitments to reduce their GHG emissions by an average of 5.2% relative to 1990 to be achieved by 2008 -2012: the so called "First Commitment Period."[11] Countries without targets (non-Annex 1 countries) can receive investments from Annex 1 countries by hosting Clean Development Mechanism (CDM) projects.

The Kyoto Protocol established a belief that a wealthy minority of the world's countries and corporations are the principal cause of climate change. The foundation of further global climate justice movements stem from this and further believe the adverse effects of climate change fall first and foremost on the developing nations that suffer the greatest percentage of the global poverty. The provisions for this Protocol end December 2012 and hence the push for a

[9] Ibid.
[10] Galindo L., op. cit.
[11] Ben H. de Jong, et al., "Greenhouse gas mitigation potential of combining forest management and bioenergy substitution: A case study from Central Highlands of Michoacán, Mexico." *Forest Ecology and Management* 30 April 2007: p. 398-411.

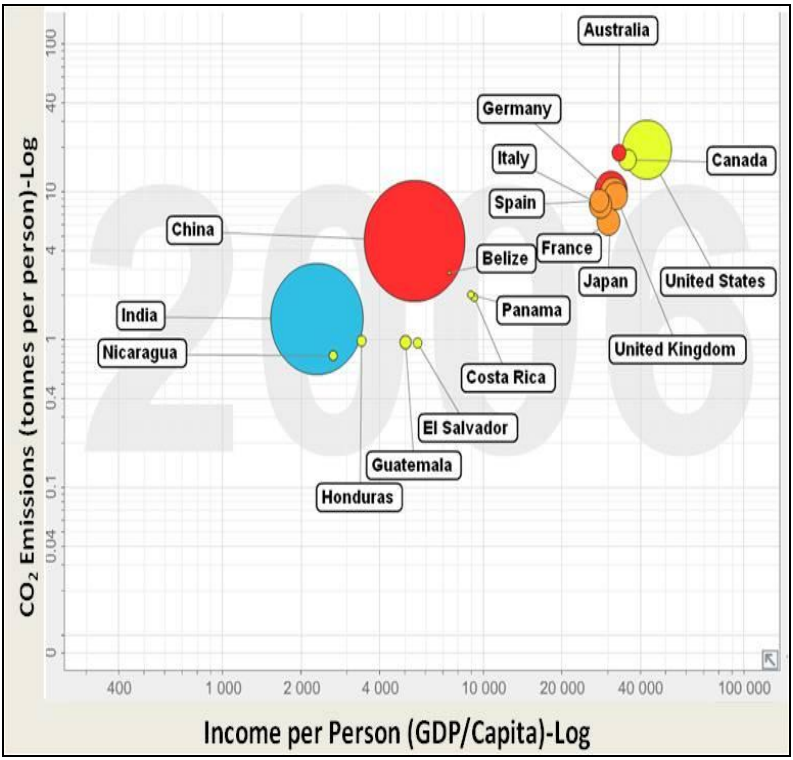
continuation at the United Nations Climate Change Conference in Copenhagen in December 2009 and again in Cancun in 2010.

The debacle of the Copenhagen Accord[12] is a direct result of the fact that developing countries (led by China) and communities are unlikely to ignore the wealthy nation's historical responsibility for the causes and consequences of climate change. They also perceive that the wealthy minority continues to consume an excessive proportion of the Earth's limited environmental space. Furthermore, there appears to be some resentment and mistrust of proposals, if adopted, which would lock developing countries into low and rapidly decreasing per-capita shares, denying them the environmental space needed to build the houses, schools, roads and infrastructure that developed countries possess. Such proposals are deemed to deepen the debt of developed countries rather than honoring it, leveraging past injustices into a future climate regime, and proposing a system in which the "polluter profits" and the "poor pays" for the excessive historical and current consumption of the rich countries.[13] In fact, President Evo Morales of Bolivia, hosted his own Climate Change Conference in April 2010 to further push similar ideas and challenge the UN, and more importantly, the US.

On a global scale, China and the United States are the largest and second largest overall contributors to global warming at 24% and 22%, respectively. However, in respect to per capita and per GNP, the United States far exceeds the rest of the world (see Figure 2). This spurs the grand debate of who pays for the impact.

[12] Hassol S., op. cit.
[13] World Bank, "Climate Change by the Numbers" 2003, http://siteresources.worldbank.org/DATASTATISTICS/Resources/WDI08_section3_intro.pdf.

Figure 2: Carbon Dioxide Equivalent Emissions per Capita and per GNP[14]



At the IFCCC Cancun 2010, the US had two goals: reinforce an international agreement on climate change that entails comparable efforts from all major GHG emitters, and avoid being blamed if the talks are seen to fail. However, China was a critical barrier to achieving both goals because it continues to demand that all developed countries including the US, adopt legally binding international obligations to cut

[14] "Carbon Dioxide Equivalent Emissions per Capita and per GNP," *Gapminder: Unveiling the beauty of statistics for a fact based world view,* http://www.gapminder.org.

their own emissions, while insisting that all others, including China, be exempt.[15]

The inability of the US administration to make a meaningful commitment to reduce its emissions to an adequate extent has been problematic. In fact, it is now clear that Congress will not adopt a comprehensive climate bill. As such, other developed countries are reluctant to honor their own commitments, or even retain the existing regulated system. Furthermore, Russia and Japan have openly indicated a reluctance to continue with the Kyoto Protocol, due to the non-involvement of the US. Other major developing countries have also shown a reluctance to adhere to the binding disciplines. The Vice Minister and senior climate negotiator of Japan has been quoted as saying, "Japan will not agree to extend Kyoto Protocol beyond 2012 even if it means isolating itself at the UN". Australia, New Zealand and Canada, among others, have also been unwilling or reluctant to commit to Kyoto's second period. That leaves the European Union, which although it has said that it would prefers to shift to a new system, is still open to remaining in the Kyoto Protocol, if others do. Only Norway has firmly agreed to a second Kyoto Protocol period**.**

CONSEQUENCES OF CLIMATE CHANGE

The major anticipated impacts of climate change are on agriculture and food security, forest composition, health and productivity, water resources, coastal erosion and inundation, modification of biodiversity, and eco-systems. Temperatures are projected to raise an additional 2-5^{o}F in the 21st Century producing heat waves, storms, floods, hurricanes and rising sea levels due to melting glaciers.[16] Due to geographical and

