Department of Economic & Social Affairs

DESA Working Paper No. 152
ST/ESA/2017/DWP/152

October 2017

Climate Change and Social Inequality*

By S. Nazrul Islam and John Winkel

ABSTRACT

This paper offers a unifying conceptual framework for understanding the relationship between climate change and "within-country inequalities," referred here collectively as "social inequality." Available evidence indicates that this relationship is characterized by a *vicious cycle*, whereby *initial* inequality causes the disadvantaged groups to suffer *disproportionately* from the adverse effects of climate change, resulting in greater *subsequent* inequality. The paper identifies three main channels through which the inequality-aggravating effect of climate change materializes, namely (a) increase in the *exposure* of the disadvantaged groups to the adverse effects of climate change; (b) increase in their *susceptibility* to damage caused by climate change; and (c) decrease in their *ability to cope and recover* from the damage suffered. The paper presents evidence to illustrate each of the processes above. It also notes that the same analytical framework can be used to discuss the relationship between climate change and inequality *across* countries. Finally, it points to the ways in which the analysis can be helpful in making relevant policy decisions.

JEL Classification: Q53, Q56, Q59

Keywords: Climate change; inequality; exposure; susceptibility; ability to cope and recover; adaptation.

* This paper is based on a background paper that the authors prepared for the World Economic and Social Survey (WESS) 2016, devoted to the topic, "Building Resilience to Climate Change – An Opportunity to Reduce Inequalities." The authors would like to thank the WESS team members for their comments. Thanks are also due to the outside experts – in particular, Julie Ann Silva – for their comments and suggestions. Special thanks are due to the two anonymous reviewers who provided excellent comments that led to improvement of the paper. All remaining errors and shortcomings are of the authors. The views expressed in this paper are authors' personal and need not be ascribed to the organizations to which they belong. Please send your comments to S. Nazrul Islam, the corresponding author, at islamn@un.org

CONTENTS

Typesetter: *Nancy Settecasi*

UNITED NATIONS
Department of Economic and Social Affairs
UN Secretariat, 405 East 42nd Street
New York, N.Y. 10017, USA
e-mail: undesa@un.org
https://www.un.org/development/desa/publications/working-paper

Climate Change and Social Inequality

1 Introduction

Inequality has been a persistent issue in the climate change discussion. In general, it has been part of the discussion on "climate justice" issue, which in turn is a particular case of the "environmental justice" issue.[1] However, the focus in this discussion has been mainly on inequality *across countries*. For example, debates have raged and are still raging over differences across countries regarding the responsibility for *causing* climate change and the consequent responsibility for *mitigation (*and *adaptation) efforts*. The Rio principle of "Common but Differentiated Responsibility (CBDR)" was adopted to resolve this "burden" issue. Nevertheless, the *inter-country* inequality issue continues to dominate the international discussion of climate change. By contrast, *within-country* or *social* inequality has not received much attention.

To be accurate, there were attempts to incorporate within-country inequality in the mitigation discussion. For example, some researchers drew attention to the fact that people *within* a country differed regarding their Greenhouse Gas (GHG) emissions, and hence the mitigation burden should be distributed according to the GHG contribution not of *countries* but of *individuals* (see, for example, Chakravarty et al. 2007). Accordingly, they proposed a GHG emission cut-off and suggested imposition of the mitigation burden (responsibility) on all individuals who were above that cut-off, irrespective of the country in which they lived. Of course, it is possible to aggregate the individual burdens at the country level and revert the discussion to the cross-*country* framework. However, the resulting cross-country distribution of the burden would then incorporate the *within*-country inequality in GHG emission, and will not be based on just the country aggregates or averages. Though sensible from many viewpoints, this proposal however did not receive much traction, in part, due to the difficulties in measuring GHG emission at the individual level. Also, in some developed countries – for example, the USA – attention has been paid to within country inequality while remaining less aware about across-country inequality. This has been possible because of greater availability in these countries of household level data, which has not been the case in most other countries. As a result, the international discussion of climate burden continues to be conducted in terms of aggregates or averages of GHG emissions at the *country* level. Furthermore, with the switch to the "*voluntary* principle" – as embodied in the *Paris Agreement* – the issue of accurate determination of burden has become moot. Thus, attempts to incorporate *within*-country inequality regarding the *responsibility* for climate change did not go too far in the international climate change discussion.

The within-country inequality regarding the *impact* of climate change has received even less attention. The discussion of the impact was initially focused on its *physical* side, i.e. on the impact of climate change on the *nature*. With time, the *social* impact received attention, and evidence was presented regarding the relationship between climate change and *poverty* and *livelihood*. However, the interlinkages between climate change and within-country *inequality* have not yet received necessary attention. This paper aims at overcoming this weakness.

1 For a recent discussion on climate justice, see, for example Pleyers (2015). See also Bali Principles of Climate Justice (http://www.ejnetindiaresource.org/ejissues/bali.pdfenergycc/2003/baliprinciples.html) (August 29, 2002), Climate Change and Justice: On the Road to Copenhagen (https://www.boell.de/sites/default/files/BoellThema_english_2-09.pdf), Heinrich Boll Foundation, Berlin 2009. For discussion on environmental justice, see, for example, Chakraborty (2017) and Mohai, Pellow, and Roberts (2009).

Needless to say, there are many types of inequalities to consider even in a within-country setting.[2] On the one hand, there are inequalities based on demographic characteristics, such as gender, race, ethnicity, religion, and age. A second type of inequality is regarding assets and income. A third type of inequality is regarding public decision making (political power) and access to public resources, such as publicly financed health, education, housing, financing, and other services. Needless to say, these different types of inequalities are interrelated.[3] We use the term "social inequality" to refer to all these different types of within-country inequalities. This is, first of all, in the interest of parsimony. Second, the term "social inequality" gets to the heart of the matter more directly and intuitively than the term "within-country inequality" does. Third, regional (spatial) inequality within a country often overlaps with inequality regarding race, ethnicity, and religion, and finds expression in the form of inequality in income and assets. Hence, within-country spatial inequality can also be subsumed under social inequality. It should be noted that important inequalities exist within households too. Amartya Sen, for example, highlighted the intra-household bias against girls and women (see, for example, Sen 1990). In this paper, however, we do not extend the discussion to intra-household inequalities.

The concept of social inequality used in this paper is thus multi-dimensional. Due to reasons of data availability, most of the evidence it presents pertain to income inequality, showing that the people living in poverty suffer disproportionately more from the adverse effects of climate change than the rich. However, the paper presents evidence regarding similar disproportionate effects suffered by other social groups who find themselves disadvantaged due to gender, age, race, ethnicity, etc.

Some researchers have earlier noted that climate change aggravated inequality, and they provided evidence in support of this claim. There are, however, two weaknesses in this discussion so far. First, the evidences are often *indirect* and not focused on inequality. The implications regarding inequality are presented as an afterthought, so to speak. Second, the evidences presented are generally of *scatter-shot* character and there is no connection among them. This paper tries to overcome these weaknesses – particularly the second one – by presenting a *unifying conceptual framework* for discussing and studying the relationship between climate change and inequality. It shows that the relationship between climate change and social inequality is characterized by a vicious cycle, whereby *initial* inequality makes disadvantaged groups suffer *disproportionately* from the adverse effects of climate change, resulting in greater *subsequent* inequality. The paper identifies three channels through which the above process unfolds. First, inequality increases the *exposure* of the disadvantaged social groups to the "adverse effects of climate change" ("climate hazards," for short). Second, given the exposure level, inequality increases the disadvantaged groups' *susceptibility* to damages caused by climate hazards. Third, inequality decreases these groups' relative ability to *cope* with and *recover* from the damages they suffer. The paper presents evidence supporting each of these three channels.

The paper is global in scope, in the sense that it considers the relationship between climate change and social inequality in both developing and developed countries. It is aware that despite the commonalities there are differences in the concrete manifestations of this relationship. The paper tries to offer evidence from both developed countries (such the Hurricane Katarina experience of the United States) and

2 The AR5 WGII report uses the term assets to refer to "natural, human, physical, financial, social and cultural capital," as part of the "ensemble or opportunity set" including capabilities, assets and activities that make up livelihoods (IPCC, 2014, p 798). This paper uses this term in similar sense.

3 Inequality regarding assets and income influences inequality regarding political power and access to public resources. The relationship between the two goes in reverse direction too. Similarly, demographic inequalities often lead to inequalities with regard to asset, income, political voice, and access. Inequalities with regard to the latter often reinforces the demographic inequalities.

developing countries. However, more evidence has been drawn from developing countries, partly because it is the tropical developing countries which are witnessing more of the adverse effects of climate change so far.

The analytical framework presented in this paper helps in several ways. First, it helps to collect, understand, and present the available evidence more meaningfully and systematically. Second, it helps to identify the gaps in evidence, and thus point to the necessary future research. Third, it helps to promote the discussion of policies necessary to break the vicious cycle between climate change and inequality.

The paper finally notes that, though the analytical framework presented in it focuses on *within*-country inequality, it can also be applied to describe and analyse the relationship between climate change and *across*-country inequality. Greater across-country inequality may indeed increase the exposure of the disadvantaged countries to climate hazards. It may also increase their susceptibility to damage caused by climate hazards. Finally, it may also decrease their capability to cope with and recover from the damages suffered. Thus, climate change may aggravate across-county inequality too. However, to keep its scope manageable, this paper limits its attention to within-country inequality and does not extend it to across-country inequality.

The 2030 Agenda for sustainable development has brought the issues of both within- and across-country inequality to the fore and calls for the reduction of both. This paper suggests that an opportunity in the otherwise formidable challenge of climate change may be seen in the *expansion of the policy space regarding inequality*. This is because *emergency* situations often make it possible to undertake steps that are not possible in *normal* situations. The emergency posed by climate change may facilitate reduction of inequality, which is otherwise deemed to be a difficult political issue.

The discussion of the paper is organized as follows. Section 2 reviews the evolution of the climate discussion from its initial focus on the impact on nature to the impact on poverty and livelihood and then on to the impact on inequality. Section 3 presents the analytical framework that can unify the discussion of the relationship between climate change and inequality. Sections 4 reviews the evidence regarding inequality's effect on exposure of the disadvantaged groups to climate hazards. Section 5 does the same regarding susceptibility to damage by climate hazards. Section 6 reviews the evidence on inequality's impact on the ability of the disadvantaged groups to cope and recover. Section 7 discusses the combined effects of more than one channel. Section 8 notes how the analytical framework presented in the paper can also help to analyse the relationship between climate change and across-country inequality. Section 9 concludes.

2 Evolution of the discussion of the social impact of climate change

2.1 Initial focus on the physical impact

The discussion of climate change was originally focused on its physical impact, with relatively less effort devoted to documentation and discussion of the implications for the livelihood and social position of the affected people. As Skoufias (2012, p. 2) put it, "while the eyes of the world have been riveted on polar bears, Antarctic penguins, and other endangered inhabitants of the Earth's shrinking ice caps, relatively few researchers have turned serious attention – until recent years – to quantify the prospective long-term effects of climate change on human welfare."

2.2 Discussion of effects of climate change on poverty and livelihood

The broader *social* impacts of climate change and their *feedback* effects received more attention over time. An early study in this regard was the report by the World Bank (2002) and presented at the 8th conference of the UNFCCC. It noted that climate change was making achievement of MDGs difficult

by reducing access to drinking water, decreasing food security, and having adverse health effects.

Other studies followed up on the issue. The Stern report (2007) noted that climate change was expected to increase poverty owing to its effects on agriculture, flooding, malnutrition, water resources and health. The 2007/2008 *Human Development Report* devoted a chapter to the discussion of vulnerability and risks arising from climate change (UNDP, 2008). The World Bank's *Global Monitoring Report 2008*, titled "MDGs and the Environment: Agenda for Inclusive and Sustainable Development," pointed to potential impacts of climate change on poverty and development (World Bank, 2008). Brainard et al. (eds) (2009) looks in to a wide range of impacts of climate change on poverty. Some recent studies examined the issue using cross-country data, and Skoufias et al. (2011) provides a review of several such studies, taking note of the different *methodologies* used, different *units of analysis* adopted, and various policy suggestions offered.

Some studies had a more limited geographical focus. For example, Paavola (2008) focused on the Morogoro region of Tanzania; Somanathan and Somanathan (2009) on India; and Gentle and Narayan (2012) on mountain communities in Nepal. Many studies focused on poverty impacts in specific sectors, such as agriculture (see for example, Ahmed et al. 2009; Hertel et al. 2010; Hertel and Rosch 2010; and Müller et al. 2011) or in particular areas, such as urban areas (see for example, Satterthwaite et al. 2007; Douglas et al. 2008; and Hardoy and Pandiella 2009).

From broad evidence of the effects of climate change on poverty, research gradually moved to examining the *mechanisms* through which these effects work. The concept of Shared Socio-economic Pathways (SSP) was used to consider the human development aspects of climate change. Hallegatte et al. (2014) identify *four channels* through which households may move in and out of poverty – prices, assets, productivity, and opportunities – and examine the effect of climate change on each of these. Lichenko and Silva (2014) provide a synthesis, noting that the connections between climate change and poverty are, "complex, multifaceted, and context-specific." Hallegatte et al. (2016) provides comprehensive guidance on *joint solutions* so that poverty reduction policies and climate change mitigation and adaptation policies can reinforce each other.

The contribution of the Working Group II to the IPCC periodical Assessment Reports (AR) also increased gradually its focus on the human dimensions of the climate change impact. In particular, this group's contribution to AR5 (particularly Chapter 13) provides an extensive compilation of the evidence – both statistical and anecdotal, and from all parts of the world – regarding the dynamic interaction between climate change, livelihoods, and poverty.

2.3 From poverty to inequality effects of climate change

Not surprisingly, the discussion of the impact of climate change on *poverty* often extended to the impact of climate change on *inequality*. AR4 already noted that "socially and economically disadvantaged and marginalized people are *disproportionally affected* by climate change" (IPCC 2014, p. 796; italics added). Similarly, Skoufias (2012, p. 6) notes that "climate change impacts tend to be *regressive*, *falling more heavily on the poor than the rich.*" In the context of the effects of climate change on Brazil, the study notes that "there is significant variation, with *already poor regions being more affected than prosperous regions*" (Skoufias, 2012, p. 5, italics added).

