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Governance Capacity for Climate Adaptation in Nepal

By Ganesh P. Adhikari
Tribhuvan University, India

Abstract - For the last few decades, global warming has become a strong threat to human development. The climate change has been affecting on water resources, biodiversity, agriculture, forestry, and public health in specific, and the way of life in general. Nepal is highly vulnerable to the negative impacts of climate change. The crux of the problem for managing climate change adaptation is the rampant poverty. In such context, this study aims to review the key challenges of climate change governance in Nepal and to determine the extent of the Nepal's climate change governance capacity. The primary data for this study was collected by administering a score-sheet to the extensively experienced persons in the field of environment and/or climate change. This paper concludes that Nepal's climate change governance capacity is of moderate level and marginally improving since 2010.

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Governance Capacity for Climate Adaptation in Nepal

Ganesh P. Adhikari

Abstract - For the last few decades, global warming has become a strong threat to human development. The climate change has been affecting on water resources, biodiversity, agriculture, forestry, and public health in specific, and the way of life in general. Nepal is highly vulnerable to the negative impacts of climate change. The crux of the problem for managing climate change adaptation is the rampant poverty. In such context, this study aims to review the key challenges of climate change governance in Nepal and to determine the extent of the Nepal's climate change governance capacity. The primary data for this study was collected by administering a score-sheet to the extensively experienced persons in the field of environment and/or climate change. This paper concludes that Nepal's climate change governance capacity is of moderate level and marginally improving since 2010.

I. Introduction and Methodology

Nepal has a highly diversified ecology, within a very short span, extended from the high Himalayas in the north followed by middle hills to the low land terai in the south. Along with this ecological variation, the climate conditions also vary from alpine in the north to tropical in the south. The ecological/ to zoographical and climatic variations give rise to diverse culture and livelihood. The livelihood of around one-third of Nepal's population is based on agriculture and forest resources; and almost 65 per cent of agricultural cultivation is rain-fed (MOE, 2011a). Nepal is extremely vulnerable to the negative impacts of climate change mainly because of its diverse topography and fragile ecosystems.

The proper management of climate change adaptation has become a difficult task due to poverty or poor economic situation of the country. Nepal lacks the resources to finance its own development. More than 50 per cent development expenditure has been financed through foreign for the last 60 years. Official Development Assistance (ODA) as percentage of nominal GDP during 1990 to 2009 ranged from 3.5 to 6.4 percent (Adhikari, 2011). It indicates a moderate level of aid dependency.

According to Maple croft (cited in Oxfam, 2011a), Nepal is in the fourth position among 170 countries in the Climate Change Vulnerability Index (CCVI). It also applies for the next 30 years. Dixit (2010) categorizes Nepal's climate-related disasters into two types: (i) rapid-onset events such as cyclones, land-slides, avalanches and floods; and (ii) slow-onset events such as rising temperatures, forest fires, regional sedimentation, and accelerated melting of snow and glaciers. Most of the Nepali people have been suffering from water scarcity in dry season and from floods and land-slides in summer.

NAPA (2010) assessed the climate change vulnerability throughout the country. The vulnerability mapping was done on the basis of the integration of combined sensitivity, combined adaptation capacity, and specific and combined risk exposures. It has become a valuable data source for prioritizing the more vulnerable areas for adaptation planning considering specific climate change exposures. However, the possible opportunities created by the climate change have not yet been explored.

In the above given context, this paper aims to review the key challenges of climate change-related governance in Nepal and to determine the extent of the Nepal's climate change governance capacity.

The primary data for this study was collected in November 2011. The available literature on climate change governance in Nepal was first reviewed and identified some prominent challenges of climate change-related governance capacity in Nepal. For assessing the Nepal's governance capacity in relation to the management of climate change, a score-sheet was constructed by using eleven-point scale for each identified challenges. Thirty scorers were selected from Ministries, INGOs, and Universities by using the convenience sampling technique. The selected scorers were experienced more than 5 years in the field of environment. The score-sheet was administered through face-to-face contact as well as e-mail. Because of the time and resource constraints, the key limitations of the study are taking a small sample size and not collecting the detailed qualitative primary data. The accuracy of the primary data may not be high due to small sample size.

II. Sectoral Vulnerability to Climate Change

National Adaptation Program of Action (NAPA) has set six thematic issues of climate change in Nepal: (i) agriculture and food security; (ii) water resources and energy; (iii) forest and biodiversity; (iv) public health; (v) urban settlements and infrastructure; and (vi) climate-induced disaster.

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a) Agriculture and Food Security

Nepal is a land-locked country extended from the Himalayas in North to the low land Tarai with tropical climate in South within a lateral span of 200 km. More than 70 per cent of population lives on less than US$ 2 per day. About 85 per cent of Nepal's population involve in subsistence agriculture (ADB 2009 cited in MOE 2010). Mountain and Hill regions are not able to produce enough food to meet the local demand. NPC (2011b) states that agricultural productivity has remained stagnant or declined across the country. Its agriculture is largely dependent on the monsoon rain. The monsoon affected by the climate change is expected to modify agricultural activities due to upward shifting altitudinal boundaries and loss of biodiversity.

The adverse effect of climate change on agricultural production is mainly due to delayed or below average rain fall and sometimes flooding because of heavy rain fall. Even in the fertile Tarai, 1997, 1998, 1999, 2006 and 2008 were food deficit years (NPC 2011b). The surplus food of Tarai cannot be easily transport to the remote Hills and Mountains. For this reason, there is no guarantee of food security in the remote areas of Nepal.

b) Water resource and Energy

Water is available in the form of snow, surface water and groundwater. Hydrological system of the earth is highly complex. The volume of precipitation and evaporation is determined by temperature. Soil moisture depends upon the land system. Time, duration and amount of water available depend upon the hydrological cycle and temperature.

As a result of the climate change in recent years, the intensity of precipitation has been increasing and the temporal incidence of precipitation has been changing. The rapid melt of snow in Himalayas formed new glacial lakes and rapidly expanded the existing ones. Global warming has become an increasing threat of glacial lake outburst floods (GLOFs), floods, drought, siltation, inundation, mass wasting, erosion and water source depletion (NPC 2011b).

Cloud line and frost lines have shifted up due to warming of atmosphere. It has become a causal factor for changing rain fall patterns. The prolonged droughts have been occurring annually in Tarai region since 2005. As a result, the farmers compelled to turn way from planting cereals and embrace horticulture (NPC 2011b).

The increased global warming seriously affects on hydropower generation in long-run. Most of the hydropower plants in Nepal are based on run-off-rivers originated from high mountains or Himalayas. The predominant source of energy supply is the hydropower sector which is very vulnerable to climate change.

c) Forest and Biodiversity

Forests occupy 39.6 per cent (5,830,360 ha) of total land area in Nepal (MOE 2010). Protection, conservation and use of forest resources are necessary to support the livelihood of ruala people and for sustainable development of environment and biodiversity. From environmental perspective, more forest cover help maintain biodiversity and balance ecology; from agricultural perspective, more land requires to produce enough food for the growing population. The trade-off between these two perspectives is a matter of high level policy decision.

Nepal is rich in biodiversity and ecosystem levels due to the diversity in topography and climate. The diversity ranges from the dense tropical monsoon forest of the Tarai in the North followed by the deciduous coniferous forests of the sub-tropical and temperate Hills to the sub-alpine and alpine pastures and Himalayas in the North.

Biodiversity has become vulnerable to climate change in Nepal because of shifting altitudinal boundaries for plant, the shrinking of plant habitats, plant migration, species loss, forest fire, and extended drought (NPC 2011b).

From the management perspective, some of the prominent problems in the biodiversity sector are high population pressure, rampant poverty, low level of public awareness, and insufficient human resources for climate resilient development in Nepal.

d) Public Health

The impact of climate change on public health heavily occurs mainly in backward communities where there is poor sanitation. Increased flooding contaminates the drinking water causing water-borne diseases, such as diarrhea, cholera and worm infestation. Global warming creates a favorable climate for mosquito breeding that may cause kala-azar, malaria, and dengue fever. The changes in temperature may also be favorable to harmful bacteria and viruses that cause typhoid, encephalitis and hepatitis-B. Thus, the climate change tends to increase morbidity and mortality due to the increased communicable diseases.

e) Urban Settlements and Infrastructure

Almost all the urban settlements in developing countries have been developed in an evolutionary or haphazard rather than a planned process. There are no greenery belts in between industrial zones and in residential area. Most of the urban Infrastructures such as transport, electrification, water supply and sanitation, housing and communication networks are also in sub-standard level in terms of safeguarding them from natural hazards and man-made disasters (NPC 2011b).

Damaged infrastructures hinder the other sectors of development. If the infrastructure of power supply is damaged, for example, ire hinders the industrial production including many other business activities and incurs a huge economic loss. Likewise, the damage of roads impedes the movements of people, good and services. It may also cause vehicle accident,

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the man-made disaster. In some case, the water of drain pipe inters into the pipe of drinking water and then people get sick of water-borne diseases.

Many residential buildings constructed before a decade have no provision of ceiling-fan in Kathmandu. The importance of ceiling-fan and increased height of room are now being realized because of climate change. It seems not sustainable and very costly to reconstruct the building. Thus, the urban settlements and infrastructures must be sustainable and environment-friendly.

f) Climate-Induced Disaster

The remarkable climate-induced disasters in Nepal are floods, landslides and droughts. These disasters threat the security of life and property of the people. Such disasters affect more to the poor and the disadvantaged communities than to well-off urban communities.

In order to protect the life and property from disasters, it is necessary to make disaster management sustainable and environmental-friendly in a planned way. The focus must be given to mobilize technical experts as much as possible to facilitate the local people to make their disaster management plans, programs and activities sustainable.

III. Review of the Climate Change Policy Framework

Nepal has signed the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 and it came into force in July 1994. The Kyoto Protocol also came into force in December 2005 (MEST, 2008). Nepal has attended almost all Conference of Parties (COP) meetings under the UNFCCC for raising national issues and negotiating the international agreements. Nepal has been internalizing the global agreements by borrowing the global ideas for the formulation of national policy. Whatsoever, the level of internalization may be low due to the complexity and a variety of global agreements. After becoming a party to UNFCCC, Nepal's policy focus directed to environmental protection. Environmental Protection Act 1996 and Environmental Protection Rule 1997 were passed for protecting and controlling environmental pollutions in the country. In order to implement these legal provisions, Government of Nepal (GON) have been setting standards related to industrial waste water and air quality in different points of time. Nepal Vehicle Emission Standard 1999 and National Ambient Air Quality Standard 2003 have been reforming in the line of regional and global standards (MOE, 2011c).

The issue of climate appeared as a national development agenda only when this issue is addressed in Interim Constitution of Nepal 2007 and the Three-Year Interim Plan (2008-2010). The GON prepared a separate paper of "climate Change Policy" only in 2011. The current policy document (MOE, 2011b) realizes present situation, identifies problems and challenges, sets objectives, and states policies and strategies to achieve the goal of improving livelihoods by mitigating and adapting to the adverse impacts of climate change. The broader contents of the policy are adaptation, low carbon development paths and natural resource management. The content of the policy seems congruent with the international agreements such as UNFCCC, Kyoto Protocol, and the different sessions of COP to the UNFCCC. The policy paper also focuses on the effective implementation of the National Adaptation Program of Action (NAPA). The effective implementation of NAPA requires a strong organizational structure.

The Government of Nepal has two chief climate change coordination and policy forums. They are: (i) the Climate Change Council (CCC) formed in July 2009; and (ii) Multi-Stakeholder Climate Change Initiatives Coordination Committee (MCCICC) formed in July 2010. CCC is the high-level policy and coordination body formed under the chairmanship of Prime Minister; and it aims at providing national level policy guidance and long-term directions. MCCICC is the program level coordination body formed under the chairmanship of the Minister of Environment (MOE). It aims at improving communication and coordinating climate change initiatives including adaptation funding. In addition to these chief forums, the GON has also created the Climate Change Management Division (CCMD) under the MOE. CCMD is responsible for coordinating climate change works of the government.

Oxfam (2011a) claimed that the MOE is not capable enough as a focal point and it has no sufficient human and financial resources for implementing the climate change adaptation programs. The National Adaptive Capacity Assessment carried out under the Pilot Program for Climate Resilience (PPCR) in November 2010 highlighted several challenges including insufficient financial, technological and human resources, and the poor institutionalization of risk management in government, academia, civil society or vulnerable sectors, municipalities, and districts or communities (World Bank/ADB/IFC, 2010 cited in Oxfam, 2011a).

IV. Review of Financial Partnership in Climate Change

Because of being a party to UNFCCC, Nepal is eligible to access finance from the Global Environment Facility (GEF) special funds—the Least Developed Countries Fund (LDCF) and Special Climate Change Fund (SCCF). The Adaptation Fund (AF) is also accessible under the Kyoto Protocol. The National Adaptation Program of Action (NAPA) administered by UNDP is funded by LDCF and supported by UNDP, DFID and DANIDA. The Ministry of Environment (MOE)

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leads this program. Ministry of Forest and Soil Conservation (MOFSC) and the Ministry of Agriculture and Cooperatives (MOAC) are also leading for some significant adaptation programs mostly funded by bilateral agencies as well as pooled donor funds (Oxfam, 2011a).

There are several donor-funded climate change programs and capacity-building initiatives in Nepal (see: Oxfam, 2011a). Most of such projects are being implemented by the World Bank and ADB. The Oxfam's report also indicates that, among the bilateral donors, DFID seems a leading donor for climate change financing in Nepal. Oxfam (2011b) introduces ten organizations (mostly INGOs) working in the climate change sector in Nepal. Among them, Warnock International focuses on mitigation, Action Aid Nepal and United Mission to Nepal on Disaster Risk Management (DRM), Care Nepal and Practical Action Nepal on research, and World Wildlife Fund Nepal on multi-sect oral activities. The projects of INGOs in Nepal usually cover a limited geographical area of the Country. The World Bank and ADB are the leading donors for supporting the capacity-building initiatives in Nepal. The technical assistance component is the most critical component of foreign aid in general and also in climate change sector. Oxfam (2011a:14) reports that "… there is a confusing array of separate technical assistance capacity strengthening projects funded by different donors to a number of ministries. These are largely operated by teams of international and national consultants in project implementation units attached to ministries but closely handled by their donors". It indicates the lack of country-ownership of aid activities in Nepal.

V. Findings

The literature on climate change reviewed in this paper indicates some prominent challenges in climate change-related governance capacity in Nepal. They are: (i) lack of technical personnel in public sector; (ii) a week organizational strength and coordination mechanism; (iii) lack of country-ownership of aid activities; (iv) unsustainable donor-funded capacity-building initiatives; (v) insufficient internalization of global policies; and (vi) lack of the institutionalization of climate change governance in different segments of society. This section devotes to identify the degree of the above listed challenges, by using primary data.

Table 1 : Nepal's Climate Change Governance Capacity Assessment

Issues in Climate Change Governance Capacity	Average Response Score (Range= 0 to10)	
	Until 2009	2010 onward
Sufficiency of human resource in public service	4.2	4.6
Organizational strength and coordination mechanism	5.1	5.5
Level of the country-ownership of aid activities	5.4	6.9
Sustainability of donor-funded capacity-building initiatives	4.7	5.0
Level of the internalization of global climate policies	5.1	5.6
Sufficiency of rules, regulations and procedures in:		
a. Policy level	6.3	6.8
b. Front-line bureaucracy	5.9	5.9
c. Academia/ Media	6.6	6.8
d. Civil society	6.4	6.6
e. Community level	4.3	4.6

Source: Field Survey, 2011.

The Table 1 shows the average scores of Nepal's climate change governance capacity in different issues. All the response scores in the Table are very close to the median value (6) of the capacity score. It indicates that Nepal's climate change governance capacity is of moderate level. The Table also shows that most of the corresponding average response scores of '2010 onward' are slightly higher than that of 'until 2009'. It indicates that Nepal's climate change governance capacity is marginally increased from 'until 2009' to '2010 onward'.

In order to measure the climate change vulnerability in Nepal, NAPA (2010) used the combined adaptation capacity by adding the weighted values of socio-economic, technology and infrastructure sub-indices. On the basis of this measurement, the combined adaptation capacity of only 3 districts were of very high level, 5 districts were of high level, 33 districts were of moderate level, 22 districts were of low level, and 12 districts were of very low level. Three districts having a very high level of adaptation capacity were Kathmandu, Kaski and Lalitpur. This fact indicates that the overall adaptation capacity of Nepal was of very close to moderate level.

VI. Conclusion

Nepal is extremely vulnerable to the negative impacts of climate change mainly because of the predominance agricultural occupation in a diverse topography and fragile ecosystems. Rural poverty is the crux of the problem for managing climate change adaptation in Nepal. Because of being an aid

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dependent or a developing country, Nepal's climate change governance capacity is frequently charged of weak organizational structure, insufficient human resources, lack of country-ownership of aid activities, unsustainable donor-funded capacity-building initiatives, and insufficient internalization and institutionalization of global development policies.

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Strategic Trade Policy as Response to Climate Change?

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Strategic Trade Policy as Response to Climate Change?

An Empirical Assessment of the Political Economy of Climate Policy

Andreas Freytag [α] & Leo Urban Wangler [σ]

Abstract - Based on German experiences, this paper discusses the political economy of climate protection. The objective is to come to a better understanding of why climate change has become one of the main topics at the domestic agenda in some countries, despite the fact that there are obvious free-riding problems resulting in increasing difficulties for international policy coordination. Using a strategic trade policy framework, the paper theoretically discusses the incentives for domestic policymakers to advocate an ambitious climate policy and assesses these incentives empirically with econometric methods.

I. Introduction

The problem of climate change is of a global nature. As long as economic growth is not disentangled from an increase in greenhouse gas (GHG) emissions, the problem of climate change is likely to increase. One common argument is that the global problem encourages free-riding and reduces national incentives to contribute to climate change mitigation policies. Thus, international policy coordination is an attempt to reduce the related problems.

One example of international cooperation aiming to reduce coordination problems is the Kyoto-Protocol (KP). Even though the KP was an attempt to make countries act cooperatively, strategic behavior could be observed at the ratification stage (decision to ratify or to free-ride on the agreement) as well as the implementation stage (over or underinvestment to fulfill the requirements agreed by ratification). Differences in national cost structures combined with strategic interaction between countries makes coordination difficult. A recent example was the negotiation for a follow-up agreement to the KP which took place in December 2009 in Copenhagen (e. g. Macintosh; 2010; Nicoll et al.; 2010). Despite the global nature of the problem, some governments did start to restructure their energy policies. It seems that they take the climate change problem seriously (e. g. the German government by supporting diffusion of green technologies (GTs)[1]). Interestingly, it turns out that the same countries argue forcefully in favor of more strict environmental standards on the international platform.

The fact that some countries invest relatively more than others in the abatement of climate change is somehow counterintuitive if we apply the general wisdom that free-riding of particular countries negatively affects the international competitiveness of non-free-riding-countries. Investment costs related to GTs seem to be a burden that increases the costs of energy consumption within a country. It is, therefore, an interesting question why some countries are more motivated than others in implementing policy measures that have a seemingly positive impact on the problem of global warming and promote actively high environmental standards at the international level instead of free-riding themselves.

We argue that the initiative for structural change at the national level can be an outcome of international environmental agreements (IEAs) aimed at reducing problems related to climate change. However, as we also observe free-riding, not all countries are able to restructure their energy policy. Differences in political systems as well as cultural aspects might be a reason for the observed heterogeneity. In contrast to the common view, the main argument of our paper is that free-riding by some countries may encourage other countries to increase investment in abatement measures instead of reducing it. Our arguments are based on a political economy framework in combination with international trade policy.

The paper is organized as follows. In section 2, we briefly discuss the costs of global climate change and the global attempt to solve the problem. In section 3, we focus on the particular German case. Different political economy explanations that help to explain the observed heterogeneity among countries follow in section 4. In section 5, we use a simple theoretical framework to explain a country's solo run to provide a global public good in climate policy. Our political economy reasoning is empirically assessed with the help of a negbin model in section 6 where we use the patent applications of German green technology firms as a proxy for their expectations about future export sales. Conclusions round off the paper.

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[1]In this paper we define GTs as technologies able to produce electricity using renewable energy sources (e.g. photovoltaics, solar, geothermie, biogas, water, wind mills etc.) and therefore, have the potential to substitute for GHG emitting conventional energy sources.

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II. Climate Change Problem and Climate Policy

There are studies trying to make predictions about the costs related to climate change (e. g. Latif; 2010; Stern; 2007). Without policy response, costs of changes in temperature are expected to increase at a level of from 5- 20 percent of global annual gross domestic product (GDP). These costs can be reduced by climate policies. However, there are substantial differences between regions (cf. Hope; 2006; Mendelsohn et al.; 2000; Nordhaus and Boyer; 2003; Nordhaus and Yang; 1996; Tol; 2002). The allocation of costs has further an intertemporal dimension. Estimates came to the result that it is "cheaper" to react today than in the near future because doing nothing will increase costs (Kemfert; 2005).

Another problem is related to non-cooperative behavior of particular countries and changes in relative prices. As stated by Sinn (2008), it may be the case that the abatement of industrialized countries does not affect the speed of global warming as initially intended because the reduced demand for energy by some industrialized countries simply lowers world market prices and increases the demand for energy by those countries which do not intervene to reduce energy consumption (the so-called "rebound effect"). Problems to coordinate international policies lead Lomborg (2006) to suggestions of alternatives to the option of cutting GHG emissions.

It can be seen that costs related to climate change depend strongly on the policy measures implemented. Country specific costs can be reduced significantly if there is international cooperation. However, free-riding on the international level increases country specific costs of climate abatement policies. Based on these arguments, global environmental problems constitute an international prisoners' dilemma. Climate protection has the characteristics described as "tragedy of the commons" (Hardin; 1968) and countries have to cooperate to find solutions for the common pool problem (e. g. Ostrom; 1990). The Kyoto Protocol is an attempt to coordinate international policies.

By signing the KP countries agreed to a reduction in the emission of GHGs to a specified level measured in percentages of the base year 1990. Between 2008 and 2012 countries are supposed to reduce the average emission of GHG by about 5.2 percent of the 1990 reference-level. Europe agreed to reduce the emissions of GHG by 8 percent in comparison to the emissions of 1990. The KP was coupled with the condition that at least 55 member states, which altogether produce more than 55 percent of the global emissions of CO_2, have to ratify the protocol before it can enter into force (Kyoto Protocol; 1998, p. 19).[2] The 55 percent rule was fulfilled when Russia ratified the KP in November 2004. Therefore, the KP came into force in February 2005. In 2011 188 countries and other governmental entities have ratified the KP. The United States, the largest single emitter of GHG signed but did not ratify the KP at the national level.

III. Climate Policy in Germany

Once international treaties are negotiated, countries have to implement policies to fulfill what has been agreed. The alternative is to free-ride on the international agreement. Germany has chosen a mixed strategy to reduce the emission of GHG. On the one hand, there is the market solution (implemented in Europe) of trade with certificates related to GHG emissions.[3] Germany has the target to reduce emissions by about 21 percent in 2012 compared to 1990 baseline emissions. On the other hand, the government is using incentives to encourage the application of particular (allegedly) climate friendly technologies. For instance, the former "red-green" government coalition[4] passed the so-called "Renewable Energy Sources Act" (EEG) to support renewable energies by the use of technology specific feed-in tariffs. In what follows, we will focus on the promotion of GTs and its connection to climate change as this is an interesting case from a political economy perspective.