[15] Brian M. Fagan, *Floods, famines, and emperors: El Niño and the fate of civilizations,* (New York, NY: Basic Books), 1999.
[16] Lenny Bernstein, et al., *Climate Change 2007: Synthesis Report*, IPCC November 2007.

climatic variances, the temperature rise varies by region. Vulnerable regions in both the northern and southern hemisphere will bear the brunt of the effect of climate change. NASA satellite images have revealed that a significant amount of Arctic ice has disappeared to about half of what it was five years ago. Greenland's ice sheet has lost almost 19 billion tonnes of its volume, which prompted climate scientist Jay Zwally to remark, "At this rate, the Arctic Ocean could be nearly ice-free by 2012".[17] This may present both a more traditional security threat, as nations such as Russia, race to claim the opening oil and seabed riches, as well as control the Northwest Passage, which could reignite and expand a regional risk, as well as a climate change risk of enormous proportions. The conditions of life on Earth have already been altered, even as we remain largely ignorant of the long-term consequences on biodiversity.[18] The opening of the Arctic Passage would have a huge economic effect on the Panama because, if it remains open all year long, it would offer a shorter route sea transport and obviates the need for usage of the Panama Canal. This would have a tremendous impact to Panama's economy.

Central America is already experiencing adverse effects of climate change. This include sea level rise, temperature increases, predicted water shortages and other related phenomena such as increased tropical cyclones/hurricanes, coral bleaching, among others, as will be discussed below.

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[17] Seth Borenstein, "Artic Sea Ice Gone in Summer within Five Years?" *National Geographic News,* Washington Associated Press, 12 December 2007, http://news.nationalgeographic.com/news/2007/12/071212-AP-arctic-melt.html.

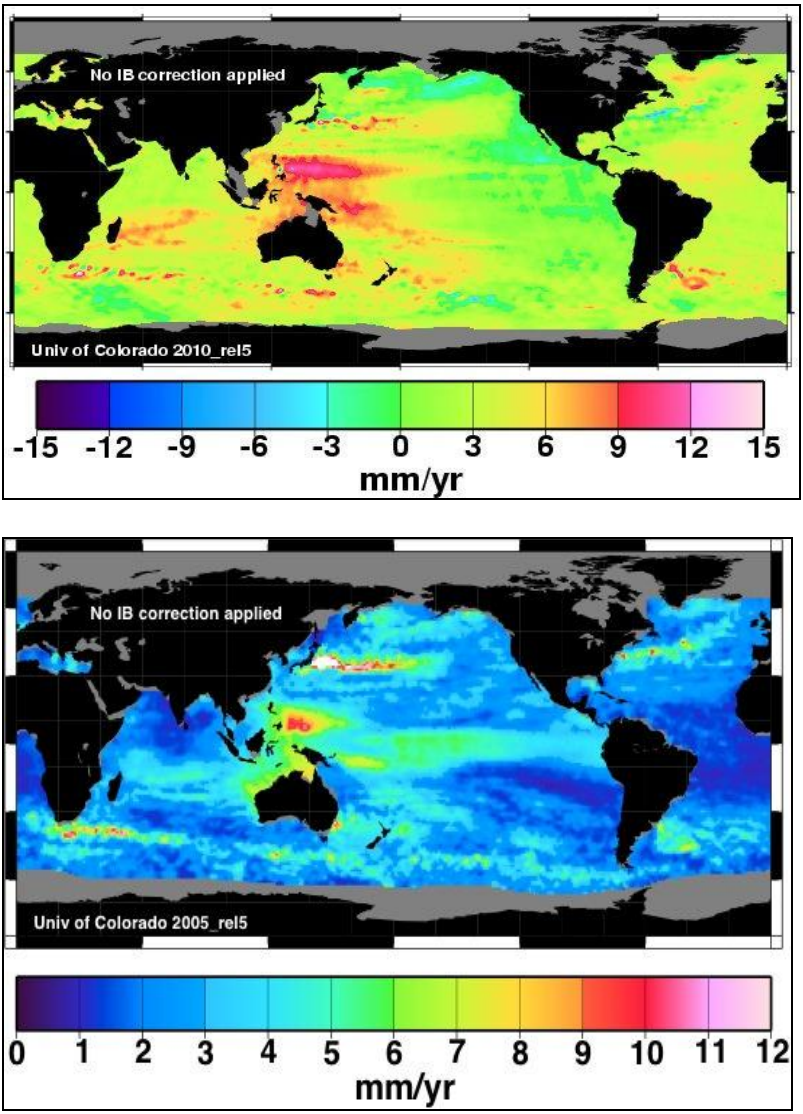
[18] Richard M. Adams and Dannele E. Peck. "Drought and Climate Change: Implications For The West." *Western Economics Forum* 1.2 (2002): 14-19. *AgEcon Search,* http://ageconsearch.umn.edu/handle/27990.

CENTRAL AMERICA: EFFECT OF TEMPERATURE INCREASE

Rise in Sea Level

Central American countries all have in common socio-economic challenges. Among these are: a heavy dependence upon the natural resource base (agriculture, forestry, fishing, tourism); susceptibility to the vagaries of international trade; lack of economies of scale; high transportation and communication costs; extreme vulnerability to natural disasters; scarce land resources; and ever increasing pressures on coastal and marine environments. Therefore, rising sea levels potentially threaten all coastal regions in Central America. The following sections specifically address the various trends of sea level rise as a result of temperature increase over the past two decades.

Figure 3: Local Trends in Sea Level determined over an 18 year (1992 - 2010) Period.



Predicted Water Shortages on Agriculture and Food Security

Changes in temperature and precipitation in Central America will very likely decrease the cover of vegetation that protects the ground surface from wind and water erosion in certain areas, turning currently productive farmland into an ecological disaster similar to the dust bowl experienced in the American and Canadian prairies in the 1930s. Studies have shown that climate change associated with increasing levels of carbon dioxide is likely to affect developed and developing countries differentially, with major vulnerabilities occurring in low-latitude regions.[19] In certain regions, the risk of crop failure on a year-to-year basis is likely to increase. According to the UNFCCC, a possible manifestation of the impact of climate change on small states includes a shortening of the sugar cane growing season in Belize, which could result in an acceleration of maturation that would reduce yields by up to about 30 per cent.