References to inequality are more frequent in the AR5 WGII report. Its overall conclusion is that climate change "*exacerbates inequalities*" (IPCC 2014, p. 796, italics added). It notes that socially and geographically disadvantaged people – including people facing discrimination based on gender, age, race, class, caste, indigeneity and disability – are particularly affected negatively by climate hazards (ibid). As noted above, exacerbation of inequality can happen through disproportionate erosion of physical, human, and social assets. AR5 WGII finds evidence

regarding each of these. Even climate change adaptation expenditure is often found to be driven more by wealth than by need, so that these expenditures end up aggravating inequality (Georgeson et al. 2016).

2.4 Deficiencies of the discussion of the linkages between climate change and inequality

Despite the progress above, the discussion of the interlinkages between climate change and inequality so far suffers from several deficiencies. The most important of these is the *lack of a unifying conceptual framework*. As a result of this lacking, the evidence presented has a *scattershot* character. AR5 itself recognizes this deficiency, noting that "despite the recognition of these complex interactions [between climate change and inequality], the literature shows *no single conceptual framework* that captures them concurrently" (IPCC, 2014, p. 803, italics added).

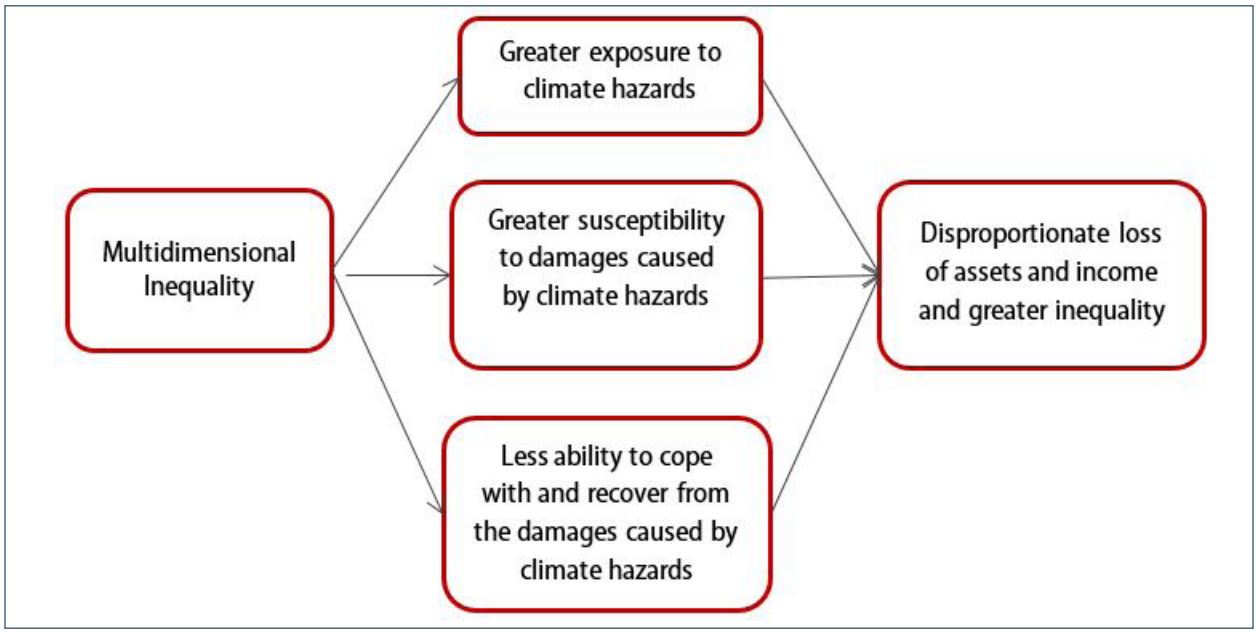
Second, the evidence provided so far is often of *indirect* and *conjectural* nature. In many cases, the discussion remains limited to *general* statements. Often the evidence provided is location and impact specific, and extrapolations are made on its basis. Relatively few studies have attempted to examine *directly* the effect of climate change on inequality.

This paper aims at addressing the weaknesses above. In particular, it offers a unifying conceptual framework for capturing and studying the interlinkages between climate change and social inequality. The framework helps to collect, understand, present and discuss the evidence in a more organized, logical, and meaningful way. It helps to identify the gaps that exist in the evidence gathered so far, and thus to point out future directions of research necessary to fill these gaps. Finally, it also helps to discuss the policies needed to address the problems of inequality in the context of climate change.

3 Analytical Framework

In this section, we present the analytical framework for the discussion of the relationship between climate change and inequality. We begin by noting the

Figure 1
Three effects of inequality on disadvantaged groups



Source: Authors, based on the discussion in the text.

three channels through which inequality aggravates the situation of the disadvantaged groups vis-à-vis climate change.

3.2 Three channels of influence of inequality

The evidence suggests that inequality aggravates the position of the disadvantaged groups of the society vis-à-vis climate change impact in the following three major ways (Figure 1).

a. increase in the *exposure* to climate hazards,

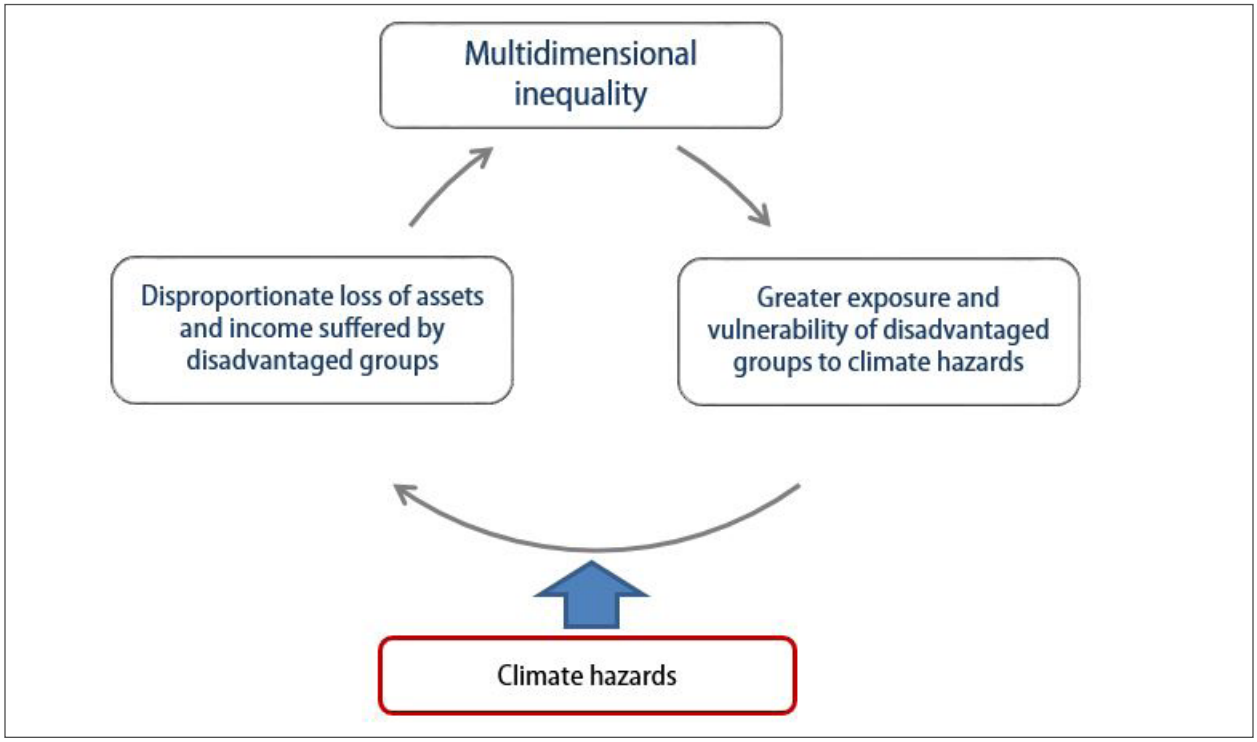
b. increase in the *susceptibility* to damage caused by climate hazards, and

c. decrease in the *ability* to cope with and recover from the damage.

To have a preliminary idea about how these channels work, consider the following example. One of the consequences of climate change is increased flooding. Evidence shows that inequality often compels the disadvantaged groups to live in areas that are more prone to flooding, thus increasing their exposure to flooding caused by climate change. Second, among all living in the flood zone, the disadvantaged groups prove to be more susceptible to the damages caused by flooding. For example, their houses get completely washed away or be damaged seriously, because these are often made of flimsy materials. By contrast, the houses of the more well-to-do suffer less damage because these are generally made of sturdier materials, such as brick and concrete. Finally, the disadvantaged groups have less ability to cope with and recover from the damages caused by floods. For example, the rich may buy insurance and thus get compensated for the damages. By contrast, the disadvantaged groups may not be able to afford such insurance and thus have to absorb the entire loss, leading to greater loss of their asset position.

3.3 "Climate change – inequality"

Figure 2
Inequality and climate change vicious cycle



Source: Authors, based on the discussion in the text.

vicious cycle

As a result of the combined effect of the three channels above, climate change and inequality are locked in a vicious cycle, whereby climate change hazards end up aggravating inequality. Figure 2 explains how this cycle works. It begins with multidimensional inequalities, which then cause greater exposure of the disadvantaged groups to climate hazards, increase their susceptibility to damage caused by these hazards, and decrease their ability to cope with and recover from the damage. As a result, when the climate hazards actually hit, disadvantaged groups suffer disproportionate loss of income and assets (physical, financial, human, and social). Climate change thus makes inequality worse, thus perpetuating the cycle.

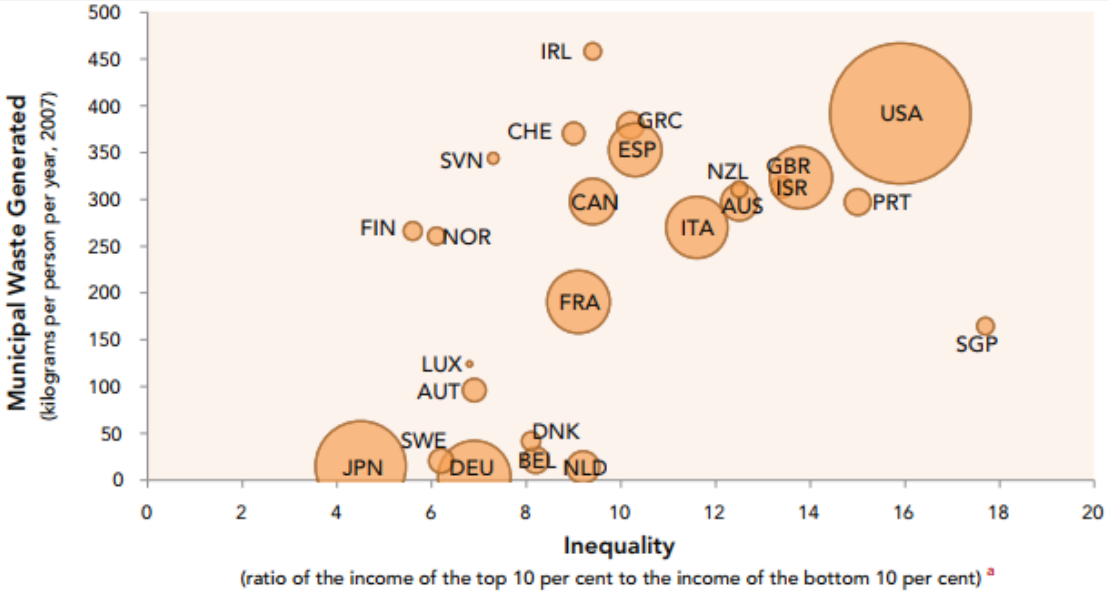
3.4 Endogeneity of climate change and the reinforced vicious cycle

The scheme in Figure 2 treats climate change effects as *exogenous*. In reality, however, there is a feedback effect of inequality on climate change, making the above vicious cycle stronger and more worrisome. This happens in several ways.

In a previous paper (Islam 2015), we discussed how inequality aggravates environmental deterioration, including climate change. Reviewing the evidence, the paper showed, for example, that among OECD countries, those with higher inequality tend to have higher per capita levels of waste generation (Figure 3), consumption of water (Figure 4), and consumption of meat and fish (Figure 5). In view of these positive associations, it may be expected that countries with higher inequality will tend to have higher levels of per capita GHG emissions. Figure 6 provides some evidence in this regard showing that the correlation between inequality and per capital GHG emissions is at least weakly positive. Inequality thus indeed aggravates climate change.

