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Fair sharing of Water and Distributional Impact of Climate Change

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Abstract

Management of international and global environmental and natural resources are usually subject to likely externalities. Such externalities are the result of locational, economic, political and technological asymmetries among the states that share them. The international community had developed mechanisms to deal with equity and efficiency aspects of such resources. Yet, those mechanisms known as treaties, fall short of providing sustainable equity measures. This paper examines the fair sharing of water and the distributional impact of climate change, using empirical observations. The paper concludes that both the 1997 Convention on international water and the 1992 Kyoto Protocol to control CO2 emissions (and its CDM mechanism) have not succeeded addressing equity in handling the negative impacts and the allocation of likely benefits from mechanisms that were designed to address these externalities.

Introduction

I would like to start this paper by commenting on a couple of empirical observations related to international and global resources that are shared and affected by different nations. The resources I refer to are climate and water. These resources have been subject to market failure and are governed by treaties that have been designed with efficiency and equity consideration in mind.[1] The feature that characterizes these resources, among many other features, is the distribution of power among the countries involved. This distribution of power is embedded in the use patterns of the resources, which have led also to the market failure associated with their exploitation, and the need for a regime to correct for such failure. In the case of water we find many examples where geographic location and military and political powers affect the *de facto* historical allocation of the water in the shared international waterway, and in many cases led to externality in the form of pollution (Colorado- USA and Mexico) or flooding (Ganges-India and Bangladesh) that affect the downstream riparian state (Dinar, S., 2006). In the case of global warming, past and present emissions, mainly, by industrialized countries, led to a global externality (global public bad) affecting mainly weaker, less industrialized economies (Mendelsohn et al, 2005).

With such impacts of power and level of development on the outcome of unregulated international and global resource regimes, it is no wonder that the literature and the policy dialogue more frequently include equity consideration in addition to the traditional economic benefit-cost analyses (Lange et al., 2007). Equity aspects are important components in the recent climate change negotiations (Ringius et al., 2002), where they enter the welfare levels of the 'losers' and 'gainers' because the special nature of the climate change problem allows decomposing policy interventions into both those affecting climate target greenhouse gas emission reductions and those related to the distribution of cost burdens and compensations, which is crucial in evaluating the equity consequences of any climate regime (Lange et al., 2007).

In the case of international water, geography of the river basin and asymmetric level of economic development of the riparian states leads to power relations that affect the water use in

[1] I will use interchangeably equity and fairness.

the basin and lead to basin externalities. The study of international water treaties (Wolf, 1999; Dinar, S. 2006; 2007) suggest several principles that have been practiced in international water law, the discipline behind international water agreements.

The 1966 Helsinki Rules for managing international water provide guidelines for 'reasonable and equitable' allocation of shared waterway. Article V of the Helsinki Rules includes parameters that have to be taken into account in order to allow for equity considerations. They include (1) basin's geography hydrology, climate; (2) riparian's past and existing water use; (3) economic and social needs of the riparians and the population of each riparian; (4) comparative cost of development of water and availability of alternative water sources; and (5) likely harm to one riparian by use of the water by the other riparian. These guidelines for equity consideration in international water agreement were not effective due to their ambiguity. Equity was interpreted by each riparian to a water body in a different way, leading to many unresolved equity issues in the negotiation process of the water treaty (Wolf, 1999).

The 1997 Convention on the Law of the Non-navigational Uses of International Watercourses was an international effort to provide guidelines for incorporation of equity consideration in international water treaties. It attempted at correcting the shortcoming of the 1961 Helsinki's Rules by providing definition of 'Reasonable and equitable use' of water from an international waterway with an obligation not to cause significant harm, using several factors, such as geography, hydrology, ecology, social and economic needs of the riparian states, population, externalities, and existing and potential uses (Wolf, 1999).

Both the 1961 Helsinki Rules and the 1997 Int'l Water Convention were 'abused' by the countries seeking their own interest in defining what equity rule should govern the allocation of commonly shared water. One can find many nuances used, but all can be categorized into two or three groups of criteria: (1) right-based criteria (first in use first in right, land-based right, water-source-based right); (2) need-based criteria (population-based). Each of these equity considerations is expected to satisfy needs and rights without causing significant or appreciable harm to either riparians; and finally (3) economic criteria for allocation, based on value of marginal unit of water and compensation thereafter (Wolf, 1999).