Developing countries already struggle with large and growing populations, and malnutrition rates would be particularly vulnerable to changes in food production.[20] Changes in the distribution of plant pests have implications for food safety. Ocean warming would increase the number of temperature-sensitive toxins produced by phytoplankton, causing contamination of seafood more often at an increased frequency of poisoning. Control of ambient conditions in the food production process, including animal husbandry and

[19] V. Ramaswamy and J.R. Christy, "Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences," January 2010, (United States Global Climate Change Science Program), http://www.climatescience.gov/Library/sap/sap1-1/finalreport/sap1-1-final-all.pdf.

[20] Anthony J. McMichael and R. Sari Kovats, "Climate Change and Climate Variability: Adaptatins to Reduce Adverse Health." *Environmental Monitoring and Assessment* 61.1 (2000): 49-64.

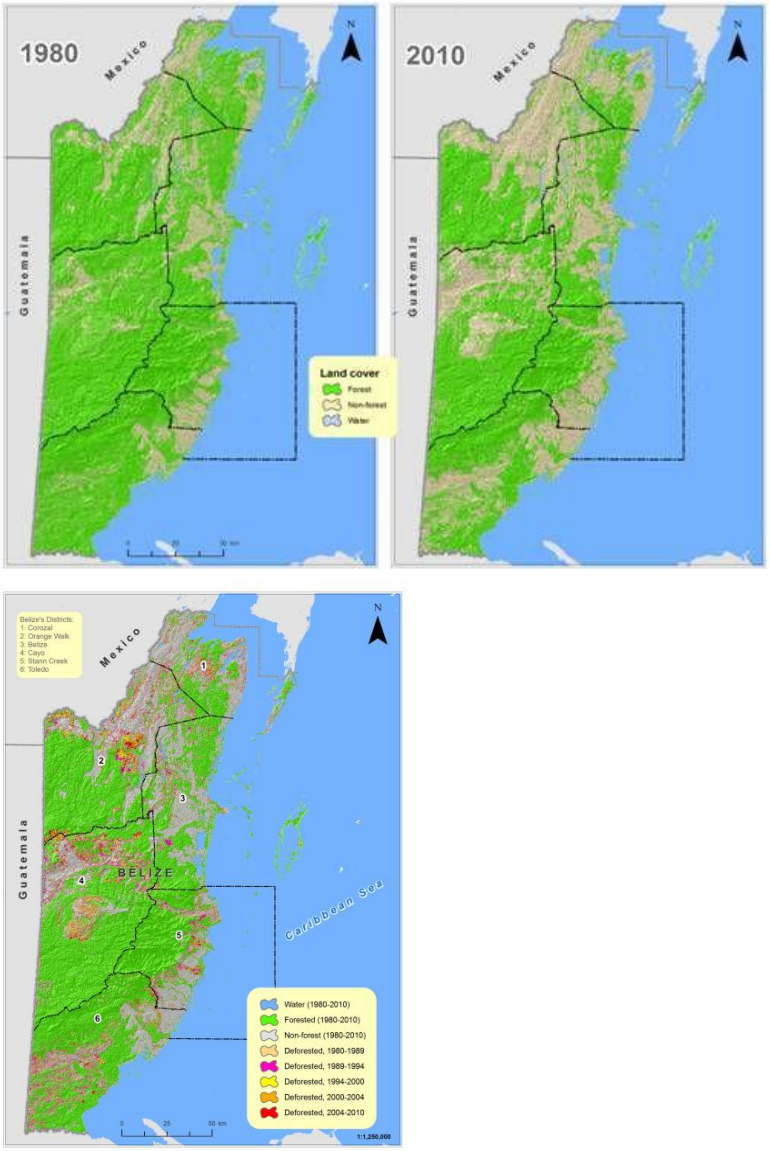
slaughtering, to avoid the adverse effects of climate change is highly recommended.[21]

Forests are defined by the Land Use, Land Use Change and Forestry (LULUCF) as tree crown coverage of between 10 - 30% with trees that are between 2 – 5 meters tall over a minimum area of 0.05 – 1.0 hectares. Afforestation, reforestation, deforestation and forest management provide relatively low cost opportunities to combat climate change by serving as a carbon sink for removal of greenhouse gases. Afforestation addresses land that has not been forested for at least 50 years, whereas reforestation is confined to land that was not forested as of December 31, 1989. Based on NASA Landsat satellite imagery from 1980 – 2010[22], Belize's forest cover has declined from 75.9% in 1980 to 62.7% as of late February 2010. Average annual deforestation was estimated at 0.6%, equaling the clearing of some 24,835 acres (9,982 hectares) of forest per year. Protected areas have helped to conserved forests, with only a small percent of forests being cleared within the past thirty years, as compared with a quarter of forests outside of protected areas during the period.

[21] Ana R. Moreno, "Climate Change and Human Health in Latin America: Drivers, Effects, and Policies", *Reg Environ Change,* 6, pp. 157-164, 2006. http://www.environmentalexpert.com/Files/0/articles/8845/Climatechangeandhumanhealth.pdf.

[22] E.R. Anderson, E.A Cherrington, A.I. Flores, J.B. Perez, R. Carrillo, Carrillo R., and E. Sempris. 2008. "Potential Impacts of Climate Change on Biodiversity in Central America, Mexico, and the Dominican Republic." CATHALAC / USAID. Panama City, Panama.

Figure 4: Decline of Belize's Forest Cover from 1980 to 2010[23]



[23] Galindo L., op. cit.

Water Resources and Water Security

Annual precipitation in parts of Latin America is predicted to decrease as climate change worsens, and there is some evidence that this has begun to happen. In other areas, access to potable water is threatened whenever major flooding or landslides occur as evidenced in Belize, Guatemala and Honduras. As such, whether water supply is threatened by excess precipitation or by droughts, many countries have taken measures to ensure an adequate supply of water. Nicaragua for example, has plans to build infrastructure to store rainwater, to increase water security in times of drought. An example of situations to be avoided in Central America is a reduction in quality and quantity of water due to climate change, as has happened in Bolivia. This prompted an attempt of privatization of water in two of the three largest cities, Cochabamba and La Paz/El Alto, which led to civil unrest.[24] The two concessions to foreign private companies in the respective cities were prematurely ended in 2000 and 2006 respectively. This is a glaring example where, a multinational corporation seized an opportunity to provide a commodity from what was perceived by locals, as a naturally inherited resource (water), which threatened the national security of Bolivia.

