Development and Sustainability in a Warming World: Measuring the Impacts of Climate Change

BACKGROUND RESEARCH PAPER

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Synopsis

This paper explores the impacts of climate change on global development outcomes such as health, economic growth, and poverty, and evaluates options for climactic change. It also develops a set of transposable indicators for measuring climate changes and sustainability in terms of both mitigation and adaptation. With the possible future scenario of an increase of 4 degrees in global temperature over the coming period, this paper will attempt to demonstrate the casual link between climate change and six affected categories of development including: economics and agriculture; water; ecosystem and biodiversity; human health; coast regions; and, forced migration and conflict as a means of developing a standardized criterion of climate change effects on development.

Introduction

In their current manifestation, the *Millennium Development Goals* are presented as a blueprint to galvanize governments and private actors towards a substantial reduction in extreme poverty levels by 2015 (Sachs, et. al 1502). While the links between poverty and climate change are unsurprisingly complex, academic research and discourse find finds itself approaching these two themes not as interconnected subjects, but rather as variably distinct entities. Cohen et al (1998) that even though climate is one of the symptoms of unsustainable development, the two concepts continue to coexist under separate epistemologies, to the extent that climate change has not influenced the sustainable development discourse.

Indeed, as emphasized by published data from the National Aeronautics and Space Administration, the National Climatic Data Center and the European Environmental Agency, development features rarely in the discussion of indicators for the measurement of climate change and environmental degradation (NASA, 2012; NCDC, 2012; EEA, 2012), despite observations that the impacts of environmental degradation falling disproportionately upon developing countries and the poor (McMichael 2004-2005). Yet, it is increasingly rehearsed in the climate change research that in this interface of climate and development, the latter emerges that climate policy goals are not considered a priority for many developing countries as other development issues such as poverty alleviation and energy security remain centre stage on the development agenda. (Halnaes and Garg, 2011).

In addition, one main observation is that, those most deeply affected by changes in global environmental trends seem less to be the beneficiaries of concentrated efforts towards positive progression, but rather appear resigned to be left out in the cold. However, Sachs notes that by targeting the root causes of development stagnation and regression, particularly embodied by climate change, the international community may achieve complementary positive results in both sectors (1502). To do so will require climate change being understood and filtered through the empirical lens of sustainable development priorities, which would support the clarification and simplification of related policy avenues.

This paper will respond to several questions as a means to unify research on development issues and related climate change, thereby presenting a critical base upon which future study and international action can be undertaken. First, using a variety of sources, this paper will provide six-fold criteria of observable impact areas of climate change on sustainable development. Second, each of the impacts will be evaluated in detail, intrinsically demonstrating the argued casual links. Third, this paper will broach the linked issues of institutional deficit and sustainability, detailing issues of strategy derailment caused by a lack of solid organizational foundation. While institutions themselves have the ability to support adaptation and mitigation processes, many of the impacts above find their roots in the absence of robust institutional arrangements that will enable and sustain both adaptative and mitigative processes. Lastly, looking towards the future, several questions will be answered in turn to enable the co-ordination of policy and research responses to climate change and sustainable development: what can be done to mitigate observable effects in the immediate future; what policy targets and partnerships must be developed to achieve a reduction in environmental degradation; and, what are the appropriate avenues for education and awareness in regards to climate change that will promote an engaged public?

Developing Standardized Criteria of Climate Change Effects on Development

According to the United Nations Economic Commission for Europe, effective indicators of change, as a generalized term, require four distinct characteristics: they must be relevant to the current context; they must be easy to understand; they should be reliable; and, based on accessible data (UNECE Expert Group on Indicators, 2005). Indicators should utilize both qualitative and quantitative measurements as a complementary means of presenting information, which in this instance is the observable impact of climate change on development (UNECE Expert Group on Indicators, 2005). However, it is noted that where possible quantitative demarcations should be given priority due to their evaluative effectiveness and limited scope for potential bias (UNECE Expert Group on Indicators, 2005). In some situations, particularly when measuring social issue performance, qualitative analysis can be employed as required (UNECE Expert Group on Indicators, 2005).

Indicators point to an issue or condition as a measure of how well a system is working, which can subsequently support the determination of potential solutions for any concerns (UNECE Expert Group on Indicators, 2005). While the proposed indicators forwarded in this paper may not necessarily be agreed upon by all those in the global research community, they can and should be considered as an important foundation for future research.

According to a report by Lord Nicholas Stern, a two-degree rise in global temperatures will conclusively cost approximately one per cent of the world's total gross domestic product in order to mitigate effects (The Economist, 2009). The World Bank, however, has countered that for developing states, the impact will be much more severe, with climate change costing upwards of four to five per cent for some (The Economist, 2009). The Office of the High Representative of the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UNOHRLLS) indicates that the least developed countries (LDC) are a group of 49 states recognized as the world's poorest and weakest, with extremely low gross domestic product assets, severe economic vulnerability, and lack of significant and prosperous human resources (2009). Compared to developed countries, LDCs emit little of the world's greenhouse gases but remain incredibly vulnerable to its effects, particularly due to their inability to adapt (UNOHRLLS, 2009). In order to be classified as a highly adaptable state, one must possess: a stable and prosperous economy; a significant degree of access to technology; well-delineated roles and responsibilities for implementation of adaptive strategies; systems for national and local information dissemination; and, an equitable access to resources (UNOHRLLS, 2009).

Yohe (2002) argues (see also IPCC Chapter 18 – Fourth Assessment Report) that the determinants of adaptive capacity includes:

- range of available technological options for adaptation
- the stock of human capital including personal security and education
- the stock of social capital including property rights
- the systems ability and access to spread risks
- decision makers ability to manage information – their ability to determine which information is credible and the credibility of the decision makers themselves
- the availability of resources and distribution of resources across populations
- The attribution of the source of stress and the importance of the exposure to its local manifestations

As such, it is presented that these states, in addition to other developing states not classified as an LDCs will be the most vulnerable to climate change and its effects.

In the report "Turn Down the Heat – Why a 4C Warmer World Must Be Avoided," the World Bank outlines several impacts of climate change, emphasizing that the most adverse effects of climate change will be felt primarily in developing states which lack adequate infrastructure and support mechanisms to adapt efficiently (World Bank, 2011; OECD, 2002; European Commission, 2006; Mizra, 2003). The report notes that the areas, which will be adversely affected, include: agriculture, as part of generalized economic impacts; water resources; ecosystems and biodiversity, including resultant natural disasters; and, human health (World Bank, 2012; Overseas Development Institute, 2002). These conclusions are equally reflected by the UNOHRLLS, which also emphasizes the addition of coastal regions, tourism and settlement to the growing list of impacted areas in developing states (UNOHRLLS, 2009).

