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Entwining Climate Change Adaptation and Mitigation with Development

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***Abstract*: There is a growing understanding of the possibilities to choose and implement climate response options in several sectors to realise synergies and avoid conflicts with other dimensions of sustainable development. The human impact of geo-physical disasters, 91% of which are climate-related, has experienced a loss of 1.3 million lives with leaving another 4.4 billion injured (UNDP, 2019). This article reviews the complementarities, similarities, differences between climate change adaptation and mitigation, in addition to how these strategies are entwined with Development. Both climate change adaptation and mitigation strategies significantly affect each other, therefore it is important to see what consequences of their interconnected nature can have on development. This work shows that development interventions may not always incorporate climate change considerations, but when they do, they help generate a strong relationship between sustainable development and climate change policies amongst other macro and global benefits. The paper initiates by conceptualising some of the heavily used climate change strategy jargons, adaptation and mitigation in particular, followed by an analysis of typology of their inter-relationships from various perspectives and concludes by linking the climate change strategies to development.**

***Keywords*: Climate change, Adaptation, Mitigation, Development, Climate action, Climate strategies, IPCC, Community impact, Energy-poverty, Climate change, Conflict, Green innovation**

1. Introduction

A. Climate Change

The Intergovernmental Panel on Climate Change, IPCC (2007) refers climate change to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer whether due to natural variability or as a result of human activity. "Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land-use" (IPCC, 2001b). The United Nations Framework Convention on Climate Change, UNFCCC (1992) defined climate change as: "A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." A distinction is made by the UNFCCC (1992) definition between climate change that is attributable to human activities altering the atmospheric composition of the globe and climate variability attributable to natural causes. "Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC, 2001a). The IPCC takes a much broader view by stating that climate change can occur as a result of natural variability and human activity. Thus, the definition is made on a wider basis by bringing the fact that either of the two or both can be seen as the cause behind climate change. Table 1 provides a snapshot view of the impacts from projected changes in extreme climatic events, this would help develop ideas on climate change impacts on development and livelihood.

B. The linkage between climate change and development

"Climate change is a serious risk to poverty reduction and threatens to undo decades of development efforts" (Sperling et al, 2003). In both research and policy until recently, the two communities of climate change and development communities operated largely independently of one another (Swart et al, 2003). The reasons that have been accrued for the same are

Table 1
Examples of Impacts from Projected Changes in Extreme Climatic Events. Adapted from IPCC (2001) and Mukhopadhyay (2017)

Simple Extremes	Representative Examples of Projected Impacts
Higher Maximum temperatures	1. Increased heat stress in livestock and wildlife; increased incidence of death and serious illness in both urban and rural poor 2. Increased risk of damage to several crops
More intense precipitation events	1. Increased flood, landslide, mud-slide damages 2. Increased soil erosion and flood run-off
Complex Extremes	
Increased summer drying over mid-latitude continental interiors and associated risk of droughts	1. Increased risk of forest fires 2. Decreased crop yield along with fall in water resources quantity and quality
Increased Asian Summer Monsoon precipitation variability	1. Damages in temperate and tropical Asia 2. Increased Flood and Drought Magnitude