From a theoretical point of view most GTs available, even today, are costly alternatives compared to conventional energy technologies (wind turns out to be an exception). The political argument for investment into GTs is to foster the development of GTs and to reduce global warming (EEG; 2009, section 1, purpose). There is an obvious connection between the problem of climate change and industrial policy, as feed-in tariffs are set on different levels what allows for the diffusion of more cost-intensive GTs. The range of feed-in tariffs in 2003 was from 6.5 Cent/KWh for electricity produced by using water and biogas up to 51.62 Cent/KWh for electricity produced with solar.[5] This has led to a remarkable diffusion of GTs (comparefigure 3 and figure 4, Appendix, page 16). From 2000 to 2011 electricity produced with renewable energies increased from 6.4% to 17% (BMU; 2011, p. 12). This is puzzling and needs an additional explanation.

Another observation, that can be made, is that the German government takes an active role in

[2]The so-called 55 percent rule has important implications: It gives countries the opportunity to free-ride without nullifying the whole agreement. The free-rider problem is, thus, mitigated and it is more likely that the agreement will be implemented.

[3]The importance of defined property rights as an efficient solution for the externality problem has been highlighted by Coase's (1960) seminal paper. For theoretical considerations compare Baumol and Oates (1988).

[4]The coalition between the Social Democrats and the Green party from 1998 to 2005.

[5]The average market price for electricity in 2003 was reported by the German statistical office to be 8.78 Cent/KWh (including the costs for GTs).

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international environmental negotiations. First of all, it can be seen that the German government established one of the highest GHG emission reduction targets within Europe. Second, at the G8 summit at Heiligendamm (Germany) in June 2007, the German government tried to use its role as an agenda setter to actively promote climate policies (e. g. Freytag and Wangler; 2011). There is further evidence that Germany as a member of the European Union is one of the leading industrial countries with respect to climate change and renewable energy policies (e. g. Weidner and Mez; 2008). With the recent event of the nuclear catastrophe in Fukushima (Japan) the current energy policy in Germany changed even more in favor of renewable energies. According to a new energy concept by the German government it is the aim to reduce GHG emissions until 2020 by about 40%, until 2030 by about 55%, until 2040 by about 70% and until 2050 by about 80-95% compared to 1990 baseline emissions (BMWI; 2011, p. 5). These GHG reduction targets are ambitious and are also surprising due to the fact that international policy coordination is confronted with difficulties.

Interestingly, the German government tries to foster actively the export of green technologies. For this purpose, in 2002 the German Bundestag nominated the German Energy Agency to be responsible to promote actively the export of GTs. Under the label "Renewable Made in Germany" there is a whole concept of marketing for the related products and there is active support to create international networks, to create knowledge about potential export markets of GTs and to provide active services facilitating foreign market entrance (e.g. by active lobbying). The support by the German Energy Agency is not limited to German companies alone, criteria for support is in close connection to the job creation in the GT sector within Germany.[6]

The findings of the previous sections can be summarized as follows: With respect to the climate change problem, there is the need for international policy coordination. This coordination, however, turns out to be difficult and perceived as a failure. If we follow this line of arguments, it is surprising that an industrialized country like Germany takes a leading position in climate policies despite the fact that coordination failures increase country specific marginal abatement costs. It seems that politicians in Germany have a long term time horizon by actively promoting the diffusion of GTs as this policy (if at all) will only have in the long run a positive impact on the world climate. This behavior is somehow puzzling as the general wisdom suggests that politicians are rather short term oriented.

IV. Political Economy Considerations

a) *Behavioral Assumption*

From a political economy point of view politicians are considered as rational actors that are mainly concerned about re-election (Schumpeter; 1987b). Incentives to foster structural change in the energy sector are rather low as this is costly and reduces the political influence of conventional energy producing companies. This helps to understand the difficulties in particular countries to invest into climate abatement policies. Due to the free-riding of other industrialized countries, we also should not expect that politicians in Germany seriously support diffusion of GTs. Obviously, this is not the case. As stated in the previous section there was an observable diffusion of GTs and in the future they will be of increasing importance. The aim is to achieve a share of 35% by 2020, in 2030 the share shall be 50% and in 2050 the share of renewable energies of cross electricity consumption shall achieve 80% (BMWI; 2011, p. 5).

Theory suggests huge difficulties for policies aiming to foster structural change in the energy system. Today the support for most GTs is still not profitable under current relative prices. The described empirical observation is therefore counterintuitive and needs an additional explanation.

A standard political economy explanation refers to the median voter model (Black; 1948; Downs; 1957). The government follows the median voters' preferences which are increasingly directed to protect the climate. Therefore, the government invests relatively more than other countries into climate protection as this is in line with median voter preferences within the country. The likelihood of such a political preference for early investment into abatement policies is doubtful, due to international free-riding behavior and the relatively high investment costs that are related to GTs.

If we take into account that international preferences are characterized through a game with national elections on a first stage and the delegation of representatives to international levels on a second stage, there is still some explanatory power related to the median voter theorem. The described model is known as strategic delegation model of IEA formation. In the underlying game voters delegate their decision power to agents representing the country at international negotiation tables. The agents, usually the government, then have the power to negotiate the terms and conditions of an international agreement.

This setting is generally applied as a two-stage game within a two country setting. At the first stage voters (using majority rule) elect their preferred politician who, at the second stage, is responsible to negotiate the international treaty. Foreign election outcomes are taken as given for the election on the national level. This allows voters to select the candidate that represents most favorable their position in the international policy game.

One basic feature of the underlying game is that it is rational for voters to elect a politician with different preferences than their own; with the result that

[6]To get more insights see DENA (2011), p. 14.

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international outcomes deviate from the median voter's 'true' preferences. It is rational for voters to strategically misrepresent individual preferences if the election outcome gives an advantage at international policy negotiations (see Persson and Tabellini; 2000, Chapter 12). There are different economic phenomena such as international tax policies and the provision of transboundary public goods to which the strategic delegation approach has been applied to (e. g. Böhringer and Vogt; 2004; Buchholz et al.; 2005; Dolado et al.; 1994; Kempf and Rossignol; 2010; Persson and Tabellini; 1992; Roelfsema; 2007; Segendorff; 1998).

Segendorff (1998) finds that voters will choose politicians that have stronger preferences for the private good compared to themselves. The idea behind is that this lowers the reservation utility and thus, weakens the bargaining position of the other agents participating in negotiations. They find a gap between cost and actual willingness to pay in particular for the USA what might serve as an explanation for the withdrawal of the USA from the Kyoto agreement. Buchholz et al. (2005) study the effect of strategic delegation with a focus on IEAs. They find that in the equilibrium the median voter in each country chooses a government that is less concerned about environmental problems compared to himself, with the intuition that this improves a country's position at the international bargaining stage.

The results described allow to explain why investment into climate protection might be too low. This is different from the described German position within the international climate policy-game. However, models of strategic delegation are also helpful to explain why countries might support rather strict environmental standards on international levels. Roelfsema (2007) studies the effects of strategic voting within a two country setting and non-cooperative behavior with a focus on the Kyoto protocol. Two equilibria are possible. One where politicians are less concerned about the environment than the median voter and one in which politicians have a higher preference for the environment compared to the median voter. There will either be a 'race to the bottom' or a 'race to the top', depending on the strength of the environmental preferences of the median voter.

Models of strategic delegation can help to explain why politicians in some particular countries are highly engaged for environmental protection also at international levels. In Germany it seems that strategic delegation leads to high preferences for international climate standards. Median voters' preferences might be different from those of the delegates.

Strategic delegation allows delegates to promote long term environmental targets as long as in the short run partial gains at the regional level exist, like short term employment in the GT industries (generating directly observable growth in the GT industry). Politicians are not directly sanctioned by the voters if they convincingly argue that diffusion of GTs is related to future export sales. The job creation in a particular GT industry (Blanco and Rodrigues; 2009; Hillebrand et al.; 2005; Lehr et al.; 2008; Lund; 2009) very likely creates stable (or increasing) transfer flows to the particular GT industries (lock-in effect). Politicians can maximize their political support function (in the short run) with this job increase and at the same time justify these transfers by expected future payoffs (e. g. future exports) related to the investment. This relationship between short term employment and long term export expectations might be the main reason for the observable diffusion of GTs within Germany and the strong preference for high international standards to protect the climate.

The described policy will only pay off in the future if other countries also adapt to the high German standards. This explains why the German government has to support a rather strict environmental position on international meetings. The aim is to prepare future export markets in order to make the (over) investment into GTs profitable. Thus, for investment into GTs it mainly holds in a one-shot game that free-riding behavior of other countries is problematic for the domestic government and its climate abatement targets. From a dynamic perspective, this free-riding behavior in the short run may further encourage governments for ambitious unilateral political action, as long as it can be expected that other countries over time have to increase their environmental standards, as well. Such an increase seems to be likely in the context of climate change with its long term time horizon.

What still has to be answered is the reason for the observed heterogeneity between countries with respect to be able to start investment into GTs. One explanation might be that governments act ideology driven or that under particular circumstances they have the opportunity to implement partisan policies. As climate change requires structural change within the economic system, some governments are not able to overcome the resistance of the interest groups within the system in the short run. These governments are obviously forced to free-ride on international environmental agreements. Over time the government composition might change and policy reforms might be established. Especially partisan politics seem to be a good explanation why the GT sector in Germany could initially become possible. There was a kind of window of opportunity when the green party for the first time became part of the German government under the so called red-green coalition as the green party could express its preferences for climate friendly policies (from 1998 to 2005).

b) Strategic Interaction

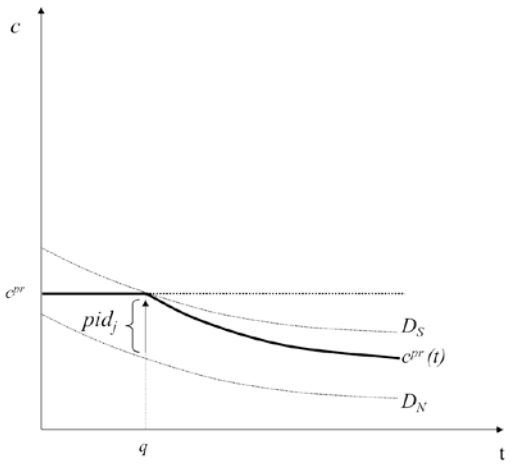
There are existing theoretical papers that use game theory to evaluate strategic interaction between countries in the case of environmental policy (e. g. Barrett; 1994; Rege; 2000; Ulph; 1996; Ulph and Ulph;

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2007). In this paper we focus on the German case and try to explain the political calculus behind the climate policy of the German government.

Without any policy induced demand for a certain GT *j*, there is no intersection between supply and demand and marginal production costs are assumed to be constant. Diffusion of GTs is not observable. Diffusion is related to the regulations within the energy system allowing GTs to diffuse. We further assume learning curve effects, thus, the cost curve has a negative slope (compare Madsen et al.; 2005; Nemet; 2006).[7] This is depicted in Figure 1 (page 12), where *t* stands for time, c^{pr} represents the marginal production costs, D_N stands for the demand for a certain GT *j* without policy induced demand (pid_j) and D_s stands for the demand for a certain GT *j* with policy induced demand. We refer to pid_j as diffusion of GTs that results from domestic political intervention. What we have in mind can be interpreted as command and control policies with characteristics similar to those of the *EEG*. Theoretically, however, pid_j could also represent diffusion of GTs as a result of market-based instruments such as tradable certificates or subsidies. In any case, the parameter is exogenous and can be directly influenced by national legislation.

Figure 1 : Learning curve effect



To start with, we assume that only one country – in our framework the home country (*H*) – implements measures that allow for diffusion of GTs. The measure taken is a policy induced demand for renewable energy at a level that allows the GT industry to establish. There is no international trade in GTs as the foreign country (*F*) free-rides on climate change mitigation policies. The resulting effect is a comparative advantage for the national GT industry (first mover advantage) as it moves rightwards on the learning curve.

Concentrating on the domestic consequences of supporting renewable energy beyond the market demand for GTs (under the assumption that *F* does not support the GT sector), the balance is negative. Because conventional substitutes for producing energy exist, the creation of the GT sector generates costs in *H* that can be translated into a reduction in the level of national GDP. In addition to the environmental regulation, these costs reduce the initial comparative advantages of other industries (that use energy as input and compete in international markets). Additional pressure comes from the short run free-riding strategy in country *F*. In other words: $Y_H^{n1} < Y_H^i$ (Y_H^{n1} stands for "new GDP" with policy induced demand for GTs and without exports, the latter for the GDP without policy induced demand for GTs).

We get further insights when comparing both countries. Without any support being given to the GT sector the initial GDP of both countries is the same. This means that $Y_H^i = Y_F^i$ (Y_F^i stands for the GDP without any support for the GT industries in *F*). *H* is the first who implements GTs.[8] If we compare the GDP levels of both countries after *H* has decided to implement a GT sector, in the short run we have the case that $Y_H^{n1} < Y_F^i$. This line of arguments is well known and can directly be applied as an explanation for the free-riding problem, resulting in an international prisoners' dilemma.

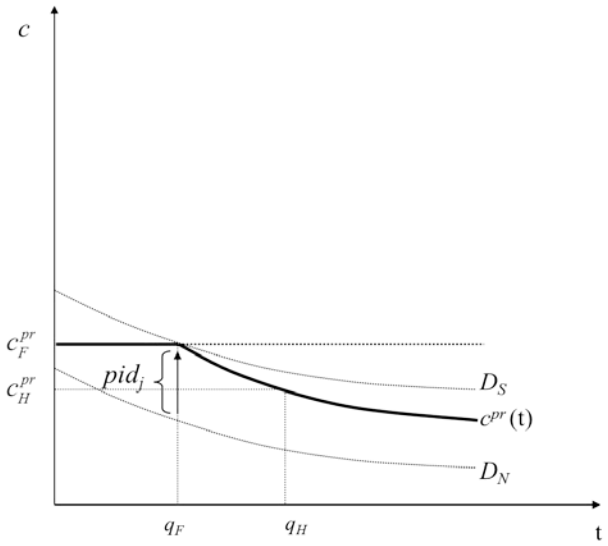
We now turn to the open economy. Because we assume that *H* enters the market of GTs before *F*, it moves rightward on the cost curve. Hence, considering exports does lead to a change in the results. If *F* decides later to enter the GT market and starts its own production, it has to start at a higher point on the cost curve. Figure 2 shows that c_F^{pr} are expected to be higher than c_H^{pr}. The support for a certain GT industry in *F* could have different reasons. One striking argument is that knowledge creation about the problem of climate change makes free-riding over time more and more difficult to be maintained. Changes in *F'* s policy can be supported by international attempts of *H'* s government to "lobby" internationally for global environmental standards. A change in the government composition in *F* is one further explanation.

[7]For a general discussion of learning curve effects and competitive markets see Rasmusen et al. (1997).

[8]We argue that this is due to the political process. Apart from this, both countries can be assumed to be symmetric.

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Figure 2 : Different marginal production costs



It is highly sensible to use a framework of strategic trade policy to explain why *H*'s government has strong incentives to support high environmental standards on an international platform. The first mover advantage stems from the chance to increase market power within markets with incomplete competition (e. g.Brander and Spencer; 1985). Thus, political support (or more generally a policy induced demand) can help the industry to exploit the rents that might be related to early market entrance.[9]

Different scenarios are plausible. For instance, one could expect a scenario in which *F* decides in a later phase than *H* to implement a transfer scheme per unit of energy produced (e. g. a FIT) by a particular GT (what is captured by pid_j). We assume that producers located in *F* are also able to produce GTs, but they operate on a higher marginal cost curve. This allows the GT sector in *H* to enter the market in *F* as a Stackelberg leader (scenario 1). Alternatively, high environmental standards might be the result of supranational negotiations (scenario 2). The high environmental standards increase the demand for GTs indirectly. Results for plausible other scenarios are summarized in table 4 (Appendix, page 23).

Based on the previous reasoning, it becomes obvious that politicians in *H* have strong incentives to (1) make use of industrial policy to support the national GT industry even though other countries free-ride, (2) to support high environmental standards at an international level and (3) to cooperate with the GT industry on international interests.

We now look at the expectations related to exports of GTs (scenario 1 and scenario 2). The expected price-demand function is given by $p^e = A^e - q^e_{H_j} - q^e_{F_j}$ (where p^e is the expected prices, A^e represents the expected size of the GT market with exports, $q^e_{H_j}$ stands for the expected quantity sold by the GT industry *j* located in *H* and $q^e_{F_j}$ stands for the expected quantity sold by the GT industries$_j$ (*j*=photovoltaics, …,windmills) located in *F*. Expected profits (π^e) of the GT industry$_j$ located in *H*, due to export of its technology to *F*, can be formulated as follows:

$$\pi^e_{H_j} = q^e_{H_j}(A^e - q^e_{H_j} - q^e_{F_j} - c^{pr}_{H_j} + pid^e_{F_j}) - c_{l_j}. \quad (4.1)$$

Note that we do not assume a monopolistic market in the GT sector in *H*. What we assume is that all GT industries in *H* are supposed to be symmetric and able to supply GTs at the same marginal costs and therefore, $\pi^e_{H_j}$ represents aggregated profits. Politicians and representatives of the different GT industries in *H* are aware of their advantage in international competitiveness. Therefore, both groups expect to benefit from an increase in environmental standards in *F*. Obviously, gains are related to the export of GTs.

If industries in *H* and *F* are operating on different cost curves, as depicted in figure 2 (page 13), then equation 4.1 can be solved as a Stackelberg game (compare Appendix b 2, page 23). We assume that *H* enters the export market as Stackelberg leader.

We then get as an expected outcome that $q^{e*}_H > q^{e*}_F$ and exports (in contrast to the short term considerations) contribute positively to *H'* s level of GDP. The result $q^{e*}_H > q^{e*}_F > 0$ can be interpreted as potential extra gains for the GT industry in *H* (if *F* was free-riding in the short run and decides later to support diffusion of GTs without discriminating against *H'* s industry). This is one reason why there might be a strong interest in *H* to invest heavily in the diffusion of GTs and "to lobby" internationally for high environmental standards internationally.

How does this result translate into *H'* s changes in GDP (*Y*)[10]? We can substitute the calculated values for $q^{e*}_{F_j}$ and $q^{e*}_{H_j}$ into equation 4.1 and obtain the expected profit $\pi^e_{H_j} > 0$. This profit can be directly translated into national welfare gain ($\pi^e_{H_j} = y^e_H > 0$). This leads to the result that $y^e_H > 0$ reduces the loss in GDP related to the pid_{H_j} without any exports in the short run. With exports, the expected new GDP $Y_H^{e^{n2}}$ ($Y_H^{e^{n2}} = (Y_H^{n1} + y^e_H)$) is bigger than Y^{n1} (the GDP without any exports of GTs). So far we have the case that $Y^i_H > Y_H^{e^{n2}} > Y^{n1}_H$. The model implies that exports of GTs can generate welfare gains which enter positively into the GDP of *H* compared to the first situation which

[9] Only if countries subsidize their industries in order to be the first to enter into the market, a prisoners' dilemma is present and both countries would be better off without the subsidy (Brander and Spencer; 1985, p. 95)

[10] Note that the welfare analysis is limited to the GDP and, therefore, ignores welfare gains due to the reduction of GHGs. In our study benefits of climate change protection are not taken into account. A cost-benefit analysis therefore would come to very different results.

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is described by Y_H^{n1}.[11] Thus, once the GT industry has been successful in establishing itself at the national level, the GT industry (in both, *H* and *F*) and the government (in *H*) have common interests at the international level.

Finally, just how realistic the expectation is that there is a long run net benefit for country *H* from subsidizing its GTs, has to be discussed. As table 4 (Appendix 4, page 23) shows, "only" in scenario 3, case (a), does the first mover advantage not lead to higher exports because of direct support in *F* for the GTs there. However, as q_F^{e*} is also bigger than zero, one can expect that the industry in *F* also gains. This implies less resistance in *F*.[12] All other scenarios are characterized by increasing exports. Thus, there are, at least, three political economy arguments that politicians in *H* use in support of the GTs, strategically:

1. GT industry *j* expects higher profits,
2. national governments can reduce the political costs caused by the policy induced demand for GTs,
3. The GT industry in *F* can also generate profits which is important to reduce resistance against international standards.

The intuition behind the framework presented is to analyze political incentives which we now try to incorporate into an econometric model.

V. Econometric Model

To test our theoretical argument, we propose an econometric model. With this model, we try to assess empirically whether the alleged strategy of the government and the GT interest groups is indeed observable in reality. The question is whether or not the link between climate policy and industrial policy has an influence on export expectations related to GTs (eventually leading to an increase of GDP beyond the free-riding status quo). This is, of course, difficult to estimate, as expectations cannot be modeled easily. We argue that expectations about future export sales and thus profits ($\pi_{H_j}^e$) are best expressed in patent applications and grants in foreign target countries ($PATENT^{HF}$). The econometric model is, therefore, constructed in a way that it tries to proxy equation 4.1 ($\pi_{H_j}^e = q_{H_j}^e (A^e - q_{H_j}^e - q_{F_j}^e - c_{H_j}^{pr} + pid_{F_j}^e) - c_{l_j}$) econometrically.

We build the model on the assumption that diffusion of GTs (as a result of *pid*) reduces marginal production costs. This relationship $pid_{H_j} : c_{H_j}^{pr} \rightarrow c_{H_j}^{pr}(pid_{H_j})$ is proxied with installed capacity (measured in MW) of industry specific technologies (pid_{H_j}) in *H*. We further assume that in the equilibrium without trade in GTs, pid_{F_j} is lower than pid_{H_j} (such that $c_{H_j}^{pr} < c_{F_j}^{pr}$) and politicians located in *H* make use of international "lobbying" to create and/or to further increase pid_{F_j} in order to be able to exploit their comparative advantage in future trade sales (in the model described as intra-industry trade). Formally: $\pi_{H_j}^e$ proxied by $PATENT^{HF}$ and $c_{H_j}^{pr}(pid_{H_j})$ proxied by $(INCAP^H)$ gives the functional form that we are interested in. This then leads to the relationship $(INCAP^H : PATENT^{HF} \rightarrow PATENT^{HF}(INCAP^H))$ Thus, if there is a positive correlation between $PATENT^{HF}$ and $INCAP^H$, we see a rationale for politicians located in *H* to actively support the interests of the different GT industries at the international level.

As controls we add public expenditures on research and development in the home country (RuD^H), energy prices in the foreign country $(CPIE^F)$, as well as electricity consumption in the foreign country (ELC^F). We also control for structural change in the patent system by including all patents applied in the foreign country $(APATENT^F)$ which measures all patent applications in the specific country (this variable can also be interpreted as a proxy for A^e). Due to a lack of information, we have to ignore the costs of lobbying (c_{l_j}). As our model makes use of future expectations, we do not have information on $q_{H_j}^e$, $q_{F_j}^e$, and $pid_{F_j}^e$ which is expected to be significantly higher than the observed variable pid_{F_j}.

In the following paragraphs, we describe in more detail our data-sources. The time frame of the dataset is from 1992 to 2002.[13] The institutional settings analyzed are the SEG (1990-1999) and the EEG (2000-2002). The four sources of the data are the German Patent Office, the International Energy Agency (IEA), Eurostat and the Federal Ministry for the Environment (BMU). The industries of interest are wind, solar, water & ocean, geothermal and biomass.