Using the research above, one can present a tentative classification of directly impacted sustainable development sectors by climate change: economic impacts, particularly agriculture and tourism; water resources; ecosystems and biodiversity, including natural disasters; human health; and, coastal region degradation. The following discussion however should be viewed within the context of sustainable development as a "moving" target and goal, and strategies for its achievement, as well as analysis of its impact, must never remain stagnant. As mentioned above, each of these five divisions will be evaluated in turn, causally linking their stagnant and regressive developmental impacts to climate change.

Economics and Natural Resources

In 2011, the World Bank predicted that if the current rates of poverty reduction continued along similar trends as they have since 2005, headcounts based on $1 and $2 earnings per day as the primary indicator may become obsolete as a measure of population well-being (World Bank, 2011). Unfortunately, equally noted was the growing concern that if climate change is not halted, the rise in global temperatures and its resultant effects could slow or even reverse progress on poverty reduction (World Bank, 2011). The direct impacts of climate change on developing economies are argued to include the loss of human life, livelihoods, assets and infrastructure through extreme climatic events, which will be discussed further below (Richards, 2003). Indirectly, climate change variation is predicted to slow and alter origins of economic growth, including the ability of the poor to engage in non-agricultural sectors while simultaneously increasing both poverty and nullifying any potentially positive outcomes from macroeconomic policies, trader and private sector investment (Richards, 2003). This is particularly relevant when taking into account studies which suggest agricultural GDP growth is 2.2 times as effective at reducing poverty as non-agricultural GDP (Hertel, 2010).

Developing countries are more dependent on agriculture and other climate-sensitive natural resources for income and well-being (World Bank, 2011), thereby directly linking climate change effects to potential economic growth and prosperity. Without this primary source of income, which may be ravaged by environmental collapse, development will certainly stall or regress. The United Nations has predicted that by 2100, parts of the Sub-Saharan Africa, considered to be one of the most vulnerable regions of the world, will experience a two to seven per cent loss in GDP due to climatic effects on agricultural production (UNOHRLLS, 2009).

Agricultural yields are of primary concern related to the economics of climate change, as crop production remains one of the largest financial drivers of developing states. Recent estimates showcase that nearly eight hundred million people around the world are chronically undernourished, a large portion of them children under the age of five (Hertel, 2010) Climate modeling has demonstrated results which consistently show negative impacts on world crop yields, even with potentially beneficial rises in CO2 and relative farm adaptation techniques, which have been argued by some to account for a positive political response to environmental change (Parry et. al., 2004). All scenarios in Parry's study resulted in a dramatic decrease in crop production from between nine to 22 per cent, which is equally likely to increase the financial disparity amongst developing and developed states (Parry et. al., 2004). Recent research by the Commission on Sustainable Agriculture and Climate Change notes that temperatures rising more than three degrees risks overall decreases in global food production capacity that would be profoundly destabilizing even in places where good production remains localized (Beddington, 12). In tropical, and sub-tropical world regions, areas which include some of the highest hunger levels, climate change could cause crop yields to fall 10-20% or more, between now and 2050 (Thornton, 2). Developing countries alone, which account for 90% of irrigated wheat growth worldwide, could see a drop of crop yields by close to 13%, and rice yields by 15% without adaptation measures being put in place, while demand for these foodstuffs in these impoverished regions is expected to double by 2050. (Thornton, 3, 9). Estimates for Africa are no more positive: warmer temperatures could depress continental harvest rates by between 10-20% (Thornton, 9). Without broaching the link between climate change and food security today, the addition of an estimated 2 billion people on the planet will only exacerbate the situation further (Thornton, 10).

This research equally substantiates claims by the *Third Assessment Report of the Inter Governmental Panel on Climate Change* which argued that crop yields in the most tropical and sub-tropical regions will be significantly reduced due to environmental degradation, as rain-fed crops begin to pass the maximum temperature threshold beyond which they cannot survive (Richards, 5). Some studies have predicted that the resultant crop production loss could be up to 30 per cent, drastically affecting the economic viability of developing states, although as the maximum temperature tolerance of crops will differ it has also been suggested that states such as China could experience a 25% rise in cereal production from the same climate phenomena (Richards, 5). Field tests have shown that for most crops, surpassing a temperature threshold of 30 degrees Celcius will typically result in decreased yields (Thorton, 9). The United Nations has equally advanced more pessimistic numbers, denoting that a reduction of 50 per cent in rain-fed crops could occur by 2020 along with a five to eight per cent increase in arid land on the African continent in conjunction with the complete loss of production ability for some food stuffs including wheat (UNOHRLLS, 2009).

The question remains, however, as to what impact a lack of available financial and physical resources will have on individual poverty, the reduction of which is primarily linked to an increase in development. According to Hertel, since the poor tend to spend the highest share of their income on food, adverse climate change is expected to have a disproportionately negative effect on them, for economics dictate that reduced production results in higher prices which poor families may already have difficulty meeting (2010). Additionally, adverse climate change will hurt farm household earning unambiguously, with welfare loss being the greatest difficulty, while equally resulting in a rise in food prices and a loss of purchasing power for poor consumers (Hertel, 2010). Without significant improvements in agricultural productivity, through investment and access to new technology, vulnerability to climate change amongst the poor with continue, adaptation will be unattainable and poverty reduction, particularly in Sub-Saharan Africa, will be difficult to achieve (Schlenker, 2010). As concluded by the OECD, and highlighted in the previous sections of this paper, "climate change will compound poverty. Its adverse impacts will be most striking in the developing nations…[and] within these countries, the poorest, who have the least resources and the least capacity to adapt, are the most vulnerable" (OECD 2003).

As noted, it would be difficult, if not impossible, to discuss the effects of climate change on development without identifying the links between the categories presented in this paper, particularly that of 30-40% of significant natural disasters resulting from carbon emissions (Richards, 2003). In 2000, exceptionally heavy rains in Mozambique were implicated as the primary factor in the destruction of over one-third of the country's staple food (i.e. maize) and the deaths of 80 per cent of its cattle herds, impacting more than 400,000 people (Mizra, 2003).

In 1999, cyclones in India destroyed 80 per cent of its standing crops and almost half a million head of cattle (Mizra, 2003). Hurricane Mitch in 1998 pushed 165,000 people in Honduras below the poverty line, due particularly to a 29 per cent loss in available crops and a linked 18 per cent loss in assets for the poorest members of society (Richards, 2003). Flooding has affected between 20.5 per cent and 70 per cent of land in Bangladesh, causing extensive damage to the primarily agricultural-based economy (Mizra, 2003). As well, Guinea is expected to lose close to 30 per cent of its rice-producing fields as a result of permanent flooding by 2050 (UNOHRLLS, 2009). Permanent or semi-permanent flooding itself is characterized a slow onset of sea level rises and land subsidence, causing a overall failure of drainage and water management systems, with a long or indefinite duration (Jha, 56). It can be seen through these cases, as well as numerous others, that climate change can be the spark leading to natural disasters, which then impacts the staple economic drivers of developing states, such as agriculture, leading to significant roadblocks to economic development.