mainly the following few. Firstly, the most obvious reason that pops up in mind is that the two fields are ruled by separate disciplines from a conceptual standpoint: climate change by the natural sciences and development by the social sciences (Cohen et al, 1998). Around 1980s, natural scientists first identified and discussed the problem of global warming, and since then, the political process that surrounds climate change, largely through the United Nations Framework Convention on Climate Change (UNFCCC), counts immensely on the science community to inform policy. Although the realisation was there about environmental challenges, such as natural resource scarcity, land degradation and pollution and that they posed major challenges to development, yet it was seen as a science problem and not as a social problem. Thus, the link between climate change and development didn't gain prominence. For instance, much can be predicted about enhanced atmospheric temperatures and associated heat waves, but these probably affect poor communities less than climate related events such as floods, droughts and cyclones for which the links with climate change are more tenuous (Huq et al, 2006). On the contrary, development community incorporates multiple social sciences which aim to identify and also describe the social, political and economic impediments to International development. Secondly, much has been said about climate change discourse based on long-term projections generated by the Global Circulation Model (GCM) that typically run up to 100 years (in the case of sea level rise, it may be for several hundred years), whereas most development scenarios are of much shorter term just like the Millennium Development Goals (MDGs) which are set for 2015. Thus, the development school of thought have empirically seen climate change as a long-term problem that does not tally with more urgent concerns such as food security, HIV/AIDS or pollution. Also, another obstacle is differing geographical scales. This is because climate change can at best confidently predict impacts at the regional or local level. While regional models are increasingly robust, development work necessarily needs more certainty at the local or even national scales. (Huq et al, 2006)

Following decades of research data, projection, debates and policy discussions it is now commonly agreed that climate change is not just an environmental issue, but also a development one. It is thus relevant to understand what linkage Climate Change has with development. Contemporary research has conducted several studies to bring the climate change and development communities closer. For example, the concept of livelihoods approach which is in development research but has now been incorporated into climate studies to assess vulnerability (Burton et al, 2003). To link poverty and climate variability together required research partnerships at different levels with research organisations, Non-Government Organisations (NGOs), and developing countries. The Intergovernmental Panel on Climate Change (IPCC) is undeniably the key body responsible for developing, nourishing and assessing the literature on climate change. It acknowledges the fact that development may be the most effective policy framework to address climate change mitigation and is critical to the success of adaptation strategies (Nazam et al, 2003a).

Newell (2004) viewed that "Policy integration is perhaps the greatest contribution that governments can make towards providing climate protection and it is also potentially the least economically costly". Policies need to underline the relevance of climate change issues to development policy-makers and practitioners. Although the issue of policy integration has been increasingly realized yet countries differ to the extent to which they have been successful in incorporating climate change issues into their development activities. In underdeveloped and some developing economies of the world, the primary sector planners design tools to mitigate disasters and apparently climate-proof their national planning process and policies (Huq et al, 2006). For example, Bangladesh Comprehensive Disaster Management Programme assesses measures for overall risk reduction instead of providing relief aid, this is to mainstream climate change considerations into development planning. In Sudan, a country that has systematically and significantly suffered from drought, the Higher Council of Environment and Natural Resources (HCENR) recognized that a large share of Sudan's vulnerability could be sourced at its low adaptive capacity and a consequential result of poor development and poverty alleviation measures. (WHO, 2004). Subsequently, Sudan's Poverty Reduction Strategy Process (PRSPs) also started encompassing climate change issues in development policy making and planning discourses.

There is a strong interconnection between sustainable development and climate change policies. Sustainable development policies include change tools that are often found making shifts in institutional and technological setups and partnerships. This trigger consequent changes in regional/national economic policies and in sectoral environmental strategies as well. Further, these alterations along with innovation in existing technological setup potentially project alternative development pathways. All these changes in development community might in return contribute to climate change and its policies.

C. Defining Adaptation and Mitigation

1) Adaptation

"Adaptation is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented" (UNDP, 2004). The UK Climate Impact Programme (2003) interestingly brings in the use of the term climate variability, which refers to the climate changes taking place around the globe. "The process or outcome of a process that leads to a reduction in harm or risk of harm or realisation of benefits associated with climate variability and climate change" (UKCIP, 2003).The definition given by IPCC (2001a) is made on a much wider basis because it not only touches on the notions covered by the earlier definitions, but also brings in the different classification of adaptation which is available in climate change literature.