Impact of Climate Change on Ecosystems

Biodiversivity (the variety of all forms of life, from genes to species to ecosystems) is a fundamental building block of many of the services that ecosystems provide. Biodiversity contributes to the function of an ecosystem and is difficult or impossible to recover or replace once it has eroded.[25] In an

[24] Military Advisory Board, *National Security and the Threat of Climate Change*, (Alexandria,Va.: CAN) April 2007.

[25] Peter Backlund, et al., 2008. "*The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States*," Synthesis and Assessment Product 4.3 Report by the U.S. Climate Change Science Program and the Subcommittee on Global

analysis of 866 peer-reviewed papers exploring the ecological consequences of climate change worldwide, nearly 60% of the 1,598 species studied exhibited shifts in their distributions and/or timing of their annual cycles that correspond to large-scale climate change patterns. Maintaining the integrity of ecosystems, such as forest habitat and wetlands, can provide defense against outbreaks of the opportunists that carry diseases, and provide a buffer against climate vagaries and extremes, whether or not there is any change in the overall climate regime. Early interventions can save money and lives.[26] Mangrove accretion on land may or may not be able to keep pace with rising sea levels, depending on the composition of the forest, tidal range and sediment supply. Mangrove forests could be lost with a one meter rise in sea level in some states.

Climate Change Severity Index

Dynamics and impacts of climate change involve complex feedback loops driven by human-produced greenhouse gases emitted into the atmosphere; therefore, it is necessary to develop models that demonstrate potential scenarios in the future. The most sophisticated models include the flow of atmosphere, oceanic, glacial, and terrestrial energy and mass. Each of these models is run numerous times under different conditions, as defined by Special Report on Emissions Scenarios (SRFS), prepared for IPCC. These scenarios represent best case and worst case scenarios under different circumstances in which the population, economy, technology, energy, and land-use, change and grow with time. Consequently, development interests can be more directed at increasing human wealth, or they can be more

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Change Research and the Subcommittee on Global Change Research. June, 2010; Washington, DC: U.S. Department of Agriculture.

[26] Paul R. Epstein, "Climate, Ecology and Human Health," *Consequences: The Nature and Implications of Environmental Change*, 1997;3(2), U.S. Global Research Information Office. http://www.gcrio.org/CONSEQUENCES/vol3no2/climhealth.html.

concerned with fostering a sustainable future by preserving the environment.

Anderson et al.[27] assessed the potential impacts of climate change on the biodiversity of Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama by identifying the critical habitats: places where climate change is projected to most greatly threaten biodiversity. This model describes the spatial distribution of ecosystems in terms of a Climate Change Severity Index (CCSI).

CCSI is a measure of how far a location will be placed outside of its current climate comfort zone. It is constructed utilizing baseline climate data and derived monthly anomaly data. The spatial scales depend on the detail of the available climate data and the raw quantitative values are interpreted as shown in Table 2:

Table 2: Range and Significance of CCSI Values[28]

Values	Severity
0 - 0.24	Low severity
0.25 - 0.49	Approaching significant changes
0.5 - 0.74	Significant changes vary during year
0.75 - 0.99	Pushing comfort zone limits
1.00 -1.99	Outside comfort zone
2.00+	Far outside comfort zone

[27] E.R. Anderson, E.A Cherrington, A.I. Flores, J.B. Perez, R. Carrillo, Carrillo R., and E. Sempris. 2008, opp cit.
[28] Galindo L., op. cit.

The CCSI itself is derived from two variables: Temperature Change Severity Index and a Precipitation Change Severity Index.

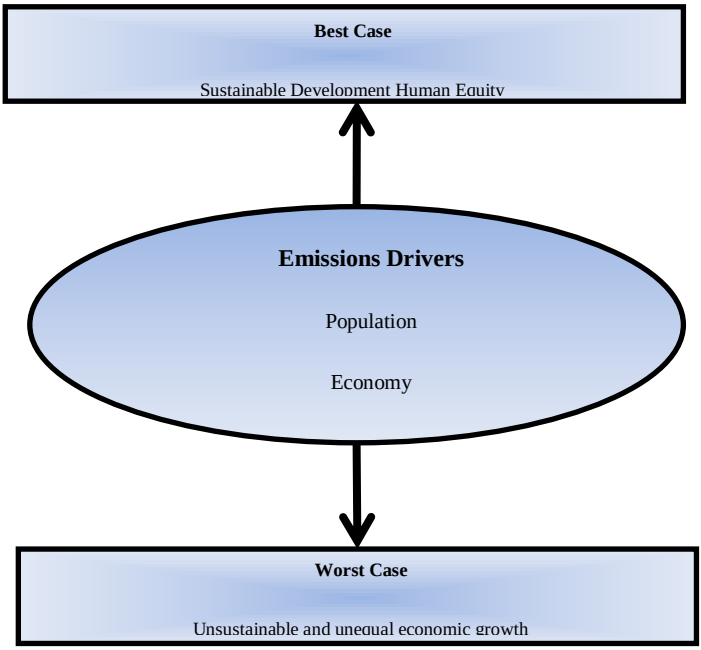
Temperature Change Severity Index (CCSIt): $= \frac{Annual\ mean\ scenario\ temperature - Annual\ mean\ baseline\ temperature}{Baseline\ temperature\ range}$

Precipitation Change Severity Index (CCSIp): $= \frac{Annual\ scenario\ precipitation\ accumulation - Annual\ baseline\ precipitation\ accumulation}{Baseline\ precipitation\ accumulation\ range}$

and Climate Change Severity Index (CCSI): $= \frac{CCSIt + CCSIp}{2}$

The potential impact of climate change within a given ecosystem depends on its elevation because vegetation at lower altitude has a higher risk of being impacted. Furthermore, significant consideration is given to ecosystems of very small extents with a very high average CCSI. The impact of climate change on species-rich ecosystems and Central America can be assessed in terms of a worst case or a best case scenario as depicted in Figure 5.