Figure 7 presents the *reinforced* vicious cycle between inequality and climate change, with the feedback effect of the former on the latter taken

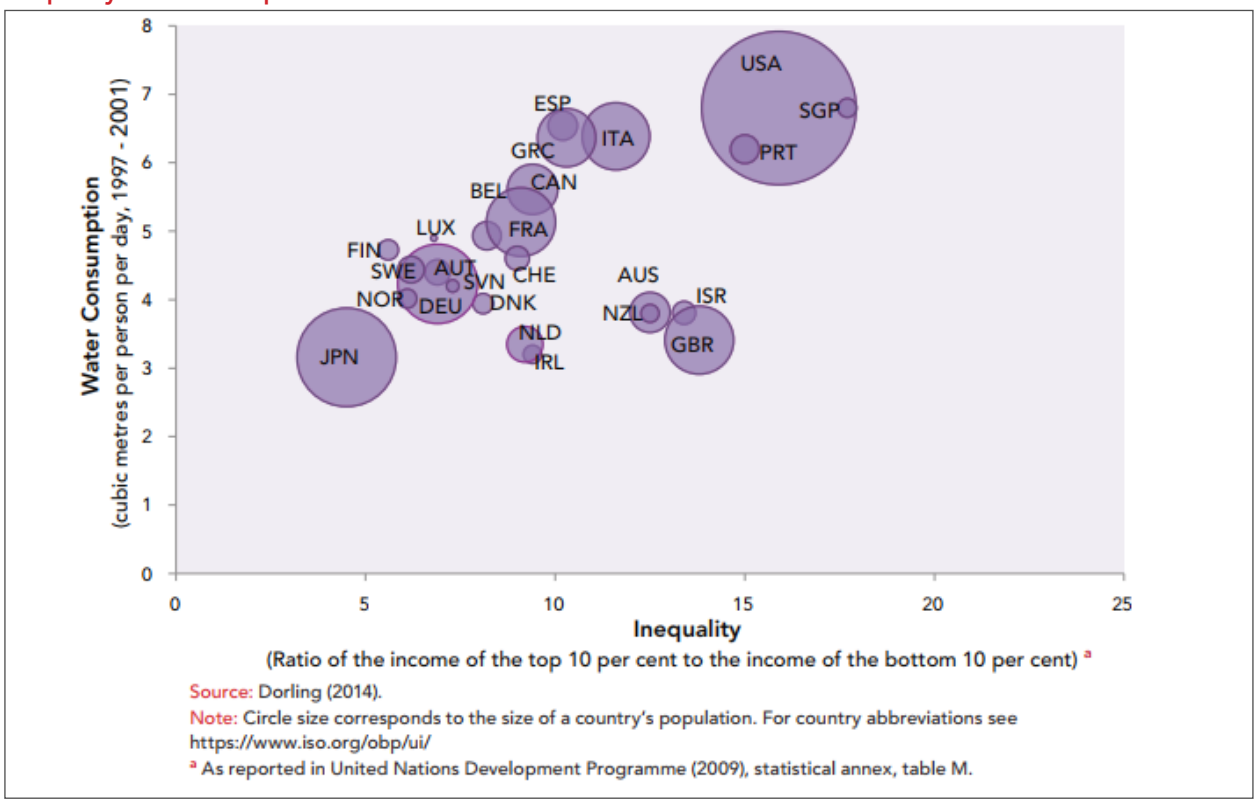
Figure 3
Inequality and municipal waste generated across countries



Source: Dorling (2014).
Note: Circle size corresponds to the size of a country's population. For country abbreviations see https://www.iso.org/obp/ui/
[a] As reported in United Nations Development Programme (2009), statistical annex, table M.

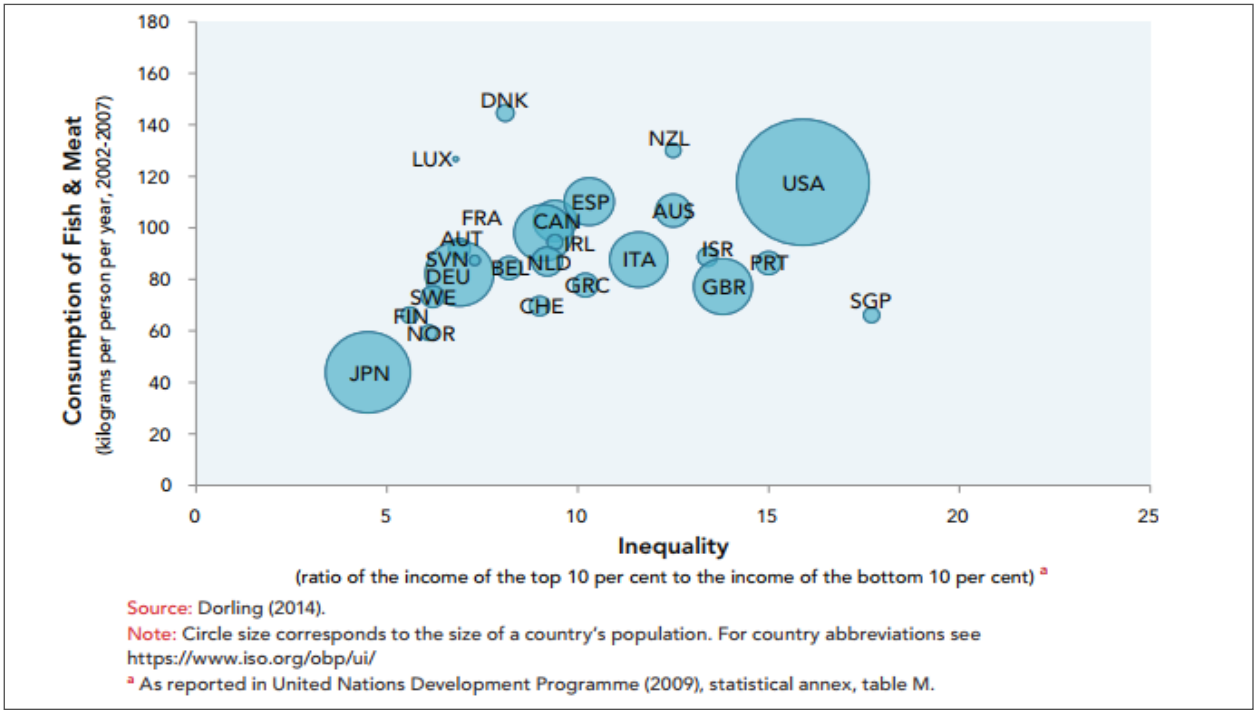
Source: Dorling 2014.

Figure 4
Inequality and consumption of water across countries



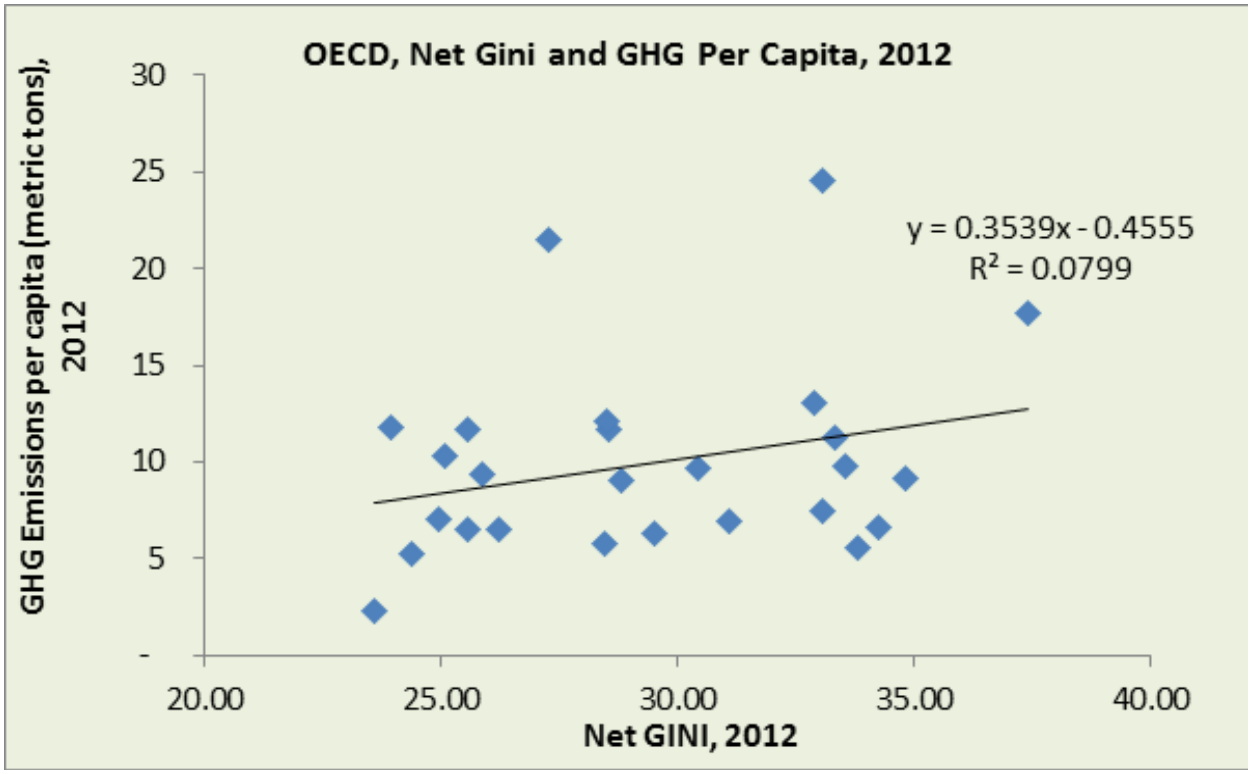
Source: Dorling 2014.

Figure 5
Inequality and consumption of fish and meat across countries



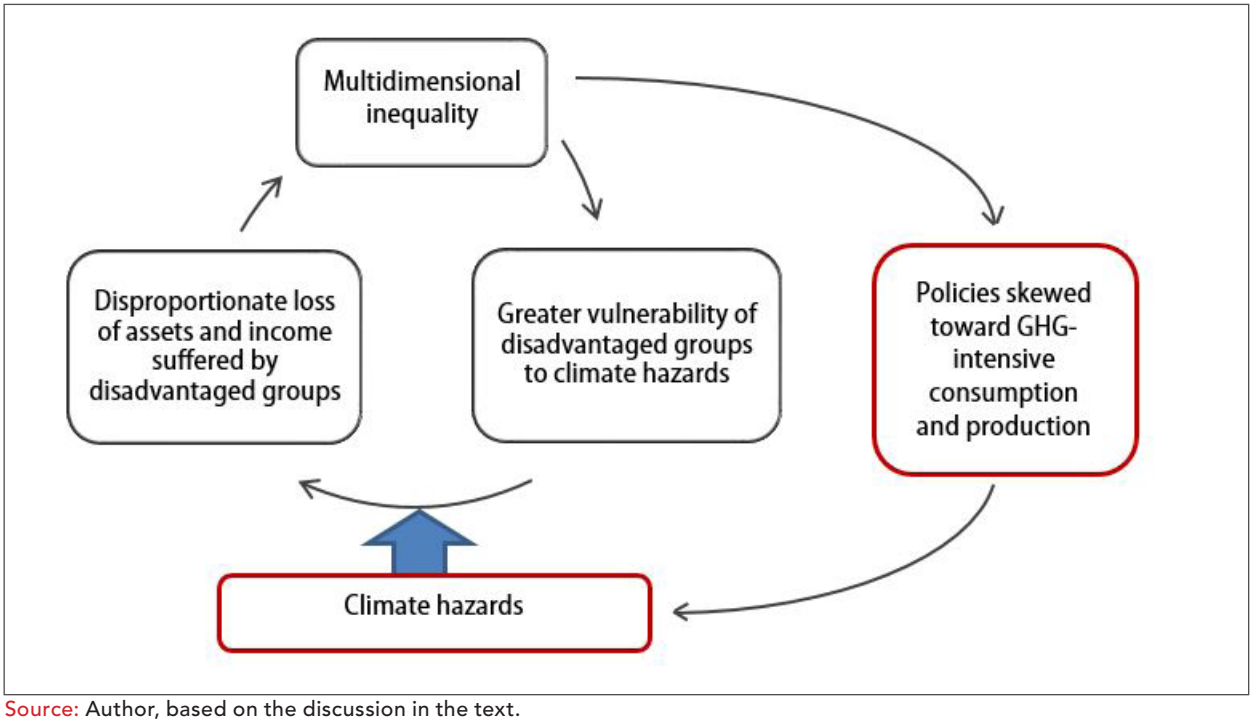
Source: Dorling 2014.

Figure 6
Positive relationship between inequality and per capita GHG emission among OECD countries



Source: Author, based on data from OECD (on GHG emissions) and Salt () (on inequality).

Figure 7
Reinforced vicious cycle between inequality and climate change



Source: Author, based on the discussion in the text.

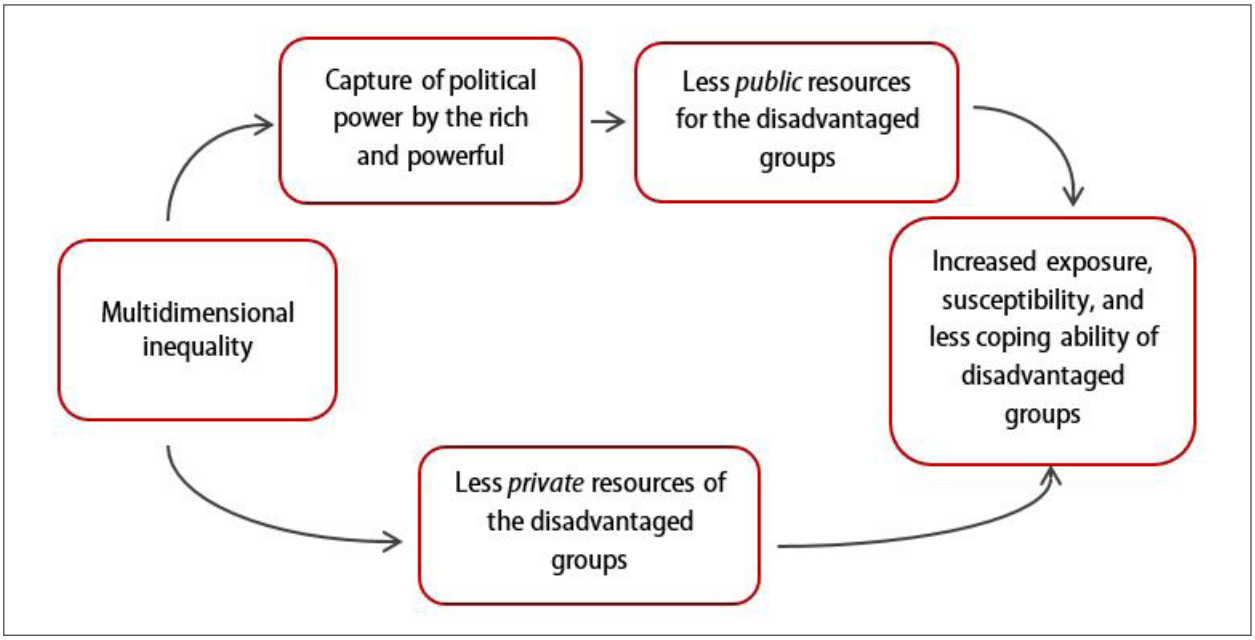
into account. Instead of being exogenous to the causal flow, climate change is now *endogenous*, working through the outer loop of the scheme. Needless to say, this endogeneity makes the task of breaking the vicious cycle between climate change and inequality even more important and urgent.