Table 2
Types of Climate Change Adaptation. Adapted from IPCC (2001)

Types of climate change adaptation	Definitions
Anticipatory Adaptation	Adaptation that takes place before impacts of climate change is observed. This is also known as proactive adaptation.
Autonomous Adaptation	Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Sometimes it is also known as spontaneous adaptation.
Planned Adaptation	Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return, maintain, or achieve a desired state.
Private Adaptation	Adaptation that is initiated and implemented by individuals, households or private companies. Private adaptation has usually been observed in the actor's rational self-interest.
Public Adaptation	Adaptation that is initiated and implemented by governments at all levels. Public adaptation is usually directed at collective needs.
Reactive Adaptation	Adaptation that mainly takes place after impacts of climate change has been observed.

"Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects which moderate harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation" (IPCC, 2001a). There are various types of adaptation and related terminology commonly found in research work, Table 2 classifies and expounds on them.

In this context it is also very relevant to comprehend what adaptive capacity in relation to climate change impacts generally means. It can be defined as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. In other words, it can be referred to as the whole of capabilities, resources and institutions of a country or region to implement effective adaptation measures.

2) Mitigation

"Mitigation can be defined as an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases" (IPCC, 2001a). It can also be perceived as the technological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to climate change, mitigation implies implementing policies to reduce Green House Gas (GHG) emissions and enhance sinks. In its 2007 Synthesis Report, the Intergovernmental Panel on Climate Change (IPCC) observes that there is "high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change" (IPCC, 2007).

3) Complementarities, differences and similarities between adaptation and mitigation

From the definitions of adaptation and mitigation, it follows that mitigation can reduce impacts (positive and negative) of climate change and consequently reduce the adaptation challenge in often an indirect way, whereas adaptation can be said to be selective; it can take advantage of positive impacts and reduce negative ones (Goklany, 2005). The implications of adaptation can be both positive and negative for mitigation. Example for positive implication can be afforestation which may be a part of a regional adaptation strategy but can also make a positive contribution to mitigate. On the contrary, adaptation actions that require increased energy use from carbon-emitting sources, e.g., indoor cooling, would affect mitigation efforts negatively (Klein et al, 2007). Emissions reductions, expressed as CO2 equivalents, achieved by different mitigation actions can be easily compared and if the costs of implementing the actions are known, their cost-effectiveness can also be determined and compared (Moomaw et al, 2001).

However, the benefits of adaptation are more difficult to express in a single metric, impeding comparisons between adaptation efforts. As the effects of adaptation are mostly local or regional, the benefits will be valued differently basing on the social, economic and political context within which they tend to occur. Benefits of present mitigation are generally observed over several decades mainly because of stay for a long duration of greenhouse gases in the atmosphere (e.g., ancillary benefits such as reduced air pollution are possible in the near term), whereas many adaptation measures are found to act effective at once reducing vulnerability to climate variability. As climate change continues with its toll, the benefits of adaptation (i.e. avoided damage) will increase over time. From this difference, it can be perceived that there is a delay between incurring the costs of mitigation and realising its benefits from smaller climate change. On the contrary, the time span between expenditures and returns of adaptation is usually much shorter. Perhaps due to the nature of this difference, the initiative for mitigation has tended to stem from international agreements and ensuing national public policies, sometimes supplemented by community-based or private-sector initiatives, whereby the bulk of adaptation actions have been motivated by the self-interest of affected private actors and communities, possibly facilitated by public policies (Klein et al, 2007).

Mitigation holds global benefits (ancillary benefits might be realised at the local/regional level), as it leads to involve a sufficient number of major greenhouse-gas emitters to foreclose leakage, whereas adaptation typically works on the scale of an impacted system, which is regional at best, but mostly local (although some results of adaptation might result at the international level, for example by changing international commodity prices in agricultural or forest-product markets).