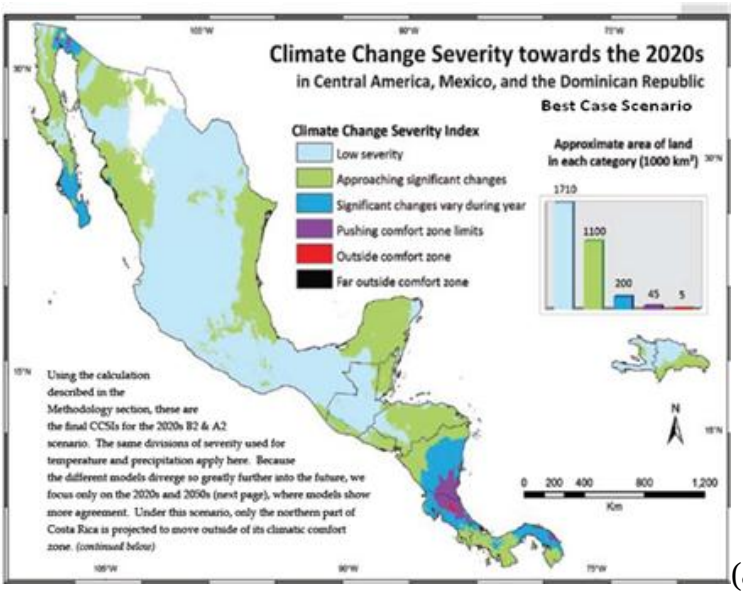
Figure 5: Conceptual Breakdown of Climate Change for Best and Worst Case Scenarios[29]



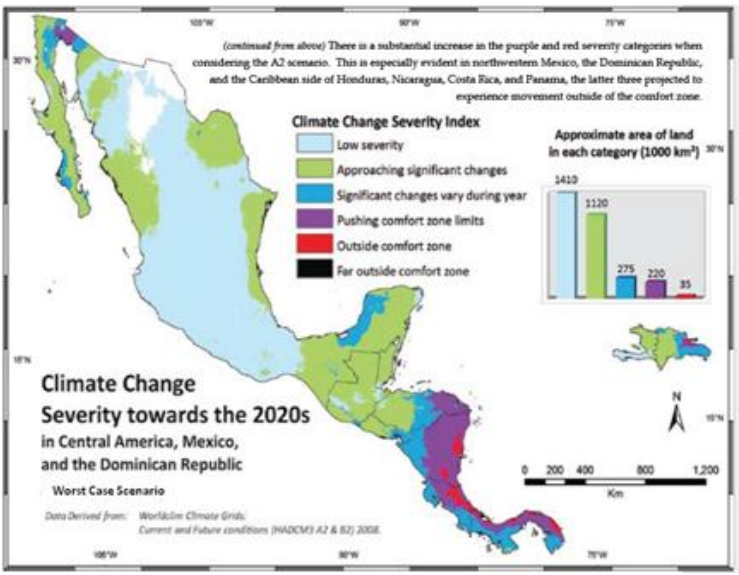
The following maps (Figure 6) display climate change severity index in terms of vegetation/land cover for the best case and worst case scenarios in Central America by the 2020s and 2050s.

[29] Anderson E.R., op. cit.

Figure 6: Climate change Severity Index in 2020s; (a) Best Case Scenario and (b) Worst Case Scenario[30]



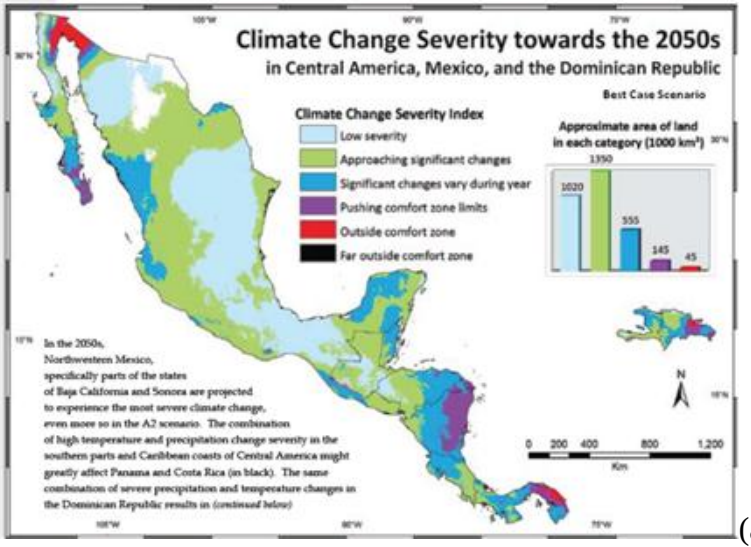
(a)



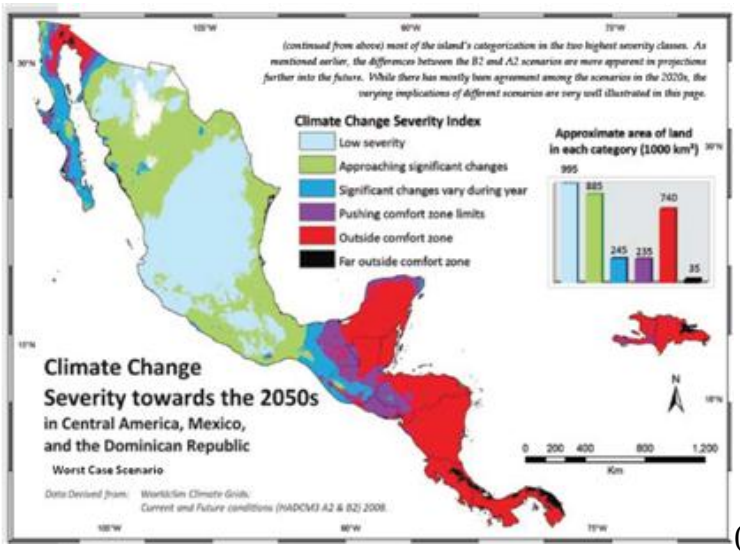
(b)

[30] Ibid.