In the case of climate change agreements, developing countries as well as environmental NGOs in industrialized countries argue that developed countries with high per capita greenhouse gas emissions are responsible for global warming and thus must take the lead in combating climate change both in terms of developing abatement technologies and in terms of being responsible solely for meeting emission reduction targets. As a results, such equity considerations lead to developing countries to face less stringent obligations or complete exemptions from emission reduction targets. While equity considerations are introduced also among industrial countries in the process of emission reduction targets burdens (Raymond, 2003), I will refer mainly to equity considerations among developed and developing countries.

Such as in the case of water, there are several equity principles that dominate the literature on climate change negotiations (Rose et al., 1998; Ringius et al., 2002). These equity considerations include (1) the egalitarian principle, which is based on equal per capita emissions; (2) the sovereignty principle which is based on a percentage reduction of current emissions equal to the share of the country emissions in the global greenhouse gas emissions; (3) the polluter-pays principle, which taxes a country relative to its emission share in order to pay for global abatement costs of greenhouse gas emissions; (4) the ability-to-pay principle, which calculate payment share for global abatement cost based on the country's GDP share in the global GDP (5) The contingent exemption principle, which states that a poor country with a GDP lower than a certain level is exempted from any obligation for greenhouse gas emission reductions until a certain level of GDP per capita is reached, somewhere in the future.

Dealing with equity considerations, Mendelsohn et al., (2005) introduce the concept of compensation (income transfer). They suggest that not only poor countries are exempted from abatement cost, but also that the industrial, rich, nations of the world should address whether a compensation program for poor countries is adequate. Compensation to poor countries has been discussed to help finance mitigation and adaptation, but the most obvious compensation for poor countries is to invest in economic development. This conclusion stems from the findings in their analysis where distributional damages from climate change discriminate significantly poor countries. These countries will bear the brunt of the damages from climate change even though they made only a small or no contribution to cumulative GHG emissions.

In this paper I try to demonstrate whether or not and how were the international and global treaties able to address equity, using data and examples from several case studies and global climate change impact analyses. The next section will introduce a simple model that allows the incorporation of power into resource pollution/utilization levels and explains how power affects the pollution/utilization levels. Section three uses results from several studies that analyze equity consideration in water resources and climate change to demonstrate how poorly our treaties/agreements treat equity. And finally, section four will conclude and extrapolate the discussion, addressing policy implications.

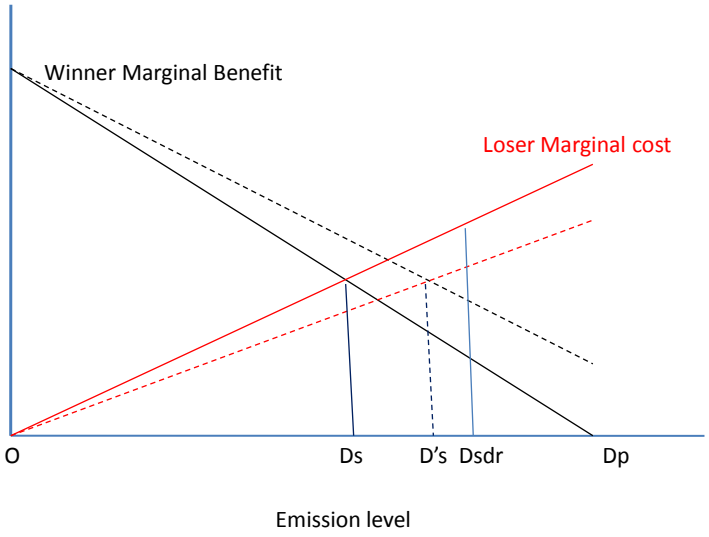
Power and level of emission/extraction

In the simple case of two parties or groups (e.g., rich and poor, upstream and downstream) involved in emission of or extraction from a joint media (atmosphere, river), a great deal of the outcome can be explained by referring to the concept of winners and losers, namely, the ones in the group who net benefits from a policy the two groups agree to implement, or that is imposed on them by a regulator. In other words, the losers lack the power to prevent the winners from imposing cost on them, or withdraw more benefits than their fair share. Following Boyce (2002) it can be argued that the asymmetry power-weighted social decision rule explains such outcome by affecting the valuation of costs and benefits of the policy and by affecting the rate of time preference of the outcomes of policies.