This section has argued that agriculture and other natural resources, which account for a substantial portion of economic momentum in developing states, will be adversely affected by climate change. For instance, agriculture and services derived from natural resources support the livelihoods structures of 70% of people in sub-Saharan Africa and represent 40% of export earnings and 50% of GDP. Climate change will pose considerable threats to a sector that though perceived as an engine of growth continues to be an under-performing sector. Significantly, food security will drastically diminish which could result in several outcomes, including forced migration or conflict as will be discussed later. While there may be certain benefits from warmer temperatures such as longer growing seasons in colder climates, a growth in crop yields for the first 3 degree Celsius increase, and new opportunities for global shipping through arctic regions (Guardian, *Good Thing*, 2012), it will most certainly create substantial and prevalent negative effects on the poorest states, particularly in South East Asia and Sub-Saharan African, whose dramatic reduction in crop yields are predicted to result in a stagnation of development and significant humanitarian disasters. Approaches to limiting climate change, and promoting effective means of adaptation will be necessary if extreme hunger and the regression of development is to be avoided. Studies in climate modeling have revealed that the combined effect of higher temperatures, hydrology and agricultural practices are increasingly contributing to desertification in some areas and at the same increasing levels of soil salinity in others. Rising sea levels as well as coastal erosion are having negative impact on agricultural productivity and heightening the consequences of soil salinisation in coastal areas.

Climate Change and Water Resources

To realize the impact of climate change on water and human security requires first that one understands the distribution of fresh to salt water on Earth. In 2012, approximately 98% of aqua reserves on the planet were salt-water, with the remaining 2% being fresh sources (Mcintyre, 2012). Of those fresh water resources, 70% is in the form of snow and ice, 30% is groundwater, and less than 0.5% is surface-based, cradled in lakes and rivers (Mcintyre, 2012). With such a limited portion of global reserves being immediately accessible to low-income populations and states, the impact of climate change on water sustainability is all the more serious. The rapid urbanization in some developing countries is increasing water demands and changing industrial uses as well as demands for hydropower. Consequently, impacts from climate change on water resources will have ripple effects on human development and other critical resources.

The following section will engage with four broad climate change impacts on water resources, detailing present and predicted difficulties, as well as avenues for adaptation and mitigation: availability and demand; quality; socio-economic issues; and, extreme events. Within these categories exist many additional direct and indirect impacts of climate change on water resources, which will require additionally comprehensive analysis in the future.

Availability and Demand

The Intergovernmental Panel on Climate Change (IPCC) notes that it is very likely that the costs of climate change will outweigh any related benefits when analyzed on a global scale (44). Particularly, the reduction of freshwater availability, facilitated by climate change, has been directly linked to a general increase in worldwide water stress and a decrease in sustainability (Alavain, 21). While there is substantial variability in projections across studies on levels of water stress, largely dependent on modeling methodology and included external drivers such as population growth and intervening adaptation measures, studies have predicted that anywhere from 2.7 to 4 billion people will be affected by limited freshwater supplies in 2050 (Alavain, 21) (Diop, 2008). Interestingly, using a per capita water availability indicator, the IPCC argues that climate change can be argued as facilitator of overall reduced water stress at a global level as increases in runoff are more concentrated in the world's most populous regions, thus demonstrating the potential disparity amongst research (IPCC, 45). However, this model risks skewing results as it fails to account for increased stress during dry-seasons, lower population density regions, changes in seasonal patterns and frequency of extreme events (IPCC, 45).

Higher temperatures and increased variability of precipitation in general are expected to lead to increased water demand for personal and industrial use (IPCC 44). It is argued that in projections of future water stress, the primary and dominant dependent variable is the growth of domestic water use, as stimulated by income and population rises (IPCC 45). Particularly in regions termed as having a "difficult hydrology" by the World Bank, which includes variable precipitations and absolute water scarcity (Alavain 23), the projected negative effects of climate change-instigated increased precipitation and runoff variability are expected to outweigh any benefits stemming from increased annual runoff overall (IPCC, 45). While there is high confidence that adaptation can reduce vulnerability and support sustainable development, particularly in the short term, adaptive capacity is intimately connected to social and economic development, which continues to be unevenly distributed across the global (IPCC 49). In water-insecure regions of the world, characterized by extreme hydrological variability, a poor endowment of water resources, or inadequate capacity, infrastructure and governance institutions, climate change is projected overall to make water security and sustainability harder to both achieve and maintain (Alavain 23).

Quality

Water quality affects a wide range of impact areas and is necessary for the continued resilience of human populations. Unfortunately, changes in water quality are primarily the result of human activities on land that generate pollutants, which subsequently can be attributed to facilitating an increase climate change features (Arthuton, 131). Higher water temperatures, increased precipitation intensity and longer periods of low flows are projected to exacerbate many forms of water pollution, including sediments, nutrients, dissolved organic carbon, pathogens, pesticides, salt and thermal pollution (IPCC, 43). This is then argued to promote algae blooms, and increase the content of bacteria and fungi in global water resources, thereby impacting human health (IPCC, 43).

The United Nations Environmental Programme argues that human health is *the* most important issue related to water quality (Arthurton, 131). Improving water resource management, increasing sustainable access to safe drinking water and basic sanitation has the capacity to improve the lives of billions (UNESCO, 103). However, as previously noted, poor aqua quality and a warmer global climate can lead to a propagation of water and vector pathogens as well as major point and non-point pollutants include microbes, nutrients, oxygen-consuming materials, heavy metals, persistent organics, sediments and pesticides (Arthurton, 131). More intense rainfall, stemming from increased human-induced climate change, will likely lead to an intensification of these pollutants in water supplies, primarily facilitated by enhancing transportation avenues into surface water and reservoirs for pathogens and dissolved toxins such as pesticides, and in increasing levels of erosion leading to a, overall deterioration of water quality (IPCC, 43). Additionally, an increased occurrence of lower river flows is argued to lead to a decreased contaminant dilution capacity, and thus higher pollutant concentrations, with the issue being compounded in areas experiencing climate change induced decrease in runoff (IPCC, 43). Lower minimum flows imply less water volume for dilution and hence higher concentrations of pollutants when measures at points of discharge (Whitehead, V). For example, the River Tame within the heavily urbanized area of Birmingham shows in an increased level of phosphorous concentrations during higher temperature seasons, due to reduced flows and thus decreased dilution capacity (Whitehead, 26). These results are not localized phenomena: testing by Schneider et al. denote that changes in global temperatures will result in increased intermittency of river flows for the geographical area around the Mediterranean Sea, such as the Tiber river in Rome, with isolated cases of zero-flows also being expanded in number (336). This situation, caused by climate change, will negatively impact water quality as the concentration of pollutants increases when flows decrease (Schneider, 336). The authors predict that in the continental European climate zone, where high amounts of water are extracted for industrial purposes such as electricity generation, climate change is likely to further reduce river flows remarkably from spring until autumn (Schneider, 336), thereby decreasing dilution capacity of water for toxins and increasing pollution levels.