The empirical approach we use to test the theoretical framework looks at the patents, with a priority on the German Patent Office (GPO) applied by German inventors and which are also protected at the European

[11] Above a certain threshold, it might be the case that the gains are bigger than the losses, such that $Y_H^{e^2} > Y_H^i > Y_H^{n1}$.

[12] In addition, legal contracts for *F* might render scenario 3, if *F* is a WTO member and cannot just increase restrictions on GTs. That reduces incentives for opposition in *F*. This might also stiffen opposition in *F* as it cannot easily protect its own industry.

[13] We are limited to this time span even though the data range is from 1990-2005. We drop the observations before 1992 as we assume that patenting abroad before 1992 was not related to diffusion of GTs under the SEG. Another problem is related to the huge time lag between patent application in Germany and the date when the patent is granted in a foreign country. As the dataset we use contains patent counts of patents that have already been granted in Germany and the foreign countries, after 2002 the dataset is biased. The reason for this is that there might be patents that have been applied for in foreign countries but have not been granted, so far. We therefore restrict the dataset to the observations until 2002. A summary of the data included in our dataset is provided in Appendix, page 24.

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Patent Office (EPO), Japanese Patent Office (JPO) and/or the American Patent Office (APO), respectively. Therefore, we are able to consider the protection of knowledge in different markets. The patent counts we use also contain information about the dynamics of patent application over time. The number of patents issued can, therefore, also be interpreted as diffusion of innovation and expectation for future export receipts.

For the regression, we propose to use patent applications, $PATENT^{HF}$, as a dependent variable. $PATENT^{HF}$ measures patents filed to German inventors at the EPO, the JPO and the APO. As for the timing, we use the priority date which is the date of the patent application at the GPO.[14] If the patent is granted in the foreign country, protection begins with the priority date. The huge time lag that may occur by regressing patents applied in foreign countries on their priority dates is not as problematic as it seems to be at first glance. This is related to the patent cooperation treaty (PCT). Inventors, who desire patent protection in other countries, usually make use of the PCT. According to the PCT, there is only a time span of one year to name the foreign countries in which protection is desired. Note that this information is very important with respect to our assumptions about the time lags implemented in the regression analysis. For patents granted in a foreign country, the protection will go back to the application date in the home country. The rationality behind patenting abroad should be positively correlated with export expectations or the aim to sell licenses of a certain technology to the foreign country.[15]

For the study, we use a predefined list of patent classes from table 5 (Appendix, page 25) to extract the patents of the overall sample. Even though key words have been used to find out whether these groups are exactly the international patent classification (IPC) classes where the technologies of interest will be patented, it might be that patents are applied in other groups which are not captured by our list.[16]

The evidence presented at figures 5-9 (Appendix, page 22) shows that patents in the wind mill mill industry, solar industry and biomass industry have generally increased after 1998. For the other two industries, there is no observable trend. The presented figures display the development since 1990-2005. It can be seen that, especially in the case of WIND, patent counts have decreased considerably since 2002. One possible explanation lays within the huge time lag we are confronted with when looking at patent applications that have been granted in foreign countries. We, therefore, drop observations after 2002 and assume that within a three year time span most foreign patent applications are granted.

The previous arguments are now summarized to formulate our hypotheses. We use $PATENT^{HF}$ as a proxy for export expectations as described in our strategic trade policy framework. Strategic knowledge protection in foreign countries represents the first "mover advantage" from the theoretical part. We argue that feed-in tariffs in Germany are used strategically under the EEG to generate comparative advantages. $INCAP^{H}$ is, therefore, used as a proxy to test whether it is true that the strategic use of feed-in tariffs did generate positive export expectations captured by $PATENT^{HF}$. Hypothesis 1 (H1) is formulated as follows:

H1: There is a positive relationship between installed capacity of GTs in Germany $INCAP^{H}$ and international patent applications ($PATENT^{HF}$).

The second variable of the model is the installed capacity of renewable energies in the specific region $INCAP^{F}$. As an increase of $INCAP^{F}$ enhances export expectations to the foreign region it should be positively correlated with patents filed in this region in order to protect knowledge. This leads to hypothesis 2 (H2):

H2: An increase in installed capacity abroad $INCAP^{F}$ has a positive impact on international patent applications.

In addition to these two hypotheses there is the general assumption that there are significant differences with respect to region (r) and time (t).

H3a: There are differences between EPO, JPO and APO because the markets are different from each other.

H3b: Most dynamics take place in Europe.[17]

H3c: International patent applications caused by $INCAP^{H}$ are significantly higher under the EEG compared to the SEG.

H3a and H3b capture the spacial dimension. H3c is related to the time dimension. To test H3c, we implement time dummies for the SEG and the EEG. We suppose a significant change in coefficients as Germany started to connect industrial policy with the climate change issue under the EEG.

We now turn to the estimation of our econometric model. The core model that shall be estimated is

$$PATENT^{HF} = f(\underset{+}{INCAP^{H}}, \underset{+}{INCAP^{F}}).$$

[14]Because nearly all patent applications are first filed in the home country of the inventor (Popp; 2006, p. 52), we can look at patents with priority at the GPO applied for protection in other countries.

[15]This is somehow clear, because if H is the leader in a certain technology, the follower F cannot export to H as long as inventors in H have applied for a patent. Because patent applications are costly, it is plausible to assume that patent applications abroad go in hand with the commercial value of the invention related to the foreign marketplace.

[16]Note that the extraction of the data has been done by an algorithm able to get rid of the problem of double counting of a certain patent. Therefore, double counting cannot be considered to be a problem in our study.

[17]Europe has the highest share of renewable energies (6.9 percent) compared to the other countries of the analysis (Johnstone et al.; 2010, p. 134).

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$RuD^H{}_+$, $APATENT^F$, $CPIE^F$ and ELC^F are added to the core model as controls.[18] The dataset is constructed on three dimensions: (1) Time *t*, (2) Technology *i* and (3) Region *r*. A simple approach would be to estimate the regression for the EPO, JPO and APO separately. In this case there would be the estimation of three different panels. For each panel the estimation would be

$$PATENT_{i,t}^{F^r} = \beta_0 + \beta_1 RuD_{i,t-1/2}^H + \beta_2 INCAP_{i,t}^H + \beta_3 INCAP_{t-1}^F + \beta_4 APATENT_{t-1}^F + \beta_5 ELC_{t-1}^F + \beta_6 CPIE_{t-1}^F + \alpha_i + \varepsilon_{i,t}. \quad (5.1)$$

The cross-section with different technologies (*WIND*, *SOLAR*, *WATER*, *GEO*, *BIO*) is indexed by $i = 1,\ldots,5$, and $t = 1993,\ldots,2002$ represents time. For RuD^H and $INCAP^H$, as well as for $CPIE^F$, we implement period dummies from 1992-1999 (for the SEG) in the first period, and 2000-2002 (for the EEG) in the second period. The dependent variable is a vector with patent applications by German inventors in the other regions ($PATENT_{i,t}^r$), measured by the number of patents granted in *r* (at priority date). The independent variables include a vector with German technology specific public *R* & *D* expenditures ($RuD_{i,t}^H$), diffusion of the specific technology in Germany measured in MW ($INCAP_{i,t}^H$), diffusion of all green technologies (not industry specific) in region *r* ($INCAP_t^F$) and all patents filed at region *r* ($APATENT_t^F$). ELC_t^F is a vector with electricity consumption per capita in region *r* and $CPIE_t^F$ is a vector with the price index for energy. Because of collinearity of patent applications regarding $r = EPO, JPO, APO$, we integrate the third dimension with the same regression. In order to do so, we build region specific interaction terms. Fixed effects are integrated into the model by α_i in order to capture unobservable technology specific heterogeneity. All the residual variation is captured with the error term $\epsilon_{i,t}$.

Important for our model are the assumptions made about time lags and the implemented period dummies. Because our dataset allows for dynamic model specifications, time lags have to be implemented to be in line with economic theory.[19] As the priority date indicates the application date in Germany, we expect a one year or a two year time lag for RuD^H. For $INCAP^H$ no time lag is assumed. This assumption makes sense, as the diffusion of the technology in Germany can only take place when the technology is already developed. For $INCAP^F$, $APATENT^F$, ELC^F and $CPIE^F$ a one year time lag is assumed. We justify our assumptions on the time lags with reference to the PCT. According to the PCT, most of the patents applied at the national level extent to patent applications in foreign countries within a time frame of one year. We overcome this problem by just looking at those patents that already have been granted in Germany. This is a very pragmatic way of dealing with the problem of a time lag of four or five years between the patent application at a national patent office and the patent granting of a foreign patent office.

As proposed by Johnstone et al. (2010), we use a negative binomial regression for estimation of the model from equation 5.1 but extend the panel by the third dimension (*r*). The events we "count" are the patent applications in different international levels indicated by *r*. The estimation is done for five technologies and eleven years (1992-2002) with three regions. This leads to a sample with 180 observations.

In what follows, we take a closer look on the estimation outcomes. The results of our reference model are presented in table 1, page 16 (estimation results under assumption of a one year time lag for RuD^H). Under the SEG and EEG, we find support for hypothesis 1. As seen, the evidence for hypothesis 2 is mixed but rather weak. Only for JPO such evidence is found. There is no evidence that can be found for hypothesis 3a and hypothesis 3b. To test hypothesis 3c we use a Chow-test and compare $INCAP_{1992-1999}^H$ with $INCAP_{2000-2002}^H$. We find significant differences for EPO ($p = 0.0580$) and JPO ($p = 0.0713$). For APO the difference is not significant under conventional statistical terms ($p = 0.1220$). However, if we look at the coefficients, we can see that the relationship under the EEG is smaller compared to the SEG what contradicts our hypothesis. We, therefore, have to reject H3c.

[18] Compare also Popp (2001; 2002).

[19] For a more detailed discussion on time lags related to patent data compare Hall et al. (1986). Brunnermeier and Cohen (2003) also make an econometric study and make the assumption that there is no lag at all. The result from Griliches (1998) also suggests that with respect to *R* & *D* the time lag can be assumed to be rather small.

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Table 1 : Fixed effects negative binomial regression

$PATENT^{HF}$	EPO	JPO	APO
$lag1RuD^{H}_{1992-1999}$	-0.0049777	-0.0033792	-0.000487
	(0.0084893)	(0.0104979)	(0.0082184)
$lag1RuD^{H}_{2000-2002}$	-0.0181687	-0.0207956	-0.0241105
	(0.0131117)	(0.0178787)	(0.0147366)
$INCAP^{H}_{1992-1999}$	0.0002195***	0.0003652***	0.0003087***
	(0.0000659)	(0.0000929)	(0.0000816)
$INCAP^{H}_{2000-2002}$	0.000108***	0.0002239***	0.0002005***
	(0.0000263)	(0.0000361)	(0.0000313)
$lagINCAP^{F}$	0.0000161	0.0008603**	-0.0000788
	(0.0000279)	(0.0005283)	(0.000058)
$lagAPATENT^{F}$	-194*e*-06	-0.0000594	0.0011413**
	(0.0003891)	(0.0002586)	(0.0005508)
$lagCPIE^{F}_{1992-1999}$	0.0022767	-0.0023875	0.0011234
	(0.0185545)	(0.0178013)	(0.020191)
$lagCPIE^{F}_{2000-2002}$	0.0092491	0.0009691	0.0070262
	(0.0158542)	(0.0177275)	(0.0170407)
$lagELC^{F}$	-0.0084317	-0.0087497**	0.0025994***
	(0.0054865)	(0.0040787)	(0.0008591)
β_0	32.48477		
	(28.06769)		
Wald chi2	214.33		
Nr. of observations:	165		

Significance: *** ≤1%, ** ≤5%, * ≤10%

As a robustness check we present an additional model (table 2, page 17) with a two-year time lag for public *R* & *D* expenditures. It can be observed that compared to our reference model (table 1, page 16), the results for *R* & *D* change. Under the SEG, public *R* & *D* gets significant for EPO and APO. For our main variable of interest, $INCAP^{H}$, under the SEG hypothesis 1 is only confirmed for JPO. For EPO and APO it has to be rejected. Under the EEG, $INCAP^{H}$ remains significant, confirming hypothesis 1. It can be seen that the right specification of the lag structure for public *R* & *D* is crucial for the econometric model. The comparison between the different lag structures shows that for the EEG our findings remain significant. There is a robust finding for our strategic trade hypothesis for the time frame related to the EEG.

In order to control for first order serial correlation, we show in table 7 (Appendix, page 26) a model estimated by a simple first differences ordinary least squares (OLS) model. We still get significant results for $INCAP^{H}_{2000-2002}$ in JPO and APO. This demonstrates the relatively robust finding for hypothesis 1 (table 7, Appendix, page 26). If we run a Poisson model instead of a negbin model (Table 6, Appendix, page 26) some of the results change and become significant but the overall picture remains the same.

Even though the model is sensitive to model specification, different estimations have shown that $INCAP^{H}$ is a quite robust predictor for $PATENT^{F}$ under the EEG. As the theoretical model from section 4 mainly refers to this time period, the econometric model offers important insights related to our theoretical reasoning.

VI. Conclusion

We analyze the climate change debate from a perspective of political opportunity and economic

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rationality. We use a strategic trade policy framework to explain the political interests behind the climate change debate. We argue that the main reason behind active support of green technologies in Germany (until Fukushima) was related to the positive export expectation for GTs. This also explains why high environmental standards are in the political

Table 2 : Fixed effects negative binomial regression

$PATENT^{HF}$	EPO	JPO	APO
$lag2RuD^{H}_{1992-1999}$	0.0124475*	0.0112177	0.0169526**
	(0.0072587)	(0.0100838)	(0.007521)
$lag2RuD^{H}_{2000-2002}$	0.007152	0.0037132	0.0048226
	(0.0107887)	(0.0160282)	(0.0126935)
$INCAP^{H}_{1992-1999}$	0.0000967	0.0002333**	0.000125
	(0.0000729)	(0.000104)	(0.0001025)
$INCAP^{H}_{2000-2002}$	0.0000872***	0.0001909***	0.0001545***
	(0.0000283)	(0.0000389)	(0.0000395)
$lagINCAP^{F}$	0.0000675	0.0035497	0.0002025
	(0.0001194)	(0.003328)	(0.0003636)
$lagAPATENT^{F}$	0.0028577	-0.001055	0.0038894
	(0.0040687)	(0.0010724)	(0.0037222)
$lagCPIE^{F}_{1992-1999}$	-0.0023775	-0.009236	-0.0082064
	(0.0250123)	(0.0233636)	(0.0258147)
$lagCPIE^{F}_{2000-2002}$	0.0649717	0.0547221	0.0583138
	(0.0790413)	(0.0794015)	(0.079379)
$lagELC^{F}$	-0.0458226	-0.0312807	0.0048331
	(0.0539446)	(0.0298639)	(0.0030676)
β_0	147.7299		
	(173.8297)		
Wald chi2	163.21		
Nr. of observations:	150		

Significance: ***≤1%, **≤5%, *≤10%

interest of countries benefiting from exporting GTs. International climate change policy is complementary to export expectations for GTs. The theoretical welfare effects of one country's industrial policy, therefore, strongly depend on the policy reaction of other countries.

Different to the common view, we argue that free-riding of other countries encourages the German government to foster diffusion of GTs. The empirical evidence shows that for the time span analyzed, positive export expectations could be observed. The main driver we identify for this behavior is the installed capacity of GTs in Germany. This seems fairly plausible and can be interpreted as positive experience that helps also to stabilize international environmental agreements.

The theoretical reasoning in combination with the empirical evidence suggests that one can expect Germany producing positive GT spillovers as long as this goes in hand with job creation on the national level in combination with future exports. International experience, however, also suggests that other countries will not open their markets easily. Instead, the German policies may be replicated and other countries may subsidize their own GT industry which renders the German policy unsuccessful. For this case we should expect that Germany reduces its ideal role in international climate policies.

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Appendix

a) Symbols, Figures and Tables

Abbreviations

APO	American Patent Office
BMU	German Ministry of Environment
CO_2	Carbone Dioxide
EEG	Renewable Energy Source Act
EPO	European Patent Office
FDI	Foreign Direct Investment
FIT	Feed-in Tariff
GDP	Gross Domestic Product
GHG	Green House Gas
GPO	German Patent Office
GT	Green Technologies
IEA	International Energy Agency
IPC	International Patent Classification
IPCC	Intergovernmental Panel on Climate Change
JPO	Japanese Patent Office
KP	Kyoto Protocol
NO_2	Nitrogen Dioxide
PCT	Patent Cooperation Treaty
R&D	Research and Development
SEG	Electricity Feed Law
SO_x	Sulfur Dioxide

Symbols Math

π^e	Export Expectations
A^e	Expected Market Size
c_{l_j}	Costs of Lobbying
c^{pr}	Marginal Production Costs
D_N	Demand for GT j without pid_j
D_S	Demand for GT j with pid_j
F	Foreign country
GT_j	Green Technology Index $j = 1,\ldots, n$
H	Home-country
p	Price
pid_j	Policy Induced Demand
q^e	Expected Quantity Exported
r	Region
t	Time
Y	GDP
j	Different GT Industries

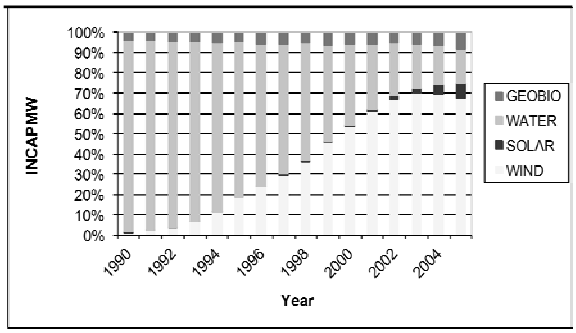
Symbols Econometrics

$PATENT^{HF}$	Patent Applications (Dependent Variable)
RuD^H	Research and Development (Home Country)
$INCAP^H$	Installed Capacity of Industry Specific Technology (Home Country)

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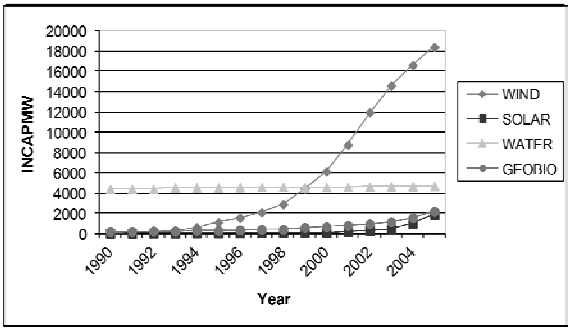
$CPIE^F$	Index for Energy Prices (Foreign Country)
ELC^F	Electricity Consumption (Foreign Country)
$INCAP^F$	Installed Capacity of Industry Specific Technology (Foreign Country)
$APATENT^F$	All Patent Applications (Foreign Country)

Figure 3 : Diffusion of GTs as percentage of total capacity of all GTs measured in MW



Source: Own illustration, data source BMU (2008).

Figure 4 : Diffusion of GTs measured in MW of all GTs installed



Source: Own illustration, data source BMU (2008).

Table 3 : Remuneration (FIT) for different GTs in 2003

Technology j	Remuneration (2000-2003) (ct/KWh)	Annual Reduction (d)
Wind (WIND)	9.1	1.4%
Solar (SOLAR)		
Capacity<100KW	51.62	5.0%
Plants on building capacity <5 MW	48, 1	5.0%
Biomass (BIO)		
Capacity<500KW	10.0	1.0%
Capacity>500KW<5MW	9.0	1.0%
Capacity>5MW<20MW	8.5	1.0%
Hydro (WATER)		
Capacity<500KW	7.67	0%
Capacity>500KW<5MW	6.5	0%
Landfill and sewage gas (BIOGAS)		
Capacity<500KW	7.67	1.5%
Capacity>500KW<5MW	6.5	1.5%
Geothermal plants (GEO)		
Capacity<20MW	8.5	0%
Capacity>20MW	7.0	0%

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Figure 5 : Patent applications in WIND

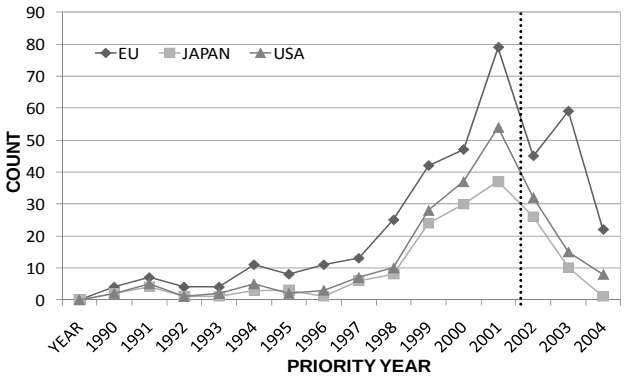


Figure 6 : Patent applications in SOLAR

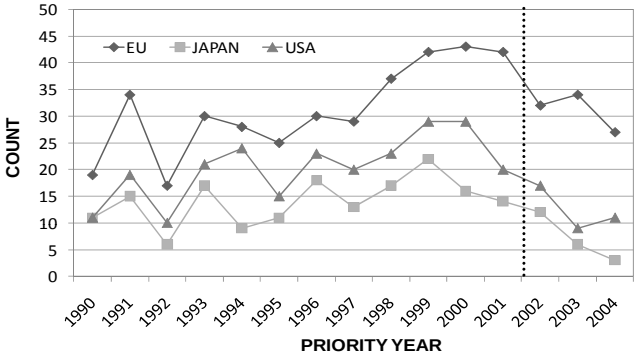


Figure 7 : Patent applications in BIO

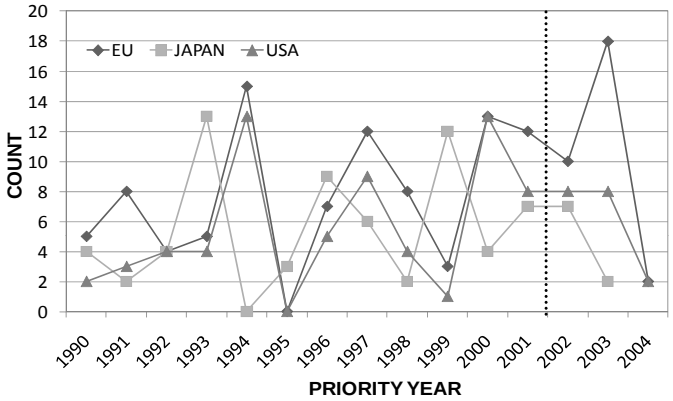


Figure 8 : Patent applications in GEO

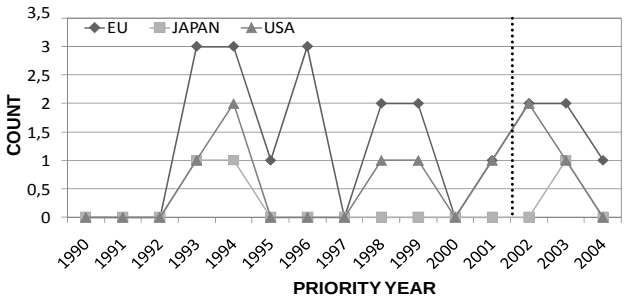
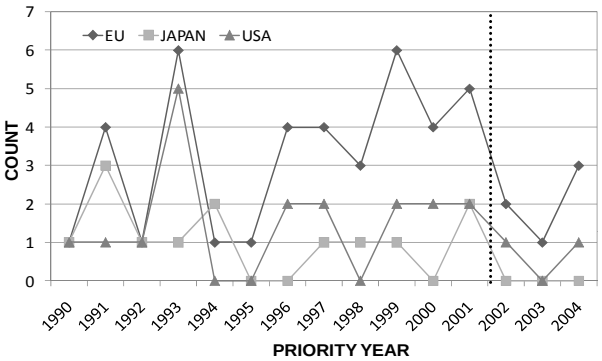


Figure 9 : Patent applications in WATER



Source figure 5-9: EPO, compare App. C, p. 24.