Assume that both the winners have a linear downward marginal benefit function and that the losers have a linear upward cost function. In the case of the solid line functions the social optimum is obtained at D_s. Therefore, any departure from D_s would be interpreted as a result of the asymmetry power-weighted social decision rule that allows the winners to impose level of pollution/extraction that is not socially fair. For example, the point D_{sdr} represents winners that are several times more powerful than the losers.

If the winners and/or the losers are getting richer, this might lead to an optimum that resides within higer emission levels (Figure 1).

Figure 1: Emission/extraction level when parties have power (based on Boyce 2002)



Comment: Dashed lines represent situation after income redistribution

The red and blue dashed lines represent richer winners (higher marginal benefit curve) and richer losers (lower marginal cost curve). D'_s ($>D_s$) represent a social situation where both winners and losers become richer. Intersection between blue solid line and red dashed line as well as intersection between red solid line and blue dashed line represent situations where one group only became richer (say, by income transfer). In these latter cases, still the social optimum leads to higher level of emission/extraction. As can also be seen, the higher the asymmetry of increased power or wealth between the winners and the losers the closer will the corresponding social optimum to the emission/extraction levels that are associated with a situation the both the winners and losers became wealthier.

Equity performance of water allocation arrangements

I will provide three counts skepticism in the ability of existing water allocation arrangements to take care of equity considerations: An analysis of trade in Nile water, an analysis of water and energy exchange in the Aral Sea, and an analysis of riparian complaints for non-compliance with treaty allocation arrangements.

Nile water trade

I start by referring to a study that introduced a cooperative water market structure into the troubled Middle East. The study used the economic concept of trading water and trading efficient water use technologies so that the saved water is traded for its value (Dinar and Wolf, 1994). The regional water market involved the following components. Israel sells water saving advanced irrigation and knowhow to Egypt. A small amount of the Nile water that is saved from technology improvement is sold to Israel and transferred via a canal. Having the additional water Israel releases water to Gaza and to the West Bank from its National Water Carrier. An Engineering-Economic model provided a feasible solution to the regional water market. Dinar and Wolf (1997) compared between several allocation schemes and concluded that all are in the core of the regional game (Dinar and Wolf, 1997). The core equation are presented in equations [1]-[6].

[1] $\beta_i \geq 0\,, \quad i = EG, IL, GS, WB$

[2] $\beta_{EG} + \beta_{IL} \geq 90.70$

[3] $\beta_{EG} + \beta_{GS} \geq 8.00$

[4] $\beta_{EG} + \beta_{IL} + \beta_{GS} \geq 96.30$

[5] $\beta_{EG} + \beta_{IL} + \beta_{WB} \geq 120.90$

[6] $\beta_{EG} + \beta_{EG} + \beta_{GS} + \beta_{WB} = 126.50$

where, β_i is the allocation of water-related benefits to player *i*, and EG, IL, GS, and WB are Egypt, Israel, Gaza Strip, and West Bank respectively.

The core equations suggest that the negotiation set of this game is quite wide (Dinar and Wolf, 1997). A Shapley and a Generalized Shapley allocation schemes applied to the game, satisfy core conditions for individual and group rationality.

Table 1: Shapley and Generalized Shapley Values for a hypothetical Nile water transfer treaty (Million of $US).

Player	EG	IL	GS	WB	Total
Shapley	57.7	56.4	2.4	10.0	126.5
Generalized Shapley	63.7	45.8	2.8	14.2	126.5

Source: Dinar and Wolf (1994)

Do these allocations satisfy also fairness consideration? Egypt is probably the player that would consider the Shapley allocation to be most unfair. The main reason is that Egypt and Israel end up with almost similar payoff from the trade, which may be perceived unfair to Egypt who provides the resource to be traded.[2]

Modeling Aral Sea water and energy swap.