Socio-Economic Impacts

The World Bank notes that agriculture is by far the largest user of water, accounting for almost 70% of global withdrawals and 90% of global consumptive water use in 2009 (Alavain, 26). While an individual may drink between 2-4 liters of water a day, it takes between 2,000-5,000 liters of water to produce an individual's daily food (Alavain, 26). Over 80% of global agricultural land is rain fed; this means that productivity in these regions is depended on precipitation for evaporative demands and soil moisture distribution (IPCC, 59). Irrigated agriculture land, representing approximately 18% of production is directly reliant on the availability and quality of ground-based freshwater resources and associated capacity of natural replenishment of reserves (IPCC, 59). The IPCC notes that both too little water as well as too much water can have disastrous effects on crop production, with each scenario being a plausible outcome of climate change in different regions of the world (IPCC, 59). Precipitation shifts, occurring through extreme events, erratic rainfall and seasonal shifts in runoff can alter ground nutrient content, leading to extreme soil conditions incapable of sustaining crop growth (Alavain, 26). Climate-induced pressure on water resource sustainability is also argued to "lead to increased competition between irrigation needs and demand from non-agriculture sectors, potentially reducing the availability and quality of water resources for food" (IPCC, 59). As such, future increases in agriculture production, particularly emphasized by projected expansion of irrigated crop systems in the developing world, must be matched by the distribution of climate resilient sustainable adaptation technology such as desalinization systems, and improved water management and efficient-use programmes.

Extreme Events

Water-related extreme events, including flooding and drought, account for 90% of all natural and in 2010, some 373 natural disasters killed close to 300,000 people, directly affected nearly 208 million others, and cost states almost $110 billion (UNESCO, 115). Although a variety of climatic and non-climate processes influence their emergence, frequency and intensity, according to the World Bank, there are indications that climate change may have already had an impact on number of occurrences, the duration and the impact flooding and droughts, with the number of inland flood episodes doubling from 1950 to 2005 (Alavian, 18). Specifically, the Federal Emergency Management Agency's flood risk area has doubled in 2013 for New York City, citing expected tidal surge increases and higher water levels (Buckley, 2013). In a Climate Central Report, two thirds of their analyzed coastal locations in the United States, include 85% of regions outside the Gulf of Mexico, global warming is predicted to double the chance of "century floods" occurring each year (Straus 4). This trend has been associated with an increasing frequency of heavy precipitation events, a trend projected to become more common in most regions throughout the 21st century (IPCC, 41). The rise of flooding is also likely to bring with it an increase of water contamination by chemicals, pathogens, soil and heavy metals, thereby impacting regional human health (IPCC, 68).

It is equally likely that the global area impacted by regular droughts will increase over the next century, as a byproduct of a warming world, and instigating climate change (IPCC, 42). In a single model study of global drought frequency, the proportion of land surface experiencing this extreme event were projected to increase by 10 to 30 fold (IPCC, 42). Particularly in regions of the world that rely on glacial melt water for dry-season aqua supplies, the increase of drought is likely to be substantial (IPCC, 42).

Both flooding and droughts could be tempered by appropriate sustainable infrastructure investments, and by changes in water and land-use management (IPCC, 74). In 2010, the World Bank reported that government expenditures on disaster prevention are generally lower than overall relief spending, which rises after an extreme event and remains high for several subsequent years (UNESCO, 116). However, beneficial prevention requires not just an increase in funds, but a knowledge-supported targeting of sustainable adaptation measures, which recognizes the above noted linkages between impact areas, thereby improving effectiveness of spending (UNESCO, 116).

Climate Change and Biodiversity

On May 13th, 2013, the Guardian Newspaper reported new research suggests that as global temperatures continue to rise, over one third of common land animals, and more than half of plant species could see dramatic losses by the end of this century (Press Association, 2013). These latest predictions, published in the journal "Nature Climate Change," show an estimated loss of more than half of habitat ranges for 57% of plant and 34% of animal life, as a direct consequence of climate change (Press Association, 2013). The largest numbers of plants and animals were likely to be lost from sub-Saharan Africa, Central America, Amazonia and Australia, with significant plant species reductions also predicted in North Africa, Central Asia and South Eastern Europe (Press Association, 2013). Studies by Bellard et. al., further add that 35% of the world's bird population, 52% of amphibians, and 71% of warm water reef-building corals are also very susceptible to even the slightest change in global temperatures (Bellard, 372). While a 4% portion of animal species are expected to benefit from climate change, the study's authors predicted that an estimated 4 degree Celsius temperature rise will result in dramatic, global ecosystem collapse affecting not only state economies and potential for sustainable development, but agriculture, air quality, clean water access and tourism (Press Association, 2013). These conclusions are also evidenced by researchers at McGill University who argued in a 2012 study that the loss of biodiversity, most particularly plant and animal life, appears to impact the health and sustainability of ecosystems as much as human-originating environmental stressors, including pollution and climate change (Lee, 2012). Therefore, an aggregate conclusion could suggest that climate change induced biodiversity loss will be critically severe on global ecosystem health.

Direct Effects of Climate Change on Biodiversity

Impacts of climate change on biodiversity vary widely in different regions of the world, and will be largely dependent on the ability of plants and animals to evolve biological adaptation traits, as well as human-based supportive sustainability measures (CDB Secretariat, 2010). At the most basic level of biodiversity, climate change is reported to decrease genetic diversity of populations due to directional selection and rapid migration, which in turn affects ecosystem function and resilience (Bellard, 365). This means that climate change will cause shifts in a species' geographical range, delimiting boundaries and prompting changes in migratory patterns, thereby allowing previously innocuous, alien species to enhance their reproductive capacity and their competitive power against native plants and animals (Thuiller, 550) At a higher level, climate change is expected to directly effect what is termed as biodiversity's "web of interactions," whereby the response of some species to environmental degradation will indirectly exacerbate difficulties for dependent organisms, many of which exist in a symbiotic relationship with their primaries (Bellard 365). Shifts in ecological conditions could support the introduction and spread of animal and plant disease, including parasites and pathogens, into environments which would not possess any natural immunity against them (EPA, 2013).

Climate change is predicted to be substantial enough over the next century to affect complete biomes, or entire regional groupings of distinct plant and animal communities, leading to ecologically irreversible tipping points of environmental degradation (Bellard, 366). The most damaging of all, however is continued projection of species loss, with "extinction-committed" rates being predicted as between 15-37% by 2050 if current climate change trends continue (Thomas, 2004). Much of this will derive from ocean and marine life which are unable to adapt to substantial increases in water acidity levels derived from carbon dioxide absorption (CDB Secretariat, 2010). Additionally, other biodiversity effects of climate include: changes in genetic richness and an increase in mutation rates; decreased survival rates and disease susceptibility; changes in plant and animal phenology; shifts in interspecies relationships include desynchronization and disequilibrium; and, an overall loss of biological community productivity and ecosystem services (Bellard, 366).

