

**David Castells-Quintana, Maria del Pilar Lopez-Uribe and
Thomas K.J. McDermott**

Geography, institutions and development: a review of the long-run impacts of climate change

**Article (Accepted version)
(Refereed)**

Original citation:

Lopez-Uribe, Maria del Pilar, Castells-Quintana, David and McDermott, Thomas K. J. (2016) *Geography, institutions and development: a review of the long-run impacts of climate change*. *Climate and Development* . ISSN 1756-5529

© 2015 The Authors

This version available at: <http://eprints.lse.ac.uk/65147/>
Available in LSE Research Online: January 2016

LSE has developed LSE Research Online so that users may access research output of the School. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LSE Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain. You may freely distribute the URL (<http://eprints.lse.ac.uk>) of the LSE Research Online website.

This document is the author's final accepted version of the journal article. There may be differences between this version and the published version. You are advised to consult the publisher's version if you wish to cite from it.

Geography, institutions and development: A review of the long-run impacts of climate change

David Castells-Quintana^{ab}
Maria del Pilar Lopez-Uribe^c
Thomas K.J. McDermott^{de}

December 2015

Abstract

The links between climate change, economic growth and economic development have gained increasing attention over recent years in both the academic and policy literature. However, most of the existing literature has tended to focus on direct, short run effects of climate change on the economy, for example due to extreme weather events and changes in agricultural growing conditions. In this paper we review potential effects of climate change on the prospects for long-run economic development. These effects might operate directly, via the role of geography (including climate) as a fundamental determinant of relative prosperity, or indirectly by modifying the environmental context in which political and economic institutions evolve. We consider potential mechanisms from climate change to long-run economic development that have been relatively neglected to date, including, for instance, effects on the distribution of income and political power. We conclude with some suggestions for areas of future research.

Acknowledgements

We are very grateful for helpful comments on earlier drafts from Mintewab Bezabih, Declan Conway, Florence Crick, Sam Fankhauser, Stephane Hallegatte, Guy Jobbins, Hayley Leck, Annika Olsson, Helen Parker, Estelle Rouhaud, Maria Waldinger, and two anonymous referees. Any remaining errors are the sole responsibility of the authors. We acknowledge the financial support received by the UK Government's Department for International Development and the Canada's International Development Research Centre, under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAS). The views expressed in this work are those of the creators and do not necessarily represent those of the UK Government's Department for International Development, the International Development Research Centre, Canada or its Board of Governors. A longer version of this article is available as Grantham Research Institute Working Paper No.198.

^a AQR-IREA. Universidad de Barcelona, Av. Diagonal, 690. 08028. Barcelona, Spain. dcastells@ub.edu (corresponding author)

^b Departamento de Economía Aplicada, Universidad Autónoma de Barcelona, 08193 Bellaterra, Barcelona, Spain.

^c Economics Department. London School of Economics, Houghton Street, London WC2A 2AE, UK. M.D.Lopez-Uribe@lse.ac.uk

^d School of Economics, University College Cork, College Road, Cork, Ireland. thomas.mcdermott@ucc.ie

^e Grantham Research Institute, London School of Economics, Houghton Street, London WC2A 2AE, UK.

1
2
3
4
5
6
7
8
9
10
11 *Geography, institutions and development: A review of*
12 *the long-run impacts of climate change*
13
14
15
16
17
18

19 **Abstract:**

20
21 The links between climate change, economic growth and economic development have gained increasing
22 attention over recent years in both the academic and policy literature. However, most of the existing literature
23 has tended to focus on direct, short run effects of climate change on the economy, for example due to
24 extreme weather events and changes in agricultural growing conditions. In this paper we review potential
25 effects of climate change on the prospects for long-run economic development. These effects might operate
26 directly, via the role of geography (including climate) as a fundamental determinant of relative prosperity, or
27 indirectly by modifying the environmental context in which political and economic institutions evolve. We
28 consider potential mechanisms from climate change to long-run economic development that have been
29 relatively neglected to date, including, for instance, effects on the distribution of income and political power.
30 We conclude with some suggestions for areas of future research.
31
32
33
34
35
36

37 **Keywords:**

38 Climate change, geography, institutions, economic growth, development
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1. Introduction

The links between climate change and economic development have gained increasing attention over recent years in both the academic and policy literature. Understanding the effects of climate change on economic development is fundamental not only for the design of optimal mitigation and adaptation strategies but also in the design of broader strategies for long-term economic development.