The Aral Sea Basin, shared by 5 asymmetric states, demonstrates the ability of the weak, small upstream states to contemplate strategic arrangements for water and water-related resource exchange, beyond its fair share in the regional allocation of payoffs. Kyrgyz Republic and Tajikistan, two small upstream states have succeeded to convince the three downstream states, Turkmenistan, Uzbekistan, and Kazakhstan, to buy their hydropower that is produced in the summer when the water is released for irrigation in the downstream states irrigated agriculture, in exchange of producing electricity during the winter. The two upstream states face difficulties to produce then electricity in the next winter due to low levels of water in the reservoirs. This agreement is provided in exchange for other sources of energy supplied by the downstream states during the winter.

In the 1992 Bishkek Agreement, supply of oil, coal, and natural gas are exchanged during the winter between the 2 upstream states and the 3 downstream states against water to be

[2] As an anecdotal addition I would say that when the results were introduced to Egyptian colleagues in 1993 they did not comment on the equity aspect but on the legal aspect of Egypt not being able to transfer water out of the Nile basin due to the existing treaty with Sudan.

released during the spring and summer. The problem is that in drier years when upstream states release less water they also receive less fuel and during wet years when downstream states irrigate less they often return less fuel in the winter (Dinar, S., 2005:151). The agreement is also used by the downstream states as a threat, during cold winter times (Dinar A., 2009: 306, Box 16.1).

Dinar A. (2009) applied a cooperative game framework to the Syr Darya basin, following the principles of the 1992 Bishkek Agreement, mainly to test the sustainability and equity/fairness of the treaty under various water supply conditions. The Syr Darya is a sub basin of the Aral Sea, involving three riparian states, Tajikistan (upstream), Uzbekistan (midstream), and Kazakhstan (Downstream). Tajikistan owns the Toktogul reservoir that allows it to store and release water and to produce electricity. The Energy-water swap agreement game was played, following several scenarios of water availability in the river, resulting from impact of future climate change. In that game, the three countries could act unilaterally or cooperatively, investing in reservoir infrastructure, in irrigation improvements, and also by modifying the size of irrigated area.

The results of these simulations were then incorporated into cooperative game theory framework that produced payoff allocations among the riparian states Tajikistan (A), Uzbekistan (B), and Kazakhstan (C) I will not present all results, but only a couple of them that shed light on equity considerations. Table 2 provides a snapshot of several representative results that demonstrate the powerful role of Player A, which goes beyond its regional political, economic, and military capacity. By owning the reservoir, player A actually demonstrate what is called in international water hydropolitics “sovereignty” over the resource. This situation governs many of the international water treaties and allows strong and weaker upstream states to dictate water allocation regimes in international water (e.g., Turkey in the Euphrates-Tigris).

Table 2: Shapley Value allocations (incremental payoffs, Millions of $US) and shares, and Loehman's power index for various regional water allocation scenarios

Scenario	Player	A	B	C	Total
No one invests	Shapley Value Allocation	1173.33	266.33	117.33	1557
	Share in payoff	0.75	0.17	0.08	100
	Loehman Power Index[3]	0.52	0.33	0.15	100
Only A invests	Shapley Value Allocation	1193.33	270.83	121.83	1586
	Share in payoff	0.75	0.17	0.08	100
	Loehman Power Index	0.53	0.32	0.15	100
Only B invests	Shapley Value Allocation	1212.33	336.83	107.83	1657
	Share in payoff	0.73	0.20	0.07	100
	Loehman Power Index	0.52	0.36	0.12	100
Only C invests	Shapley Value Allocation	1190.83	266.33	144.83	1602
	Share in payoff	0.74	0.17	0.09	100
	Loehman Power Index	0.52	0.31	0.17	100
All 3 invest	Shapley Value Allocation	1247.83	341.83	137.33	1727
	Share in payoff	0.72	0.20	0.08	100
	Loehman Power Index	0.52	0.34	0.14	100

Source: Dinar A. (2009).