Figure 7: Climate change Severity Index in 2050s; (a) Best Case Scenario and (b) Worst Case Scenario[31]



(a)

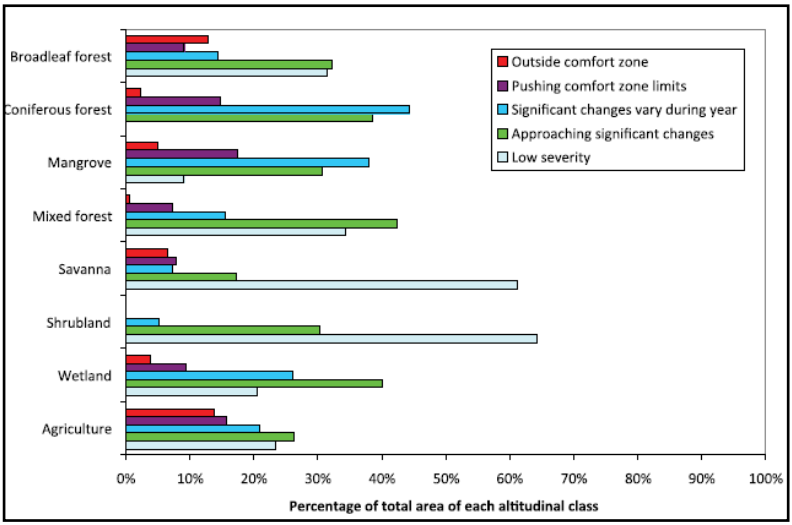


(b)

[31] Ibid.

While only a few countries Belize, Nicaragua and Honduras have the higher severity classes, in the best case scenario, by 2020 every country is projected to experience these changes, except for Guatemala. Therefore, the aforementioned projections suggest that in the light of the fact that Guatemala is the most unstable and the poorest in the hemisphere, government officials while being cognizant of the effects of climate change, may well devote fewer resources to mitigation efforts. As shown in Figure 7, it is possible that movement outside of the comfort zone will occur somewhere in every Central American country.

Figure 8: Average Climate Change Severity Index per Vegetation/Land Cover, Worst Case Scenario in the 2020s[32]

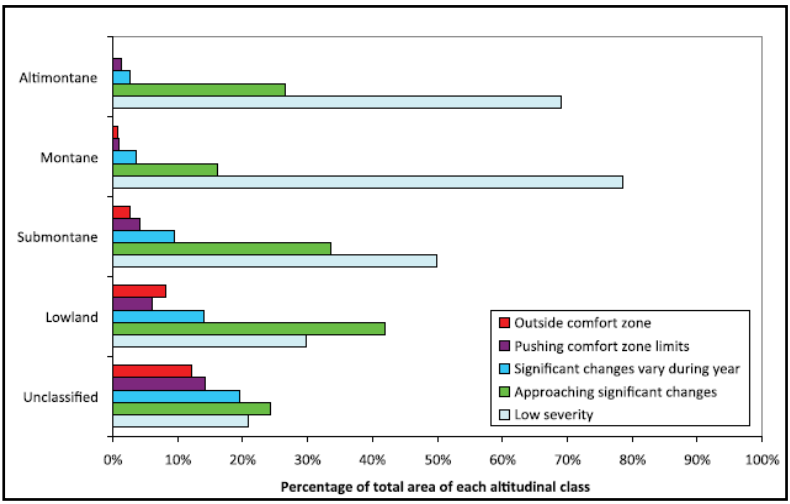


It should be noted that the CCSI maps depicted above do not locate actual ecosystems where climate change is projected to be more severe. However, the following graphs provide trends of the potential impact of climate change on species-

[32] Ibid. Pg. 35-36

rich ecosystems in terms of vegetation/land cover and altitude under worst case scenarios by the 2020s.

Figure 9: Average Climate Change Severity Index per Altitudinal Level, Worst Case Scenario in the 2020s.[33]



As seen in Figure 8, most ecosystems except for shrub land will experience some conditions far outside their comfort zone under the worst scenario in the 2020s. Broadleaf forests and agriculture, in particular have the highest percentage of climate changes that are projected to move outside of the comfort zone. Savannas and mangroves also have considerable amounts of highly susceptible areas. It is evident from the ecosystem map that shrub land, broadleaf forests, and agriculture are the most extensive land cover types and that nearly a quarter of the broadleaf forests have a high severity index. Additionally, there is cause for concern that 30% of agricultural areas are also projected to experience highly severe climatic changes.

[33] Ibid. Pg. 36-37

In terms of altitude, there seems to be a decreasing trend of severity with increasing elevation. This is most likely because ecosystems at higher altitudes are more adaptable to greater ranges in temperature; thus, they could potentially be more resilient to the changes in climate.

In the worst case scenario, projected climate change with altitude approaches the comfort zone limits or is outside the comfort zone (purple or red) in only submontane, lowlands and unclassified altitudinal classes (Figure 9). As seen in Figure 6 and 7, these classes of higher severity lie in parts of Costa Rica, Panama and Nicaragua. Whereas, in the worst case scenario, every class of vegetation or land cover type except shrub land is projected to experience movements outside of the comfort zone (Figure 7).

POLICY RESPONSE TO CLIMATE CHANGE

Under the Kyoto Protocol, there are three mechanisms by which GHGs can be reduced, namely Clean Development Mechanism (dedicated for developing countries), Emissions Trading (Cap-and-Trade) and Joint Implementation, which allows Annex 1 countries with reduction commitments to invest in projects that reduce emissions in other Annex 1 countries.

Clean Development Mechanism (CDM)

The CDM was established by Article 12 of the Kyoto Protocol of the UNFCCC to enable developed countries to offset their emissions by funding climate change mitigation projects in non-Annex 1 countries. In particular, project investments must contribute to sustainable development in the host country, and must be independently certified in terms of "certified emission reductions" or CERs.[34] A CER

[34] Martin Khor, "Cancun Climate Conference: Some Key Issues," *The South Centre*. Web. March 2011,

is a tradable unit issued by the United Nations (UN) through the CDM and is equal to one metric tonne of CO_2 equivalent of GHG emissions reduction.

CERs have become a commodity, which can be bought and sold in a new environmental market, for example at the Chicago Climate Exchange (CCX), which is a voluntary GHG emissions cap-and-trade scheme based in North America. As such, the dictates of this market has led to daunting challenges for smaller economies, particularly those without international connections. For example, transaction costs for implementation of the CDM are cost prohibitive for smaller economies. Additionally, only large scale operations in agroforestry, integrated rural forestry and energy related projects meet the CDM requirements. Furthermore, there is what is referred to as "people issues"[35] that are byproducts of CDM investment projects that could have potential negative impacts on local food security and development options. Large forest sinks could run counter to other sustainable development initiatives seeking goods and services from forests that may be benefitting poor and forest-dependent people.