The analytical framework presented above is not entirely new. Various earlier studies have used similar frameworks. Some of these have used the term "vulnerability," and accordingly these have often been described as the "vulnerability" frameworks. For example, AR5 considers the impact of climate hazards with respect to "vulnerability" and "exposure." (see IPCC 2014, Summary for policymakers, p. 3). The discussion however makes it clear that by vulnerability, the authors include both "susceptibility" and "ability to cope and recover," as defined in this paper. Others, however, define "vulnerability" as to include "exposure" and "ability to cope and recover."[4] To avoid these terminological ambiguities, we prefer in this paper to spell out the dimensions in their "primary form," so to speak, and avoid an additional, intermediate layer of terms, about which the literature does not seem to have a consensus. Anchoring the discussion to the "primary forms" of the effects also leads to a sharper understanding of the relationship between inequality and climate change.

3.5 Economic and political channels of influence of inequality on differential effects of climate change

It may be noted further that the three effects of inequality identified above can be transmitted through two channels, namely the *economic* channel and the *political* channel (Figure 8). The economic channel works through reduction of *private* resources available to the disadvantaged groups. For example, in

Figure 8
Economic and Political transmission channels of the effects of inequality on disadvantaged groups



Source: Authors, based on the discussion in the text.

4 See Turner et al. (2003) for a discussion of alternative vulnerability frameworks. See also https://www.weadapt.org/knowledge-base/vulnerability/vulnerability-frameworks.

an unequal society, the disadvantaged groups have less asset and income from their own resources, and hence they cannot but be more exposed and susceptible to climate hazards and be less capable to cope and recover.

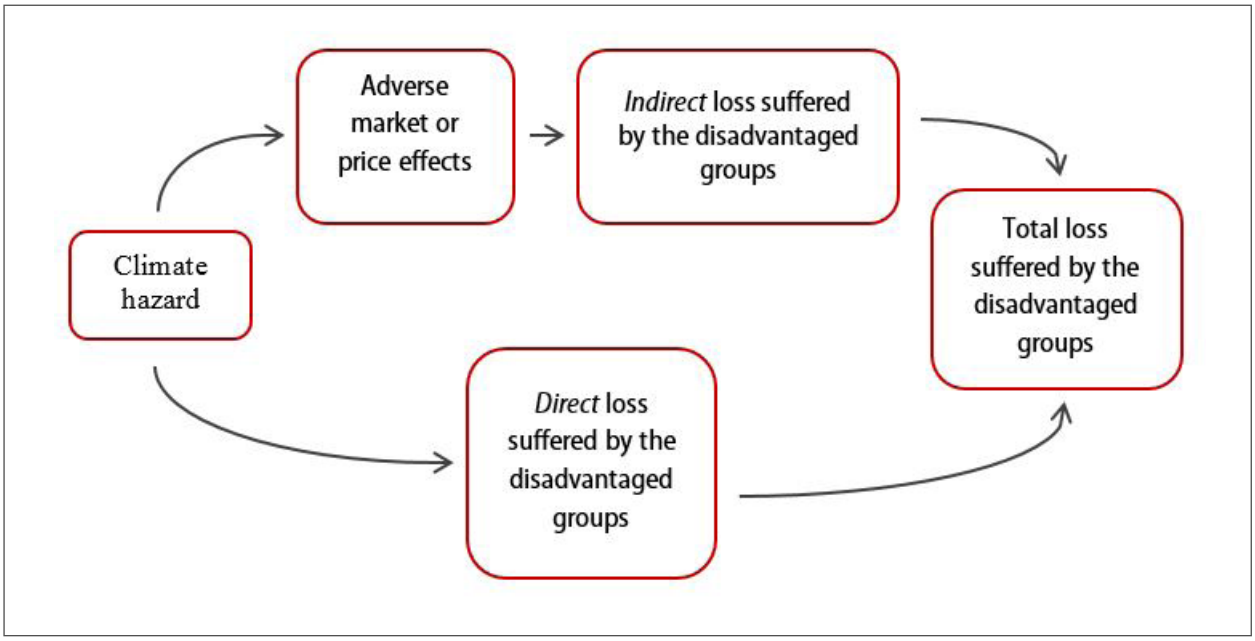
The political channel, on the other hand, works through the state power. In an unequal society, the advantaged groups (who own most of the productive assets) usually "capture" or exert dominating influence on the state and skew its policies in their favour. As a result, they can deploy more of the *public* (state) resources for their protection against climate hazard, leaving the disadvantaged groups less.

Boyce (1994, 2003) offers a formalization of the political channel through which inequality aggravates environmental degradation, including climate change. He points out that in reality social decisions are not based on maximization of the *simple* sum of utilities that accrue from a particular decision to different members of the society. Instead they are based on a *weighted* sum, in which the utilities of the advantaged (powerful) groups get greater weights, resulting in Power Weighted Social Decision Rule (PWSDR). It so happens that the GHG-intensive activities serve more the utilities of the advantaged groups, who can also shield themselves from the adverse effects of climate change through greater protection. As a result, inequality leads to public policies that leave the disadvantaged groups more exposed and susceptible to climate hazards. As noted earlier, even adaptation policies often benefit the advantaged groups more than the disadvantaged. The influence of politics on determining the effect that disadvantaged groups suffer due to adverse climate effects can be quite pervasive.

3.6 Direct physical vs. indirect, market-mediated effects of climate hazards on the income and asset position of the disadvantaged groups

The evidence also shows that the disadvantaged groups suffer disproportionately from both *direct* and *indirect* effects of climate hazards. This is illustrated in Figure 9. For example, the destruction of crops by

Figure 9
Direct and indirect effects of climate hazards on disadvantaged groups



Source: Authors, based on the discussion in the text.

climate change-induced flooding is a direct effect. However, the flood may also cause the general food price level to rise, causing additional difficulties for those disadvantaged groups who have to buy food from the market. This is the indirect, market-mediated effect. Similarly, climate hazards may cause the insurance premiums to increase, making it harder for the disadvantaged groups to buy insurance coverage.

The framework above shows how the relationship between social inequality and climate change is characterized by a vicious cycle and identifies the various causal channels through which this cycle operates. We now turn to the empirical evidence that, on the one hand, validates the vicious cycle hypothesis and, on the other hand, shows how the analytical framework above helps to present, understand, and analyse this evidence.

The empirical evidence presented below often concerns extreme weather events, the more frequent recurrence of which is generally attributed to climate change. This is in part because these events have sharp cut-off points regarding their timing. Also, they draw more attention and are more amenable to before-and-after impact study. By contrast, the slow-onset hazards are more diffuse and more prone to confounding factors. However, this does not mean that the slow onset hazards are less important from the viewpoint of the inequality reinforcing effect of climate change.

4 Effects of inequality on exposure to climate change hazards

In general, exposure tends to be determined primarily by the *location* of dwelling and work. Given the location, however the exposure is influenced by the *nature of work* and tasks performed for livelihood. Both economic and political channels of influence of inequality play a role in determining the location and livelihood.

4.1 Greater exposure to flood, erosion, salinity, mudslides, etc.

According to Neumann et al. (2015), a significant part of the population in developing regions now live in "low-elevation coastal zone" and 100-year flood plains, and their number is increasing in both absolute terms and as proportion of the population (Table 1). In general, coastal and near-shore habitats and their ecosystems are more exposed to the

Table 1
Population living in low-elevation coastal zones and 100-year flood plains in developing countries

	Population		Low elevation		100-year flood plain	
Region	2000	2030	2000	2030	2000	2030
Africa	811	1562	54	109	13	24
Asia	3697	4845	461	640	137	200
Latin America & Caribbean	521	702	32	40	6	8
Total	5029	7109	547	789	156	232
Least Developed Countries	645	1325	93	136		
World	6101	8626	625	939	189	282

Source: B. Neuman et al., 2015, tables 4 and 5 (scenario B). Scenario B is based on projections from UN population data at the "low end" of global population growth, meaning global population is expected to be 7.8 billion by 2030. It also assumes inclusive social, political and economic governance. In other words, the most generous of the four scenarios examined in the paper – the other three have higher estimates.

effects of climate change (Barbier, 2015). Generally, it is the disadvantaged groups, who find themselves compelled to live in these areas, because they cannot afford to live in safer areas. A large percentage of the populations of low elevation coastal zones are rural – 84 per cent in Africa, 80 per cent in Asia, 71 per cent in Latin America and the Caribbean and 93 per cent in the least developed countries (Neuman et al., 2015). As is known, the incidence of poverty is greater in rural areas than in urban areas.

It is also instructive that more people now live in deltas, which are frequently subject to flooding of both types – coastal flooding due to sea level rise and river flooding due to higher precipitation (Table 2). Researchers find that more of the people living in the precarious parts of the deltas belong to the disadvantaged groups (Lou et. al 2015 and Brouwer et al. 2007).

In addition to flooding and erosion, the people living in coastal areas and in deltas also suffer from salinity intrusion (Dasgupta et al., 2014 and Rabbani et al. 2013). Shameem et al. (2014) estimate that 70 per cent of farmers in some coastal areas partially or fully ceased farming due to high levels of salinity. Due to their concentration in coastal areas and deltas, the disadvantaged groups are thus more exposed to salinity intrusion caused by climate change.

However, greater exposure of the disadvantaged groups to climate hazards is not limited to rural areas only. Even among urban populations, it is the disadvantaged groups that are particularly exposed to climate hazards. An example of this can be observed in Dhaka, Bangladesh, where Braun and ABheure (2011) find that slum dwellers are more likely to live in areas prone to natural hazards. In general, many slums are located in low-lying spots of urban areas that are at high risk of flooding. Similarly, in many

Table 2
Deltas in developing regions (in countries with population greater than 2 million people)

Region	Population living in deltas (2015 estimates, in millions)
Africa	
Nile (Egypt)	49.2
Niger (Nigeria)	31.5
Limpopo (Mozambique)	4.4
Asia	
Ganges-Brahmaputra (West Bengal-India/Bangladesh)	166.2
Mekong (Viet Nam)	35.2
Changjiang (Yangtze)(China)	33.1
Pearl (China)	27.1
Huang He (Yellow)(China)	16.6
Chao Phraya (Thailand)	16.4
Red (Hong)(Viet Nam)	16.1
Irrawaddy (Myanmar)	12.1
Krishna (India)	6.8
Godavari (India)	5.9
Mahanadi (India)	4.5
Indus (Pakistan)	4.4

Sources: Woodroffe, 2010, Overeem and Syvitski, 2009.

Latin American countries disadvantaged groups are found to set up their dwellings along risky hill slopes in urban areas, exposing them to mudslides that are becoming more frequent due to climate change (Painter, 2007).

4.2 Greater exposure to drought, heatwaves, water scarcity, etc.

About 40 percent of the Earth's land surface and

Table 3
Dry lands populations (estimations as of 1995)

Region	Population (million)	Dry lands population (million)
Africa	720	326
Americas & Caribbean	1093	182
Asia	3451	1475
Developing Regions	4533	1983
World	5702	2130

Sources: WRI, 1997.

29 percent of the world's population live in arid, semi-arid, and dry sub-humid aridity zones, which are facing additional challenges due to climate change (Table 3). There is a larger concentration of disadvantaged groups of people (such as pastoralists and ethnic minorities) in these areas (WRI, 1997).

Two thirds of the global population are estimated to live under conditions where water is severely scarce for at least one month of the year (Mekonnen and Hoekstra, 2016). This exposure is expected to increase with climate change. For example, the number of people exposed to droughts could rise by between 9 and 17 per cent by 2030 under scenarios where emissions growth rates aren't reduced (Winsemius, et al., 2015). Drought exposure is also higher in rural than in urban areas (43 per cent versus 32 per cent, respectively). Given larger concentration of the people under the poverty line living in rural areas, this implies greater exposure to draught for the disadvantaged groups of people.

Cross-country data also point to greater exposure of the disadvantaged groups to water scarcity. In countries with lower human development indexes (HDI), this exposure is much greater (50 per cent) than in countries with higher HDI (14 per cent) (Christenson, et al., 2014). Given the higher rates of households engaged in agricultural production in rural areas and in low income countries, the rates of exposure of disadvantaged groups to droughts is likely to increase further with climate change.

4.3 Effect of inequality on exposure via the political channel

Often the compulsion to live in areas that are more exposed to the adverse effects of climate change is of politico-administrative nature, reflecting the political channel of causality noted in Section 3. For example, Mutter (2015) notes that both economic and administrative restrictions led to the concentration of large numbers of disadvantaged people in the Irawaddy Delta that was hard hit by the cyclone Nargis in 2008. Often economic and political factors interact and combine to influence the location decision and exposure to climate hazard. For example, economic and racial factors combined in creating the large concentration of low-income African American people in the low-lying districts of New Orleans before hurricane Katrina (Mutter 2015).

4.4 Greater exposure of disadvantaged groups via occupation and type of tasks

Given the location, an important role in determining the exposure to climate hazards belongs to occupation and type of tasks performed. For example, whether somebody works outdoors and the degree to which a person's tasks depends on weather and climate are important determinants of exposure.

Needless to say, inequality plays an important role in the choice or allocation of occupation and type of tasks performed. Apart from income and asset inequality, gender and other types of inequality play an important role in this regard. For example, rural women's lower asset positions as well as land tenure

arrangements and social restrictions limit the land available to them. This leads women farmers to work on more marginal land which is exposed to greater climate related hazards (Perez, et al., 2015). Also, social norms in many places require the women to collect water and firewood, often compelling them to travel long distances and confront hazardous situations in places where these are scarce. Consequently, they face greater exposure to adverse effects of climate change.

5 Effects of inequality on susceptibility to damages caused by climate change

Given the same level of exposure, the disadvantaged groups are generally more susceptible to damage from climate hazards. As noted above, of the people living in the same floodplain, those with houses constructed of flimsy materials are more susceptible to damage from flood than those with houses made of sturdy materials. Similarly, in an arid area, people having air conditioning are less susceptible to health damages from excessive heat than those who do not have such facilities. The livelihoods that the disadvantaged groups find compelled to pursue may also increase their susceptibility to damage from climate hazards.