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b) Theoretical Framework

i. *Different Scenarios in Subsection 4.2*

Table 4 : Scenarios 3-5

	Description		Expectations
Scenario 3	F decides to support firms located in F directly to produce GTs	Case (3a): $\pi^e_{H_j} = q^e_{H_j}(A^e - q^e_{H_j} - q^e_{F_j} - c^H_{pr_j}) - c_{l_j} \leq 0.$ No additional exports.	Case (3a): The first mover advantage does not lead to exports.
		Case (3b): $\pi^e_{H_j} = q^e_{H_j}(A^e - q^e_{H_j} - q^e_{F_j} - c^H_{pr_j}) - c_{l_j} > 0.$ If the GT industry is so competitive that it was already exporting GTs to F without any subsidies → In this case it can continue to export, if it is still able to compete with the GT industries$_j$ located in F.	Case (3b): Decreasing exports of GTs compared to the case without local content clause.
Scenario 4	H competes with the GT industry located in another country (country I) in a "third" market in F. In this case F is not able to produce GTs but is forced to buy them (e. g. because of high international environmental standards).	Case (4) There is competition between H and I. The underlying game depends on which cost curve H and I are operating. They can play Stackelberg, or if they have the same marginal costs, the market has the characteristic of a duopoly with simultaneous market entrance.	Case (4) Increase in market size → export of GTs.
Scenario 5	There is also the possibility that a firm located in H is making a direct contract with politicians in L	Case (5a): $\pi^e_{H_j} = \hat{q}^e_{H_j}\hat{p}_j - c^H_{pr_j}\hat{q}^e_{H_j} - c_{l_j} > 0.$ $\hat{q}_{H_j}$ stands for "agreed quantity of GTs" which the GT industries j located in H can sell at the agreed price $\hat{p}_j$.	Case (5a) F buys the technology from the GT industries$_j$ located in H. In this case the GT industry would sell a package of GTs to F → Increase in market size → export of GTs.
		Case (5b): $\pi^e_{H_j} = \hat{q}^e_{H_j}\hat{p}_j - c^H_{pr_j}\hat{q}^e_{H_j} - c_{l_j} - ttr > 0.$ ttr stands for "technology transfer".	Case (5b): The contract is combined with a local content clause → Increase in market size → export of GTs, but less compared to scenario (a).

ii. *Stackelberg Game*

In our framework, the GT industry j in H benefits from pid_{F_j} and enters the foreign market as a Stackelberg leader. The Stackelberg game can be solved as follows: the GT industry in H and F are assumed to maximize profits. For $F$the profit function is given by equation 4.1.

The profit maximization problem leads to

$$\frac{\partial \pi^e_{F_j}}{\partial q^e_{F_j}} = A^e - q^e_{H_j} - 2q^e_{F_j} - c^{pr}_{F_j} + pid^e_{F_j} = 0$$

$$q_{F_j} = R_F\left(q_{H_j}\right) = \frac{A - q_{H_j} - c^{pr}_{F_j} - pid_{F_j}}{2}. \quad \text{(B.1)}$$

$R_F\left(q^e_{H_j}\right)$represents the response function for F. H maximizes its expected profits with respect to $q^e_{H_j}$ by taking equation B.1 into account. It follows

$$\frac{\partial \pi^e_{H_j}}{\partial q^e_{H_j}} = A^e - 2q^e_{H_j} - \frac{1}{2}A^e + q^e_{H_j} + \frac{1}{2}c^{pr}_{F_j} - \frac{1}{2}pid^e_{F_j} - c^{pr}_{H_j} + pid^e_{F_j}$$

$$q^{e*}_{H_j} = \frac{A^e + c^{pr}_{F_j} - 2c^{pr}_{H_j} + pid^e_{F_j}}{2} \quad \text{(B.2)}$$

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Finally, we can solve the maximization problem for the industry j in F. The solution for F is given by

$$q_{F_j}^{e*} = \frac{A^e - c_{F_j}^{pr} + pid_{F_j}^e}{4}. \quad \text{(B.3)}$$

If we substitute the values for $q_{F_j}^{e*}$ and $q_{H_j}^{e*}$ into the equation 4.1, we obtain

$$\pi_{H_j}^e = \left[\frac{A^e + 3\left(c_{H_j}^{pr} - pid_{F_j}^e\right)}{4} - c_{H_j}^{pr} + pid_{F_j}^e\right]\left[\frac{A^e - c_{H_j}^{pr} + pid_{F_j}^e}{2}\right] - c_{l_j}$$

$$\pi_{H_j}^e = \frac{1}{8}\left(A^e - c_{H_j}^{pr} + pid_{F_j}^e\right)^2 - c_{l_j}. \quad \text{(B.4)}$$

The expected contribution to the national GDP oh H through exports of GTs is simply denoted as Y_H^e. This leads to

$$y_H^e = \pi_{H_j}^e = \frac{1}{8}\left(A^e - c_{H_j}^{pr} + pid_{F_j}^e\right)^2 - c_{l_j}. \quad \text{(B.5)}$$

In contrast to the costs which go in hand with policy induced demand for GTs at the national level, y_H^e enters positively into the GDP of H.[20]

c) Econometric Model

i. *Empirical Data*

Patents ($PATENT^{HF}$), source EPO: Table 5 on page 25 contains the list of patent classes from which the dataset is extracted. The "renewable energy industry specific technologies" of interest are for electricity production with wind (WIND), solar (SOLAR), water & ocean (WATER), geothermal (GEO) and biomass (BIO). The original table on patent classes comes from Johnstone et al. (2010).[21] The dataset contains patents which are *granted* in at the EPO, JPO and APO with priority in Germany (including the "Neue Bundes länder").[22] The dataset includes patents and utility patents. The data we use comes from a freely available dataset of the European Patent (DOC- DB).[23] Information captured with $PATENT^{HF}$, therefore, is industry specific (WIND, SOLAR, WATER, GEO, BIO) and country/territory specific (EP, JPO and APO).

Patent counts about patents applied in region r ($APATENT^F$), source OECD: The variable $APATENT^F$ contains information about the overall number of patents applied in the specific territory (EPO, JPO, APO). This variable captures all patents applied for at the EPO, JPO and APO with the inventor's country of residence and fractional counts. The patent counts are based on the earliest priority date. The data mainly derives from EPO Worldwide Statistical Patent Database (April 2007).[24] Information captured with $APATENT^F$ is country/territory specific (EP, JPO and APO).

German R&D expenditures (RuD^H), source IEA: The data about industry specific expenditures concerning public expenditures on research and development related to R & D in the different G T industries comes from the international energy agency.[25]The data for Germany is in million Euro on exchange rates from 2006.[26] Information captured with RuD^H is at the German level and industry specific (WIND, SOLAR, WATER, GEO, BIO).

German installed capacity of industry specific technology $INCAP^H$, source BUND: $INCAP^H$ is used as a proxy for the induced demand implemented by institutional changes because of laws such as the EEG. The data contains information about the installed capacity measured in megawatt-hours (MWh). It measures the overall installed capacity of the industry specific technology per year. The data comes from the Ministry of Environment.[27] Information captured with $INCAP^H$ is at the German level and industry specific(WIND, SOLAR, WATER, GEO, BIO).

Energy price index ($CPIE^F$), electricity consumption (ELC^F) and installed capacity of renewable energies in the foreign country ($INCAP^F$), source IEA: $CPIE^F$ is a consumer price index for energy. $CPIE^F$ is country specific. Year 2000 is set to 100, taxes are included in the calculation. ELC^F measures the electricity consumption in KWh per capita. ELC^F is country specific. $INCAP^F$ measures the overall installed capacity of renewable energies in the foreign country. Information captured with $CPIE^F$, ELC^F and $INCAP^F$ is country/ territory specific (EP, JPO and APO).

[20] This is true as long as $A^e + pid_{F_j}^e > c_{H_j}^{pr}$ and $c_{l_j} < (A^e - c_{H_j}^{pr} + pid_{F_j}^e)^2$.

[21] Note that the list is extended in the case of patent classes for WATER, because the law for renewable energy which is analyzed for Germany also changed the institutional framework for energy produced with water. On the other hand, we excluded WASTE, because we focus on GTs and therefore, WASTE is not really considered as a renewable energy source.

[22] Note that the date for the patents that are granted goes back to the date when inventors applied for the patent. Even though information about patents until 2006 is available, the analysis is restricted from 1992 to 2002. The information about the last three years is dropped to get rid of the problem that granted patents always go back to the priority date. Therefore, it is plausible to assume that the data from 2004 and 2006 contains a lack of information (Popp;2005, p. 5).

[23] For further information see http://www.epo.org/patents/patent-information/free.html.

[24] For more detailed information see Organization for Economic Co-Operation and Development (OECD), Patent Database, June 2007.

[25] For further information see http://www.iea.org/.

[26] The data for Germany at the national level does not contain information about the expenditures of regional governments.

[27] Compare BMU (2007).

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Table 5 : IPC codes for Renewable Energy Technologies*

WIND	Class	Sub-Classes
Wind motors with rotation axis substantially in wind direction	F03D	1/00-06
Wind motors with rotation axis substantially at right angle to wind direction	F03D	3/00-06
Other wind motors	F03D	5/00-06
Controlling wind motors	F03D	7/00-06
Adaptations of wind motors for special use	F03D	9/00-02
Details, component parts, or accessories not provided for in, or of interest apart from, the other groups of this subclass	F03D	11/00-04
Electric propulsion with power supply from force of nature, e.g. sun, wind	B60L	8/00
Effecting propulsion by wind motors driving water-engaging propulsive elements	B63H	13/00
SOLAR		
Devices for producing mechanical power from solar energy	F03G	6/00-08
Use of solar heat, e.g. solar heat collectors	F24J	2/00-54
Machine plant or systems using particular sources of energy - sun	F25B	27/00B
Drying solid materials or objects by processes involving the application of heat by radiation -e.g. sun	F26B	3/28
Semiconductor devices sensitive to infra-red radiation - including a panel or array of photoelectric cells, e.g. solar cells	H01L	31/042
Generators in which light radiation is directly converted into electrical energy	H02N	6/00
Aspects of roofing for the collection of energy - i.e. solar panels	E04D	13/18
Electric propulsion with power supply from force of nature, e.g. sun, wind	B60L	8/00
WATER/OCEAN		
Engines of impulse type, i.e. turbines with jets of high-velocity liquid impinging on bladed or like rotors, e.g. Pelton wheels	F03B	1/00-04
Machines or engines of reaction type; Parts or details peculiar thereto	F03B	3/00-18
Water wheels	F03B	7/00
Adaptations of machines or engines for special use; Combinations of machines or engines with driving or driven apparatus	F03B	13/00-10
Controlling	F03B	15/00-22
Adaptations of machines or engines for special use - characterized by using wave or tide energy	F03B	13/12-24
Mechanical-power producing mechanisms - ocean thermal energy conversion	F03G	7/05
Mechanical-power producing mechanisms - using pressure differentials or thermal differences	F03G	7/04
Water wheels	F03B	7/00
GEOTHERMAL		
Other production or use of heat, not derived from combustion – using natural or geothermal heat	F24J	3/00-08
Devices for producing mechanical power from geothermal energy	F03G	4/00-06
Electric motors using thermal effects	H02N	10/00
BIOMASS		
Solid fuels based on materials of non-mineral origin - animal or vegetable	C10L	5/42-44
Engines operating on gaseous fuels from solid fuel - e.g. wood	F02B	43/08
Liquid carbonaceous fuels - organic compounds	C10L	1/14
Anion exchange - use of materials, cellulose or wood	B01J	41/16

*From the original table WASTE has been excluded and WATER has been added.

Own presentation, oriented on Johnstone et al. (2010)

ii. *Alternative Estimations*

In table 6, we use a fixed effects Poisson-model which more or less replicates our results (table 1, page 16). Using a first differences model (OLS) as shown in table 7, still shows significant results for $INCAP^{H}_{2000-2002}$ in JPO and APO.

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Table 6 : Fixed effects Poisson regression

$PATENT^{HF}$	EPO	JPO	APO
$lagRuD^{H}_{1992-1999}$	−0.003891	−0.0053209	−0.0027717
	(0.0050035)	(0.0070105)	(0.0059082)
$lagRuD^{H}_{2000-2002}$	−0.0218788***	−0.0205298*	−0.0242853**
	(0.0076388)	(0.0113637)	(0.0096594)
$INCAP^{H}_{1992-1999}$	0.0001682***	0.0003202***	0.0002738***
	(0.0000476)	(0.000074)	(0.0000645)
$INCAP^{H}_{2000-2002}$	0.0000832***	0.0002117***	0.0001901***
	(0.0000172)	(0.0000279)	(0.0000242)
$lagINCAP^{F}$	4.78e−06	0.0005027*	−0.000037
	(0.0000164)	(0.0003115)	(0.0000375)
$lagAPATENT^{F}$	−0.0001206	−0.0001457	0.0007427**
	(0.000266)	(0.000173)	(0.000334)
$lagCPIE^{F}_{1992-1999}$	0.0190602	−0.003186	−0.0009674
	(0.025742)	(0.0246747)	(0.0269702)
$lagCPIE^{F}_{2000-2002}$	0.023799	−0.0020967	0.0032361
	(0.02162)	(0.0249417)	(0.0220473)
$lagELC^{F}$	−0.0035969	−0.0058992**	0.0023531***
	(0.003572)	(0.0024022)	(0.0005705)
Wald chi2	411.06		
Nr. of observations:	165		

Significance: *** ≤ 1%, **≤ 5%, * ≤ 10%

Table 7 : OLS fixed effects first differences model

$PATENT^{HF}$	EPO	JPO	APO
$lag1RuD^{H}_{1992-1999}$	−0.2735567	−0.0252574	−0.053742
	(0.1733541)	(0.0849316)	(0.1719576)
$lag1RuD^{H}_{2000-2002}$	−0.2446132	−0.0247744	−0.1965391
	(0.2085309)	(0.1635901)	(0.2077007)
$INCAP^{H}_{1992-1999}$	0.0001368	0.0021967	0.0017532
	(0.0013486)	(0.0013473)	(0.0013839)
$INCAP^{H}_{2000-2002}$	−0.0007135	0.0012767**	0.0013259**
	(0.0005851)	(0.0005684)	(0.0013259)
$lagINCAP^{F}$	0.0009494	0.0024222	0.0013545
	(0.0106794)	(0.0238106)	(0.0095546)
$lagAPATENT^{F}$	0.0060522	−0.0036444	0.0060825
	(0.0559459)	(0.0571749)	(0.0470171)
$lagCPIE^{F}_{1992-1999}$	−0.538605	0.0867416	−0.0706172
	(10.112697)	(0.7568268)	(0.5441484)
$lagCPIE^{F}_{2000-2002}$	−0.3647433	0.1282116	0.0190248
	(10.356288)	(10.207714)	(0.8598966)
$lagELC^{F}$	0.0091146	−0.0480379	0.0228105
	(0.0829318)	(0.2854876)	(0.1428906)
β_0	−8.647436		
	(88.44358)		
R-sq:	0.3082		
F(27,108)	1.89		
Nr. of observations:	150		

Significance: *** ≤ 1%, **≤ 5%, * ≤ 10

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Tourist Flow and Tourism Potential Regions of Gulmarg in Kashmir Himalayas

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Abstract - Gulmarg has a rich and diverse touristic product that holds the potential to be one of the most attractive tourist destinations for both leisure and sports tourism across the whole Kashmir Himalayan region. The place owes its importance mainly to its beautiful geo-environmental setup and unique climate. The destination has a history of tourism activities for more than five centuries. The resort has been a great attraction for several British officials posted in India and their families made Gulmarg their home for the summer months. This his to-geographical personality of the place has resulted in the development of tourist regions of interest to a range of tastes especially for holiday makers and sports and adventure tourists. Therefore present study aims at identification and delineation of the different tourist potential regions of the place which would help in proper marketing of the tourist product, management of tourist flow, optimization of economic returns and management of the environmental health of the destination for sustainable tourism development in the region.

GJHSS-B Classification : FOR Code : 040699



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Nissar A. Kuchay [α] & M. Sultan Bhat [σ]

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I. Introduction

Sustainable tourism is envisaged as leading to management of all resources in such a way that economic, social and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity and life support systems (World Tourism Organization).There has been an up-trend in tourism over the last few decades, Tourists have a wide range of budgets and tastes, and a wide variety of resorts and hotels have developed to cater for them. The developments in technology transport and infrastructure made many types of tourism more affordable. This is substantiated by the fact that international tourism receipts grew to US$1.03 trillion in 2011, corresponding to an increase in real terms of 3.8per cent from 2010.

Sustainable tourism can be seen as having regard to ecological and socio-cultural carrying capacities and includes involving the community of the destination in tourism development planning. It also Involves integrating tourism to match current economic And growth policies so as to mitigate some of the negative economic and social impacts of 'mass tourism'. Murphy (1985) advocates the use of an ecological approach, to consider both plants and people when implementing the sustainable tourism development process.

A tourism region is a geographical region that has been designated specifically for tourism purposes. The names often evoke certain positive qualities of the area and suggest a coherent tourism experience to visitors. Countries, states, provinces, and other ad-minis-trative regions are often carved up into tourism regions. In addition to drawing the attention of potential tourists, these tourism regions often provide tourists who are otherwise unfamiliar with an area with a manageable number of attractive options. Besides it also helps in the management of environment and regulation of tourist flow for the sustainable management of tourist destinations.

II. Study Area

The Gulmarg is believed to have been called '*Gurimarg*' in ancient times and the modification of the original name is said to have been made at the instance of 15th Century Kashmiri king Sultan Yusuf Shah Chak, who was enamored with the place. If it were historical endorsements that Gulmarg sought, then the visits of the Mughal emperor Jahangir established the measure of its worth. The resort was a great attraction for several British officials posted in India and their families made Gulmarg their home for the summer months. The presence of these holiday-makers was also responsible for the foundations of the two activities that Gulmarg today is best known for – golf and skiing, initiation of both dating back to the early twentieth century. Gulmarg is located 46 km from Srinagar city, geographical coordinate's 34.05°N 74.38°E. It has an average elevation of 2,690 m above mean sea level. The average temperature varies from its minimum of -4°C in January to maximum of 31°C in the month of July. The location of Gulmarg is visualized in Fig.1.

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Figure 1 : Location map of Gulmarg Development Area

III. Materials and Methods

The survey of India tope sheets at 1:25000 scales along with IRS P6 satellite data were used for the delineation of Gulmarg development area. Data regarding different variables was generated through primary survey in addition to the available secondary data. A series of indices based on natural beauty, adventures and sports, infrastructure, transportation and communication etc. were prepared and their composite score were used for the delineation of different tourist regions.

IV. Results and Discussions

a) Tourist Flow to Gulmarg

Gulmarg has a long history of tourist activities as it has remained a favourite destination of early Muslim rulers like Yusuf Shah Chak and the Britshers ruling India. Table I depicts the category wise flow of tourists during last five years. Gulmarg remains a preferred destination not only to locals but to the domestic and international tourists as well. Generally most of the tourists who visit Kashmir valley prefer to visit to Gulmarg as well. The category wise annual pattern of tourist flow to Gulmarg is represented in Fig. 2 which reflects the increasing trend in the flow of tourists to Gulmarg, in the year 2011 about 1.4 million tourists visited the place however this number has been reached in July and the total tourist flow has cross 2 million mark by the end of this year (2012).

Table 1 : Category wise Tourist Flow to Gulmarg

Year	Local	Domestic	Foreign	Total
2006	104247	390311	8101	502659
2007	268968	330466	20109	619543
2008	287934	422756	12994	723681
2009	270123	308136	6003	584262
2010	135921	319545	6773	462239
2011	425189	990460	7282	1422931
2012*	615849	1456128	7370	2079347

Source: Office of the Assistant Director Tourism, Gulmarg
*(*Figures for December, 2012 are projected)*

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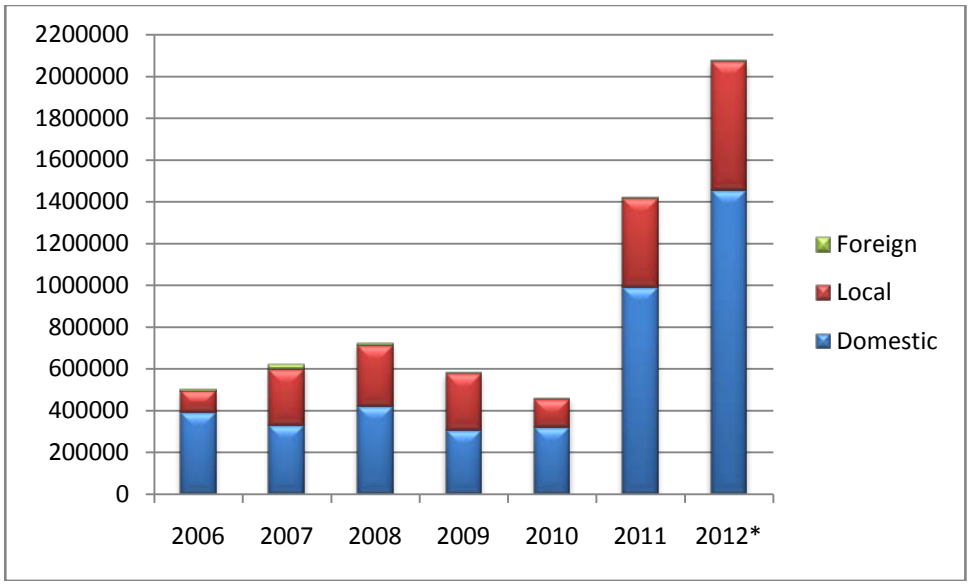


Figure 2 : Category-Wise Annual Pattern of Tourist Flow to Gulmarg, 2006-2012
*(*Figures projected for December, 2012)*

Gulmarg is an all-weather resort with refreshing summer meadows and pastoral scenes and deep-powder, long-run skiing and snowboarding during winters. Therefore tourist flow to this all season tourist destination continues throughout the year. Table II reflects the monthly flow pattern of tourists of different categories visiting Gulmarg. It is clear from the Fig. No 3 that in the year 2011 maximum tourist flow has been in the months of June-July and October-November, whereas, this year the flow has been consistently increasing from February itself and all the months have registered an increase over the past year except the month of July.