CDM has been operational since the beginning of 2006 with over 4,200 registered projects. Of those registered, over 1,000 projects could lead to certified emission reduction, (one tonne of CO_2 = 1CER) of more than 2.9 billion tonnes of CO_2 equivalent in the first commitment period of the Kyoto Protocol, 2008–2012. CDM is the only flexible mechanism available to Caribbean nations for emission-reduction (or emission removal) projects to earn CER credits. These CERs can be traded and sold, and used by

<http://www.southcentre.org/index.php?option=com_content&view=article&id=1440%3Acancun-climate-conference-some-key-issues&catid=129%3Aclimate-change-&Itemid=67&lang=en>.

[35] Martin Parry, "Effects of climate change on global food production under SRES emissions and socio-economic scenarios." *Global Environmental Change,* 14.1 (2004): 53-67.

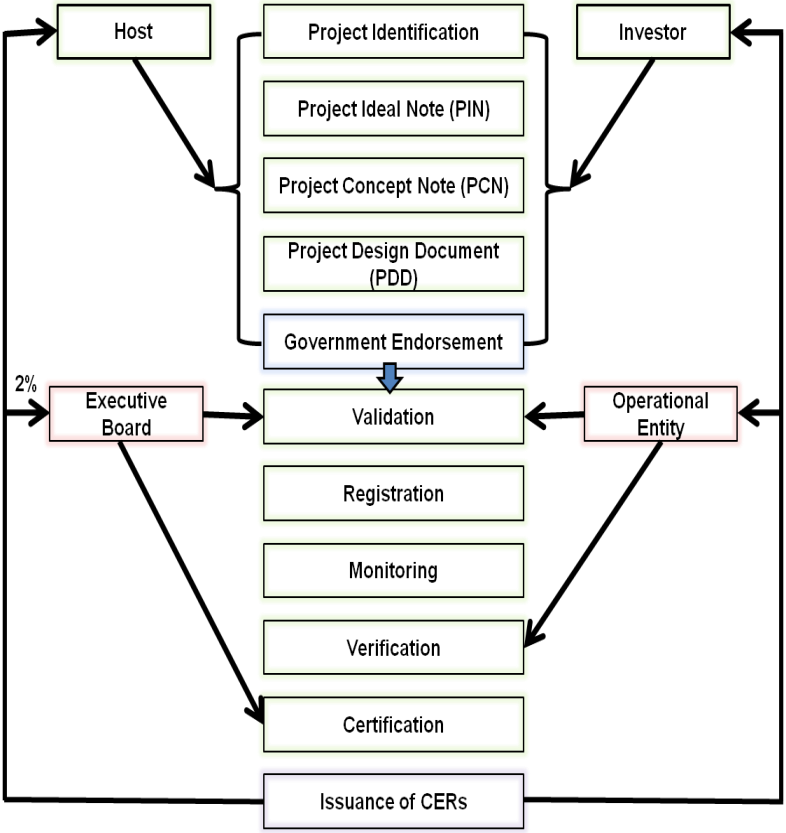
industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol. The mechanism stimulates sustainable development and emission reductions, while providing industrialized countries some flexibility in meeting their emission reduction limitation targets.

In Copenhagen in December 2009, developed countries committed to provide approximately $30 billion to developing countries to mitigate climate change effects between 2010 and 2012 for the most vulnerable countries, with a mid-term goal of 100 billion dollars a year by 2020. Furthermore, this money would be "new and additional," meaning that it was money, which had not been announced before. 'Additional' implied the funds would be additional to developed countries pre-existing aid commitments. However, nine months into 2010, developed countries have not lived up to their pledges. In fact, on a Netherlands published voluntary database where governments can disclose details on meeting their pledges, only six countries have put information on this website, and not all have forthwith on full details of their spending (World Development Movement). A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers. Energy projects, agro-forestry and integrated rural forestry have considerable livelihood benefits. However, only large scale operations will meet CDM requirements. For example, Norway has agreed to pay Guyana up to $250 million for anti-deforestation measures that could lead to decreased greenhouse gas emissions. In order to be considered for registration, a project must first be approved by the Designated National Authority (DNA) that is ultimately responsible for ensuring that the CDM project contributes to the country’s sustainable development.

Financial and Market Barriers to CDM

For smaller nations to take advantage of CDM, many challenges must be addressed. These include low economies of scale for renewable energy projects as compared with high transaction costs associated with developing a Project Development Design (PDD) report. Also, high transportation costs for travelling between countries to monitor and verify projects impose high implementation and operational barriers. In general, there is a lack of local accredited verifiers and in some cases, there is no DNA to oversee domestic CDM project activities. Furthermore, carbon funds are not readily available for small projects because focus has been placed on large projects. It is assumed, that as the global CDM market evolves, it may follow the path of foreign direct investment where the bulk of funding goes to a few larger developing countries with the infrastructure and institutions available to manage larger projects. The following chart documents the process for establishing a CDM project.

Figure 10: A CDM Project Cycle



Factors affecting CDM costs include: delivery risk associated with the host country, such as project financial and operational risks; availability of expertise within the host country (for example DOEs); and risks associated with the wider social impact of the project. For example, large forest sinks run counter to other sustainable development initiates seeking goods and services from the forest that may be benefiting the poor and forest-dependent people. There are also potential negative impacts on local food security and development options. To some extent, the more experience a country has with hosting CDM projects, the easier it is for the next developer to conduct business there.

Financial Options for CDM Projects

Developing countries will have to take steps to find portfolio investors via the prototype carbon fund of the World Bank and other Development Assistance funding sources to link up with active development initiatives and attract CDM projects. One solution to the transaction cost dilemma is to use International Development Assistance funds to establish third party involvement through the implementation of a Climate Change & Clean Development Consortia comprising NGOs, Development Banks and/or Government Extension Services network. This will strengthen the capacities of climate centers to be able to generate and disseminate reliable climate information as well as enhance the capacities of country's policy makers to be able to integrate the information into development planning. This will also provide consistent management and a financial and administrative system for cost-benefit sharing among many small players.