Wodon et al. (2014), for example, report that the poorest households in five MENA countries – Algeria, Egypt, Morocco, Syria, and Yemen – experienced higher losses of income, crops, livestock and fish caught due to climate related changes than did the rich households. Lost income reported for the lowest income households was more than double the rate for the richest (46.4% vs 20.7%). Similarly, Gentle et al. (2014) find that low income households in the middle hills region of Nepal are more susceptible to damages from climate hazards than the wealthy households. Hill and Mejia-Mantilla (2015) show that low income farmers in Uganda lost greater shares of income from limited rainfall than the average farmer because of their limited options for changing crop patterns, limited ability to apply water saving technology, and limited access to agricultural extension services and water storage sources (UNDP, 2006). Patankar (2015) shows that low income families in Mumbai required repeated repairs to their homes to secure them against 2005 flood damage, and the cumulative cost often proved to be much greater as proportion of their income than it was the case for the rich. Sometimes, the disadvantaged groups suffer more climate damage even with less exposure. For example, low income households in Honduras reported considerably higher asset loss (31 per cent) due to Hurricane Mitch than did the non-poor (11 per cent), even in areas where the former had less exposure to this hurricane than the latter (Carter, et al., 2007).

The disadvantaged groups are more susceptible to climate damages in part because of the lack of diversification of their assets. For example, the urban poor tend to have their savings in the form of housing stock, which is vulnerable to floods (Moser, 2007). Similarly, the rural poor often have their savings in the form of livestock, which is susceptible to droughts (Nkedianye, et al., 2011). Their situation contrasts with that of the wealthier households, who can diversify their assets, both spatially and financially and are therefore less susceptible to damage caused by climate hazards.[5]

One of the important ways in which inequality increases susceptibility of the disadvantaged groups to damages caused by climate change is through it health effects. Hallegatte, et al. (2016) find that the people living in poverty are more susceptible to the diseases that many climate hazards help to spread, including malaria and water borne diseases causing diarrhoea. This may be due to several reasons. For example, disadvantaged people may not have access to piped water sources, forcing them to drink water

5 The greater levels of damage as well as the more limited diversification of savings and assets feed into greater inequality of assets as a result of climate hazards. Greater susceptibility of the disadvantaged groups can therefore lead to widening of future inequality, as children of the poor families are left with diminished future capacities.

containing pathogens during floods. Indeed, there were reports of greater incidence of diseases among residents of low-income slums in Mumbai in the wake of monsoon floods (Hallegatte, et al., 2016). Similarly, disadvantaged people suffer more adverse health effects from heatwaves and high temperatures, because they cannot afford heat alleviating amenities, including air conditioning.

The greater susceptibility to health effects frequently undermines the income and asset position of disadvantaged groups in both short run and long run. In the short run, they suffer from loss of productivity, employment and income. In the long run, they suffer from loss of human capital (from lost school days, the development of chronic conditions such as stunting, and from general health and growth impacts, even future morbidity and higher mortality) (Somanathan, et al., 2014; Li, et al., 2016; Zivin and Neidell, 2014).

5.1 Gender and age inequality and susceptibility

Gender and age play an important role in determining the susceptibility to damage caused by adverse effects of climate change. As noted above, the fact that women in many countries are tasked with collecting water and firewood means that they are more susceptible to damages from climate hazards (Egeru, et al., 2014 and IPCC 2014, p. 796).[6] Sherwood (2013) finds that prolonged drought created poverty traps for women in Gituamba, Kenya. Using household surveys and village focus group studies conducted across nine countries in Africa, Perez et al. (2015) find that there are a number of issues affecting women that make them more susceptible to impacts of climate change than men.[7]

Both the young and the old prove to be more susceptible to damage caused by climate hazards than the adults. This is not surprising, given their relative fragility. For example, IPCC reports that flood related mortality in Nepal among girls was twice as high as for women (13.3 per 1000 girls). The mortality was also higher for boys than for men (IPCC, 2014, p. 807-808). Hallegatte, et al. (2016) reports greater incidence in ailments among children following floods in Ho Chi Minh City. Heatwaves have notable effects on the elderly, particularly as they are already more likely to suffer from chronic illnesses, such as coronary heart disease or respiratory diseases that can be exacerbated by heat (Hutton, 2008). Elderly people are also more susceptible to greater health effects from floods and are less able to relocate in the event of disasters (Hutton, 2008). Elderly residents of Limpopo, South Africa lacked access to labour, necessary to construct their houses to withstand flooding. Consequently, their dwellings suffered greater damage (Khandlhela and May, 2006).

These differential impacts apply across a variety of disadvantaged groups. For example, it was found in Vietnam that the elderly, widows, and disabled people – in addition to single mothers and women-headed households with small children – were most susceptible to damages caused both by floods and storms and by slow-onset events such as recurrent droughts (IPCC, 2014, p. 808-809). Similarly, Macchi et al. (2014) note that lower caste families, women and other marginal groups in the Himalayan villages in northwest India and Nepal are more susceptible to climate related effects.

5.2 Ethnic and racial inequalities and susceptibility

The degree of susceptibility often depends on ethnicity and race. For example, the minority farmers, who make up the bulk of the population in the Irrawaddy delta in Myanmar, were more susceptible to damages due to lack of effective warning systems

6 IPCC (2014, p. 796) notes that climate hazards increase and heighten existing gender inequalities. This happens because in many cases the women have to perform tasks that are more exposed to climate (such as fetching water from afar or gathering fuelwood from forests).

7 Among such issues are: limited control of land (in terms of both quantity and quality of land); less secure tenure; less access to common property resources; less cash to obtain goods or services; and less access to formally registered, public and private external organisations that foster agriculture and livestock production.

and infrastructure and therefore suffered the most in terms of lost lives, incomes and assets as a result of the cyclone Nargis in 2008 (Mutter, 2015). IPCC (2014) notes the important role of *social positions* of different groups in determining the impact of climate change. For example, in many places in Latin America, Afro-Latinos and indigenous groups were found to suffer from disproportionate climate effects. (IPCC, 2014, p. 810). Moreover, differential effect of climate change with respect to race is found in both developing and developed countries, although in both cases low income status is also intertwined with race and ethnicity status.

Effects on health were noted as an important concern regarding impacts of climate change on indigenous populations in Latin America. Climate hazards allow diseases to spread in areas where they could not previously thrive, leading to increases in rates of respiratory and diarrhoeal diseases. It has also exacerbated nutritional issues, which has further feedback effects on health outcomes for these populations (Kronik and Verner, 2010).

There are also differences in susceptibility of different population groups, depending on whether they are engaged in agricultural activities or they are pastoralists. This refers both to the types of climate related effects, such as changes in rainfall that may affect crops or forage for grazing animals in different ways, and to the different lifestyles of the two groups. For example, on the one hand, pastoralists' housing maybe temporary or less sturdy, meaning that they are more exposed to the elements. On the other hand, their way of life may limit their susceptibility because of their ability to relocate if local conditions are not conducive to their lifestyle.

5.3 Indirect market based effects of inequality on susceptibility

The disadvantaged groups often prove more susceptible via the market and price changes. In the rural areas, the disadvantaged households generally do not own much land and thus are net buyers of food. Consequently, they suffer more from food price increase caused by climate hazards. By contrast, the wealthy households, owning surplus crop available for sale, may even benefit from the food price increase. In the cities, the disadvantaged groups obviously suffer due to rise in food prices, and since expenditure on food comprises a much larger share of their budget than it is the case for the rich, they suffer disproportionately more (Ivanic, et al., 2012). According to Hallegatte et al. (2016, p. 56), the poorest households in the developing world spend between 40 and 60 per cent of their income on food and beverages, compared to less than 25 per cent of wealthier households.

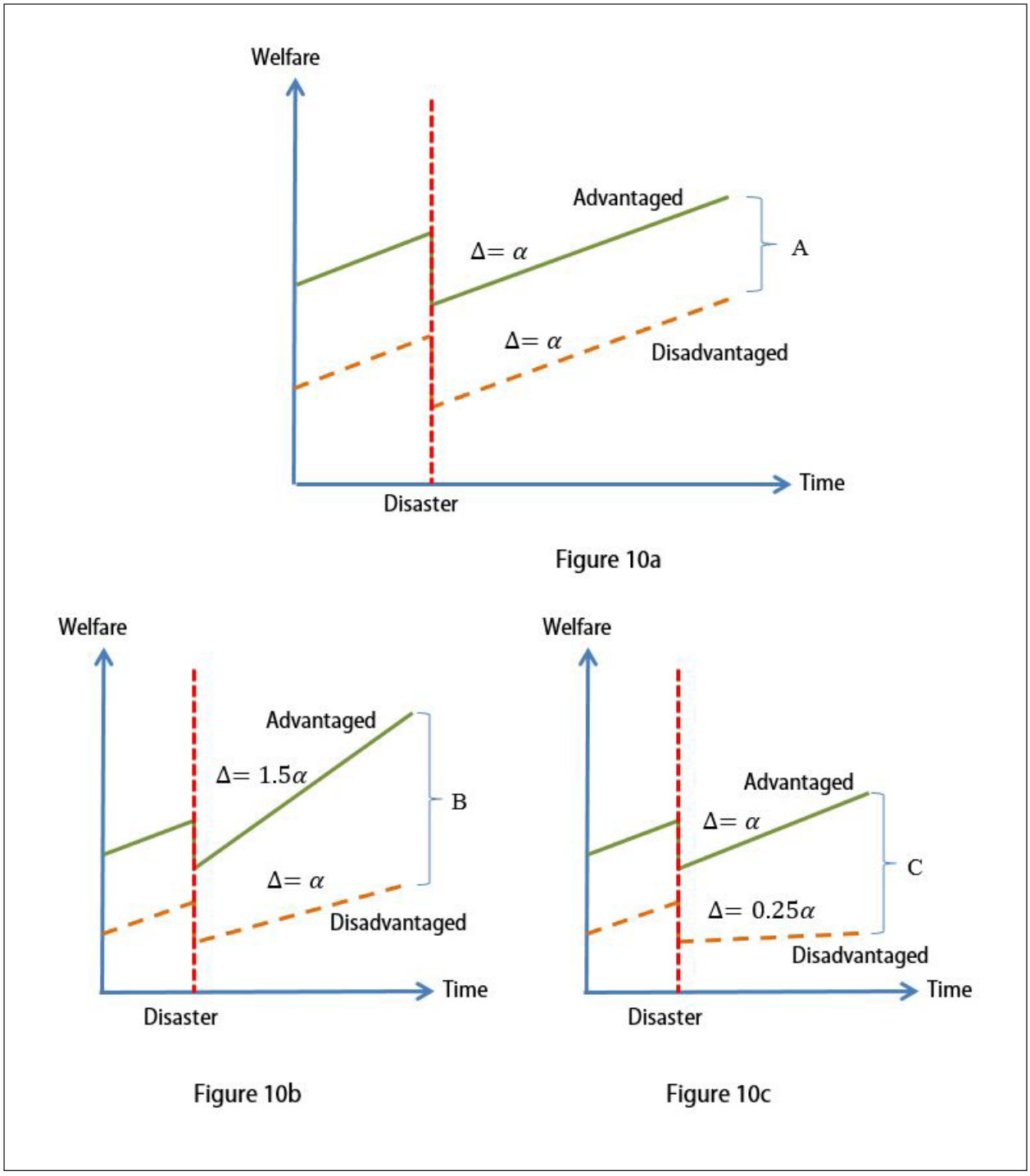
6 Effects of inequality on the ability to cope and recover

Coping and recovery are the third channel through which the "inequality-climate change vicious cycle" works. Inequality implies less resources for the disadvantaged groups to undertake coping and recovery measures. These resources can generally take four forms: (i) households' own (private) resources, (ii) community resources, (iii) resources provided by various non-government organisations (NGOs), including religious and philanthropic organizations and philanthropic activities of private companies, foundations, etc., and (iv) public resources provided by the government, including local governments. Disadvantaged groups are likely to be lacking in some, if not all, of these resources. As a result, their relative situation worsens further.

6.1 Recovery trajectories

To see how the lack of ability to cope with and recover from climate damages exacerbates inequality, we may consider recovery trajectories. In the wake of a climate disaster, even if one assumes equal exposure and susceptibility to damage between advantaged and disadvantaged households (which has been demonstrated not to be the case in the two preceding sections) the rate of recovery can be an important determinant of future inequality. If both the advantaged and disadvantaged households recover at the same rate, then the inequality (measured as

Figure 10
Differential rates of recovery from climate disasters of wealthy and poor households (based on Mutter (2015) Technical Appendix 1)



proportion) will remain constant (Figure 10a). On the other hand, if the disadvantaged groups fail to recover at the same rate as the advantaged ones, the inequality (measured as proportion) will increase (Figures 10b and 10c).

There is considerable evidence that the disadvantaged groups indeed experience slower recoveries from adverse impacts of climate change (Verner, 2010; Carter, et al, 2007; Kraay and McKenzie, 2014; Ravallion and Jalan, 2001). Barbier (2010) and Barrett et al. (2011) show that the lack of resources often forces the disadvantaged groups to cope with climate hazards in such detrimental ways as put their future adaptive and growth capacity at risk. McDowell and Hess (2012) also reach similar conclusions. In the following, we consider how inequality reduces resources of different types for disadvantaged groups and how that affects their coping and recovery ability.

6.2 Own resources

Own resources are obviously the most important determinant of the ability of a household to cope with and recover from damages caused by climate hazards.

Insurance as a coping and recovery mechanism

Having insurance is an important way to cope with and recover from unexpected damages. Unfortunately, lack of own resources often prevents the disadvantaged groups from buying necessary insurance. For example, Verner (2010) reports from Latin America that asset losses by households with higher income levels are much more likely to be insured. Mosely (2015) emphasizes micro-insurance as a way of extending insurance to those lying at the lower end of the asset and income distributions. Micro-insurance is generally targeted toward disadvantaged groups and tends to focus on particular risks, such as health risks. However, more recently, micro-insurance has extended its coverage to crop risks, using rainfall and other such objective indexes as the criteria. India's BASIX program, relying on rainfall measure, is one such example (ibid). However, unlike micro-credit schemes, micro-insurance schemes are still very few, and the rural population's most disadvantaged parts, who do not own cultivable land, cannot generally benefit from schemes focused on crop risks. Thus, unlike the advantaged sections of the society, the disadvantaged groups generally cannot avail themselves of insurance facilities as a way of coping with and recover from the damages they suffer due to climate change.