Table 2 : Category wise Monthly Tourist Flow to Gulmarg (2011,12)

Month	2011			2012*		
	Domestic	Local	Foreign	Domestic	Local	Foreign
January	12533	7366	334	30694	15691	444
February	9355	7303	785	68388	32888	749
March	19544	9961	664	105868	50187	763
April	32463	10470	1043	150371	80304	916
May	78661	35175	324	180346	70781	508
June	216957	103105	445	290525	110201	311
July	222298	159335	479	133337	130790	363
August	73835	25729	432	97641	23241	449
September	35756	18982	601	59292	37245	587
October	124391	17855	488	156328	26585	502
November	118456	15934	447	127715	17439	463
December	46211	13974	1240	55623	20497	1315
Total	990460	425189	7282	1456128	615849	7370

Source: Gulmarg Development Authority

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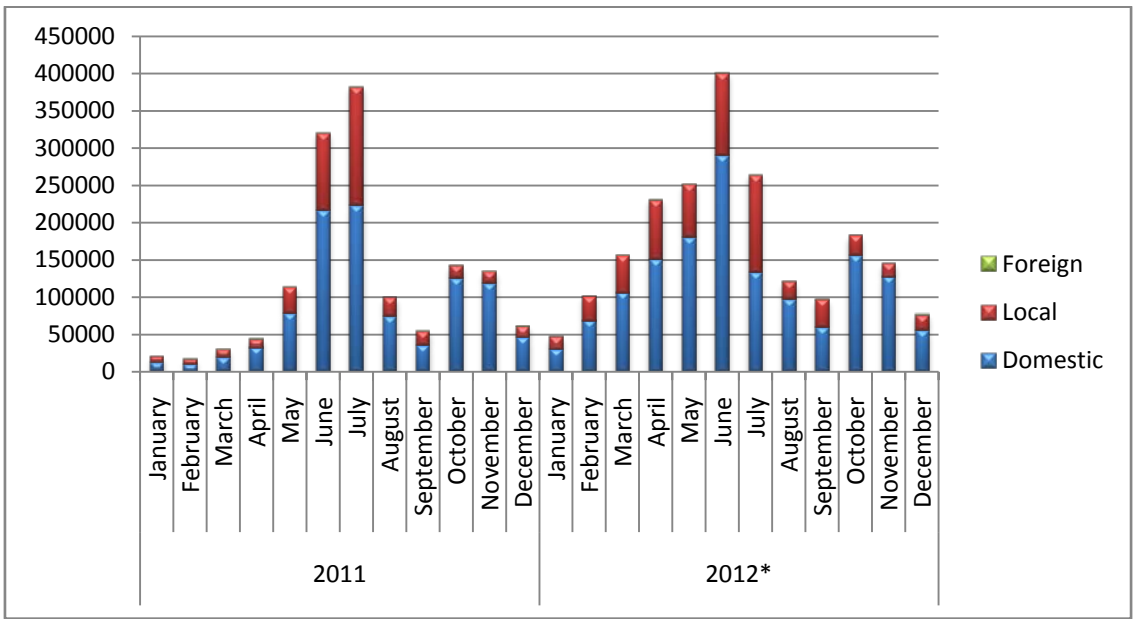


Figure 3 : Monthly flow of tourists to Gulmarg during 2011-12
*(*Figures from August to December, 2012 are projected)*

b) Tourist Perception

A brief survey of tourist perception in order to gauge the level of satisfaction about the availability of various tourist services has been conducted as reflected in Table III. The tourists have expressed mostly a positive level of satisfaction about most of the services. However, the level of satisfaction about the tour operators is considerably poor which needs to be improved by way of initiating necessary measures.

Table 3 : Index showing level of satisfaction of the tourists with respect to selected indicators at Gulmarg

S. No	Selected indicators	Tourist Perception (in percentage)				
		Excellent	Best	Good	Satisfactory	Poor
01	Climate	87	10	03	0	0
02	Attitude of Local People	14	65	10	05	06
03	Availability of tour Operators	0	25	30	10	35
04	Accessibility	51	27	13	09	0
05	Accommodation	57	20	10	06	07
06	Satisfaction with the fulfilment of vow	0	11	49	25	15
07	Local Traffic	48	21	10	08	13
08	Parking facility	51	21	12	10	05
09	Events	0	45	38	10	07
10	Souvenirs	0	15	0	55	30
11	Pedestrian ways	28	24	31	05	12
12	Parks & Green areas	53	31	5	04	07
13	Landscape beauty	80	20	0	0	0
14	Quality of water & sanitation	38	23	20	06	13
15	Shopping facility	38	24	21	07	10
16	Food availability	32	32	18	07	11

Source: Sample Survey of Tourists, 2011

Note: The weight age of the above indicators was derived with the help of scale 1-5.Here 1 means that tourists are very unsatisfied with a particular component & 5 means that tourists are very satisfied with a particular component.eg, for each indicator 20 persons have been approached and they have showed different responses to different indicators giving their own weight age.

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c) Traffic Flow to Gulmarg

The traffic flow of Gulmarg varies from season to season round the year. A perusal of Table IV highlights the fact that there is a huge flow of tourists during the summer season including local, national and international tourists, while during winter season the traffic flow declines to a larger extent. As depicted in Fig. 4, from April to October (warmer season) the traffic flow to Gulmarg is high as compared to other months. This includes all the tourists, local, national and international. The tourists visiting Gulmarg during winter season are mainly of national and international character because of winter sports activities.

Table 4 : Monthly Traffic Flow to Gulmarg for the Year 2011

Month	Private Cars	Sumo/Matador	Buses
January	2106	3330	170
February	3274	4216	225
March	7322	8102	308
April	8417	9209	347
May	12200	13887	340
June	12748	14019	352
July	13122	14513	363
August	11584	12781	251
September	10356	11223	302
October	9693	10336	263
November	7621	7782	207
December	6233	6597	184

Source: Gulmarg Development Authority

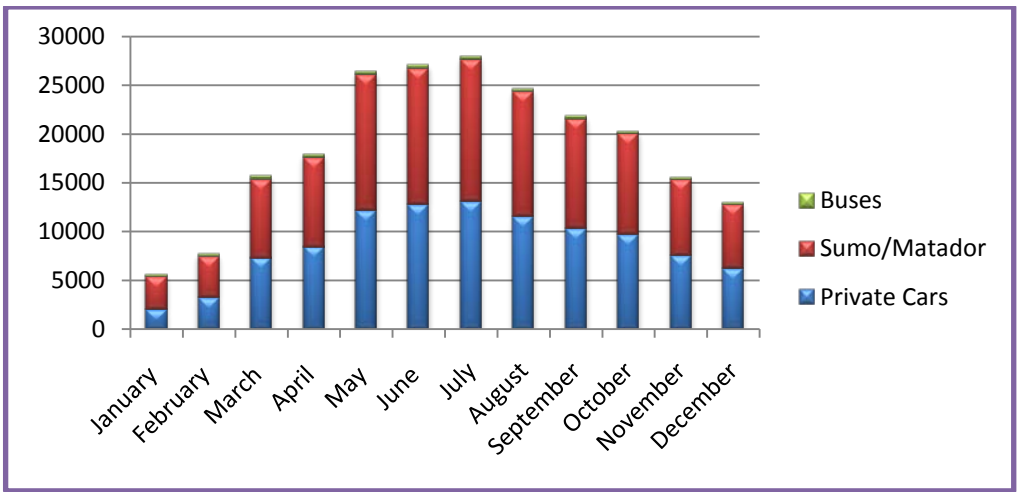


Figure 4 : Monthly Traffic Flow Pattern to Gulmarg

V. Tourism Potential Regions

Gulmarg is a multiple attraction tourist place and offers a varied range of tourist related attraction, therefore to analyze the different areas of tourist interest it has been divided into following tourist regions.

a) Gulmarg Gondola Region

Gulmarg Gondola is the world's second highest and Asia's highest and longest operating cable car since the closure of the Mérida cable car of Venezuela in 2008. The gondola operates in two stages – first stage is from Gulmarg base to the bowl of Kangdoori and the second stage is from Kangdoori to Ararat peak. The two-stage ropeway ferries about 600 people per hour to and from the gondola main station in Gulmarg to Ararat Summit.

i. *Gondola Lift - Gulmarg to Kangdoori*

Gondola car is one of the main attractions of the place. The first of two sections of the cable car rises from the cable station at Gulmarg at an altitude of 2700 m to bowl shaped Kangdoori at an altitude of 3100 m – a vertical rise of 400m.

ii. *Gondola Lift – Kangdoori to Afarwat*

The second stage of the Gulmarg-Afarwat cable car project connects Kangdoori station at 3100 m with the heights of Afarwat peak at 3,979 m – Afarwat is the mountain that looms over Gulmarg and is the magnet for serious skiers.

b) Golf Course Region

Gulmarg Golf Course is the world's highest golf course. The 18-hole, par 72 Gulmarg golf courses is

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quite hilly. The golf club itself was built in 1904, by British residents. It also offers table tennis and billiards. Temporary membership can be bought for the duration of stay. Course remains open from April to November, after which it is covered in a blanket of snow. This Government Golf Course was the second to be built by the British in India after the Royal Calcutta Golf Club. By the 1920s the resort had two 18-hole courses, the 'Upper Course' and the 'Lower Course' and one 9-hole middle course (the "Rabbits Course"). The only course to survive, however, exists where the Upper Course used to be. It was redesigned in 1970s by Peter Thomson. At an altitude of 3,730 m Gulmarg golf course is among the highest & most beautiful green golf course in the world.

c) Gulmarg Skiing and snow-boarding Region

While Gulmarg is an all-weather resort with refreshing summer meadows and pastoral scenes, the main reason to come here, at least in winter, is the off-piste, deep-powder, long-run skiing and snowboarding. The Himalayan resort of Gulmarg is one of the newest and increasingly popular ski destinations. Due to its geographic location Gulmarg gets some of the heaviest snowfalls in the Himalayas and it has earned the distinction of being the best ski resort in the Himalayas. Skiing was first introduced to Gulmarg by two British Army officers who established the first ski club in 1927 although it wasn't until 7-8 years ago when Gulmarg's name really first started to appear on the cognoscenti's hot list. Some of the best slopes in the country for beginners and intermediate skiers are available at Gulmarg. Skiing equipment is available on hire from the Ski-Shop. In winter Gulmarg's natural slopes and inclines turn into the country's premier skiing resort. Not all tourists who visit in winter come for skiing – some simply are there to watch the skiing or to enjoy a holiday in the snow. Among the multitudes of slopes, there are a few which are serviced by ski lifts. Most of the skiing becomes centered on these slopes, which are specially suited to beginners and intermediate level skiers, with ski runs ranging from 200 m to 3kms, instructors are available for both levels. With the operation of the Gulmarg Gondola Cable Car, it has become all the more convenient for advanced skiing enthusiasts, as they can gain a ski run of nearly 3 km with the help of this cable car which goes through Kangdoori to Afarwat.

d) Other Attractions

i. *Khilanmarg*

A path of some six kilometers and an ascent of about six hundred meters from Gulmarg take to the little highland dale of Khilanmarg. The narrow bridle path is lined by grassy knolls and a variety of trees and shrubs that include masses of daises, mulberry, berberis and walnut among others.

ii. *Alpathar Lake*

At a distance of about 13 kilometers from Gulmarg, at an altitude of around 3840 m is the little lake of Alpather. Like many other high-altitude lakes in the mountainous parts of the western Himalayas, this lies in a shallow mountain bowl and is surrounded by limited plant growth.

iii. *Religious Shrines*

There are four main religious shrines in and around Gulmarg. A few kilometres from this glade, is the tomb and shrine '*Ziarat*' of the noted Muslim saint *Baba Rishi* built in 1480AD. Other important religious sites include Rani temple, dedicated to *Lord Shiva,* and the old St. Mary's Church built by the British holiday-makers. Also in Gulmarg's vicinity is the Avantiswami temple that dates back to the ninth century and is dedicated to *Lord Vishnu*.

VI. Conclusion

Nestled with stunning peaks in the Himalayan ranges, Gulmarg is a spectacular picnic spot attracting all kinds of tourists with its lush green backdrop, beautiful landscapes, flowering gardens, serene lakes and pleasant climate during the summers and falls. This imposing hill station was a pleasure resort for kings and royal family members and a summer retreat for the British officers during the British rule in India. Gulmarg Gondola, one of the highest cable cars in the world, reaching 3,979 meters. Gulmarg is the heartland of winter sports in India. Due to its steep terrain, the region is popular amongst advanced and extreme skiers from around the world and has been visited by a number of ski professionals. Gulmarg golf club is the highest green golf course in the world. There are a few places of religious importance near the resort. The summer is equally busy. With temperatures ranging from 25 to 30 °C, Gulmarg attracts outdoor sports fanatics with its world class golfing, trekking, mountain biking, horse riding, water skiing, and fishing. It has been observed that the tourist flow is highly imbalances vis-a-vis the various tourist regions and different seasons of the year. During the summer months certain regions remain over crowded, beyond their carrying capacities which is a great threat to the fragile ecological setup of the region. Therefore, there is an urgent need to regulate the tourist flow across the different tourist regions and different seasons of the year through proper marketing, infrastructure development and better accessibility. This in turn will help in minimizing the adverse environmental impacts, maximizing the economic gains and over all sustainable development of the region.

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Ecosystem Services for Disaster Risk Reduction: A Case Study of Wetland in East Delhi Region, India

By Swati Singh, Sreeja S. Nair & Anil K. Gupta
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Abstract - Ecosystem services are the benefits that societies receive from the nature. These may be in the form of regulating, provisioning, supporting or cultural services. Wetland being one of the most productive ecosystems provides these services at no cost. These ecosystems also contribute to reducing disaster risk by serving as natural protective barriers or buffers and, thus, mitigating hazard impacts. But many such wetland ecosystems are tremendous stressed due to anthropogenic pressure. Wetlands on the fringes of river channels in the city are looked upon as a resource for different land use planning. The capital Delhi manifests all the ills that a river system (Yamuna) can possibly face, made the city more vulnerable and disaster prone as evident from frequent incidences of flood, water crisis and disease outbreak. Rapidly increasing urbanisation with limited integration of values and functions of flood plains in developmental planning has led to their fragmentation.

Keywords : *wetland; ecosystem services; disaster risk reduction; yamuna river.*

GJHSS-B Classification : *FOR Code : 050102*



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Ecosystem Services for Disaster Risk Reduction: A Case Study of Wetland in East Delhi Region, India

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Abstract - Ecosystem services are the benefits that societies receive from the nature. These may be in the form of regulating, provisioning, supporting or cultural services. Wetland being one of the most productive ecosystems provides these services at no cost. These ecosystems also contribute to reducing disaster risk by serving as natural protective barriers or buffers and, thus, mitigating hazard impacts. But many such wetland ecosystems are tremendous stressed due to anthropogenic pressure. Wetlands on the fringes of river channels in the city are looked upon as a resource for different land use planning. The capital Delhi manifests all the ills that a river system (Yamuna) can possibly face, made the city more vulnerable and disaster prone as evident from frequent incidences of flood, water crisis and disease outbreak. Rapidly increasing urbanisation with limited integration of values and functions of flood plains in developmental planning has led to their fragmentation. This study is an attempt to assess the present state of ecosystems, its services particularly in reducing the risk of water and climate related disasters like flood, drought and epidemics in East Delhi and part of National Capital Refion.

Keywords : wetland; ecosystem services; disaster risk reduction; yamuna river.

I. Introduction

Wetland ecosystems are crucial to our natural wealth. They provide us with services worth trillions of US dollars every year entirely free of charge making a vital contribution to human health and well being (Ramsar Convention, 1971). Wetlands are one of the most productive ecosystems of the world which along with supporting unique flora and fauna provides range of ecosystem services (MA, 2005). Wetland ecosystems contribute to reducing disaster risk by serving as natural protective barriers or buffers and thus mitigating hazard impacts (Gupta & Nair, 2012). Well managed ecosystems can provide natural protection against common natural hazards, such as landslides, flooding, wildfires, storm surges and drought (Rieux et al., 2009). Ecosystem decline increases Disaster risk both by reducing the ability of an ecosystem to act as a natural buffer, as well as by reducing people's resilience by reducing their bases for Livelihoods such as food, medicine and construction materials (Proust Network, 2008).

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a) Ecosystem Services of Wetland

Natural systems are humanity's "life-support system" providing essential "ecosystem services" for existence and socio-economic well being (MA, 2005). Decline in ecosystem services influence the resources available to the people and, hence, lead to increasing vulnerability to hazards, and thereby decrease their resilience against disasters. The conservation and restoration of ecosystems such as forests and wetlands plays an essential role in reducing disaster risks such as flood, drought and storm (Wetland International). The Fourth Assessment Report of IPCC (2007) while reporting about the increased frequency and intensity of disasters due to climate uncertainties, suggested for strengthening ecological systems as part of adaptation and mitigation strategies (IPCC report, 2007).

Ecosystem services are the benefits that individuals and communities obtain from ecosystems. These include "regulating services" such as regulation of floods, drought, land degradation and disease, along with "provisioning services" such as food and water, "supporting services" such as soil formation and nutrient cycling, and "cultural services" such as recreational, spiritual, religious and other non-material benefits (Table 1).

Table 1 : Ecosystem Services provided by derived from wetlands

Services	Comments and Examples
Provisioning	
Food	production of fish, fruits and grains
Fresh Water	storage and retention of water for domestic, industrial, and agricultural use
Fibre and Fuel	production of logs, fuelwood, peat, fodder
Biochemical	extraction of medicines and other materials from biota
Genetic materials	genes for resistance to plant pathogens, ornamental species, and so on
Regulating	
Climate Regulation	source of and sink for greenhouse gases; influence local and regional temperature, precipitation, and other climatic processes
Water Regulation (hydrological flows)	groundwater recharge/discharge

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Water purification and waste treatment	retention, recovery, and removal of excess nutrients and other pollutants
Erosion regulation	retention of soils and sediments
Natural Hazard regulation	flood control, storm protection
Pollination	habitat for pollinators
Cultural	
Spiritual and inspirational	source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems
Recreational	opportunities for recreational activities
Aesthetic	many people find beauty or aesthetic value in aspects of wetland ecosystems
Educational	opportunities for formal and informal education and training
Supporting	
Soil formation	sediment retention and accumulation of organic matter
Nutrient cycling	storage, recycling, processing, and acquisition of nutrients

Source: Millennium Ecosystem Assessment, 2005

Integrated management of land, water and bio resources promotes conservation and sustainable use. This provides the basis for maintaining ecosystem services, including those which contribute to reducing disaster risks. Restoring wetlands on crop fields resulted in a net increase of ecosystem services in the Mississippi Alluvial Valley in US including green house gas mitigation, nutrient mitigation and waterfowl recreation and therefore net benefit to the society (Jenkins et al., 2010). Wetlands consist of characteristic assemblages of species that interact with each other and their environment. Some coastal ecosystems including mangroves forests, coral reefs and salt marshes, help to reduce the risks associated with coastal hazards such as storm surge and coastal flood. Such ecosystem also provide a host of associated services which may be lost if natural systems are replaced by built structures (McIvor et al., 2012). A study conducted by the scientists at the University of Delhi and Duke University has shown that coastal villages in Orissa with the widest mangrove belts suffered fewer deaths as compared to those with narrower belts or no mangroves in the devastating Super Cyclone of 1999 (Das et al., 2009). The interactions within and between the biotic and abiotic components of wetland ecosystems provide various ecosystem services to the human society. Some of the ecological functions provide direct economic benefits whereas others provide indirect support and protection to an economic activity. The State of Louisiana has adopted policy guidelines for using natural wetlands to assimilate nutrients in secondarily treated municipal effluent, thus utilizing ecosystem services of natural wetlands. In addition to water quality improvement, wetland assimilation provides additional ecosystem services, including increased vegetative productivity, surface accretion, and carbon sequestration (Young KO Et Al., 2012). The floodplain wetland system provides several ecosystem services, key being regulation of hydrological regimes, groundwater recharge, water quality improvement, support to biodiversity and life support system, effective in flood control, waste water treatment, reducing sediments loads, low input sustainable agriculture, fisheries development, tourism and valuable for educational and scientific interest and recreational benefits. River floodplains have been reported as potential sites to mitigate extreme events in the hydrological cycle (Mitch et al., 2000).

Wetland ecosystems are under tremendous pressure due to various anthropogenic activities. Notwithstanding the high value of the ecosystem services that wetlands provide to humankind, wetlands continue to be degraded or lost due to the effects of agricultural intensification, irrigation, water extraction for domestic and industrial use, urbanisation, infrastructure and industrial development and pollution (Russia et al., 2013). Wetlands on the fringes of river channels in the city are looked upon as a resource for different land uses. Studies show that the value of converting Thai mangroves to shrimp farms, draining freshwater marshes for intensive agriculture in Canada, and operating unsustainable fishing practices on coral reefs in the Philippines, was between 60% and 75% lower-in the long term-than the benefits from wetland conservation and sustainable use (www.ramsar.org). Wetland ecosystems of Yamuna river corridor in Delhi are one such live example. The capital city faces all the ills that a river system can possibly be faced with (Yamuna Jiye Abhiyan, 2007) and made the city more vulnerable and disaster prone.

Under the UNDP's Disaster Risk Management Programme in India, Disaster Management Plans were developed. However, these plans focussed primarily earthquake and fire hazards and on structural interventions. Non-structural interventions are limited to training, awareness generation and interventions focusing on ecosystems have been lacking. Since Delhi is predominantly urban ecosystem approach for livelihood resilience and disaster mitigation has not received attention in the past.

This study is an attempt to assess the role of wetland ecosystem in East Delhi and the services provided by these systems. An analyses of ecosystems role in reducing the risk of water and climate related disasters like flood, drought and epidemics has been undertaken.

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II. Material and Methods

a) Study Area

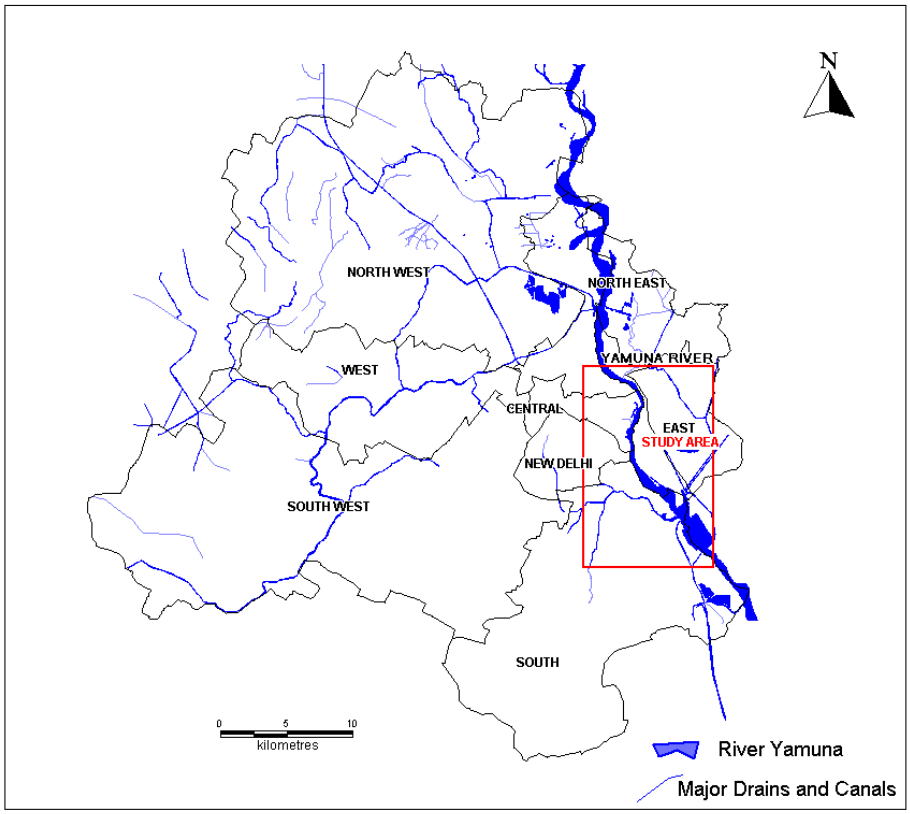


Figure 1 : Map showing the study area

Delhi, the capital city of India lies between 28.380 N and 77.120 E in latitude and longitude respectively. The River Yamuna (Figure 1), a major tributary of Ganges, is one of the key natural infrastructures of Delhi city. The total length of the river in the city is 50 Km between its entry at Pala and exit at Raipur. Its floodplains extends to an area of 94.84 km2comprising forests, agriculture land, settlements and lakes/ponds and can hold lot of water-about 2 billion cubic meters. The maximum width of the active floodplain is observed near Okla. where a large quantum of water is brought through Hindu cut. Despite high urban stress, the floral diversity of the floodplains is rich including 74 species of macrophysics and 90 species of phytoplankton. Faunal diversity encompasses 62 species of zooplankton, 55 species of benthos, 36 fish species and 131 bird species (wetland International-South Asia).