Table 2 suggests that country A gets the majority of the regional gains resulting from any of the scenarios simulated. Depending on the investment decisions by the basin riparians, A gets always the majority of the incremental payoff (72-75%) and extracts more than 50% of the coalitional gains, even if other players invest in improvements. Thus, A gets a rent to its geographical superiority in the basin.

Conflicts among riparian signatories to int'l water allocation treaties (1953-2005)

While the two case studies of international water described above provide evidence that equity is hard to obtain in international water we still lack the global picture of all hundreds of water treaties signed in the past 150 years. A proxy that measures complains regarding states not

[3] The Loehman Power index α_i compares the gains to the player with the gains to the coalition. $\alpha_i = \frac{\beta_i - v(\{i\})}{\sum_{i \in N}(\beta_i - v(\{i\}))} \quad i \in N, \quad \sum_{i \in N} \alpha_i = 1$. Where β_i is the allocation solution for player i, N is the number of players, and $v(\{i\})$ is the value of the coalition where i acts individually.

respecting allocation agreements over international water can be found in the data used by Dinar S et al., (2009). The data indicates states grievances regarding fairness aspects of bilateral and multilateral treaties. The severity of the grievances was measured on a scale of 0 to -7, with 0 indicating indication of incompliance by officials in the country, and -7 indicating threats to open war.

Table 3: Complaints of signatories to water allocation treaties regarding their fair implementation

Severity[4]	Frequency	Cumulative %
-7	0	0.00
-6	23	2.40
-5	21	4.70
-4	10	5.70
-3	91	15.40
-2	264	43.30
-1	362	81.70
0	173	100.00
Total	944	100.00

Source: unpublished data (Dinar, S. et al., 2009)

The table suggests that during the past 150 years there have been 944 incidents of complaints against existing treaties, the majority of which express mild positions (in the range of 0- -3) and the minority expressing strong positions against the treaty (in the range of -4 -7).[5] My interpretation of these data is that some signatory riparian states to international water treaties do behave in an un-equitable/unfair way as it is being interpreted by at least one of the other signatories to the treaty, indicating that the treaty did not provide an appropriate and sustainable mechanism for fairness.

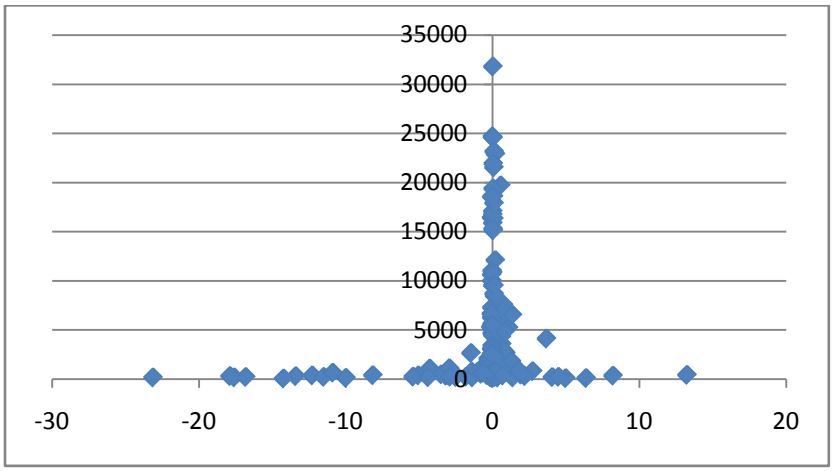
[4] The more negative the number the more sever is the complaint

[5] Some of the treaties have more than one case of complaints. Many of the complaints occur in years where the basin experienced lower water flows than those anticipated in the treaty.

Equity in climate change and its governing treaty mechanisms

Climate change, its impact and policy interventions to mitigate such impacts have stirred emotional discussions regarding the equity and fairness of both the distribution of impacts, and the distribution of benefits from certain mechanisms to offset the impacts. As a global bad, climate change is handled by a supra national regulatory agency. It is obvious that in spite of the effort that is being invested to ensure most equitable treatment of climate change, there are still significant inequalities in both the distribution of impact and the interventions to mitigate it, as can be seen in the analysis below. Mendelsohn et al (2005) estimated market-based impacts of climate change on all countries in the world, using several future scenario models (Global Circulation Models) of precipitation and temperature (Figure 2).