Another important way in which the inability to get insurance affects the well-being of the disadvantaged people is the following. In absence of insurance, the disadvantaged households often cannot avail themselves of the high return but high risk crops. Instead they remain stuck with low risk but low yielding crop cultivation, leading to greater inequality over time (Clarke and Dercon 2015).

Conflicting choice between physical and human capital

In coping with climate hazards, the disadvantaged groups often face a difficult choice between protecting their *human* capital and preserving their *physical* capital. Because of the absence of health insurance, these households face large expenses when hit by diseases in the wake of climate hazards. To meet these expenses, they often sell physical assets, thus undermining their future income earning ability (Clark and Dercon, 2015). Poverty-stricken households in Ethiopia were found to be forced to sell livestock assets during droughts whereas the more well-off households were not (Little, et al, 2006). In fact, the latter often benefitted from the low prices at which the former had to conduct their distress sales. After the famines in Ethiopia in 1984-1985, it took a decade for asset-poor households to bring livestock holding levels back to pre-famine levels (Dercon, 2004). These are examples of disadvantaged households trying to maintain a minimum consumption level by liquidating their physical assets.

On the other hand, sometimes disadvantaged households reduce their consumption and human capital investments to dangerously low level to hold on to their meagre physical assets (Carter, et al., 2007). However, such drastic reductions often have deleterious long-term effects on the health and education

of the members of the households. In Sub-Saharan Africa, asset-poor households are more likely to provide their children with lower-quality nutrition and are less likely to take sick children to medical consultations following climate hazards. This can have long term impacts on these children and their prospects for development (Hallegatte et al. 2016). Often disadvantaged households withdraw their children from school to save expenses, thus jeopardizing their future education outcomes. For example, it was found in Mexico that the children who are temporarily withdrawn from school are 30 per cent less likely to complete primary school than those children who stay in school (de Janvry et al., 2006). The damage to health and education of the children can perpetuate inequality through generations (Baez, et al, 2010; Mancini and Yang, 2009)

6.3 Common property and social resources

Common property resources shared by the community can be an important part of coping and recovery strategy of the climate affected people. For example, coastal populations in Bangladesh with closer proximity to mangrove reserves were better able to cope in the wake of Cyclone Aila (Akter and Mallik, 2013).[8]

The disadvantaged groups generally rely more heavily on access to the commonly owned ecosystems for getting timber, fish, and other means of sustenance, which help them to smooth consumption and tide over climate shocks (Barbier, 2010).[9] For example, households in tropical and subtropical smallholder systems in South Asia and Sub-Saharan Africa derive considerable fractions of their incomes from commonly owned ecosystems.[10]

Unfortunately, the benefits of the common property resources traditionally accruing to the disadvantaged groups are getting threatened in several ways. First, climate change is leading to degradation of many of the commonly owned ecosystems. This degradation is undermining the wellbeing of the disadvantaged groups more than that of the advantaged groups. For example, Noack et al. (2015) finds that in many communities in Latin America, South Asia and East Asia, the top quintile relies on these services to a lesser degree than all other quintiles, meaning that the highest income residents are least exposed to the adverse effects of climate change on these ecosystems. Second is over extraction, leading to resource depletion, which then affects the wellbeing of the disadvantaged groups more.[11] Third, advantageous groups in many cases are establishing their control over common property resources and are either restricting or shutting off the access of the disadvantaged groups to these resources. This encroachment and private appropriation of what used to be commonly held resources undermines the resource position of the disadvantaged groups.

Often the discrimination in access to commonly owned resources has a gender and ethnic dimensions. For example, Perez et al. (2015) note that women have more limited access to common property resources, and this limitation serves as a factor leading to differential impacts from climate change hazards. Matin et al. (2014), on the other hand, provide evidence showing that dominant ethnic groups can control resource management and resource use at the expense of other ethnic groups.

8 The availability and access to social capital can provide households that may have limited access to other resources the means to cope with climate hazards. For example, Braun and Aßheure (2011) find that social capital plays an important role in the ability to cope with floods in Dhaka, Bangladesh.

9 Continuously growing resource stocks such as fish and timber are less sensitive to weather fluctuations than annual crops, which may aid resilience.

10 Howe et al. (2013) surveyed literature on climate change and ecosystem services and they point to effects of hazard regulation and soil and water regulation in low elevation coastal zones and dryland margins as the main avenues of effect on lower income households.

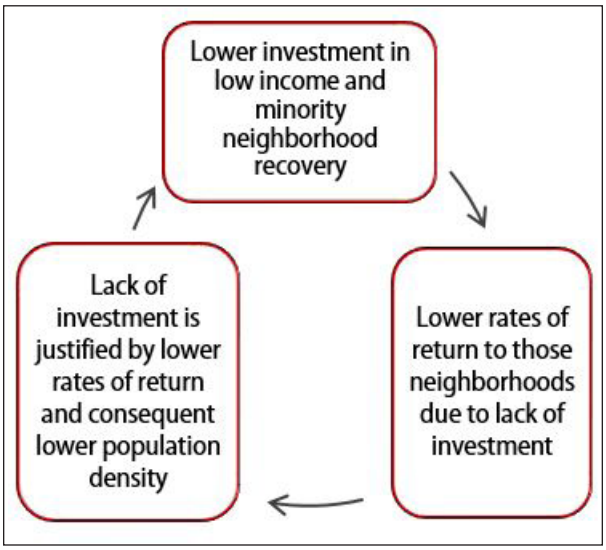
11 The use of these types of ecosystem resources can act as coping mechanisms for periods of reduced income, but this can lead to over-extraction and reduced sustainability of these ecosystems (Hallegatte, et al., 2016).

6.4 Public resources

The use of public resources for coping and recovery is frequently a function of political dynamics of the society and which groups are in a position to direct resources to serve their interests. We noticed above the Power Weighted Social Decision Rule, according to which social decisions are taken based on welfare functions in which the utilities of the advantaged groups receive greater weights.

A striking example of disadvantaged groups getting less public resources needed for coping with and recover from climate damage is provided by the Hurricane Katrina experience in New Orleans, USA. Though areas inhabited by low income and black population suffered worse damage, the public recovery efforts in these areas proceeded at much slower rates than in areas inhabited by wealthier and while population (Mutter 2015, Finch et al. 2010).[12]

Figure 11
Vicious circle between recovery effort and non-return of African-Americans of New Orleans city following Hurricane Katarina



Source: Authors, based on the discussion in the text.

Discouraged by slow and inadequate recovery efforts in their neighborhoods, many African Americans, displaced by Katarina, did not return. Their slow return helped to justify devotion of less resources for recovery. A vicious circle thereby emerged, resulting in permanent non-return by many African-Americans (Figure 11). For example, almost 100,000 African-Americans did not return to the city of New Orleans by 2013, as compared to around 11,500 white residents. As a result, the share of African-American in the population of the city decreased from 66.7 to 59.1 per cent in 2013 (Srinath et al. 2014). The ability to return to the city had long-term effects, as those who could return had better labour market outcomes than non-returnees (Groen and Polivika 2008). It has been pointed out however that the low recovery effort in the African-American inhabited areas was in part a conscious policy choice aimed at discouraging construction and habitation in these areas which were also more vulnerable to flooding due to their low elevation.[13]

The Katarina experience therefore illustrates how economic and racial inequalities combined to allocate less resources for coping and recovery by disadvantaged groups, resulting in perpetuation or even aggravation of inequality.

Similarly, in Bangladesh, following the great flood of 1988, a huge amount of public resources was devoted to the construction of the Greater Dhaka Western Embankment, aimed at protecting the capital city residents from future flooding, ignoring the fact that the embankment will aggravate flooding for the rural population outside the city perimeter. This was possible because the utility of the city residents, who on average have higher income and greater political clout, received greater weight in the social welfare function than did the utility of the rural folks (Islam 2016).

12 For example, the Lakeview neighborhood was one of the neighborhoods with lowest elevation in the New Orleans Parish, and yet it was able to recover much quicker than other areas, due to, in part, the relative wealth of that neighborhood (Srinath et al. 2014).

13 See for example, FEMA (2016) Hurricane Katrina: A Decade of Progress through Partnerships, https://www.fema.gov/hurricane-katrina-decade-progress-through-partnerships (accessed on September 7, 2017).

Thus, discrimination with regard to allocation of public resources may combine with less private and community resources available to disadvantaged groups to make coping with and recover from climate change inflicted damages very hard for them, perpetuating and even aggravating inequality.

7 Combination of channels

In the above we saw evidence of inequality reinforcing effects of climate change through the three channels separately. Though these channels are conceptually distinct, often the evidence represents the combined effect of all three or any two of them. This is in part because of the absence of an analytical framework so far. In part, this is also because it is not always easy to distinguish in actual evidence the effect of the different channels, despite their conceptual distinction.

Also, important in this connection is the prevalence in the literature of terms standing for effects of various combinations of the channels above. One term that has been used widely is "vulnerability," which did not always have the same meaning in different works. IPCC (2015) defines vulnerability to refer to a combination of "susceptibility" and "ability to cope and recover." Consequently, evidence has often been presented for "vulnerability" without distinguishing its two components.

Evidence of combined effect can be found, for example, in Medeksa (2009), who, using a disaggregated General Equilibrium (GE) model for Ethiopia, concludes that climate change will reduce agricultural production and output in sectors linked to agriculture, and will also raise the Gini coefficient of inequality in the country. Dennig et al. (2015), running a variant of the Regional Integrated model of Climate and the Economy (RICE), point to greater vulnerability to climate change of lower income households versus higher income households and consequent increases in inequality. Yamamura (2013), using a panel dataset of 86 countries over almost 40 years, finds that the immediate effect of natural disasters – including those related with climate change – is to increase inequality. Verner (2010) shows that the inequality enhancing effect of the natural disasters tends to persist.

While helpful for general understanding of the relationship between inequality and climate change, these (composite) evidences do not clarify the causality and hence prove to be less useful from policy viewpoint. The analytical framework presented and the three channels identified in this paper may therefore prove helpful in future field level study of the relationship between inequality and climate change.

8 From within-inequality to across-inequality

The analytical framework presented in this paper can be used to study and understand the relationship between climate change and across-country inequality.

First of all, looking across the world, we see that low-income countries are more exposed to the adverse effects of climate change. More of these countries are, inter alia, located in tropical areas; have low elevation; lie in hurricane, cyclone, and tsunami zones; situated in arid areas, already facing water scarcity; and so forth. Consequently, they are more exposed to such climate change effects as sea level rise; salinity intrusion; increased incidence, scope, and ferocity of cyclones and hurricanes; precipitation imbalance; and so forth. By contrast most of the high-income countries are located in cold and temperate zones, where some people in fact welcome temperature increase, arguing that it will elongate the crop growing season, increase the crop area, reduce home heating expenses, and so forth, leading to increase in output and well-being. While experience has tempered some of these early expectations, it remains the case that these countries are generally less exposed to sea level rise, increase in the incidence of hurricanes, and other adverse consequences of climate change. Thus, it is a historically given fact that low-income countries are generally *more exposed* to the adverse effects of climate change.

Second, low-income countries are also *more susceptible* to the damages caused by climate change effects. The reasons are not too far to see. For example, the Netherlands – a high-income country – is also low lying and is exposed to sea level rise. However, it has built sea walls and other structures, so that it is not as susceptible to damages caused by sea level rise as is the case with many low-lying, low-income, tropical island countries.

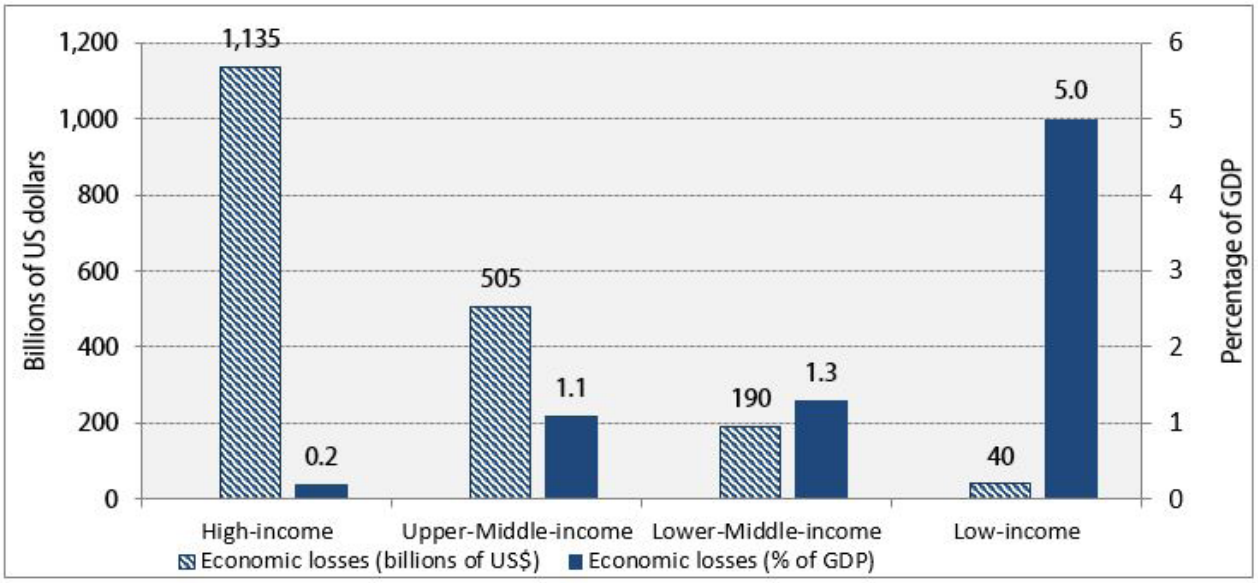
Some proximate evidence of the fact that low-income countries suffer more damage from climate change effects can be seen from the information presented in Figure 12. It shows that losses from weather related disasters during 1995-2015 accounted for 5 percent of the GDP of the low-income countries, as compared to only 0.2 percent for the high-income countries.

Finally, the low-income countries also have less capability to cope with and recover from the damages caused by climate change effects. For example, unlike in high-income countries, most people in low-income countries lack insurance, so that they cannot muster private resources to cope with and recover from climate damages. Also, low-income countries have less public resources to be devoted to help the affected people to overcome their losses. The United States allocated about $60 billion to compensate for the damages suffered by the people and areas that suffered from the Hurricane Sandy. The entire GDP of most of the low-income countries is less than that amount.