However, it can be argued that adaptation and mitigation are related at different levels of decision-making. As of the sharing

Table 3
Classification of Interrelationships between Climate Change Adaptation and Mitigation, adapted from Klein et al (2007)

Adaptation > Mitigation	Mitigaton > Adaptation
Individual responses (household or community-based) to climatic hazards that increase or decrease greenhouse-gas emissions	More efficient energy use and renewable sources that promote local development and regional economies
More efficient and regulated community use of water, land, forests	Clean Development Mechanism (CDM) projects on land use or energy use that holistically support local economies and livelihoods
Tourism use of energy and water, with outcomes for incomes and emissions	Health benefits of mitigation through reduced environmental stresses
Effective natural resource management to sustain resilient livelihoods	Smart Urban planning, green building design and recycling with benefits for both Adaptation and Mitigation

of costs and resources, adaptation and mitigation are related at different levels of decision-making. It can be argued that at a highly aggregated scale, mitigation expenditures divert social or private resources, thereby reducing funds available for adaptation. However, if the inspection is done on a deeper scale, the actors and budgets involved are quite different in this context. While both options alter relative prices, which can lead to slight adjustments in consumption and investment patterns and thus to changes in the affected economy's development pathway, direct trade-offs are hard to find (Klein et al 2007). Considering the details of specific adaptation and mitigation activities at different level of regions and sectors it shows that adaptation and mitigation can have a positive and negative influence on each other's effectiveness. The nature of these inter-relationships (positive or negative) often depends on local conditions. Moreover, some inter-relationships are direct, involving the same resource base (e.g., land) or stakeholders, while others are indirect (e.g., effects through public budget allocations) or remote (e.g., shifts in global trade flows and currency exchange rates). Table 3 discusses the nature of the inter-relationships between climate change adaptation and mitigation.

4) Mitigation affecting Adaptation

Since several years, discussions that inadvertently invites the diverse and complex inter-relationship between adaptation and mitigation has been land-use and land-cover changes. For example, carbon sequestration in agricultural soils offers positive link from mitigation to adaptation. It creates an economic commodity for farmers (sequestered carbon) and makes the land more valuable by improving soil and water conservation, thus enhancing both the economic and environmental components of adaptive capacity (Boehm et al, 2004; Butt and McCarl, 2004; Dunmanski, 2004). Afforestation and reforestation have always offered themselves as important mitigation options. But it has observable adaptation gains too. For instance, competition for land by mitigation projects would increase land rents, and thus commodity prices, thereby improving the economic position of landowners and enhancing their adaptive capacity. Also, land conversion and deforestation process have been a major source of greenhouse-gas emissions which has consequently led to unsustainable agricultural production patterns in various parts of the world. Attempts to abate or halt this process by incentives for forest conservation have often offered benefits for local climate, water resources and biodiversity (Boehm et al, 2004; Butt and McCarl, 2004; Dunmanski, 2004).

5) Adaptation affecting mitigation

Many adaptation options in different impact sectors are known to involve increased energy use and hence interfere with mitigation efforts if the energy is supplied from carbon-emitting sources. In this context, two main types of adaptation-related energy use can be distinguished: one-time energy input for building large infrastructure (materials and construction), and incremental energy input needed continuously to counterbalance climate impacts in providing good and services. For example, rural renewable electrification can have both huge emissions implications (WEA, 2000) and adaptation implications (Venema and Cisse, 2004). Adaptation to changing hydrological regimes and water availability will also require continuous additional energy input. In water-scarce regions, the increasing re-use of wastewater and the associated treatment, deep-well pumping, and especially large-scale desalination, would increase energy use in the water sector (Boutkan and Stikker, 2004). Yet again, if provided from carbon-free sources such as nuclear desalination (Misra 2003; Ayub and Butt, 2005), even energy-intensive adaptation measures need not run counter to mitigation efforts.

The magnitude and relative share of sustained adaptation related energy input in the total energy balance depends on the impact sector. In agriculture, the input-related (CO2 in manufacturing) and the application-related (N20 from fields) greenhouse-gas emissions might be significant if the increased application of nitrogen fertilisers offers a convenient and profitable solution to avoid yield losses (McCarl and Schneider, 2000). Operating irrigation works and pumping irrigation water could considerably increase the direct energy input, although, where available, the utilisation of renewable energy sources onsite (e.g., wind, solar) can help avoid increasing greenhouse-gas-emissions (Mukhopadhyay, 2017; Mukhopadhyay & Mukhopadhyay, 2019).