Figure 2: Change in GDP (%) in 2100 in all countries due to climate change impact as a function of the GDP per capita in 1990.

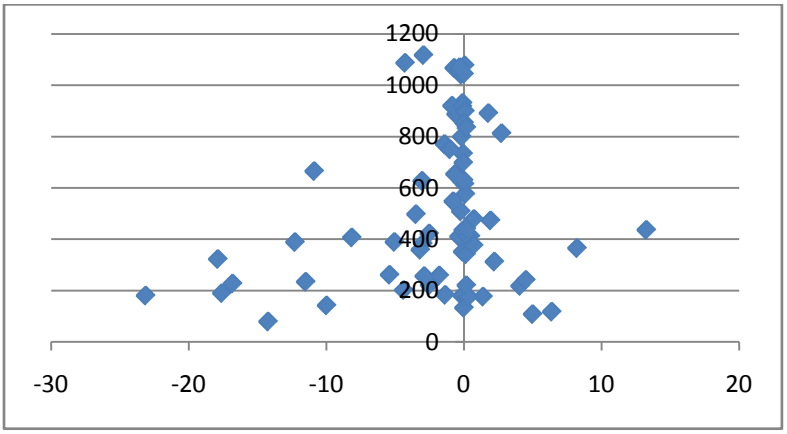


Source: Data in Mendelsohn et al. (2005)

Figure 2 reveals the embedded inequity of the impacts. The change in GDP per capita in the year 2100 is plotted against the GDP per capita in 1990. The impacts, measured as change in GDP in 2100 are distributed such that countries with high GDP per capita in 1990 have a very small change in GDP per capita in 2100 while countries with low per capita GDP in 1990 having a significant impact. It is clearly seen that rich countries, many of which are blamed for contributing to climate change, are barely affected by future climate change.

When focusing on the low income countries, with annual GDP per capita that is lower than $1100 ($3/day), it is clear that the distribution of impact is skewed towards the lower income countries (Figure 3), many of which are in the low latitude countries (Africa and South America, not shown in the figure).

Figure 3: Change in GDP (%) in 2100 in low income countries due to climate change impact as a function of the GDP per capita in 1990.



Source: Data in Mendelsohn et al. (2005)

This inequality in the impact of climate change has been recognized and discussed in various forums. Proposed mechanisms have been proposed, including direct compensations to assist in adaptation measures, subsidized insurance policies to address impact by climate, and a mechanism for investing in economic development of low income countries.

If compensation is considered, how will a compensation program be designed? One idea that has been circulated in the UNFCCC (United Nations Framework Convention on Climate Change) negotiations is to provide some compensation to help poor countries mitigate emissions (see Marrakesh accords at www.unfccc.int). One possibility is that an international fund such as GEF (Global Environmental Facility) could subsidize adaptation. For example, the GEF could provide poor countries with financial and technical support for joint-public adaptations such as water projects, coastal protection, or endangered species protection.

Another possibility is to create a climate impacts insurance fund for low latitude countries. Countries could apply for relief from the fund whenever they suffer a climate impact. Unlike severe events such as hurricanes and floods, the gradual nature of global warming will make it very difficult to estimate and measure damages as they occur.

A final alternative is to compensate low latitude countries by investing in their economic development. Rapid development could help low latitude countries adapt to future climate change by reducing vulnerability although it would increase emissions. As countries develop, they move away from agriculture making their economies more resilient to climate change, and able to improve their technological capacity. An economic development program could address the imbalance between those who currently benefit from emissions and those who are likely to pay the consequences of climate change. A well-designed economic development program would bring large benefits directly to the people of poor countries, such as the clean development mechanism (CDM).