We thus see that low-income countries in general are more exposed to the adverse effects of climate change. They are also more susceptible to the damages caused by climate change. They also have less ability to cope and recover. Consequently, climate change is worsening the relative position of the low-income countries, thus aggravating inequality across countries. Also, the climate change reinforcing (feedback) effect is true for cross-country inequality. The Power Weighted Decision Rule operates to a certain extent at the international stage too.[14]

Figure 12

Economic losses from weather-related disasters (billions of dollars) and as percentage of GDP by income group, 1995-2015



Source: United Nations (2016).

14 Though formally all countries have the same weight (one country, one vote principle) in the UNFCCC, in actual negotiations, the high-income countries generally enjoy more leverage than the low-income countries.

It wouldn't be wrong to speculate that international climate change mitigation efforts would have been more vigorous if the countries across the world were more equal.

The above brief discussion shows that the analytical framework presented in this paper can be used for studying the relationship between climate change and across-country inequality too. Elaboration of this relationship can be a topic for future research.

9 Concluding Remarks

This paper offers an analytical framework for studying the relationship between social inequality and climate change. It shows that this relationship is characterized by a vicious cycle, whereby initial inequality makes disadvantaged groups suffer disproportionate loss of their income and assets, resulting in greater subsequent inequality. It shows that inequality exerts the disproportionate effects through three channels, namely (i) increased exposure of disadvantaged groups to climate hazards, (ii) increased susceptibility to damage caused by climate hazards, and (iii) decreased ability to cope with and recover from the damage. The paper provides evidence supporting the proposed analytical framework.

The climate discussion has proceeded through successive stages. At the initial stage, the focus was on the physical effects of climate change. At the next stage, more attention was paid to the social effects. The discussion at this stage frequently drew inferences regarding inequality but did not quite focus on it. The discussion now needs to move to the next, third stage, with the focus on inequality. The analytical framework presented in this paper can be of much help in this regard. It may help to sharpen the research questions; identify the information gaps; classify the gathered information in a uniform manner and using uniform terminology; present the information in a coherent way; and be comprehensive in scope.

There are significant policy implications of the analysis presented in this paper. At a broad level, the discussion of the paper can help to achieve the SDGs. SDG-11 calls for reduction of inequality while SDG-13 calls for mitigation of climate change. The discussion of the paper shows that it may be possible to address these two goals simultaneously. The key here is inequality reduction, which can help to contain the adverse effects of climate change. Moreover, through the feedback effect, it may mitigate climate change itself. Thus, a virtuous cycle may replace the current vicious cycle.

At a more concrete level, the distinction made by the paper among "exposure," "susceptibility," and "ability to cope and recover" should be of much help in formulating policies that can address these different inequality-enhancing effects. There are overlaps among these effects, as noted in the paper, and often policies are needed that can address more than one of the effects above. However, the distinction above should be helpful in knowing what is being addressed and where to start from, instead of being overwhelmed by the enormity and complexity of the task. Also important is to note that the concrete forms that the three effects take depend on a country's concrete circumstances. Thus, the analysis of this paper does not suggest "one-size-fits-all" type policies. Instead, it points to the necessity of policies based on deeper analyses of the concrete circumstances of a country.

Of course, to be successful in making use of the linkages between inequality and climate change presented in this paper, it will be necessary to know how to reduce inequality. This is a big question that remains outside the purview of this paper. Here again, much will depend on the concrete circumstances of a country.

REFERENCES

Abdi, Omar A., Edinam K. Glover and Olavi Luukkanen (2013). Causes and Impacts of Land Degradation and Desertification: Case Study of the Sudan. *International Journal of Agriculture and Forestry*, vol. 3, no. 2, p. 40-51.

Adepetu, A. A. and A. Berthe (2007). Vulnerability of Rural Sahelian Households to Drought: Options for Adaptation. Final Report Submitted to Assessments of Impacts and Adaptations to Climate Change (AIACC), Project No. AF 92. Washington, D.C.: International START Secretariat.

Ahmed, Syud A., Noah S. Diffenbaugh and Thomas W. Hertel (2009). Climate volatility deepens poverty vulnerability in developing countries. *Environmental Research Letters*, vol. 4, no. 3, p. 1-8.

Akter, Sonia and Bishawjit Mallick (2013). The poverty-vulnerability-resilience nexus: Evidence from Bangladesh. *Ecological Economics*, vol. 96, p. 114-124.

Anbarci, N., Escaleras, M., Register, C. (2005). Earthquake fatalities: the interaction of nature and political economy. *Journal of Public Economics* 89, p 1907–1933.

Baez, Javier, Alejandro de la Fuente and Indhira Santos (2010). Do Natural Disasters Affect Human Capital? An Assessment Based on Existing Empirical Evidence. IZA Discussion Paper No. 5164.

Barbier, Edward B. (2010). Poverty, Development and Environment. *Environment and Development Economics*, vol. 15, no. 6, p. 635-660.

___(2015). Climate change impacts on rural poverty in low-elevation coastal zones. Policy Research Working Paper no. 7475. Washington, D.C.: World Bank.

Barbier, Bruno, Hamma Yacouba, Harouna Karambiri, Malick Zoromé and Blaise Somé (2009). Human Vulnerability to Climate Variability in the Sahel: Farmers' Adaptation Strategies in Northern Burkina Faso. *Environmental Management*, vol. 43, no. 5, p. 790-803.

Barrett, Christopher B., Alexander J. Travis and Partha Dasgupta (2011). Biodiversity conservation and poverty traps. *Proceedings of the National Academy of Sciences of the United States of America*, vol. 108, no. 34, p. 13907-13912.

Ben Mohamed, Abdelkrim (2009). Climate Change Risks in Sahelian Africa. *Regional Environmental Change*, vol. 11, sup. 1, p. 109-117.

Boyce, James K. (1994). Inequality as a Cause of Environmental Degradation. *Ecological Economics*, vol. 11, p. 169-178.

Boyce, James K. (2003). Inequality and Environmental Protection. Political Economy Research Institute (PERI) Working Paper no. 52. Amherst, MA: University of Massachusetts.

Brainard, Lael, Abigail Jones and Nigel Purvis (eds.) (2009). Climate Change and Global Poverty: A Billion Lives in the Balance? Washington, D.C.: Brookings Institution Press.

Braun, Boris and Tibor Aßheuer (2011). Floods in megacity environments: vulnerability and coping strategies of slum dwellers in Dhaka/Bangladesh. *Natural Hazards*, vol. 58, p. 771-787.

Brooks, Nick (2006). Climate change, drought and pastoralism in the Sahel. Discussion note for the World Initiative on Sustainable Pastoralism.

Brouwer, Roy, Sonia Akter, Luke Brander and Enamul Haque (2007). Socioeconomic Vulnerability and Adaptation to Environmental Risk: A Case Study of Climate Change and Flooding in Bangladesh. *Risk Analysis*, vol. 27, issue 2, p. 313-326.

Campanella, Richard (2011). An Initial Interpretation of 2010 Racial and Ethnic Geographies of Greater New Orleans.

Carter, Michael, Peter D. Little, Tewodaj Mogues and Workneh Negatu (2007). Poverty Traps and Natural Disasters in Ethiopia and Honduras. *World Development,* vol. 35, no. 5, p. 835-856.

Chaktaborty, Jayajit (2017), "Focus on environmental justice: new directions and international research, *Environmental Research Letters*, Vol. 12, pp. 1-4.

Chakravarty, Shoibal, Ananth Chikkatur, Helen de Coninck, Stephen Pacala, Robert Socolow, and Massimo Tavoni (2007). Climate Policy Based on Individual Emissions, Princeton, NJ, Princeton University Center, Princeton University.

Christenson, Elizabeth, Mark Elliot, Ovik Banerjee, Laura Hamrick and Jamie Bartram (2014). Climate-Related Hazards: A Method for Global Assessment of Urban and Rural Population Exposure to Cyclones, Droughts and Floods. *International Journal of Environmental Research and Public Health*, vol. 11, no. 2, p. 2169-2192.

Clarke, Daniel and Stefan Dercon (2015). Insurance, Credit, and Safety Nets for the Poor in a World of Risk. In *Financing for Overcoming Economic Insecurity*, Nazrul Islam and Rob Vos, eds. New York: Bloomsbury and United Nations.

Cotula, Lorenzo (2006). Water Rights, Poverty and Inequality: The Case of Dryland Africa. Human Development Report Occasional Paper 2006/2. New York: United Nations Development Programme.

D'haen, Sarah Ann Lise, Jonas Østergaard Nielsen and Eric F. Lambin (2014). Beyond local climate: rainfall variability as a determinant of household nonfarm activities in contemporary rural Burkina Faso. *Climate and Development*, vol. 6, no. 2, p. 144-165.

Dasgupta, Susmita, and others (2010). Vulnerability of Bangladesh to Cyclones in a Changing Climate: Potential Damages and Adaptive Cost. World Bank Policy Research Working Paper 5280. Washington, D.C.: World Bank.

Dasgupta, Susmita, Md. Moqbul Hossain, Mainul Huq and David Wheeler (2014). Climate change, soil salinity, and the economics of high-yield rice production in coastal Bangladesh. Policy Research Working Paper no. WPS 7140. Washington, D.C.: World Bank.

de Janvry, Alain, Frederico Finan, Elisabeth Sadoulet and Renos Vakis (2006). Can conditional cash transfer programs serve as safety nets in keeping children at school and from working when exposed to shocks? *Journal of Development Economics*, Vol. 79, no. 2, p. 349-373.

del Ninno, Carlo, Paul A. Dorosh, Lisa C. Smith and Dilip Roy (2001). The 1998 Floods in Bangladesh: Disaster Impacts, Household Coping Strategies, and Response. International Food Policy Research Institute Research Report 122. Washington, D.C.: International Food Policy Research Institute.

Dennig, Francis, Mark B. Budolfson, Marc Fleurbaey, Asher Siebert and Robert H. Socolow (2015). Inequality, climate impacts on the future poor and carbon prices. *Proceedings of the National Academy of Sciences*, vol. 112, no. 52, p. 15827-15832.

Dercon, Stefan (2004). Growth and shocks: evidence from rural Ethiopia. *Journal of Development Economics*, vol. 74, p. 309-329.

Di Lernia, Savino (2006). Building monuments, creating identity: Cattle cult as a social response to rapid environmental changes in the Holocene Sahara. *Quaternary International*, vol. 151, no. 1, p. 50-62.

Douglas, Ian, Kurshid Alam, Maryanne Maghenda, Yasmin Mcdonnell, Louise Mclean and Jack Campbell (2008). Unjust waters: climate change, flooding and the urban poor in Africa. *Environment and Urbanization*, vol. 20, no. 1, p. 187-205.

Egeru, Anthony, Eseza Kateregga, Gilber Jackson Mwanjalolo Majaliwa (2014). Coping with Firewood Scarcity in Soroti District of Eastern Uganda. *Open Journal of Forestry*, vol. 4, no. 1, p. 70-74.

Finch, Christina, Christopher T. Emrich and Susan L. Cutter (2010). Disaster disparities and differential recovery in New Orleans. *Population and Environment*, vol. 31, no. 4, p. 197-202.

Gentle, Popular and Tek Narayan Maraseni (2012). Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal. *Environmental Science Policy*, vol. 21, p. 24-34.

Gentle, Popular, Rik Thwaites, Digby Race and Kim Alexander (2014). Differential impacts of climate change on communities in the middle hills region of Nepal. *Natural Hazards*, vol. 74, p. 815-836.

Georgeson, Lucien, Mark Maslin, Martyn Poessinouw and Steve Howard (2016). Adaptation responses to climate change differ between global megacities. *Nature Climate Change*, p. 1-6.

Groen, Jeffrey A. and Anne E. Polivka (2008). The Effect of Hurricane Katrina on the Labor

Market Outcomes of Evacuees. *American Economic Review*, vol. 98, no. 2, p. 43-48.
Hallegatte, Stephane and others (2014). Climate Change and Poverty: An Analytical Framework. World Bank Policy Research Working Paper 7126. Washington, D.C.: World Bank.
Hallegatte, Stephane and others (2016). Shock Waves: Managing the Impacts of Climate Change on Poverty. Washington, D.C.: World Bank.
Hardoy, Jorgelina and Gustavo Pandiella (2009). Urban poverty and vulnerability to climate change in Latin America. *Environment and Urbanization*, vol. 21, no. 1, p. 203-224.
Hashizume, Masahiro, and others (2008). Factors determining vulnerability to diarrhoea during after severe floods in Bangladesh. *Journal of Water and Health*, vol. 6, no. 3, p. 323-332.
Hein, Lars, Marc J. Metzger and Rik Leemans (2009). The local impacts of climate change in the Ferlo, Western Sahel. *Climatic Change*, vol. 93, p. 465-483.
Heinrigs, Philipp (2010). Security Implications of Climate Change in the Sahel Region: Policy considerations. Paris: Organization for Economic Cooperation and Development Sahel and West Africa Club Secretariat.
Hertel, Thomas W., Marshall B. Burke and David B. Lobell (2010). The Poverty Implications of Climate-Induced Crop Yield Changes by 2030. Global Trade Analysis Project (GTAP) Working Paper no. 59.
Hertel, Thomas W. and Stephanie D. Rosch (2010). Climate Change, Agriculture and Poverty. World Bank Policy Research Working Paper 5468. Washington D.C.: World Bank.
Hill, Ruth and Carolina Mejia-Mantilla (2015). Welfare and Shocks in Uganda. Background Paper prepared for World Bank Uganda Poverty Assessment. Washington, D.C.: World Bank.
Holthuijzen, Wieteke and Jacqueline Maximillian (2011). Dry, hot and brutal: Climate change and desertification in the Sahel of Mali. *Journal of Sustainable Development in Africa*, vol. 13, no. 7, p. 245-268.
Howe, Caroline, Helen Suich, Paul van Gardingen, Atiq Rahman and Georgina M. Mace (2013). Elucidating the pathways between climate change, ecosystem services and poverty alleviation. Current Opinion in Environmental Sustainability, vol. 5, no. 1, p. 102-107.
Hulme, Mike, Ruth Doherty, Todd Ngara, Mark New and David Lister (2001). African climate change: 1900-2100. *Climate Research*, vol. 17, p.145-168.
Hutton, David (2008). Older People in Emergencies: Considerations for Action and Policy Development. Geneva: World Health Organization.
IPCC (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability. New York: Cambridge University Press.
Islam, S. Nazrul (2015). Inequality and Environmental Sustainability. United Nations Department of Economic and Social Affairs (DESA) Working Paper, no. 145. New York: United Nations.
Islam, S. Nazrul (2016). *Let the Delta be a Delta*, Dhaka: Eastern Academic.
Ivanic, Maros, Will Martin and Hassan Zaman (2012). Estimating the Short-Run Poverty Impacts of the 2010-2011 Surge in Food Prices. *World Development*, vol. 40, no. 11, p.2302-2317
Khandlhela, Masingita and Julian May (2006). Poverty, vulnerability and the impact of flooding in the Limpopo Province, South Africa. *Natural Hazards*, vol. 39, p.275-287.
Kraay, Aart and David McKenzie (2014). Do Poverty Traps Exist? Assessing the Evidence. *Journal of Economic Perspectives*, vol. 28, no. 3, p. 127-148.
Kronik, Jakob and Dorte Verner (2010). Indigenous Peoples and Climate Change in Latin America and the Caribbean. Washington, D.C.: World Bank.
Li, Xiaodong, Kwan Hang Chow, Yimin Zhu and Ying Lin (2016). Evaluating the impacts of high-temperature outdoor working environments on construction labor productivity in China: A case study of rebar workers. Building and Envrionment, vol. 95, p. 42-52.
Lichenko, Robin and Julie A. Silva (2014) Climate change and poverty: vulnerability, impacts and alleviation strategies. *WIREs Climate Change*, vol. 5, p.539-556.
Little, Peter D., M. Priscilla Stone, Tewodaj Mogues and Workneh Negatu (2006). Moving in Place: Drought and Poverty Dynamics in

South Wollo, Ethiopia. *Journal of Development Studies* vol. 42, no. 2, p. 200-225.