Sustainable Development, Biodiversity and Ecosystems

The United Nations Development Programme notes that human survival and wellbeing depends upon healthy and sustainable biodiversity and ecosystems, as well as the goods and services they provide (UNDP, 13). The loss of biodiversity is a challenge for all, but most particularly for the world's poor, who maintain a substantial dependence on ecosystem goods and services for their livelihoods and subsistence (UNDP, 13).

Unfortunately, the links between biodiversity and ecosystem goods and services, and the role they play in the world's economic progress are not well understood (UNDP, 13). For the most part, environmental goods and services are a public good and thus do not have a fixed market or price, resulting in their losses being rarely included in global economic accounts (Conceição, 2012). Despite this, however, there is evidence that integrating biodiversity and ecosystem management objectives into sustainable development policies and practices, including production sectors, supports overall sustainability (UNDP, 21). Termed the "Green Economy," future accounting systems must internalize the costs and values of natural assets under standardized, global reporting classifications in order to further recognized the indivisible link between economics and biodiversity (UNDP, 21).

In simplest terms, a green economy itself is low-carbon, resource efficient and socially inclusive, where growth in income and employment are driven by public and private investments that reduce pollution, enhance energy efficiency, and prevent the loss of biodiversity and ecosystem services (Ayres, 16). To obtain a green economy is to incorporate broader environmental and social criteria into key economic performance calculations and indicators, such as adjusting gross domestic product to account for pollution, resource depletion, declining ecosystem services, and distributional consequences of natural capital loss for the poor (Ayres, 16). A green economy will recognize that the goal of sustainable development is improving the quality of human life within the constraints of the environment, while equally addressing the concerns of intergenerational equity and eradicating poverty (Ayres, 19). While the transition to a green economy will be different for all states, there are common enabling conditions which will be required, including: robust national regulations, policies, subsidies and incentives, as well as international market infrastructure and accessible technical assistance, mostly directed towards fossil-fuel dependent brown economies (Ayres, 22). A green economy approach has the opportunity to fundamentally change standardized norms of global wealth calculations, thereby including the impacts of climate change on natural capital into the baseline variables of development, which has the potential to effectively improve both mitigation and adaptation efforts.

Climate Change and Human Health

Although underlying all other effects, the detrimental degradation of human health from climate change merits a further examination. In 1992, at the Rio Earth Summary, world leaders recognized that, "Human Beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature" (Smith, 656). This position thus became immortalized as the First Principle of the Rio Declaration, acknowledging that without healthy human beings, sustainable development is simply not attainable. In 2003, the World Health Organization published their seminal report *Climate Change and Human Health – Risks and Responses*, which persuasively argued that impact of environmental degradation, the rising of global temperatures and the continued release of greenhouse gas emissions into the atmosphere would be dramatically detrimental to human health, via pathways of varying complexity, scale, directness and timing (McMichael, 11, 14). A contemporary, and indeed rather dramatic example of interlinking facilitating pollution and resultant human health issues are the so-called "Cancer Villages" in China, officially acknowledged in 2013 (Mosbergen, 2013). The absolute degradation of environmental systems surrounding these industrial areas, including the use of toxic chemicals otherwise banned in the developed world, has been directly connected by environmentalists and outside observers to the burgeoning cancer rates in China, now identified as the country's "top killer" (Mosbergen, 2013). Therefore, with a clear link between increasing climate change driven by pollution and other greenhouse gas emissions, and the assurance of human health in order to achieve a mitigating level of sustainable development, it is necessary to explore the impacts of the former on the latter.

The health impacts of climate change can be synthesized via currently available research. The IPCC Third Assessment Report denotes both direct and indirect effects of climate change on human health. Beginning with the former, climate change brings with it increased heatwaves and other extreme events (McMichael, 47). While humans have the ability to adapt long term to a range of climate changes, the immediate result of increased frequency and intensity of heatwaves, in particular, is an increased risk of death and serious illness in older age groups, those with pre-existing conditions and the urban poor (McMichael, 47). Such was the case in 2003, with between 22,000 and 45,000 heat-related deaths occurring in Europe during a 3.5 degree temperature-increasing heatwave (Patz, 310). Additionally, any increase in frequency of extreme events, could cause direct loss of life, injury, and affect health indirectly through loss of shelter, population displacement, contamination of water supplies, loss of food production leading to malnutrition and famine, increased risk of disease epidemics and physical damage to public health infrastructure (McMichael, 48). According to WorldWatch, 2011 saw 820 natural disasters were recorded worldwide, 91% of which were weather related, causing 27,000 deaths and incurring $380 billion in damages (WordWatch, 2011). Between October, 2010 and September 2011 several drought hit many developing states in the Horn of Africa, resulting in the deaths of 80% of Somalia's livestock, an estimated 50,000 deaths and 13 million people in need of humanitarian aid (WorldWatch, 2011). While 2011 was a decrease in the total number of extreme events since 2010, it is well above the average number in 1980 at a recorded 630 events, highlighting a continued trend of increasing instances over the past 3 decades (VitalSigns, 2011).

Extreme climate event equally have direct health impacts in other respects. An increase in rainfall, potentially caused by climate change, has a direct relationship with disease spread by insect vectors, particularly mosquitoes which need water in other to breed (McMichael, 81). Mosquitos are well documented to be key transmitter of viral diseases such as dengue and yellow fever, and both the increased availability of wet environments caused by climate change, as well as drought-caused water-pool stagnation could equally benefit insect breeding (McMichael, 80-81). Slight increases overall in low-temperature areas could equally facilitate the greater risk of malaria transmission, one of the world's most pervasive diseases, with 2.5 billion people at risk, 0.5 billion cases and over 1 million deaths per year (McMichael, 82). Analysis of diarrhea reports in the Pacific Islands also suggest a positive correlation with increased temperatures, with an estimated 3% increase in cases per 1 degree rise (McMichael, 85). In Peru, there was an indirect link of 8% increases in hospital intake for diarrhea and dehydration cases per 1 degree rise (McMichael, 113).

In a summary report by the US Centers for Disease Control and Prevention, with the National Institutes on Health, a number of other climate change induced health impacts can be both observed today, but more importantly, are predicted for the future: altered seasonal temperatures are predicted to increase respiratory allergies and related diseases; the decrease in Ozone protection, thereby augmented daily exposure to ultraviolet radiation could exacerbate the well understood links between it and higher cancer risk; changes associated with heat stress and a rise in the body burden of airborne particles may be enough to exacerbate existing cardiovascular disease; malnutrition, caused by decreased foodstuff productivity, is predicted to rise with increased climate change; as mentioned previously in this paper, increased water temperature can be directly attributed to pathogen levels; and, the increase of global temperatures expanding vector ranges of disease, thereby raising the number of individuals at-risk (Portier, vi). While much of this is predictive, without proper mitigation and adaptation, the line between empirically based hypothesis and reality is rather thin.