Delhi region has suffered major floods during years 1924, 1947, 1967, 1971,1975,1976,1978, 1988, 1993, 1995, 1998 and 2010. The 1978 was the worst ever flood in Delhi when water Level reached at 207.49 m (danger level is 204.83 m) with discharge 2.53 lakh cusec at old Railway bridge (7.0 laky cusec discharge was released from Tajewala) when130 villages and 25 urban colonies in Delhi were submerged in water. As per the map of flood prone areas prepared by Central Water Commission, Delhi has been classified into thirteen zones based on the flooding risk in relation to incremental rise in the water level of the of the Yamuna. Beside this, the Delhi flood control order (2011) also divides the National Capital Territory Delhi (NCTD) into four flood sectors, namely, Shahdra, Wazirabad-Babrapur, Alipur and Nangloi-Najafgarg sectors. A detailed analysis of the eight flood affected villages during 2010 September, from the North Delhi, has shown tremendous land use land cover changes over past two decades (Satija, 2011). During the September 2010, rainfall in Delhi was 359.7 mm, 180% more than the normal rainfall. Urban floods are becoming a perennial feature of the city due to inadequate drainage, uncontrolled development and land use changes particularly in the Yamuna Flood Plain.

III. Methodology

Transect walk was carried out across the corridor of river Yamuna in Delhi to identify and explain the relationships among floodplain, natural vegetation, cultivation, human activities & settlement pattern and understand the various ecosystem services provided by

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the wetland. Transect walk as suggested by de Zeeuw (2004) helps understanding natural resources, present land use pattern, vegetation, changes in the physical features and cropping systems, etc in villages, and public resources, land use, social differentiation and mobility in urban communities. A questionnaire based survey was carried out to have perception of communities living on the fringes of wetland on disasters faced by them and ecosystem services provided by the wetland. Experts view (academicians, ecologist, practioners, and bureaucrats who are versed with the study site) on the integration of ecosystem services and DRR were also taken. Scoring was done (on the basis of number of hazards addressed by one ecosystem service) for analysing the ecosystem services and DRR aspects addressed and based on the scores importance were attached as high (4-5), medium (3) and low (<3). In this study five is the highest score.

IV. Discussions

a) *Ecosystem services of wetland of East Delhi*

The availability of water near Okhla throughout the year helps to maintain minimum water level required for functioning of the floodplain. The surplus water during monsoon percolates down and helps to control floods and maintain moisture regimes during lean period. Bioaccumulation of key nutrients in floodplain helps to reduce pollution stress, and thereby, leading to development of rich biodiversity habitat. Okla. Bird Sanctuary (notified in 1990 by UP Govt.) situated in Gautama Buddha Nagar is rich in avifaunal diversity and presently inhabits more than 145 bird species include 22 species of resident water birds, 44 species of resident terrestrial birds, 43 species of migratory water birds and 26 species of terrestrial migratory birds. The sanctuary covers rich aquatic, semi-aquatic and terrestrial habitat where more than 25 species of aquatic plants, 110 species of terrestrial plants including herbs, shrubs, climbers, grasses and trees have been recorded (Divisional Forest Officer, Gautama Buddha Nagar, UP, 2012). Table 2 provides the list of some of flora and fauna of the region respectively. Tourism has increased in the sanctuary including foreign tourists. The park is adding considerable revenue to the district. From November, 12 to March, 13 the income generated from the park was approximately nine laths Indian rupees.

Table 2 : List of fauna and flora found in Okhla Bird Sanctuary

Fauna	Flora
Pavo cristatus	Argemone Mexicana
Columbia livia	Calatropis procera
Paser domestica	Commelina benghalensis
Cercomola fusca	Tribulus trestis
Culicicapa ceylonensis	Eclypta alba
Luscinia svecica	Azolla pinnata
Megalaima zeylanica	Phyla nodiflora
Lanius vittatus	Ipomoea fistulosa
Orthotomus sutorius	Ipomea cairica
Corvus splendens	Typha anagustifolia
Prinia socialis	Typha elephantine
Sturnus vulgaris	Sacharum spontaneum
Nectarinia asiatica	Phragmites karka
Anthus rufulus	Vetiveria zizanoides
Accipiter badius	Ischaemum indicum
Elanus caeruleus	Eichhornia crassipes
Dendocitta vagabundaanas	Tridax procumbens
Anus crecca	Anagallis microphyllus
Anser anser	Vernonia cineria
Anus phenelop	Convolvulus microphyllus
Aythya fuligula	Sida acuta
Sterna acuticauda	Solanum nigrum
Larus ridibondus	Solanum surratence
Rhodonessa rufina	Datura metel
Chlidonias hybridus	Ricinus communis
Phalacrocorax	Thevetia peruviana
Anhinga melanogaster	Launaea procumbens
Ciconia episcopus	Parthenium hysterophorus
Mycteria leucpcephala	Cassia tora
Tachybapptus ruficollis	Abutilon indicum
Porphyrio porphyrio	Cannabis sativa
Himantopus himantopus	Cyprus iria
Fulika atra	Zizyphus mauritiana
Sterna aurantia	Alstonia scholoris
Actitis hypoleucos	Albizia procera
Tringa totonus	Ficus benghalensis
Ardea cinerea	Ficus religiosa
Egreta garzetta	Tamarindus indica
Circus aeruginosus	Bauhinia purpurea
Anus acuta	Aegle marmelos
Philomachus pugnax	Bombax ceiba

Source: Divisional Forest Officer, Gautam Budha Nagar, UP, 2012

Communities residing in the floodplain derive their basic needs like water for drinking, irrigation and domestic purposes from the floodplains of Yamuna. For drinking purpose hand pumps are available and water depth is found to be 10-15ft. Bore wells are used for irrigation. Agriculture and labour are the sources of livelihood of the communities. The floodplain is very fertile and supports lots of cultivation of vegetables, horticulture and floriculture. Vegetables commonly grown are beans, cauliflower, cabbage, bottleguard, lady's finger, onion, potato, spinach, corn and bitter guard. It was surprising to find out that cultivators used urea, diammonium phosphate (DAP) and other chemical fertilizers in their fields. Community didn't complain about diseases caused by water. However, dengue outbreaks have been reported after monsoon and floods in the entire city.

The key services from the wetland ecosystems in East Delhi are as follows:

b) *Exposure and Risks*

The Flood plains of river Yamuna in Delhi are critically threatened due to biotic, biotic and huge

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urbanization pressures. Biotic stress includes uncontrolled siltation and weed infestation, uncontrolled discharge of waste water, industrial effluents, etc. Biotic stress includes encroachment resulting in shrinkage of area, anthropogenic pressures leading in habitat destruction and loss of biodiversity etc. Rapidly increasing urbanization with limited integration of values and functions of floodplains in developmental planning has led to their fragmentation. Flows in the river are drastically reduced due to upstream abstractions for irrigation, industrial and domestic water supply. Conversion of floodplain areas for developmental activities like Naiad toll bridge, Akshardham Temple, Millennium depot, Delhi Secretariat, Commonwealth games infrastructure etc. are making the region more vulnerable. From risk perspective, degradation of floodplains is increasing flooding risks to the city along with stresses related to food and water scarcity.

In 2010, the city witnessed one of the worst floods due to heavy rainfall. The flooding was gregarious due to the development within the natural course of the river. Yamuna water entered Delhi after being released from *Tajewala* and *Hathnikund* barrages up North, the water had lesser area to accommodate itself on the floodplain since a chunk of the floodplain–the size of the Commonwealth Games Village–was no longer available to the river that earlier remained for centuries.

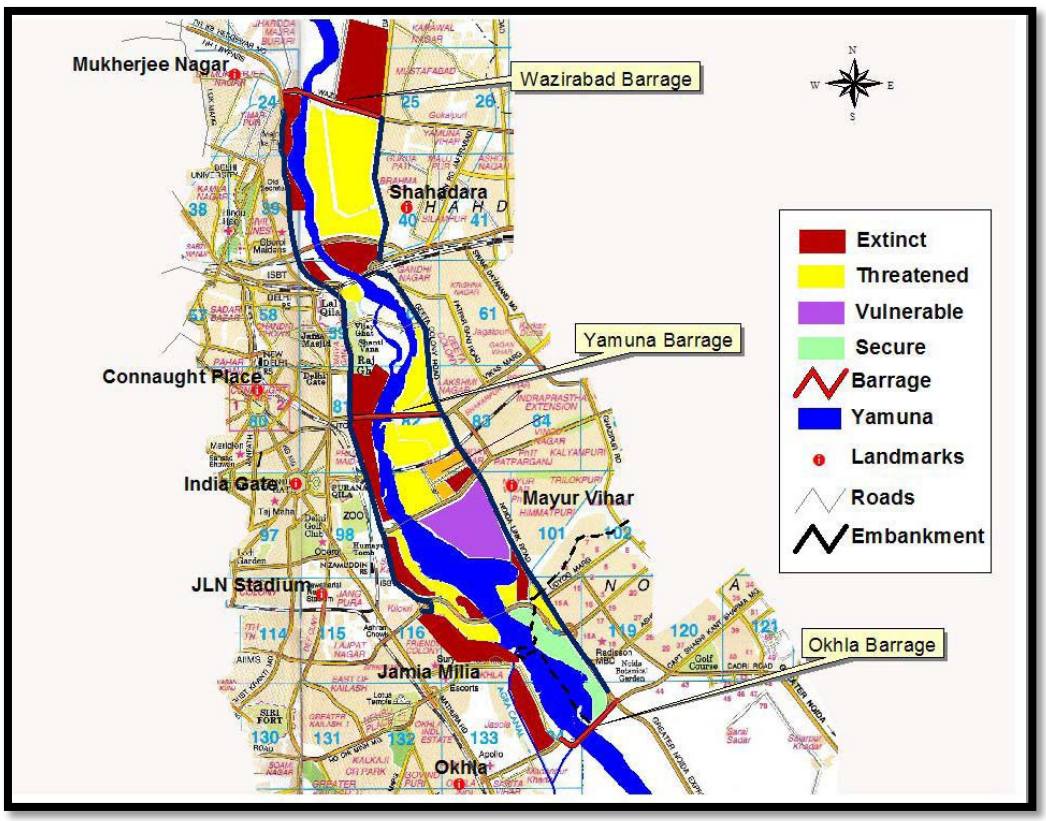


Figure 2 : Vulnerability map showing present State of river bed in Delhi
(Source: Yamuna jiyeAbhiyan)

As evident from the figure 2, the entire river bed in the west between the ring road and stream has been lost due to construction and developmental activities. A tour through the Yamuna flood plain gives the glimpse of encroached wetland. Indraprastha thermal power plant was established on the bank of the river to discharge waste generated directly into the flowing water. Memorials of our several leaders and politicians had been built in the floodplain between Nigambhod Ghat and Rajghat. Millennium Bus Depot (Asia's biggest depot) which was constructed during Common Wealth Games remained flooded for almost three months in 2010 because of no drainage system. Ironically, it happened just before a month for games to commence. Ponds, near Bahaullah drain have disappeared due to bridges and flyovers and have now been converted into parks full of water hyacinths showing atrophic condition. The important lung space of the city has been lost converting it into heat island.

Many marginalized communities depend upon the ecological services provided by the wetland to meet their day to day requirements (table 3) and figure 3. Migratory birds that come to Okhla Sanctuary used to rest at Gautama Buddha Park which has now been converted into concrete political park with all open land converted to paved areas. Ecologist and Conservationist working with Okhla sanctuary say that Gautama Buddha Park has negatively affected the

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species diversity and also the duration of stay of migratory species has lessened. The reason is non availability of tree species for nesting and food. The species that have not been sighted in the sanctuary from last 5-6 years are paradise flycatcher, Egyptian vulture and great spotted eagle.

Table 3 : Ecosystem services provided by wetland of Delhi

Ecosystem Services		Explanation
Regulating		
E1	Storing excess water during heavy rainfall	Safe passage of excess waters in the city
E2	Ground water recharge	Source of surface and ground water which is much needed to meet the city's growing needs of water for domestic, industrial and agricultural uses.
E3	Disease regulation	Helps in control of water borne diseases
E4	Carbon Sequestration	Act as an essential carbon storage and thus help in climate change mitigation
E5	Shelter belt	Provides a potential shelter belt against advancing land degradation
E6	Thermal regulation	Regulates thermal currents in the city where summer temperatures are today becoming unbearable with every passing year in the context of climate change and global warming.
Provisioning		
E7	Livelihood Support	Production and sell of vegetables and fruits like water chestnut, lotus root, green vegetables are key means of sustenance particularly for slum dwellers
E8	Fisheries	Hardy and tolerant fish species found in the river stretch except in upstream of Wazirabad barrage where still major and minor carps are found The fish species found are rohu, katla, mrigal, channa, singada etc.
E9	Water for drinking, domestic purpose and irrigation	Source of drinking water to major part of the city. Also provide water for irrigating crops
Supporting		
E10	Support heavy nutrient load	Vegetation such as water hyacinth and different grass species like Typha, Phragmites carca, Lamphrophyla etc. are found that take up nutrients received from the nearby drainage and thus help in controlling water pollution
E11	Sediment retention and accumulation of organic matter	Organic fertilizers are made from the water hyacinth after processing. Also bio fuels by briquetting have been made.
Cultural		
E12	Recreational	Okhla Bird Sanctuary in Gautam Buddha Nagar provides a source of recreational activities. More than 145 species are reported from Okhla out of this about 50% are migratory birds, 36% are resident birds and rest are vagrant sightings. A variety of both native and exotic species of plants are found in the sanctuary
E13	Educational	Source of formal and informal education and training, Many school children visit the bird sanctuary along with researchers and scholars.
E14	Aesthetic	Wetland provide scenic beauty

Unplanned urbanization has drastically altered the drainage characteristics of natural catchments by increasing the volume and rate of surface runoff. Drainage systems are unable to cope up with the increased volume of water and are often encountered with the blockage due to indiscriminate disposal of solid wastes. Twenty prominent sewage and drainage system that carries the untreated loads of in and around Delhi is increasing the vulnerability of the sanctuary. Total quantity of sewage generated in Delhi is around 2,871 MLD whereas the capacity of sewage treatment plant is 1,478 MLD only. The figure clearly indicates that 1,393 mld of untreated sewage is directly discharge into the river (*Source: wetland International-South Asia*). Table 4 reveals role of floodplain in addressing various hazards and in disaster risk reduction.

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Table 4 : Hazards and Disaster Risk Reduction- Role of Floodplain

	Addressing Hazard	Comments
H1	Flood	Addressing flood hazard by means of spread and passage of flood waters during the monsoon every year and exceptional floods once every decade or more (1978, 1988, 1995, 2010).
H2	Epidemics	Addressing epidemics like dengue and malaria
H3	Drought	Addressing meteorological drought in the capital by supplying water for irrigation during lean period
	Reducing Vulnerability	
V1	Physical vulnerability	Reducing physical vulnerability by providing buffer to build in infrastructure like irrigation system, municipal water supply, sanitation and drainage by checking land degradation both to the people as well as of the ecosystem
V2	Economic vulnerability	Reducing economic vulnerability by providing stable source of income from fruits, vegetables and fisheries
V3	Livelihood vulnerability	Reducing vulnerability of local people who are dependent on wetland for their livelihood like vegetables and fruits along with addressing issue of food security. Also reducing vulnerability of the people who are dependent on fisheries for their livelihood support
V4	Environment Vulnerability	Reducing environmental vulnerability by checking water scarcity, providing suitable environment for fish breeding, taking nutrient loads from the drainage system etc. around the city.
	Increasing Capacity	
C1	Governance	Strengthens knowledge and policy environment which in turn helps strengthening governance and hence increasing the capacity to address disaster in a holistic way. It helps traditional DM professionals and engineers recognise DRR benefits of ecosystems
C2	Society and economy	Communities are engaged in diverse and environmentally sustainable livelihoods resistant to hazards.
C3	Land use management and structural design	Effective land use and structural design that complement environmental, economic, and community goals and reduce risks from hazards.
C4	Risk Knowledge	Leadership and community members are aware of hazards and risk information is utilized when making decisions.
C5	Warning and evacuation	Community is capable of receiving notifications and alerts of flood, warning at-risk populations and individuals acting on the alert.
C6	Emergency Response	Mechanisms and networks are established and maintained to respond quickly to flood and drought disasters and address emergency needs at the community level
C7	Disaster Recovery	Plans are in place prior to hazard events that accelerate disaster recovery. engage communities in the recovery process and minimize impacts/

V. Opportunities and Challenges of Integrating Ecosystem Approach in Disaster Risk Reduction

Ecosystem approach to DRR is widely advocated as second paradigm shift in disaster management, as it directly links with the livelihood of the people and sustainability of their resources (Gupta, 2012). This calls for emphasis on natural resource management, ecosystem services, land-use and adaptation to climate change within the strategies of disaster prevention, preparedness and post-disaster relief and recovery process (India's National Policy on Disaster Management, 2009, section 5.1.6). Most of the floodplains have been encroached for developmental projects. However, there are opportunities available for developing ecosystem approaches for reducing disaster risks due to climate change in Delhi and nearby areas. Table 5 presents an effort to assess and rate the ecosystem services in DRR framework.

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Cattle Egret a residential Bird of the Okhla Bird Sanctuary



Typha grass used by the villages for thatched roof and making mats



Water Hyacinth used as organic Fertilizer and bio-fuel



Vegetables and Fruits gown in the flood plains



Shallow aquifers in the flood plains serves as a source of potable water ,domestic use and agriculture



Control Floods and addresses water scarcity by storing excess water

Table 5 shows that each of the ecosystem services addresses one or more DRR aspects. Out of 14 ecosystem services by the wetland of East Delhi four are highly important (E1R, E7P, E9P and E11S), one holds medium importance (E8P) and rest are of relatively low importance. The scoring and importance attached does not discourage the other ecosystem services provided by the wetland rather it gives the priority for such services that can be integrated in the DRR framework.

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Table 5 : Integrating Ecosystem services and Disaster Risk reduction of the wetland of East Delhi

	Ecosystem Services	DRR aspects addressed	Scoring	Importance
E1R	Storing excess water during heavy rainfall	H1, V1, C3,C5	4	High
E2R	Ground water recharge	V4	1	Low
E3R	Disease regulation	H2	1	Low
E4R	Carbon Sequestration	V4	1	Low
E5R	Shelter belt	V1	1	Low
E6R	Thermal regulation	V4	1	Low
E7P	Livelihood Support	V2, V3, V4, C1, C2	5	High
E8P	Fisheries	V2, V3, V4	3	Medium
E9P	Water for drinking, domestic purpose and irrigation	H3,V1, V4, C3	4	High
E10S	Support heavy nutrient load	V4	1	Low
E11S	Sediment retention and accumulation of organic matter	V1, V4, C1, C3	4	High
E12C	Recreational	C1	1	Low
E13C	Educational	C4	1	Low
E14C	Aesthetic	V4	1	Low

Note: R, P S and C stands for regulating, provisioning, supporting and cultural services of ecosystem respectively.

a) *Opportunities of integration of ecosystem services in DRR aspects and interventions*

Yamuna Action Plan (YAP): Yamuna Action Plan is one of the largest river restoration projects in India. It is a bilateral project between Government of India and Japan which is executed by the National River Conservation Directorate, Ministry of Environment and Forest. The YAP I launched in 1993 addressed the issues of pollution control and integrated development of river system. The main components of the plan include interception, diversion and treatment of sewage, low cost sanitation, river front development, construction of electric crematoria, forestation along the riverbanks and community participation. With inception of YAP II and leaving aside the present political issues, YAP could be seen as one of the opportunities and platform for key management interventions with the support of Government of India.

Environment Impact Assessment of development projects: EIA is an anticipatory mechanism for assigning quantitative values to the parameters indicating the quality of environment before, during and after a major activity, project or incident, thus allowing measures to ensure ecological compatibility and economic efficiency in decision making. EIA, in pre disaster prevention and mitigation phase helps in precise decisions regarding planning risk reduction and choices of mitigation methods, technology and locations for activities.

Alternate power generation: Renewable energy (hydro and solar) usage should be increased to lessen the loads on thermal power plants. Government should subsidized and support renewable energy resources. Weeds in and around wetland can also be used in generation of befouls, lot of research can be taken on this topic.

Restriction on indiscriminate withdrawal of groundwater: Indiscriminate use has led to over extraction of the groundwater over past few years. Yield of deep aquifer has decreased due to increased demand of water and blooming of tube wells. There is a need to regularise on groundwater usage from deep aquifers as rate of discharge is not equal to rate of extraction.

Legislations and its enforcement: India is one of the leading countries in the world in terms of environmental legislations and policies but enforcement is very poor. Sound implementation will help to check the ecosystem degradation by putting ban on negative environment practices by human beings.

Awareness generation and community involvement: Awareness generation programme at school level and also involving community at large will bring about attitudinal change regarding the conservation and protection of environment. Role of higher education and research institutions in promoting awareness is equally important besides the policy environment for facilitating a more sustainable approach.

Mainstreaming disaster management plans: Ecosystem approach cannot be looked in isolation and needs to be mainstreamed with disaster management plans at policy level because challenges of water, climate-change and increasing pressure over the finite land have intricately woven the natural geo-environmental processes to aggravate and turn into disasters.

Corporate Social Responsibility and self responsibility: Corporate should come up with an approach to take ECODRR as an initiative for protecting environment and contributing in sustainable and inclusive growth of the country. Similarly onus lies on

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each and every citizen and take responsibilities towards disaster free India and should not only depend on Government schemes and programmers.

Further Research: Researches on why the river morphology of Yamuna is changing at some places can be undertaken to have more holistic understanding of the floodplain behavior.