The CDM of the Kyoto Protocol allows emission-reduction projects that assist in creating sustainable development in developing countries to generate "certified emission reductions" (CERs) for use by the investor countries. The CDM mechanism encourages efforts aimed at reducing emissions in two ways: (1) through implementation of efficient activities, technologies and techniques in non Annex B countries (developing countries), and (2) through the possibility for entities subjected to GHG emission targets (Annex B countries) to make additional emission reduction at lesser economic cost.

The CDM provides an opportunity in the form of an intrinsic comparative advantage of developing countries that present a remarkable opportunity for international trade in emission reductions. The developed countries could reduce carbon emissions at costs ranging from $25 to well over $50 per ton of CO2 as compared to many developing countries that could do the same at costs below $5 per ton of CO2. This trade could result, over the longer term, in considerable new and additional sources of finance for developing countries for low carbon energy and infrastructure development and improved land management.

While the CDM mechanism has a great potential to fix the inequality caused by the impact of climate change on the developing world, it effectively was able to secure only the

significant saving in the cost of reducing CO2 by the developed countries. The objective of investing in development objectives in the developing countries was only partly achieved, as can be seen in the following graphs. Therefore, the climate change related inequality between the rich and poor countries has not only remained, but also deepened.

During its first 5 years, the CDM created nearly 3000 projects with a total investment of about $86.5 billion. This is a very impressive performance of the portfolio. However, of the a35 countries defined as non-Annex B ones, only 55 have been involved during the period 2003-2007 in one or more projects (Table 4).

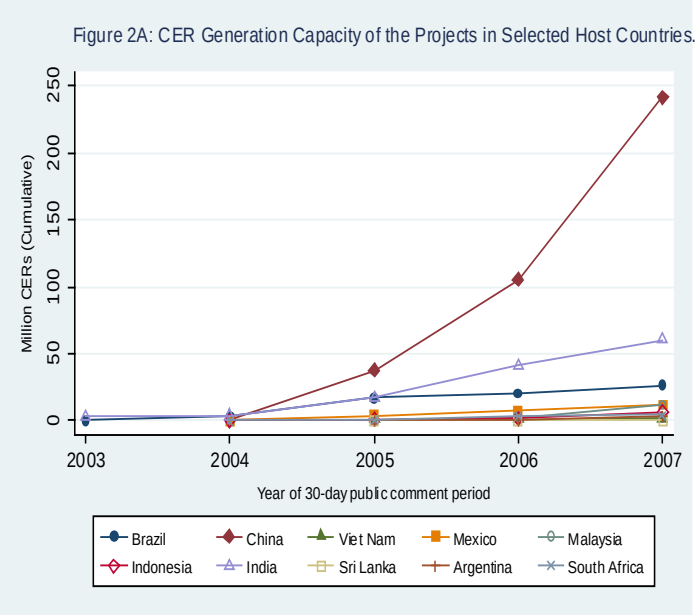
Table 4: CDM projects, investment and Certified Emission Certificates CER, between 2003-2007.

Year[1]	Number of CDM Projects	Number of Developing Countries with Projects	Expected CERs per Year (Million)	Estimated Annual Investments (Million US$)	Expected Total CERs (Million)	Estimated Total Investments (Million US$)
2003	5	5	5.53	9.79	38.75	68.76
2004	53	15	4.78	124.28	36.03	948.49
2005	434	38	91.82	956.81	722.35	7,947.39
2006	840	41	125.45	3,102.03	1,012.72	25,568.32
2007	1,592	53	209.18	6,678.43	1,652.43	52,064.67
Total	2,924	55	436.76	10,871.34	3,462.28	86,597.63

Source: Rahman et al. (2009)

But a closer look at the number of projects per country (Figure 4) suggest that most of the projects are concentrated within a handful of the developing countries, meaning that the CDM benefits are not distributed so that CDM benefits can be claimed to accommodate equity as was originally envisioned.

Figure 4: Distribution of new CERs from CDM projects during 2003-2007.



Source: Rahman et al. (2009).