CAP-and-Trade Versus Carbon Tax

Cap-and-trade is a market-based approach suggested as a means to control pollution by providing economic incentives in order to reduce emissions of pollutants. A central authority or governmental body sets the limit (cap) on the amount of a pollutant that can be emitted. The limit is allocated or sold to other companies/agencies through emissions permits, representing the right to discharge a specific volume of the specified pollutant. Firms are then required to hold a number of permits, or carbon credits equivalent to their emissions, however the total number of permits cannot exceed the cap, thus limiting total emissions to that level. By transferring, or "trading" these permits, a company can effectively pay a charge for polluting, while the seller is rewarded for having reduced emissions. Theoretically, this market-based approach allows those who

can reduce emissions most inexpensively to do so, while achieving pollution reduction at the lowest cost to society.

Using this market approach, a "Cap" is designated as a limit placed on emissions for a measured/compliance period from "covered sources" where a "credit" can be either of two carbon commodities, an "allowance", or an "offset." Allowances are allocated to covered sources, whereas offsets come from projects in uncovered sources. An Offset Credit is a tradable commodity that represents a reduction, avoidance or sequestration of 1 tonne of CO_2 or equivalent GHG. In a voluntary or mandatory cap-and-trade scenario for example, it can be derived from a project in a non-covered sector, such as agriculture or forestry. Covered sources can design their own compliance strategy, such as, reduce emissions to the cap, reduce below cap and sell unused allowances to others, or purchase offset credits and emit above cap. Emitters and other project developers can create offset credits to be used, banked or traded on an exchange.

According to Clifton[36], the current obsession with carbon trading as a primary tool for tackling climate change is high risk, irresponsible and dangerous. It is a distraction from more viable, more equitable, more effective solutions for tackling greenhouse gas emissions and providing adequate finance to developing countries for tackling climate change and adapting to its impacts. Carbon trading is unreliable, unproven and burdens developing countries with unfair responsibility for tackling climate change. The barriers to reforming carbon trading are insurmountable in practice within the time we have available to avoid catastrophic climate change. In addition, carbon market offsets are not a legitimate source of climate finance, and cannot guarantee a

[36] S. J. Clifton, "A Dangerous Obsession, The Evidence Against Carbon Trading And For Real Solutions To Avoid A Climate Crunch," (London: Friends of the Earth, 2009).

predictable flow of finance to developing countries. This type of finance rarely supports genuine low carbon development. The biggest financial beneficiary of carbon trading is the Northern carbon trading industry.

Cap-and-Trade is a complex system that is not transparent and has the potential for fraud. Nevertheless, it results in a steadily decreasing cap. As the market sets the price, there is always the potential for volatility. Whereas, a carbon tax system could be quickly implemented as the Government sets the price. It is more predictable, transparent and void of incentive to defraud. However, a steadily increasing tax can be expected.

RECOMMENDATIONS

With funding from agencies such as the World Bank, the European Investment Bank (EIB) and European Development Finance Institutions (EDFI) (the latter parties intend to establish an investment matching facility to invest in private sector climate change projects in Africa, the Caribbean and the Pacific, Asia and Latin America before the end of 2010) and others, technical cooperation projects could be funded to achieve the following:

- Conduct Greenhouse gas inventories of selected industrial sectors. This will help a country to track its greenhouse gas emission levels.
- Identify companies to finance all or co-finance part of a CDM project in return for full or shared financial returns and CERs. A company financially contributes towards the cost of a CDM project equal to some portion of the incremental cost of the project over and above the baseline technology, or finances the removal of market barriers, in return for CERs.
- Identify companies to provide loan or lease financing at concessional rates in return for CERs.

- Develop a Caribbean regional advisory body to provide assistance to Caribbean countries.
- Establish sustainable development criteria and provide other technical assistance.
- Develop a consistent host country approval process
- Provide recommendations regarding individual project approval.
- Develop specific CDM infrastructure and expertise for Caribbean countries.
- Create Credit Facility for funding CDM projects utilizing renewable energy services such as solar LED lighting, solar water pumping, solar cookers and energy efficient biomass stoves and biomass gasifiers.
- Create specific carbon funding facility for the Caribbean region to enable accessibility and decrease competition with larger economies.
- Assist project developers to implement CDM projects, monitor and report on the progress of the projects in order to reduce transaction costs.
- Develop capacity of UNFCCC focal points in the small islands developing states in order to establish and set up functions of a DNA for the host countries.
- Develop separate funds for mitigation activities.
- Utilize solar industry's potential to create jobs that help to reduce emissions, e.g. Europe's industry group said electricity from solar panels could feasibly make up 20 percent of the supply for the European Union by 2020.

CONCLUSION

Several scientific reports have revealed that the modest development gains that can be realized by some regions could be reversed by climate change. This means that climate change is not just a long-term environmental threat as was widely believed, but an economic and developmental

disaster that is unfolding. As such, addressing climate change has become central to the development and poverty reduction by the World Bank and other financial institutions. Poorer countries and communities in Central America will suffer the hardest because of weaker resilience and greater reliance on climate-sensitive sectors such as agriculture. The US should attempt to deliver capability to assist these states to deal with the effects of climate change.

Central America will have to establish financial banking mechanisms that recognize and reward carbon sinks provided by agro-ecosystems and renewable energy systems. The CDM projects addressing climate change would ensure alignment with each country's and regional priorities, as well as recipient participation in its identification, development and approval process. CDM funding should build on already existing mechanisms thereby promoting efficiency and accelerated results. Through both the public and private sector, CDM projects associated with renewable energy projects, energy efficiency, forestry, sustainable transportation and climate change adaptation projects could be designed to build resilience and place the nations on a low carbon-intensive growth trajectory.

It is critical that the transition to a low-carbon economy, while driven by the need for environmental justice, does not in itself lead to further economic and social injustices. Policies and measures to address greenhouse gas emissions and support economic transition must ensure job creation, protect pay conditions, ensure health and safety for workers and respect and promote the rights of local communities and indigenous peoples. It should protect low-income groups, and guard against the creation of further economic and social injustice. Most importantly it should also ensure good governance, including participation of affected workers and communities in the development of policies and measures to

tackle climate change, and transparency, accountability and democratic control over decision making.[37]

[37] N. D. H. Munroe, "Strengthening public services in Caribbean is focus of Commonwealth conference," *Commonwealth Secretariat*, 18 June 2010, http://www.thecommonwealth.org/news/225160/180610publicservicecaribbean.htm.

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