VI. Limitations and Challenges

The Integration of ECODRR approach has also certain limitations. Following are the key points:

- Infrastructures have already been developed on the floodplain, and, hence major chunk of wetland has already been encroached.
- Okhla Bird Sanctuary has its territory both in Delhi as well as in Uttar Pradesh. Many initiatives may face limitations due to lack of coordination between two state governments i.e. Delhi Government and Uttar Pradesh Government.
- Wetland management also involves departments like forest, irrigation, agriculture. Lack of coordination between these departments creates the bottleneck for any development initiatives.
- Sometimes political priorities and will take over zeal and enthusiasm of working towards any conservation or DRR projects. Example is Gautama Buddha Park, which was a resting place for birds have been destroyed and the area has been converted into Concrete Park.
- Hindon, a tributary of Yamuna River carries loads of industrial effluents from western Uttar Pradesh and discharges untreated wastes in Yamuna after entering in Delhi. This heavy loading of industrial effluent discharge directly into the river places an intolerable burden on the Yamuna's natural ability to assimilate pollutants and thus creates nuisance in the floodplains.
- Laws are effective only when properly enforced by the governments. Weak enforcement of legislations jeopardized the objective of development.
- Most of the people are unaware about the importance of floodplain and wetland ecosystem and the lack of awareness poses limitation to conservation efforts.
- Projecting the economic value of eco-system services is very important in today's market driven society. It is human tendency to become free riders if available free of cost. Hence, people need to pay for the ecosystem services that for these wetlands.

VII. Conclusion

Wetlands on the corridor of Yamuna are rapidly diminishing due to anthropogenic activities and have become one of the most threatened ecosystems. Pressure for conversion of wetlands for developmental purposes is very high especially in case of urban riparian wetlands. These wetland ecosystems provide many tangible and intangible benefits on a sustainable basis not only to the urban society but also to the associated dependent ecosystems. River floodplain can be consider as a tool for mitigation of flood waves or extreme low discharges, only if a floodplain management and structure respect this natural function (Pithart et al., 2007). Recognizing the importance of wetland ecosystems, the National Environment Policy of India (NEP, 2006) contains an unambiguous assertion of the need for a holistic view of wetlands, which looks at each identified wetland in terms of its causal linkages with other natural entities, human needs, and its own attributes. The ecosystem approach to disaster risk reduction advocates for sustainable ecosystems management as strategy to reduce exposure and vulnerability, through hazard mitigation or regulation as well as enhancement of livelihood capacities and resilience.

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To Study the Role Played by Green House Gasses on Climatic Change and its Further Effect on Agriculture

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Abstract - Rising fossil fuel burning and land use changes have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the Earth's atmosphere. These greenhouse gases include carbon dioxide (CO2), methane (CH4) and nitrogen dioxide (N2O), and a rise in these gases has caused a rise in the amount of heat from the sun withheld in the Earth's atmosphere, heat that would normally be radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change.

Keywords : *earth's atmosphere, ecosystems, green house gases, soil erosion.*

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To Study the Role Played by Green House Gasses on Climatic Change and its Further Effect on Agriculture

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Abstract - Rising fossil fuel burning and land use changes have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the Earth's atmosphere. These greenhouse gases include carbon dioxide (CO2), methane (CH4) and nitrogen dioxide (N2O), and a rise in these gases has caused a rise in the amount of heat from the sun withheld in the Earth's atmosphere, heat that would normally be radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change.

Climate change will have wide-ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. Changes in rainfall pattern are likely to lead to severe water shortages and/or flooding. Melting of glaciers can cause flooding and soil erosion. Rising temperatures will cause shifts in crop growing seasons which affects food security and changes in the distribution of disease vectors putting more people at risk from diseases such as malaria and dengue fever. Temperature increases will potentially severely increase rates of extinction for many habitats and species (up to 30 per cent with a 2° C rise in temperature).

Keywords : earth's atmosphere, ecosystems, green house gases, soil erosion.

I. Introduction

Broad scientific agreement now exists that continued accumulation of heat-trapping "green-house" gases in the atmosphere will eventually lead to changes in the global climate, and in the climates of regions around the world. The agreement is expressed in the 1996 report of the Intergovernmental Panel on Climate Change (IPCC), an international body of leading natural and social scientists sponsored by the United Nations Environment Programmed and the World Meteorological Organization. According to the panel's report, an increase in atmospheric concentrations of greenhouse gases equivalent to a doubling of carbon dioxide (CO2) will force a rise in global average surface temperature of 1.0 to 3.5 degrees Celsius by 2100. Average precipitation also will rise as much 10 to 15 percent because a warmer atmosphere holds more water.

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The general circulation models (GCMs) that the IPCC used to analyze climate change are in reasonably good agreement that with a doubling of atmospheric CO2 the global average temperature will rise within the range of 1.0 to 3.5 degrees Celsius, as indicated above. The models also agree reasonably well that the northern latitudes will warm more than the tropics. With respect to all other regional changes, however, agreement among the models is poor. Because human activities and ecological systems are highly variable among regions, this lack of accord greatly complicates the task of estimating the impacts of the changes on activities of interest to humans.

Despite this limitation, much useful work has been done on estimating the potential impacts of different climate change scenarios. In this paper potential climate change impacts on agriculture are examined on both a global scale and with regard to the United States in particular. Even if the reader's interest lies only in the impact on the United States, the global scale still must be considered. U.S. agriculture is inextricably entwined with agriculture worldwide. What might happen nationally cannot be understood without taking account of impacts elsewhere in the world.

II. Global Impacts

The IPCC report estimates climate change impacts on grain production at the global level and then zeros in on the estimated effect on the developed countries (DCs) of North America and Europe as well as on the less developed countries (LDCs) of Asia, Africa, and Latin America. 2 (Grain is often used as a proxy for all food because it accounts for over half of all food calories consumed in the world.) The sources of the IPCC estimates are the three different GCMs, reflecting four different scenarios for estimating climate change impact on grain production.

- First scenario - Disregards any adjustment that farmers might make to offset the impacts of climate change on grain production, and disregards the effects on production of an atmosphere richer in CO2. (CO2 is essential to plant growth, and much experimental work shows that higher concentrations of it in the atmosphere in fact stimulate such growth);

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- **Second scenario -** Incorporates the CO2 enriching effect on growth;
- **Third scenario -** Includes both the CO2 enriching effect and the effect of modest adjustments that farmers could make using currently known practices, for example, shifting to a different variety of the same crop and changing the planting date by less than one month in response to a change in the length of the growing season;
- **Fourth scenario -** Includes the CO2 effect on growth, the modest adjustments to farming just mentioned, as well as more ambitious adjustments, such as shifting to an entirely different crop, changing the planting date by more than one month, and using more irrigation.

Note : The farming adjustments considered in the IPCC scenarios apparently *did not include* developing entirely new crop varieties designed to be more productive under changed climate conditions. However, research done on the impacts of climate change in the Midwestern United States indicates that such new technologies could potentially offset much of the negative effects of climate change on crop production. And, since the climate change contemplated is not expected to be fully realized until sometime in the second half of the next century, plenty of time is still available for researchers to develop the new technologies needed to make this most advanced type of adjustment (see further discussion of this adjustment in the account of impacts on U.S. agriculture, below).

The IPCC analyses of the four scenarios are summarized in Table 1. The range in each entry reflects differences in the results obtained with the various climate models. Notably, the CO2 fertilization effect substantially reduces yield losses and may even lead to net increases in grain output in developed countries as a whole. Smaller but significant offsets are obtained by allowing for adaptive behavior by farmers. Notwithstanding these adjustments and offsets, however, climate change is indicated by the IPCC report to reduce grain yields in developing nations, underscoring the greater vulnerability of these countries.

The sharp difference in impact that climate change is expected to have on grain production in developed as opposed to less developed countries has two main causes. The first one might be called the "physical" factor. As noted above, the GCMs estimate that the high latitudes will warm more than the tropics. Most of the DCs are in the northern latitudes, and their agriculture would benefit from the longer growing seasons that a warmer climate would bring. Most LDCs, on the other hand, include much terrain in the tropics where the negative effects of a warmer climate would not be offset by other favorable trends.

The second reason might be called the "eco-structural" factor. The IPCC notes that, compared with the LDCs, the DCs have much greater economic resources that can be devoted to helping farmers adjust to climate change. In addition, the institutional structures of the DCs appear to be more efficient than those in the LDCs in mobilizing the resources needed to pursue specific social objectives, whether they be adjustments to climate change or anything else.

If the GCMs are right in predicting generally beneficial climate change in the northern latitudes, then the physical factor accounting for the difference in impacts on the DCs and the LDCs would seem to be pretty much fixed. But the effect of the eco-structural factor may be more malleable. In east and south east Asia, and to a lesser extent in south Asia, agricultural performance over the last 10 to 15 years has been impressive. Farmers have adopted new, more productive technologies as they have become available and production, both per person and per hectare, has increased. This strong agricultural performance has been part of a generally impressive economic performance in the countries of those regions.

It is not clear why some Asian countries have been so much more successful than countries in Latin America, and especially in Africa. Their success does suggest, however, that the eco structural weaknesses so common now among the LDCs are not fixed for all time. The Asian experience offers some promise that, given time and incentive to improve their material standard, farmers in other LDCs can and will seize the opportunities presented. This prospect provides some reason to hope that by the time that climate change begins to impinge negatively on LDCs, they will have developed a capacity to adjust to it well beyond what they could accomplish under present conditions. If so, the differences between the DCs and LDCs in terms of the effects of climate change on grain production could be much less than the 1996 IPCC report suggests.

Recent studies done at the U.S. Department of Agriculture (USDA) and by Cynthia Rosenzweig and Martin Parry generally support the findings of the 1996 IPCC report about the global impacts of climate change on agriculture. A 1995 USDA study, for example, indicates that-overall-the impacts would be small, taking into account adjustments in agriculture and other sectors of the economy made possible by wide trading opportunities among countries. Specifically, the study showed that, given these trading opportunities, gross world economic product in the face of climate change would be 0.2 less-or 0.1 percent more-than it would be in the absence of climate change. Allowing for trading opportunities and farm-level adjustments, including the ability of farmers to move land into and out of production depending on the economic effects of climate change, the study found that world cereal production would increase 0.2 to 1.2 percent. *These results did not include the positive production effects of CO2 enrichment.*

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Table 1 : Estimated Percentage Grain Production Changes from Climate Change

Scenario	World	Developed Countriesz	Developing Countries (Asia, Africa, Latin America)
No offsetting effects considered	-11 to -20	-4 to -24	-14 to -16
Including CO2 fertilization effect	-1 to -8	-4 to +11	-9 to -11
Including CO2 fertilization and Modest farmer adaptation	0 to -5	+2 to +11	-9 to -13
Including CO2 fertilization and more ambitious farmer adaptation	-2 to +1	+4 to +14	-6 to -7

Rosenzweig and Parry also estimated changes in cereal prices resulting from climate induced changes in production. The direction of change is consistent with well-established knowledge about price-production relationships in agriculture: Prices are what economists call "inelastic," that is, a given percentage change in production is associated with a significantly greater "opposite direction" percentage change in price. That is, a given percentage decline in production because of climate change would result in a greater percentage increase in prices, and vice versa for production increases.

III. U. S. Impacts

The 1995 USDA study mentioned above found that in the United States both crop and animal output would fall under the type of long-term climate change likely to occur in response to a doubling of atmospheric CO2 (hereafter written 2XCO2). The model used in this study took account of climate change impacts elsewhere in the world, and the consequent changes in U.S. trading opportunities in agricultural commodities. The crop production declines in the United States would be small, from 0.8 percent to 3.4 percent. Livestock production would fall between 0.5 percent and 1.3 percent.

IV. Policy Issues and Caveats

In thinking about policy issues related to prospects for global agricultural development, especially in the LDCs (where, studies show, over 90 percent of the increase in global demands for food will occur over the next 30 or 40 years), the prospective impact of climate change is at most of secondary importance. Studies done to date show that the impact on the already struggling LDCs is likely to be negative, but not disastrous (according to the IPCC report production would be down only 6 to 8 percent after accounting for on-farm adjustments). Moreover, by the time climate change impacts become significant in the middle of the next century, LDCs should be in much better shape to deal with the impacts than they are now. This will be especially the case if the world trading system in agricultural commodities remains as robust as it presently is and if the global impacts of climate change on agriculture are small (or positive). I return to these caveats below.

In addition, the amount of time before climate change impacts occur is expected to be long relative to the time needed to develop technological and managerial responses. Many of the farm level responses incorporated into the impact models described above are already known to farmers and suppliers of farm inputs. They could be adopted in a year or two. To develop entirely new technologies and practices better adapted to the changed climate, the elapsed time from beginning of research to the availability of results to farmers would be some 10 to 20 years. Thus, if significant impacts on agriculture are not likely to be felt for another 30 or 40 years, there is time to develop technological responses, if investments in agricultural research do not lag. Only development of large surface irrigation projects involves a time span comparable to that expected before the impacts of climate change on agriculture are felt. And most irrigation systems developed over the last decade or so operate by pumping groundwater. These systems require much less time to develop than surface systems.

Quite apart from the relatively long-term issue of climate change impact, many LDCs-especially in Africa but also to some extent in Latin America and parts of Asia-face immediate problems that are severe. These problems inhibit achievement of sustainable agricultural systems-6 systems that can meet rising demands for food and other agricultural commodities at socially acceptable economic and environmental costs into the indefinite future. Natural resource degradation is serious in some parts of those countries, but recent studies indicate that, in general-and contrary to a widely held view-degradation of land and water resources is not a major threat to agricultural sustainability in the LDCs. The critical issue, rather, is whether in the immediate future and over the next several decades these countries can develop the capacity to increasingly

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expand the knowledge base needed to achieve sustainable agricultural systems.

The needed knowledge is embodied in people, technology, and institutions. Over the last thirty years food output per person has increased 15 to 20 percent in the LDCs as a whole (but not in Africa). Farmers are better educated and trained, new technologies-those embodied in the Green Revolution being the outstay-nding examples-have been developed and widely adopted by farmers, and institutional performance has improved as people have become more aware of the importance of markets and secure property rights in providing farmers the incentives they need to adopt new technology.

Now, however, evidence suggests that the systems that generated the powerful increases in the three kinds of knowledge are in jeopardy. In Africa, for example, where supplies of the three kinds of knowledge are in particularly short supply, investments in rural education, after advancing smartly in the 1960s and 1970s, declined sharply in the 1980s and have not yet shown much evidence of a turn-around. Spending on agricultural research in that region also has declined in recent years, precisely the period when it should have been increasing robustly if Africa is to achieve sustain-nable agricultural systems. According to studies done at the International Food Policy Research Institute, agricultural research spending elsewhere in the developing world also is either declining in absolute amount, or the rates of increase in such spending are down sharply.

These threats to the knowledge base needed for continued progress in LDC agriculture is immediate and of major importance. If the threats can be overcome, LDC agriculture will prosper and, by the time the climate may change significantly, those countries will be in a reasonably strong position to deal with its consequences. If the threats are not overcome, the resulting economic, social, and political consequences over the next few decades will make the consequences of climate change pall in significance.

V. Implicit Assumptions

The assertion that, from a policy standpoint, the agricultural consequences of climate change on LDCs are relatively less important than other problems of agricultural development in those countries hinges on four so far implicit assumptions. One is that the GCMs used in climate change research give a reasonably accurate account of the changes that might occur, at least on global and continental scales. However, enormous uncertainty still surrounds most aspects of climate change, particularly its characteristics on sub continental and smaller regional scales. It is on these scales that, as the saying go, "the rubber hits the road," that is, where we need to know in some detail how the climate might change. We do not now know this.

A second implicit assumption is that the climate will change in what climate researchers call a "linear" fashion. That is, it will evolve without major ups and downs from what it is today to whatever it will be at equilibrium with 2XCO2 warming sometime in the second half of the next century. The assumed gradualness of the process underlies the thought that society will have time to adjust to whatever climate change may bring. The assumption of linear change, however, may prove unfounded. Some evidence from the ancient climate record suggests that, occasionally, for unknown reasons, the world's climate has changed in a rather short and chaotic fashion. If global warming produced such a response, the consequences for agriculture could be more severe. Even "linear" climate change could increase the frequency of extreme weather events, with more pronounced periods of drought and flooding. These possibilities are not picked up in the relatively benign scenarios of the IPCC and of the other researchers referred to above.

VI. Conclusion

The conclusion that the impact of climate change on global and LDC agriculture will prove less important than other issues also assumes that the impacts will be limited to those resulting from 2XCO2 warming. But the focus on 2XCO2 is simply an analytical convenience adopted by climate researchers. Nowhere is it written that the atmospheric accumulation of CO2 and other greenhouse gases must stop at an equivalent of 2XC02. Unless measures are taken to eventually bring the emissions of these gases to a level where they can be absorbed by the oceans and the terrestrial biosphere, they will continue to accumulate in the atmosphere and continue to warm the earth beyond what might occur with 2XCO2. In this case, all the studies of climate change consequence reviewed above likely would prove to be irrelevant.

Finally, the conclusion that the climate change impact on LDC agriculture is of relatively small importance assumes that LDCs will continue to make good economic progress, and that the world trading system in agricultural products will be no less robust than it is now. Both of these assumptions underlie the argument that, by the time climate change begins to pose a threat to their agriculture, LDCs will be in much better shape than now to deal with the threat. If either of the assumptions fails, then the conclusion probably would no longer be warranted.

These caveats must be kept "up front" in thinking about climate change and its consequences for global and LDC agriculture. Given that, we nonetheless must go with what we think we presently know about these consequences. What we think we know supports the conclusion that DC agriculture may in fact benefit from the kind of climate change likely to result from the conclusion that DC agriculture may in fact benefit

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from the kind of climate change likely to result from 2XCO2 warming. And, although climate change is likely to damage LDC agriculture, the LDCs face other immediate threats that far outweigh the distant ones that climate change may bring.

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Challenges of Integrating Disaster Risk Management and Climate Change Adaptation Policies at the National Level: Bangladesh as a Case

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Abstract - Disaster management and climate change adaptation emerges as the greatest long term threats that are challenging overall development efforts of Bangladesh. Government of Bangladesh is playing a central role for disaster management and climate change adaptation. The Ministry of Food and Disaster Management (Mo FDM) and the Ministry of Environment and Forestry (Mo EF) are the two key ministries responsible for developing and implementing various programs and policies for disaster management and climate change adaptation respectively. This paper discusses the challenges for linking disaster management and climate change adaptation in Bangladesh. Structural arrangements, policy development process, funding arrangement of the Mo FDM and Mo EF have analysed to understand the challenges for integration.

Keywords : *disaster risk reduction, climate change, disaster management, adaptation, sustainable develop-ment, Bangladesh.*

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Challenges of Integrating Disaster Risk Management and Climate Change Adaptation Policies at the National Level: Bangladesh as a Case

Zaheed Hasan [α], Sabiha Akhter [σ], Shammi Ahmed [ρ] & Alamgir Kabir [ω]

Abstract - Disaster management and climate change adaptation emerges as the greatest long term threats that are challenging overall development efforts of Bangladesh. Government of Bangladesh is playing a central role for disaster management and climate change adaptation. The Ministry of Food and Disaster Management (Mo FDM) and the Ministry of Environment and Forestry (Mo EF) are the two key ministries responsible for developing and implementing various programs and policies for disaster management and climate change adaptation respectively. This paper discusses the challenges for linking disaster management and climate change adaptation in Bangladesh. Structural arrangements, policy development process, funding arrangement of the Mo FDM and Mo EF have analysed to understand the challenges for integration. We find that to some extent Mo FDM and Mo EF are institutionally linked for policy development. However, there are scopes for further integration between the two ministries especially in the areas of inter-ministerial communication and collaboration. A new approach for institutional arrangement is needed which is flexible enough to support continual collaboration of the two ministries.

Keywords : disaster risk reduction, climate change, disaster management, adaptation, sustainable development, Bangladesh.

I. Introduction

Due to geographic location, high population density, wide spread poverty and poor infrastructure, Bangladesh is historically vulnerable to natural and manmade disasters. Recently, climate change has added new dimensions to the country's already existing socio economic and environmental vulnerability. Various scientific research indicate that Bangladesh is highly likely to be one of the worst victims of climate change (GOB, 2009). Climate change is posing serious threats to country's overall programs and policies for development (GOB, 2009, GOB, 2011). Considering the disasters and anticipated impacts of climate change, the government of Bangladesh has prioritized and strengthened the areas of policy development both for the disaster management and the climate change adaptation. Two separate ministries, namely the Ministry of Food and Disaster Management (MoFDM) and the Ministry of Environment and Forestry (MoEF) are primarily responsible for disaster risk management and climate change adaptation respectively. The programs and policies of the two ministries focus on to reduce vulnerabilities to achieve development goals of the country. Given the strong similarities in the nature of work of the two ministries, we argue that there is a need for further integration. We seek to explore the relation-ships between the two ministries and find out the scope for and challenges to integration. First we compare the theoretical concepts of DRR and CCA to understand the nature and scope of work. Secondly, we analyze the institutional framework and policy development, funding process for the ministries responsible for the DRR and the CCA in Bangladesh. We argue that there are scope and immediate need for further integration between the MoFDM and the MoEF, especially in the areas of knowledge sharing and policy development. However, considerable conceptual and structural challenges are evident for integration of the two ministries.

II. Exploring the Concepts

a) Disaster Risk Reduction (DRR)

Before the 1970s, disasters were viewed as natural events which were unavoidable and needed to be managed. Consequently there was no concept of prior management of risk reduction (White, 1945, Bankoff, 2001). Since 1980s views on disaster management has shifted sharply. According to the view ecological and socio-economic vulnerability of the disasters can be reduced through proper disaster management and planning (Torry, 1978, Hewitt, 1983, Gaillard, 2007, Weichselgartner and Obersteiner, 2002).

United Nations International Strategy for Disaster Risk Reduction (UNISDR) defines DRR is "a concept and practice of reducing disaster risks through systematic efforts to analyze and reduce the causal factors of disasters. Reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment and improving preparedness for adverse events are all examples of disaster risk reduction" (UNISDR, 2009

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Page 10). DRR is multi-disciplinary in nature that includes disciplines like disaster management and mitigation (Pearce, 2003). DRR recognizes the importance of links between hazards, socio economic and natural environment (Lewis, 1999; Tran and Shaw, 2007). DRR strategies include hazards, vulnerability and capacity assessment. Goals of disaster risk reduction strategies are to identify solutions for disaster risk and to improve community's ability to protect itself against disaster vulnerabilities (Wisner, 2004). However, to achieve the disaster management goals, it is important that the government and the development partner's disaster management strategies have to be properly linked with grassroots strategies. Local government role is crucial for effective implementation of DRR strategies (Anderson and Woodrow, 1989; O'Brien et al., 2006).

Unsound disaster management policy and practices might increase disaster risk and disaster losses. Therefore, to reduce the vulnerability and to ensure sustainable development it is important to have a proper disaster management policy. For the development and implementation of an acceptable DRR it is important to involve the effected community, government sector, professional and private sectors and development partners (UNISDR, 2009). The objective of DRR is to create resilient community by reducing natural and manmade hazards vulnerability through proper development policies and efforts (Smith and Petley, 2009).

b) Climate Change Adaptation (CCA)

The IPCC defines "climate change adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2001). Adaptation includes deliberate or intent adjustments in a biological and social system due to changed environmental circumstances (Gallopin 2006; Nelson et al. 2007 cited by Adger et. al. 2009). Adaptation along with mitigation is an important policy response to protect the society and the ecosystem from the future threat of climate change.

III. Similarities and Difference- Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA)

A good number of researchers, practitioners and policy makers have recently focused on the similarities and difference between DDR and CCA (Schipper and Pelling, 2006, Birkman et al., 2009, O'Brien et al., 2006, Mercer, 2010, Schipper, 2009). These researchers have found that while there are some political and physical distinctions between the scopes of each field, there are key areas of similarities. For example both DRR and CCA focus on risk management and sustainable development. Researchers advocates the increased convergence, whilst recognizing the difference between DRR and CCA agendas (Djalante and Thomalla, 2009, Mitchell and van Aalst, 2008) and discussions have occurred across academics, governments, NGOs and development agencies on how to achieve sustainable integration (Mercer, 2010, Birkmann and von Teichman, 2010, Gero et al., 2011).