Table 4 illustrates how the interrelationships between climate change adaptation and mitigation plays out their part at various scales of action - global policy level, sectoral planning stage, and at local, individual levels.

D. Linkages between adaptation, mitigation and development

"There is growing understanding of the possibilities to choose and implement climate response options in several sectors to realise synergies and avoid conflicts with other dimensions of sustainable development." (IPCC 2007) Climate change policies bring in improvement in international

Table 4
Typology of Inter-relationships between Climate Change Adaptation and Mitigation, adapted from Klein et al (2007)

Scale of action	Adaptation > Mitigation	Mitigation > Adaptation
Global/ Policy	Awareness of limits to adaptation motivates negotiations on mitigation	Clean Development Mechanism (CDM) trades provide funds for adaptation through surcharge
Regional/National Strategic Planning	Watershed planning, e.g., hydroelectricity and land cover, affect GHG emissions	Fossil-fuel tax increase cost of adaptation through higher energy prices
Local/ Biophysical community action	Increased use of air-conditioning (homes, offices, transport) raises GHG emissions	Community carbon sequestration affects livelihood

Table 5
Integrating Climate Change considerations into Development policies, adapted from IPCC (2007)

Selected Sectors	**Non-Climate Change Policy Instruments**	**Potential Effects**
Petroleum imports	Diversifying imports and domestic fuel mix and reducing economy's energy intensity to improve energy security	Emissions from crude oil and product imports
Forestry	Adoption of forest conservation and sustainable management practices	GHG emissions from deforestation
Electricity	Adoption of cost-effective renewables, demand-side management programmes, and transmission and distribution loss reduction	Electricity sector GHG emissions

development issues, for instance policies related to energy efficiency and renewable energy are often economically beneficial, improve energy security (poor people like farmers and their livelihoods are benefitted) and reduce local pollutant emissions (which in turn helps to build a healthy and a much more resilient community). Reducing both loss of natural habitat and deforestation can have significant biodiversity, soil and water conservation benefits, and can be implemented in a socially and economically sustainable manner. Forestation and bio-energy plantations can restore degraded land, manage water runoff, retain soil carbon and benefit rural economies, but could compete with food production and may be negative for biodiversity, if not properly designed. (Klein et al, 2007).

Several empirical research studies showcase how non-climate change policies can also contribute to adaptation and mitigation. Development policy interventions like macro-economic policy, agricultural policy, multilateral development bank lending, electricity market reform, energy security and forest conservation at various national/sectoral/ local levels can reduce emissions although they are not directly tailored to include climate change considerations. Table 5 illustrates many such effects that non-climate change policies have on development and environment. "Both synergies and trade-offs exist between adaptation and mitigation options" (IPCC, 2007). The examples of synergies that include properly designed biomass production, formation of protected areas, land management, energy use in buildings, and forestry, but synergies are rather limited in other sectors. Potential trade-offs include increased GHG emissions due to increased consumption of energy related to adaptive responses.

Oxfam (2009) briefs that "hundreds of millions of people are already suffering damage from a rapidly changing climate, which is frustrating their efforts to escape poverty". To conclude, it is imperative that there are significant effects of both strategies, adaptation and mitigation, on one another. Further longitudinal research would be needed for in-depth information about the interrelationship between adaptation and mitigation at regional and sectoral levels. Most mitigation studies only identify the options and costs of direct emissions reductions and pretty much stop there. Although, they do sometimes consider indirect effects of implementations and costs on other sectors of the economy, yet they don't seem to emphasise enough the necessity of dealing with the implications for adaptation options on sectors affected by climate change. Likewise, climate impact and adaptation assessments need to evaluate beyond taking stock of the adaptation options and only estimating their costs. This ignores the larger externalities of emissions.

2. Conclusion

This paper presented an overview on entwining climate change adaptation and mitigation with development.

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