In economic understanding, it is difficult to value the financial costs of decreased human health caused by climate change. However, in a study by Bosello et. al., they argue that impacts of climate change on human health have two direct impacts on a states economy: changes in labour productivity; and, changes in health expenditure (5-6). In their model, productivity is predicted to rise slightly in the United States, Europe, Japan, China and India, due primarily to the virtual absence of vector borne diseases, as well as the decrease of mortality associated with cold stress related to cardiovascular disease (Bosello, 6). However, in Energy Exporting Countries, and the "rest of the world," the higher incidence of heat-facilitated disease will dramatically reduce productivity (Bosello 6). Equally, higher incidence of health issues will evidently be associated with an increased demand to health care, which subsequently requires the state in many instances to match demand with an increase in public spending (Bosello, 6). However, as an decrease in productivity is linked to decreased economic growth, the demand for augmented health care services is likely not to be matched by available funds (Bosello, 6). The same is true for private health care options, which Bosello et. al. argue results in economic losses as forced healthcare purchase: as productivity decreases, so does familial income, thereby limited the ability for individuals to access alternative health services, or requiring them to divert essential funds from other staple purchases, such as food stuffs (Bosello, 6). Therefore, in purely economic terms, the decrease in productivity as a result of climate change-induced health issues is thereby a financial loss for the state, increase the strain on public coffers as well as private income.

As mentioned, many of the above risks can be curtailed or prevented through appropriate mitigation and adaptation strategies. Primary to this is the reduction of climate change-inducing pollution, including the recommendation to define stronger targets that what are currently in the Kyoto Protocol and other international agreements, now widely understood to be substantially less than what would be required to stop, let along reverse climate trends (Haines, 2107). Reducing the level of biomass use, and providing adequate electricity services to the urban and rural poor, would decrease health-damaging pollutants in the home (Haines 2108). The increase in renewable energy, including for automobiles and other transport utilities, could dramatically save the environment from costly greenhouse gas emissions (Haines, 2108). This would include the introduction of greening transportation policies, as well as promoting the use of public transport, walking and cycling as viable alternatives to current transport trends (Haines, 2108).

Portier et. al. note that knowledge is also one of the most strategic tools in reducing health problems in any environment: we must know how climate change impacts health if we are to mitigate causes and adapt to its effects (61). Knowledge is needed to develop evidence-based prevention strategies, focusing on the interplay between risk, location and environmental conditions, as vulnerability and resilience is heavily determined by locality (Portier, 61). Understanding local needs will be of absolute importance, as adaption and mitigation strategies will not be one-size-fits-all (Portier, 61). This necessary research on climate change and health impacts cannot occur in isolation, however, and will require an organizing, overarching programme which is integrated, focused, interdisciplinary and flexible (Portier, 63). With the appropriate tools and knowledge to support efforts to strengthen human health in the face of climate change, its impacts could be dramatically reduced, limiting human suffering and thus saving lives (Portier, 63).

Coastal Degradation and Sea Level Rise

According to the Guardian Newspaper, the people of Newtok, Alaska are poised to become the United States' first climate refugees, or individuals who have been displaced from their homes by the impact of a changing climate (Goldenberg, 2013). Current estimates suggests that the entire town could be washed away by a combination of coastal erosion and rising sea levels within the next five years, with the population to be resettled in other cities far from the water (Goldenberg, 2013). Unlike the events of Hurricane Katrina in New Orleans, Newtok is the subject of a slow moving process, and despite this time delay, a report by the United States Army Corps of Engineers suggests there is nothing that can prevent its destruction, with the town's highest point to be completely submerged by 2017 (Goldenberg, 2013). Indeed, the US Federal Government has predicted that an additional 180 aboriginal villages dotting the Alaskan coastline faced similar risks caused by climate change (Goldenberg, 2013). It is estimated that the relocation of this small, 63 house village could cost upwards of $130 million, with that total being compounded with the increasing risk of requiring similar responses for other communities (Goldenberg, 2013). If such is the situation, and indeed the difficulty, being faced by the developed world, what will be the adaptation, mitigation and effectual cost of coastal degradation for the rest of the globe, much of which lacks the available resources to engage climate change as the U.S. does?

Coastal erosion is defined as a natural process whereby the actions of wind, wave and tide wear away the coastline, causing it to retreat (Llewellyn, 1). The rate of erosion is dependent on a number of factors: coastal geology; height and frequency of waves; connectivity with other coastal systems; the presence of sediment; and, changes in sea level (Llewellyn, 1). Coastal regions provide a number of important ecosystem services, such as habitats for marine, land plant life, as well as natural protection from flooding (Llewellyn, 1). Brought on by human-induced climate change, the rates of coastal erosion are expected to increase over the next century (Llewellyn, 1).

The United Nations Environmental Programme notes that increased shoreline and coastal erosion, with climate change as a contributing phenomena, is predicted to have numerous direct and indirect impacts. First, shoreline erosion causes a situation called "coastal squeeze," whereby coastal habitats are expected to migrate inland so as to keep pace with rising sea levels (Zhu, 5). The "squeeze" occurs when migration is blocked by hard defences on the coastline, whereby the habitat is unable to extend outwards away from the sea, effectively trapping and subsequently forcing a reduction in its own size and that of other habitats already occupying the space (Zhu, 5). Second, erosion is likely to reduce the size of sandy barrier islands which effective dilute the size and force of on-coming waves, thereby facilitating their increased range and impact on land (Zhu, 5). Third, a degradation of natural coastal systems, which mitigate the frequency and impact of extreme sea-based events, increases the probability of flooding in coastal zones, causing greater damage to communities along the water which directly rely on natural barriers for defence (Zhu, 5-6). Fourth, cliff-failure may be amplified by higher water levels and increased precipitation, dependant on their natural composition, with estimates ranging from long-term losses of 1-2 meters per year (Zhu, 6-7). Fifth, delta regions, which are home to some 500 million people worldwide, provide important environmental services such as carrying large quantities of sediment into the sea (Zhu, 7). Human induced climate change is predicted to have a variety of effects on delta regions including: decreasing sediment supplies which are essential for preventing regional erosion; permanent submergence; more frequent flooding; and, an increase in tropical storm intensity (Zhu, 7). Sixth, sea rise will generally lead to erosion, higher water levels and salt water intrusion in estuaries and lagoons, causing plant and animal life to migrate inland, pressuring already present ecosystems and changing availability of resultant services for communities (Zhu, 8). Seventh, climate change may affect sensitive coral reef systems, lying off the coast of areas within the Tropics of Cancer and Capricorn, resulting in a process of coral stress and subsequent "bleeching" (Zhu, 9). There is limited evidence to suggest that corals have a high adaptive capacity, and with the destruction of these ecosystems, wave energy is increased leading to subsequent coastal erosion (Zhu, 9). Many countries depend on healthy corals for their income, with the Great Barrier Reef alone contributing over $5 billion to Australia's economy in 2005 (Cinner, 12). Lastly, climate induced sea level rise could interrupt the critical functions of stabilizing the seabed against erosion, attenuating wave energy, and providing a habitat to numerous plants and animals, performed by coastal saltmarshes, mangroves and seagrasses (Zhu, 10).