One conceptual distinction is that DRR addresses all types of hazards that include natural and manmade hazards while CCA mainly focuses on the dynamics of climate. Adaptation is viewed as a long term process for adjustments to both extreme events as well as incremental changes which are not necessarily always negative; whereas disaster is always negative (Schipper, 2009).

Some key terms are being used and understood differently by different communities in practice of DRR and CCA which could create some misunderstanding and confusions. For example, one of the well-recognized terms which have an entirely different meaning in CCA and DRR context is 'mitigation'. Under the CCA context, mitigation means "reduction of greenhouse gas emission", while in DRR "mitigation means the set of activities to reduce expected impacts of hazards" (Schipper, 2009).

Again the key actors of climate change adaptation and disaster management are different. Climate change research and programs are highly influenced by academics, scientists, donor agencies, and some specialized NGOs. Climate change adaptation policies in Bangladesh clearly influenced by top-down approach (Burton et al., 2002). On the other hand for the DRR it is the local level from where all the planning and programs starts. Due to difference in actors for the climate change adaptation and disaster risk reduction, there are differences in legislation and approaches.

Another distinction between CCA and DRR is that people can relate to disaster risk management as a tangible concept with which they have direct or indirect personal experiences. On the other hand, concept of climate change is difficult to understand. Climate change is a vague concept for many (Schipper, 2009). The similarities and differences of CCA and DRR are summarized in Table 1.

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Table 1 : Similarities and difference - DRR and CCA

Similarities	Differences
— Risk management — Focus on sustainable development — Does not apply "quick fix" approach — Protection of ecology and society are important challenges for both	— Different meaning for different terminology — Different actors responsible for policy formulation and implementation — CCA is more about responding to gradual and incremental changes. DRR is more about responding to emergencies — Generally communities have more understanding about DRR and less understanding about CCA — DRR use less technical language compare to CCA — Adaptation could be a response to positive and/or negative changes. Disaster is always viewed as negative — Sometime people perceive CCA as abstract and DRR as real

Source: (Thomalla et al., 2006, Schipper, 2009)

IV. Methodology

The objective of the study is to determine the scope and challenges of integrating the two government ministries responsible for developing and implementing disaster risk management and climate change adaptation programs and policies in Bangladesh. To address the objective, a number of data collection methods and techniques were applied. Secondary data were collected from various published documents of Bangladesh government and development partners. Ministry of Environment and Forest (MoEF), Ministry of Food and Disaster Management (MoFDM), Bangladesh climate change cell, various UN agencies, Inter governmental Panel of Climate Change (IPCC) and various scientific journals forms the secondary source of information for this research. Secondary information was collected focusing on the following topics

- Hazards in Bangladesh
- Institutional framework of the two ministries, MoEF and MoFDM
- Policy development process of the two ministries
- The various factors involved in policy development process for the DRR and CCA in Bangladesh
- The data collected for this research are mainly qualitative type. After conducting a literature survey and content analysis, the scope of and challenges to integration of DRR and CCA in Bangladesh were identified and explained.

V. Scope of Work for the Ministries Responsible for DRR and CCA in Bangladesh

Geographic location and river morphology contribute to recurring natural disasters in Bangladesh. Abnormal rainfall and earth quakes in the adjacent Himalayan range add to prevalence of disasters. According to the disaster management bureau, the major hazards in Bangladesh include floods, cyclones, riverbank erosion, storm surge, flash flood, drought, landslides, fire, and infrastructural collapse, ongoing and apprehended climate change effects are predicted to contribute to further disaster risks (GOB, 2011).

The effect of climate change have become more and more visible in last few decades in the forms of changing pattern of rainfall and temperature, prolonged drought, untimely flooding, and increased frequency and intensity of cyclones. Climate change in future will add some more disastrous events and increase intensity and frequency of current natural hazards which will have significant implications on physical, social and economic systems (GOB, 2009, GOB, 2005). Coastal resources upon which more people are dependent are likely to be severely affected due to climate variability and change. It is predicted that a 45 cm rise of sea level may inundate 10 -15% of the land by 2050 resulting in over 35 million climate refugees from the coastal districts. Increased adverse impacts would pose severe challenges to achieve the Millennium Development goals (MDGs) by 2015. The Organization for Economic Cooperation and Development (OECD) and World Bank (WB) estimated that 40% of the development assistance to Bangladesh is at risk due to various impacts of climate change (GOB, 2009).

Due to increasing frequency and intensity of disasters, disaster management and climate change adaptation are recognized crucial for development at the highest political level in the country as well as by the development partners. In the last few decades, the country along with the help of development partners has tried to shift its focus from reactive to pro-active disaster management (UNDP, 2010). In 2003, the Ministry of Food and Disaster Management (MoFDM) launched the Comprehensive Disaster Management Program (CDMP) in partnership with various international development partners like the Department for International Development (DFID), UK, United Nations Development

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Program (UNDP) and the European Commission (EC). In 2010, the government approved the National Plan for Disaster Management (NPDM), 2010-2015. The plan was developed in line with the Hyogo Framework of Action 2005-2015 and the South Asian Association of Regional Cooperation (SAARC) Framework on disaster management (GOB, 2010).

The concept of climate change adaptation is relatively new in Bangladesh. National Programmer of Action (NAPA) for Bangladesh was prepared by the Ministry of Environment and Forest (MoEF) in 2005. NAPA was prepared following the guidelines of the seventh session of the Conference of the Parties (COP7) of the United Nations Framework Conventions on Climate Change (UNFCCC). The NAPA was updated in 2009 and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) were also developed by the government in the same year (GOB, 2005, GOB, 2009). Table 2 summarizes the key hazards in Bangladesh identified by the National Plan for Disaster Management 2010-2015 and the Bangladesh Climate Change Strategy and Action Plan 2009. It is important to note that all the national level disaster management and climate change adaptation strategies were focused on to reduce vulnerability and to ensure sustainable development of Bangladesh (GOB, 2005, GOB, 2009, GOB, 2010).

Table 2 : Hazards in Bangladesh

Key hazards identified by National Plan for Disaster Management (NPDM), 2010	Key hazards identified by Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009
Natural and manmade disasters	Natural disasters
Floods	Floods
Droughts	Droughts
Cyclones and storm surges	Cyclones and storm surges
River bank erosion	Change of river morphology
Salinity intrusion	Salinity intrusion
Earth quakes	Water pollution
Arsenic contamination	Erratic rain fall
Tsunami	Erratic tidal wave
Fire	Change in average temperature
Infrastructural collapse	Sea level rises
Landslide	Increase average temperature
	Salt water intrusion
	Land inundation
	Loss of bio-diversity

VI. Current Institutional Framework for the DRR and the CCA in Bangladesh

a) Institutional framework for DRR

Over time, Bangladesh has managed to develop somewhat efficient institutional mechanism, both at national and regional level, to response and recover effectively after extreme climatic events (Khan and Rahman, 2007). Following colossal floods in the 1980s, the government with support from the United Nations Development Program (UNDP) developed a flood action plan that initiated a proactive culture of disaster management. At that point the government introduced number of institutes for forecasting for example the Flood Forecasting& Warning Centers and initiates some pilot projects to reduce vulnerability and disasters risk. A catastrophic cyclone in the 1991 spurred additional actions. With help from the UNDP, the Government established the Disaster Management Bureau. The main objective of the bureau was reducing the human, economic and environmental costs of disasters and strengthening national capacities as well as cross-sect oral partnerships. The new bureau became the institutional foundation towards integrated approach to disaster management.Between1994 and 2002, the UNDP supported the development of policies that empower and ensure better coordination of government departments responsible for disaster management. In the early 2000s, the disaster management approach was further consolidated. The government established the National Disaster Management Council (NDMC) that embraced civil society organizations and local government authorities into disaster management. The UNDP supported this consolidation through the multi-donor Comprehensive Disaster Management Programmer (CDMP). This Programmer led to revised policies, strategies and mechanisms for disaster management in details. Bangladesh became a pioneer among the least developed countries in prioritizing disaster risk reduction in national fiscal planning (UNDP 2010).

In Bangladesh at national level, the Ministry of Food and Disaster Management (MoFDM) and the Disaster Management and Relief Division (DM&RD) coordinate overall disaster management efforts. The Earthquake Preparedness and Awareness Committee (EPAC), the Cyclone Preparedness Program Implementation Board (CPPIB), the Cyclone Preparedness

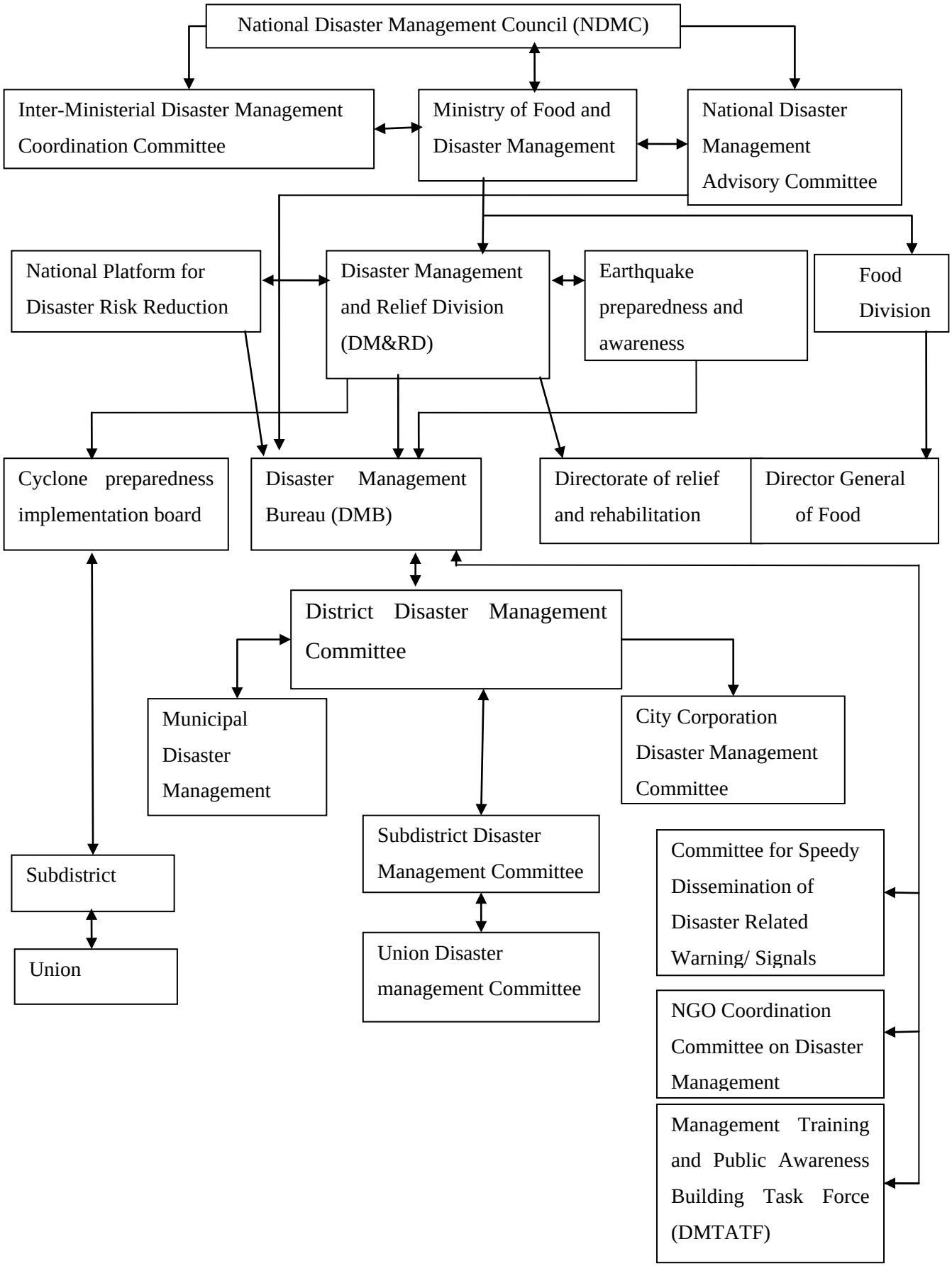
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entation Board (CPPIB), the Cyclone Preparedness Programmer Policy Committee (CPPPC) also coordinates with the Disaster Management Bureau (DMB) for implementations of their respective policies and programs. The NGO Coordination Committee on Disaster Management (NGOCC) reviews and coordinates the activities with the NGOs (as shown in figure 1).

At every district, sub-district and union level there are disaster management committees. The Disaster Management Bureau (DMB) provides all the support required by all the disaster management committee. In 1997, the ministry issued a Standing Orders on Disasters (SOD) which describes in detail the duties and responsibilities of all the concerned government agencies for disaster management. Institutional arrangements for disaster management at national, sub-national and regional level in Bangladesh are shown in figure 1.

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Figure 1 : Disaster Management institutes in Bangladesh (Source: GOB 2010 Page 43)



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b) Institutional framework for CCA

In Bangladesh, the Ministry of Environment and Forests (MoEF) is primarily responsible for development, planning and coordinating all the projects related to environment and climate change. All most all the key ministries work with MoEF for the development of pro climate change adaptation policies and projects. Many other public, private, civil society institutes, international agencies, directly and indirectly, work with the MoEF(GOB, 2009, GOB, 2005).At the regional and local level related government departments are responsible for implementing policies and programs related to environment and climate change(GOB, 2012, GOB, 2009).

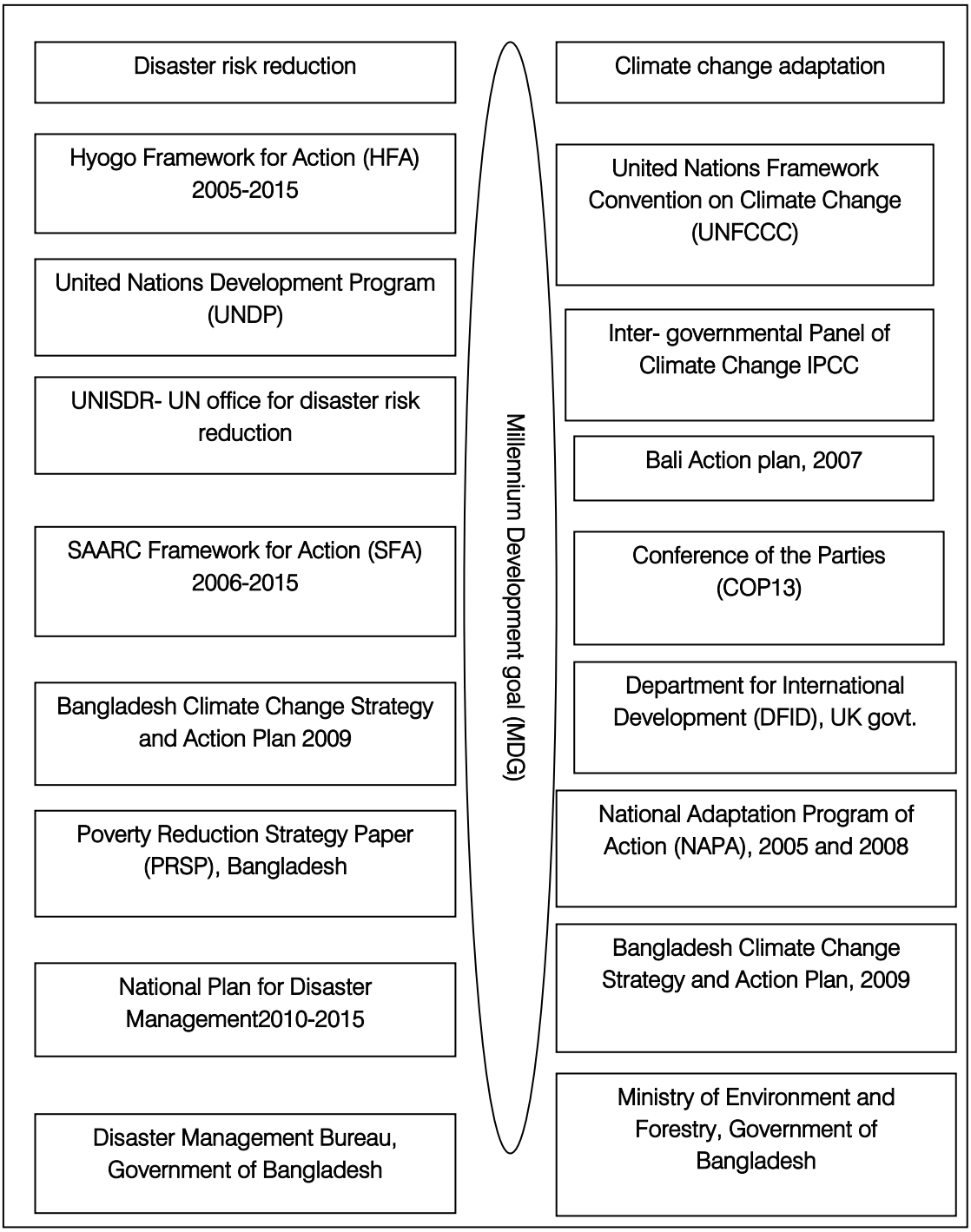
VII. Key Institutions for Policy Development for the DRR and the CCA

In Bangladesh, the major missions and visions of the government for the disaster management have been addressed in the National Plan for Disaster Management2010-2015 (NPDM 2010-2015). The NPDM was developed in coordination with various national and international institutes and agencies. Strategic goals for the comprehensive disaster management plan 2010-2015 are drawn from the South Asian Association for Regional Cooperation Disaster Management Framework 2006-2015 (SAARC-DMF 2006-2015). Other institutes and policies that have an impact on the NPDM are the Millennium Development Goals of Bangladesh, the Poverty Reduction Strategy Paper (PRSP), Bangladesh, and Hyogo Framework for Action (HFA) 2005-2015, the United Nations Framework Convention on Climate Change (UNFCCC), and the Bangladesh Climate Change Strategy and Action Plan 2009.

In 2005, the Bangladesh government has developed the National Adaptation Program of Action (NAPA), 2005 after consultation with communities across the country, professional groups, members of civil societies and following the guidelines of the United Nations Framework Convention on Climate Change (UNFCCC). After the climate change Conference of the Parties 13 (COP13) at Bali, Indonesia, in 2007, the Bangladesh government increasingly felt the need for a climate change strategy to coordinate the activities in support for the Bali action plan. The Bangladesh Climate Change Strategy and Action Plan (BCCSAP) have developed in line with the NAPA, Bangladesh. Table 3 shows the key drivers for the major policies and strategies for DRR and CCA.

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Table 3 : Global to national drivers for the DRR and the CCA policy framework



VIII. Funding for the DRR and the CCA in Bangladesh

Funding for the DRR and the CCA in Bangladesh are sourced from international donors, national budgets and private sector donors.

For the disaster management main funding sources are the government, the European Commission, the Department for International Development (DFID), UK and the United Nation Development Program (UNDP) (UNOPS, 2004). Bangladesh Climate Change Resilience Fund (BCCRF) is a multi-donor trust fund established by Sweden, The United Kingdom, Denmark, Switzerland and the European Union (EU) in 2010, together with the Government of Bangladesh and the World Bank (WB). The aim of the BCCRF is funding the projects which are recommended by the Bangladesh Climate Change Strategy and Action Plan. The fund is managed by the World Bank and the fund complements to the Bangladesh government's local fund for climate change adaptation (Sida, 2011). The World Bank (WB) does the

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review and revision of the projects recommended by the Bangladesh government. It has been argued that such role of the WB influences project design and approval (Md Shamsuddoha and Chowdhury, 2009).

IX. Scope for and Challenges of Integration

a) Scope of the work

There are similarities and differences in the nature and scope of the work of DRR and CCA in Bangladesh (see table 2). At national and regional level, CCA mainly focuses on the issues related to climatic events, where-as DRR focuses on any kind of manmade and natural disasters. Moreover, climate change information and projects have developed at a global scale, where-as the disaster management approach is mainly based on disasters which happen locally, regionally and nationally. One of the key differences is DRR focuses on emergency management and recovery along with long term sustainable development, whereas CCA mainly focuses on long term sustainability.

b) Administrative challenges

As Table 3 shows, in Bangladesh different administrative bodies with different values and principals are responsible for disaster risk management and climate change adaptation projects. Consequently, the management approach is different with different values and principles. At the same time, some area of the works for the DRR and CCA are complementary to each other, different administrative and management approaches might lead to contradicting strategies while implementing projects at the field level. For example, CCA goals mainly focus on long term adaptation whereas quick recovery from disaster is vital for DRR. It is beyond the scope of this paper to find out whether this kind of contradictions exists at the projects implementation stage. Further empirical research is recommended to find out the possible contradictions of DRR and CCA approach at project implementation stage.

c) Communication of risk and planning tools

Bangladesh has a long experience of disaster response and recovery. The country's institutional arrangements for disaster management are somewhat well organized. A good number of disaster management projects have been successfully developed and implemented at regional and community level with the support of the government, NGOs and donor agencies (ACI, 2010). On the contrary the concept and institutional arrangement for climate change adaptation in Bangladesh is relatively new. Yet interactions between the ministries responsible for climate change adaptation and disaster management in Bangladesh are limited. Lots of employees at the government level are confused about the concept of climate change (Khan and Rahman, 2007, Mirza, 2003).

d) Incoherent policy approach

An obstacle to integration of DRR and CCA can be seen in the fragmentation of development of policy from global to national level. The institutional frameworks and policy development for DRR and CCA are done mostly by different institutions with different values as illustrated in table 3. Consequently, integrating DRR and CCA become more difficult as the respective projects and policies have been developed often following the guidelines and the policies of the different institutions and legislative bodies (see table 3).

e) Different sources of funding

Different bodies are finance different projects related to DRR and CCA in Bangladesh. CCA adaptation projects are highly influenced by their donors. The World Bank (WB) plays a critical role in the disbursement and approval of the projects. On the other hand, DRR projects are mainly approved by the government at a national level and funded by the national government and international agencies (GOB, 2010). Again, at present, the funding agencies for DRR and CCA in Bangladesh are different with different norms and values. The best possible institutional arrangements for approving and funding for DRR and CCA projects is beyond the scope of this paper. However, we suggest that institutional arrangements at an international and national level for funding for both DRR and CCA projects need to be rearranged to achieve further coordination and integration.

f) Community involvement

Community participation in project development stages especially for the CCA is minimal. Greater integration of DRR and CCA can be achieved with community participation into the project planning, development and implementation stages. Communities generally do not differentiate the risks like DRR and CCA legislative bodies (Gero et al., 2010). Thus community involvement in policy development will result in robust, comprehensive and sustainable risk management. At the same time community involvement in policy development would create a link between DRR and CCA.

X. Concluding Remarks

Considering the scope of work and current institutional arrangement, it seems that the two ministries responsible for the DRR and the CCA in Bangladesh would/should remain separate for some time in future. However, there are immediate need and prospect for greater integration between the two ministries. More linkage between the ministries in terms of policy development and exchange of knowledge would reduce possibilities of duplication of efforts, increase efficiency and cost effectiveness. Evaluation of institutional arrangement is necessary to find out feasible ways for improved communication and coordination between the ministries.

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to reduce the vulnerability and to ensure sustainable development of the country.

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