Luo, Tianyi, Andrew Maddocks, Charles Iceland, Philip Ward and Hessel Winsemius (2015). World's 15 Countries with the Most People Expsoed to River Floods. World Resources Institute Blog March, 05, 2015: http://www.wri.org/blog/2015/03/world%E2%80%99s-15-countries-most-people-exposed-river-floods.

Macchi, Mirjam, Amanda Manandhar Gurung and Brigitte Hoermann (2014). Community perceptions and responses to climate variability and change in the Himalayas. *Climate and Development*, p.1-12.

Maccini, Sharon and Dean Yang (2009). Under the Weather: Health, Schooling and Economic Consequences of Early-Life Rainfall. *American Economic Review*, vol. 99, no 3, p. 1006-1026.

Marshall, Fiona and Elisabeth Hildebrand (2002). Cattle Before Crops: The Beginnings of Food Production in Africa. *Journal of World Prehistory*, vol. 16, no. 2, p. 99-143.

Matin, Nilufar, and others (2014). Group Inequality and Environmental Sustainability: Insights from Bangladesh and Kenyan Forest Commons. *Sustainability*, vol. 6, p.1462-1488.

McDowell, Julia Z. and Jeremy J. Hess (2012). Accessing Adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate. *Global Environmental Change*, vol. 22, p.342-352.

Mekonnen, Mesfin M. and Arjen Y. Hoekstra (2016). Four billion people facing severe water scarcity. *Science Advances*, vol. 2, no. 2, p. 1-6.

Mertz, Ole, and others (2011). Adaptation strategies and climate vulnerability in the Sudano-Sahelian region of West Africa. *Atmospheric Science Letters*, vol. 12, p. 104-108.

Met Office Hadley Centre (2010). Sahelian Climate: Past, current, projections. Organization for Economic Cooperation and Development (OECD) Sahel and West African Club Secretariat. Paris, OECD.

Mideksa, Torben K. (2010). Economic and distributional impacts of climate change: The case of Ethiopia. *Global Environmental Change*, vol. 20, p.278-286.

Mohai, Paul, David Pellow, Timmons J. Roberts (2009), "Environmental Justice," *Annual Review of Environment and Resources*, vol. 34, no. 1, pp. 405-430

Moser, Caroline (2007). Asset Accumulation Policy and Poverty Reduction. In Reducing Global Poverty: The Case for Asset Accumulation, Caroline O.N. Moser, ed. Washington, D.C.: Brookings Institution Press.

Mosley, Paul (2015). Assessing the success of microinsurance programmes in meeting the insurance needs of the poor. In Financing for Overcoming Economic Insecurity, Nazrul Islam and Rob Vos, eds. New York: Bloomsbury and United Nations.

Müller, Christoph, Wolfgang Cramer, William L. Hare, and Hermann Lotze-Campen (2011). Climate change risks for African Agriculture. *Proceedings of the National Academy of Sciences*, vol. 108, no. 11, p. 4313-4315.

Mutter, John C. (2015). *Disaster Profiteers: How Natural Disasters Make the Rich Richer and the Poor Even Poorer*. New York: St. Martin's Press.

Neumann, Barbara, Athanasios T. Vafeidis, Juliane Zimmermann and Robert J. Nicholls (2015). Future Coastal Population Growth and Exposure to Sea-Level rise and Coastal Flooding – A Global Assessment. *PLoS ONE*, vol. 10, no. 3, p. 1-34.

Nkedianye, Davie and others (2011). Mobility and livestock mortality in communally used pastoral areas: the impact of the 2005-2006 drought on livestock mortality in Maasailand. Pastoralism: Research, *Policy and Practice*, vol. 1, p. 1-17.

Noack, Frederik, Sven Wunder, Arild Angelsen and Jan Börner (2015). Responses to weather and climate: a cross-section analysis of rural incomes. Policy Research working paper no. WPS 7478. Washington, D.C.: World Bank.

Overeem, Irina and J.P.M. Syvitski (2009). Dynamics and Vulnerability of Delta Systems. LOICZ Reports and Studies no. 35. Geesthacht, Germany: Institute for Coastal Research.

Paavola, Jouni (2008). Livelihoods, Vulnerability and Adaptation to Climate Change in the Monogoro Region, Tanzania. *Environmental Science & Policy*, vol. 11, no. 7, p. 642-654.

Painter, James (2007). Deglaciation in the Andean Region. Human Development 2007/2008 Occasional Paper. New York: United Nations Development Programme.

Patankar, Archana (2015). The exposure, vulnerability, and ability to respond of poor households to recurrent floods in Mumbai. Policy Research Working Paper no. WPS 7481. Washington, D.C.: World Bank.

Patankar, Archana and Anand Patwardhan (2015). Estimating the uninsured losses due to extreme weather events and implications for informal sector vulnerability: a case study of Mumbai, India. *Natural Hazards*, vol. 10, p.1-26.

Perez, Carlos, and others (2015). How resilient are farming households and communities to a changing climate in Africa? A gender-based perspective. *Global Environmental Change,* vol. 34, p.95-107.

Pleyers, Geoffrey (2015), Climate Justice in the Global Age: A Social Movement Perspective (http://www.academia.edu/10357271), ISA-Sage

Rabbain, Golam, Atiq Rahman and Khandaker Mainuddin (2013). Salinity-induced loss and damage to farming households in coastal Bangladesh. *International Journal of Global Warming*, vol. 5, No. 4, p. 400-415.

Ravallion ,Martin and Jyotsna Jalan (2001). Household Income Dynamics In Rural China. World Bank Policy Research Working Paper. Washington, D.C.: World Bank.

Rentschler, Jun E. (2013) Why Resilience Matters: The poverty impacts of disasters. Policy Research Working Paper no. WPS 6699. Washington, D.C.: World Bank.

Sabates-Wheeler, Rachel (2006). Asset Inequality and Agricultural Growth: How are patterns of asset inequality established and reproduced. World Development Report 2006 Background Paper. Washington, D.C.: World Bank.

Satterthwaite, David, Saleemul Huq, Hannah Reid, Mark Pelling and Patricia Romero Lankao (2007). Adapting to climate change in Urban Areas: The possibilities and constraints in low- and middle-income nations. International Institute for Environment and Development (IIED)Human Settlements Discussion Paper Series: Theme: Climate Change and Cities – 1.

Scholl, Adam (2012). Map Room: Hidden Waters. *World Policy Journal*, vol. 29, no. 4, p. 9-11.

Sen, Amartya (1990), "More than 100 million women are missing," *The New York Review of Books*, December 20

Sen, Binayak (2003). Drivers of Escape and Descent: Changing Household Fortunes in Rural Bangladesh. World Development, *Chronic Poverty and Development Policy*, vol. 31, p. 513-534.

Shameem, Masud Iqbal Md., Salim Momtaz and Ray Rauscher (2014). Vulnerability of rural livelihoods to multiple stressors: A case study from the southwest coastal region of Bangladesh. *Ocean & Coastal Management*, vol. 102, part A, p. 79-87.

Sherwood, Amy (2013). Community adaptation to climate change: exploring drought and poverty traps in Gituamba location, Kenya. Journal of Natural Resources Policy Research vol. 5 no. 2-3, p.147-161.

Shrinath, Nihal, Vicki Mack and Allison Plyer. Who Lives in New Orleans and Metro Parishes Now? Data Center Research.

Sietz, Diana, Sabino Edgar Mamani Choque and Matthias K. B. Lüdeke (2011). Typical patterns of smallholder vulnerability to weather extremes with regard to food security in the Peruvian Altiplano. *Regional Environmental Change*, vol. 12, p. 489-505.

Sissoko, Keffing, Herman van Keulen, Jan Verhagen, Vera Tekken and Antonella Battaglini (2011). Agriculture, livelihoods and climate change in the West African Sahel. *Regional Environmental Change*, vol. 11, p. 119-125.

Skoufias, Emmanuel, Mariano Rabassa and Sergio Olivieri (2011). The Poverty Impacts of Climate Change: A Review of the Evidence. World Bank Policy Research Working Paper 5622. Washington, D.C.: World Bank.

Skoufias, Emmanuel, ed. (2012). The Poverty and Welfare Impacts of Climate Change: Quantifying the Effects, Identifying the Adaptation Strategies. Washington, D.C.: World Bank

Snorek, Julie, Fabrice G. Renaud and Julia Kloos (2014). Divergent adaptation to climate variability: A case study of pastoral and

agricultural societies in Niger. *Global Environmental Change*, vol. 29, p. 371-386.

Somanathan, E. and Rohini Somanathan (2009). Climate Change: Challenges Facing India's Poor. *Economic & Political Weekly*, vol. 44, no. 31.

Somanathan, E., Rohini Somanathan, Anant Sudarshan and Meenu Tewari (2014). The Impact of Temperature on Productivity and Labor Supply: Evidence from Indian Manufacturing. Indian Statistical Institute Discussion Paper 14-10.

Stern, Nicolas (2006). Stern Review: The Economics of Climate Change. London: HM Treasury.

Straus, Scott (2011). Mali and its Sahelian Neighbors. World Bank World Development Report 2011 Background Case Study. Washington, D.C.: World Bank.

Turner, B. L. R. E. Kasperson, P. A. Matson, J. J. McCarthy, R. W. Corell, L. Christensen, N. Eckley, J. X. Kaspersen, A. Luers, M. L. Martello, C. Polsky, A. Pulsipher, A. Schiller (2003), "A framework for vulnerability analysis in sustainability science," *PNAS*, Vol. 100, No. 14 (July 8), pp. 8074-8079

United Nations (2013). Report of the Secretary-General on the situation in the Sahel region. S/2013/354, 14 June 2013. New York: United Nations.

United Nations (2016), *Climate Change Resilience: An Opportunity for Reducing Inequalities, World Economic and Social Survey 2016*, New York, Sales No. E.16.11.C.1

United Nations Development Programme (UNDP) (2006). Human Development Report 2006: Beyond scarcity: Power, poverty and the global water crisis. New York: United Nations.

United Nations Development Programme (UNDP) (2008). Human Development Report 2007/2008: Fighting climate change: Human solidarity in a divided world. New York: United Nations.

Verhagen, A., and others (2003). Climate Change and Food Security in the Drylands of West Africa. Global Environmental Change and Land Use, Haarman, H. J. T. M., Verhagen, Jan and Rovers, C. A. (eds.). Dordrecht, Netherlands: Springer Netherlands.

Verner, Dorte (ed.) (2010). Reducing Poverty, Protecting Livelihoods, and Building Assets in a Changing Climate: Social Implications of Climate Change for Latin America and the Caribbean. Washington, D.C.: World Bank.

Winsemius, Hessel, Brenden Jongman, Ted Veldkamp, Stephane Hallegatte, Mook Bangalore and Philip J. Ward (2015). Disaster Risk, climate change, and poverty: assessing the global exposure of poor people to floods and droughts. Policy research working paper no. WPS 7480. Washington, D.C.: World Bank.

Wodon, Quentin, Andrea Liverani, George Joseph and Nathalie Bougnoux (eds.) (2014). Climate Change and Migration: Evidence from the Middle East and North Africa. Washington, D.C.: World Bank.

Woodroffe, Colin D. (2010). Assessing the vulnerability of Asian megadeltas to climate change using GIS. In D. Green et al, eds., Coastal and Marine Geospatial Technologies. London: Springer.

World Bank (2002). Poverty and Climate Change: Reducing the Vulnerability of the Poor through Adaptation. Washington: D.C.: World Bank.

World Bank (2008). Global Monitoring Report 2008: MDGs and the Environment: Agenda for Inclusive and Sustainable Development. Washington, D.C.: World Bank.

World Bank (2013). Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience. Washington, D.C.: World Bank.

World Resources Institute (WRI) (1997). Aridity Zones and Dryland Populations: An Assessment of Population Levels in the World's Drylands. New York: United Nations Development Programme (UNDP).

Yamamura, Eiji (2013). Impact of natural disasters on income inequality: Analysis using panel data during the period 1965 to 2004. MPRA Working Paper No. 45623.

Zivin, Joshua Graff and Matthew J. Neidell (2014). Temperature and Allocation of Time: Implications for Climate Change. *Journal of Labor Economics*, vol. 32, no. 1, p. 1-26.