While, the effects of erosion and rising sea levels will not be uniform across the globe, the consequences of such impacts are expected to be overwhelmingly negative and serious in deltas, coastal areas and small islands (Zhu, 11). IFAD predicts that higher rates of erosion are expected in many Pacific Islands as a consequence of projected increases in sea level (IFAD, 2009, 2). For example, for the Majuro atoll in the Marshall Islands and Kiribati, IFAD estimates that for a 1-meter rise in sea level, as much as 80% and 12.5%, respectively, of land would become vulnerable to coastal flooding and decreased vegetated wetlands (IFAD, 2009, 2). Estimated impacts of 30-50cm sea-level rise on Pacific Island coastal communities are quantified as 77,018 km of shoreline affected in 2009, with direct costs of $1.4 billion per year associated (IFAD, 2009, 2). Declines in the size of Pacific islands, due to soil erosion and sea level rise, is expected to reduce the depth of freshwater lens on atolls by as much as 29% by 2050 (IFAD, 2009, 3).

IPCC adds that the effects of soil erosion and rising sea levels will equally impact African coastal zones. Much of Africa's population and a substantial amount of industry is located along the sea: an estimated 20 million Nigerians and 66.6% of Senegal's total population, for example, live in coastal zones, while in Ghana, Benin, Togo, Sierra Leone and, again, Nigeria have positioned much of their industry in the same area (IPCC, 2013). Coastal cities such as Dar es Salaam and Mombasa have been experiencing annual population growth of 6.75% and 5% respectively (IPCC, 2013). For much of the African coastal regions, both East and West, the impacts of climate change induced sea level rise and coastal erosion have already been felt: coastal erosion has been reported to have already reached 23-30 meters in some parts of West Africa in 1989; Cote D'Ivoire has reported high levels of erosion off the Abidjan Habour area, thereby reducing its nature defences from storm surges and extreme events; 40% of mangrove areas in Nigeria and 60% in Senegal have been lost since 1980; lagoons, a substantial source of fishery resources have been substantiall polluted in Accra, Lagos and Ebrie; and, previous estimates have suggested that for a 1-meter sea level rise, 2,000 km-squared of land in coastal areas along the lower Nile delta should be expected (IPCC, 2013).

Therefore, how does the internationally community engage in appropriate mitigation and adaptation measures, and, as a complimentary question, what would they look like? Ruckelshaus et. al suggest a five fold adaptation programme: designing responses based on the value of ecosystem services in the affected region; instituting robust fisheries management policies, including the protection of at-risk stockpiles and identifying alternative and diversified livelihood options for communities; including climate change considerations in sustainability plans for aquaculture; encouraging the use of market-based incentives for companies to cease harmful practices and encourage support for coastal regeneration projects; and, the somewhat controversial practice of relocation as adaptation (156-157). Cinner argues for a three tiered adaptation and mitigation approach: local-scale actions including diversification of industry; encouraging an increased ecological impact knowledge base, and strengthening the power and resources of community groups charged with coastal management; national level provision of social safety nets for adaptation and investment in alternative energy, new industries, education, and carbon-pricing; and, at the international level, the mobilization of funding for infrastructure and adaptation, as well as the resumption and comprehensive completion of binding climate change mitigation targets and allocation of responsibilities (16-17). Lastly, it is argued that the above could be facilitated and supported by the introduction of 13 adaptive technologies recommended by the United Nations Environmental Programme: Beach nourishment; artificial dunes and dune rehabilitation; seawalls; sea dikes; surge barriers; closure dams; land claim; flood-proofing; wetland restoration; floating agriculture systems; flood hazard mapping; flood warnings; managed realignment; and, coastal setbacks (Zhu, 20). Evidently, such technologies would require the support of dedicated funding from third party states and international organizations for the developing world, as well as local tailoring to specific circumstances. However, the above suggests that a combination of knowledge, research, adaptive technology, local empowerment, national policy, and international coordination and funding could substantially support the adaptation and mitigation of climate change-induced sea level rises and coastal erosion.

Policy Recommendations

In the following section, this paper will present several broad categories of policy recommendations in support of continually evolving target of sustainable development tin face of climate change difficulties: supported adaptation; increased climate science and monitoring and evaluation; correcting resource allocation biases; improved governance and capacity building; engaging private actors; and, climate change mitigation through infrastructure development, energy technology and a "green economy".

Supported Adaptation

According to Adger, adaptation to climate change is the adjustment of a system to moderate the impacts of environmental degradation, to take advantage of new opportunities and to cope with consequences (2003). Adaptation strategies, however, particularly in states that lack the means by which to undergo potential changes efficiently and effectively, are unlikely to be taken autonomously (Adger, 2003). As such, support and passive intervention may be necessary to enhance state capacities to adapt to new conditions without becoming more vulnerable (Adger, 2003). Indeed, GermanWatch supports this claim by noting a widespread consensus that vulnerable states will need more international assistance to meet their adaptation needs (2010). It is argued that the means by which financial support is provided to states must change, demonstrated by new partnerships between donor and recipient governments, as well as horizontally with other private donors; the latter should assume significant responsibility and accountability for their own development processes (GermanWatch, 2010). That being said, continuation of auditing and oversight mechanisms found in institutions such as the Adaptation

Fund of the Kyoto Protocol should be a priority, coupled with their enhancement, to ensure that donor governments use funds appropriately (GermanWatch 2010).

Supported adaptation must equally be wary of tailoring funding packages to specific needs of states, particularly fragile countries, in order to deliver appropriate outcomes (GermanWatch 2010). It is also a scalar issue, meaning that sustainability of action is dependant on what level a strategy is deployed, the range of actors involved, and their ability to self-organize and innovate. Amongst the emerging range of adaptation practices, the UNOHRLLS notes that the diversification of livelihoods, introduction of robust international and domestic institutional architectures, adjustments in farming operations, income generation projects, and the move towards non-farm livelihood incomes represent key options (2009). The introduction of new biotechnology and related processes, including investment in water harvesting and irrigation systems, will be required to achieve such diversification (UNOHRLLS, 2009). Other measures of resilience to protect against climate change event shocks could include the improvement of early warning systems, maintenance of national foodstuff reserves, educational schemes beginning at an early age and national insurance mechanisms (UNOHRLLS, 2009) As consistently mentioned in this paper, while analysis can treat each criterion as separate, policymakers should be encouraged to identify and be cognizant of the linkages between issue areas, ensuring that isolated planning mechanisms are not maintained.