As can be seen from Figure 4, Brazil, China, India, and Mexico are the major host countries for CDM projects. More than 75 percent of the projects (2,231 of 2,924) submitted for validation during 2003-07 are located in these countries. Brazil and India are among the countries which adopted CDM projects first in 2003 (other countries are Chile, Guatemala, and South Korea). China is a relatively late adopter of CDM (with no projects in 2003 and only 2 projects in 2004), but immediately exceeded Brazil and India both in terms of number of projects. As of December 2007, 961 (33 percent of the total) CDM projects are located in China, which are expected to generate 241.6 million (more than 55 percent) of the total CERs per year. With 836 (29 Percent) projects generating 59.8 million (14 Percent) CERs per year, India is the second largest adopter of CDM among the host countries. As shown in Figure 4, other major host countries include Argentina, Indonesia, Malaysia, South Africa, Sri Lanka, and Viet Nam. On the other hand, Lao PDR is the smallest host country with only 1 CDM project. Other small CDM host countries include Fiji, Guyana, Malta, Mozambique, Singapore, Tajikistan, and

several others. It should be noted that many other developing countries are not involved et all in the CDM operation.

Conclusion and policy implications

International water and climate are resources that their (mis)use is associated with major externalities. International water connect between upstream and downstream riparian states along the river they share. Climate change connects between states that are affected differently, based on their location and of their ability to adapt to change in climate. Recognizing these externalities and the damage or potential damage by one country to others, equity-control mechanisms have been designed into the treaties that govern the allocation of international water and the regulation of the CO2 emission reduction. Both the 1997 Convention on international water and the 1992 Kyoto Protocol to control CO2 emissions (and its CDM mechanism) have not succeeded addressing equity in handling the negative impacts and the allocation of likely benefits from mechanisms that were designed to address these externalities.

It is admittedly not a simple matter to regulate costs and benefits in such complicated international and global resources that involve several users and polluters. While equity has been indicated as an important objective and discussed in many international forums, still, the results have fall short of the objectives. The equity aspects have to be given a similar importance as do get the efficiency of the international and global agreements. A role for policy makers is to adequately introduce equity measures and to monitor their performance over short periods of implementation, and not only when complaints are made by the parties involved. The Millennium Development Goals and their administration could be a good adoptable example for setting standards and monitoring their performance.

Equity should be added to the climate negotiation agenda as well. Specifically, the nations of the world should address whether a compensation program for poor countries is needed. Compensation to poor countries has been discussed to help finance mitigation and adaptation, but the most obvious compensation for poor countries is to invest in economic development. Mendelsohn et al. (2005) suggest some interesting policy interventions to address equity issues):

If compensation is considered, how will a compensation program be designed? One idea that has been circulated in the UNFCCC (United Nations Framework Convention on Climate Change) negotiations is to provide some compensation to help poor countries mitigate emissions (see Marrakesh accords at www.unfccc.int). The Marrakesh accords also recommend holding a workshop to help developing countries insure themselves against the adverse impacts of climate change. The specifics of this idea are not yet developed. One possibility is that an international fund such as GEF (Global Environmental Facility) could subsidize adaptation. For example, the GEF could provide poor countries with financial and technical support for joint-public adaptations such as water projects, coastal protection, or endangered species protection. Efficient programs that support mitigation or adaptation are definitely possible compensation schemes.

Another alternative is to create a climate impacts insurance fund for low latitude countries. Countries could apply for relief from the fund whenever they suffer a climate impact. In practice, this is likely to be difficult to administer because countries will claim harm with every weather event whether or not it is related to greenhouse gases. Unlike severe events such as hurricanes and floods, the gradual nature of global warming will make it very difficult to measure damages as they occur. Finally, paying victims compensation may create deleterious incentives that encourage people to put themselves in harm's way.

A final alternative is to compensate low latitude countries by investing in their economic development. Rapid development could help low latitude countries adapt to future climate change by reducing vulnerability although it would increase emissions. As countries develop, they move away from agriculture making their economies more resilient to climate change. An effective development program would also provide the needed technological progress that would make even climate sensitive sectors less sensitive to future climate change. But most importantly, an economic development program could address the imbalance between those who currently benefit from emissions and those who are likely to pay the consequences of climate change. A well-designed economic development program would bring large benefits directly to the people of poor countries.

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