Local institutional arrangements may equally support the means of adaptation to climate change. The introduction of micro-financing schemes, coupled with future-driven education programmes, social safety nets and welfare grants may aid in offsetting the difficulties of large-scale adaptation by poor governments (UNOHRLLS, 2009). By providing states and local populations not only with the funding required, but also by arming current and future generations with the knowledge required to support project management and attainment for adaptation goals, the international community may very well encourage poverty reduction as well as the overall mitigation of climate change effects.

International Cooperation and Institutional Deficit

In an analysis by the Council on Foreign Relations, the United Nations Framework Convention on Climate Change is classified as an "underdeveloped and inadequate system" (CFR, 2013). At the most basic level of this institutional deficit, countries continue to disagree over method of climate monitoring, financial stipulations, and legally binding aspects of these accords (CFR, 2013). The UNFCCC lacks a substantial process for monitoring emissions from states that lack the domestic capacity to audit their own totals, while it faces states such as China which argue that monitoring represents an infringement on national sovereignty, and thus incompatible with its domestic priorities (CFR 2013). The climate change regime equally fails to address issues of financing, particularly where funding streams will come from and how they will be implemented, causing the US and other emitters to move towards a form of a la carte multilateralism instead, with informal, smaller frameworks (CFR, 2013). Outside the UNFCCC, a host of not-for-profit and international organizations have begun designing separate strategies for addressing environmental issues within their own programming, much of which lacks any form of inter-institute coordination, leading to fragmentation and redundancy (CFR, 2013). The Intergovernmental Panel on Climate Change has been credited with delivering excellent research on environmental degradation, however, the Council on Foreign Relations note that some of its outputs underplay the risks for developed and developing states alike as a means of garnering political consensus and bureaucratic approval (CFR, 2013). Within the UNFCCC, critics note that institutional deficit arises particularly from the variance between commitment by states and resultant action, with states failing to adhere to agreements on emission reduction targets (CFR, 2013). The Council emphasizes that enforcement continues to be relatively non-existent for violating parties (CFR, 2013).

Peter Haas argues that within the area of global environmental policy and organizational management, there continues to exist both an institutional and governance deficit (5). According to him, there are current three broad academic arguments for the need of reform to correct this deficit: removing redundancy amongst international institutions; less competition amongst organizations would result in increase capacity and efficiency in programme management and implementation; and, the need for a stronger environmental presence throughout the international system, and particularly, within the World Trade Organization (5-6). To rectify what Haas sees as a governance deficit, he proposes the implementation of a new decentralized design principle in global environmental institutionalization, which would streamline and improve current organizational effectiveness rather than create new bodies all together (8). His solution is the association of formal and informal activities to various actor levels, depending on their current functions and possibility of effectiveness: scientists, epistemic communities and government agencies; not-for-profit organizations; media; business and industry; regional development banks; and, international organizations (8-10). By taking advantage of a decentralized network of actors who already perform individual environmental functions with some degree of efficacy, the overall governance deficit mentioned above could be reduced (Haas, 16).

Therefore, are there alternative measures which could be implemented to improve the current institutional and governance deficit in the international system? First, the cracks in the big emitter's "anti-binding targets barrier" should be rigorously explored (CFR, 2013). For example, China's latest White Paper on Energy stresses the need to save energy over developing new production supplies (Boyd, 2012), as well as the general increase of domestic concern over rising urban pollution could be exploited as a way to garner increased state support for international regimes. Second, the UNFCCC's Clean Development Mechanism could be reformed to ensure that funding is not wasted, but instead directed towards innovative and potentially successful projects in the developing world, thereby increasing international confidence in the CDM (CFR, 2013). Third, using both executive orders and a marketing programme on improving its comparative advantage, the U.S. must once again be encouraged to take a leadership role in climate change (CFR, 2013). This would require a re-tailoring of the discussion towards the potential economic benefits of the U.S. becoming a global leader in clean energy, rather than focusing on short term losses. Reframing the debate in terms of climate change as a security issue could equally yield benefits for the reduction of global institutional deficit via increased U.S. support. Fourth, in a classical rationalist sense, states will only participate in an international organization so long as they know that the risk of cheating by others is substantially reduced. As such, it is recommended that a robust, global institution could be created, with lessoned learned from the monitoring and enforcement mechanisms of other organizations, such as the WTO and the European Union (CFR, 2013). Lastly, institutional deficit could be improved by creating a global culture conducive to climate change mitigation knowledge. By this, it is meant that climate change should be included regularly on the agenda of major international groups, such as the G8 and G20 (CRF, 2013). This would increase the salience of this issue, increase its urgency and link it directly to the primarily financial discussions at these meetings, allowing for cost-benefit calculations to be performed by participant governments.

Conclusion

This paper has presented an evidenced demonstration of the casual link between climate change and five impacted categories of development including economics and agriculture; water; ecosystems and biodiversity; human health; coast regions; and, forced migration and conflict. In each section details of the links between development and its stagnation or reversion were presented, including relevant primary and secondary source material. It was further iterated throughout this paper that while for analytical purposes, the five presented categories were divided, researchers and policymakers would do well to recognize that links exist between them.

It should be noted however, while these categories allow the reader to easily classify the impacts of climate change on development, they are by no means a complete taxonomy. Future research would do well to look at other potential impacts, as well as expand on the categories presented above. For example, several authors note that climate change could cause a stagnation or reversal of development by triggering forced migration, political instability and conflict between parties vying for potable water, arable land or regions unaffected by environmental insecurity (Brown et. al., 2007; ISS, 2010). Future study should examine closely the phenomenon of "Climate Conflict," the risk it poses to developing states, as well as appropriate measures to be engaged for its mitigation and adaptation.

The paper's authors also argue that several other policy recommendations be explored in future study. First, the effects of increased climate science, and well as robust monitoring and evaluation programmes on overall global mitigation actions should be reviewed. Second, the other side of the adaptation coin, mitigation, must equally be revisited, emphasizing that for one to work, the other must be equally viable. Third, the international community must correct biases in resource allocation to the developing world, ensuring that current effective programmes are adequately funded, and new projects are developed. Fourth, the private sector must be seen as a critical partner in not only funding climate change mitigation approaches, but also for developing new technology, innovative approaches, and simply put, new ideas to broach this continuing issue.

The shift in the Earth's climate towards hotter temperatures and more difficult weather phenomena is unmistakable. Too often is political dialogue unable to divorce itself from conspiratorial-type positions of uncertainty regarding climate change. It is the hope of these authors that this paper will provide a firm base for the future study of climate change, particularly a move towards a definitive remedy for its root causes. It is our expectation that the research conducted in these pages will begin the development of innovative means by which poverty reduction, increased development and climate change mitigation can be achieved. For without expanding our understanding of the Earth's current environmental situation, the less we are going to achieve over the long term in our attempts to protect her.

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