The latest report from Working Group II of the Intergovernmental Panel on Climate Change (IPCC 2014), reflecting the state of the academic literature on climate impacts, focuses on the direct threats posed by climate change for, amongst other things, ecosystems, human health, agricultural productivity, and potential knock-on effects for issues such as food security, rural livelihoods and migration (e.g. Oppenheimer et al. 2014). We take this literature on climate impacts as a point of departure. Our intention in this paper is to step back from the immediate task of demonstrating economic impacts of climate change, identifying causal links and estimating the magnitude of potential effects – areas where the climate economics literature is perhaps currently most active – and instead, to consider potentially important directions for new research. In particular, we try to understand how the kind of impacts that have been identified in the literature – some of which are already occurring today - might affect the trajectory of economic development over many decades to come.

There has been extensive theoretical and empirical research on the *proximate* drivers of long-run economic growth. Factor accumulation (of physical and human capital) and technological progress have been identified as the main elements that account for growth differences across countries over time.¹ Trying to explain differences between countries in their rates of factor accumulation and technological progress has led to a focus in the literature towards understanding the *fundamental* determinants of economic development.² Among these, geography and institutions have probably attracted the most attention.³ In this context, a key to understanding the long-run economic effects of climate change is to understand how climate change alters these deep-rooted determinants of long-run development.

In this paper we link the literature on the fundamental drivers of economic development with that on the impacts of climate change and show what the evidence suggests about the potential effects of climate change on long-run economic growth. There is, of course, more to economic development than just economic growth. Reducing inequalities and empowering marginalised groups, for instance, are also important and integral elements of economic development that do not necessarily go hand in hand with economic growth. For low-income countries, however, achieving sustained economic growth is essential to reduce poverty and increase aggregate living standards as well as to have the necessary resources to accomplish other development-related goals.⁴ We do not review the direct effects of climate change on poverty here (see for example Olsson et al. 2014 and

1
2
3 Hallegatte et al. 2016), except to note that the uneven distribution of climate impacts –
4 with certain locations and groups of people likely to be hit hardest – could have important
5 effects on the fundamental drivers of development. Instead our focus is on the long-run
6 effects of changing climatic conditions on economic development.
7

8
9 We consider potential mechanisms from climate change to long-run economic
10 development that have been relatively neglected to date, including, for instance, effects on
11 the distribution of income and political power. Our review concentrates on the empirical
12 economics literature that attempts to measure climate impacts. However, we also briefly
13 revisit the literature on institutions, on economic growth, and on fragile states, in order to
14 highlight the possible mechanisms linking climate impacts to long-run economic
15 development. Our review suggests that there are a potentially important set of dynamic
16 interactions and feedback loops between institutions, climate (impacts and vulnerability)
17 and development, which to date have been understudied. We pay special attention to the
18 effects in low-income countries. These countries are anticipated to suffer
19 disproportionately the most negative effects of climate change. They also tend to have
20 relatively weak economic and political institutions, constraining their ability to cope with
21 climate variability and shocks.
22
23
24
25

26
27 Climate change can affect the processes of economic development directly, by modifying
28 relevant environmental conditions, with impacts for example on agriculture and labour
29 productivity, disease environments, and via the effects of extreme weather events on capital
30 formation. These mechanisms are now well established in the literature, albeit the evidence
31 base in some cases remains relatively thin given the emerging nature of this research area.
32 Aside from direct impacts, climate change might also affect development paths indirectly
33 by altering the socio-political environment within which economic growth and
34 development take place. We consider two specific channels through which climate change
35 might affect development: institutions and conflict. Both of these have profound impacts
36 on development outcomes. Each might be affected by climate change for example through
37 climate's effects on poverty, inequality and the distribution of economic or political power,
38 on the availability of resources, and on the movement of people. The potential for indirect
39 effects from climate change to development is less well established in the literature to date.
40 While there is a growing literature on climate and conflict (as reviewed for example in Dell
41 et al. 2014), it tends to be mostly a-theoretical, lacking specific causal mechanisms. It is
42 therefore difficult to draw policy conclusions from this literature in terms of how
43 governments and international organisations can minimise the risk of climate change
44 creating conflict.
45
46
47
48
49

50
51 Regardless of the strength of future mitigation efforts, our climate is already changing in
52 response to anthropogenic forcing. Further warming will continue in response to past and
53 current emissions, the effects of which on the global climate will be felt for decades to
54 come (Solomon et al. 2007). On current trajectories future warming is likely to substantially
55 exceed the 'dangerous' threshold of two degrees above pre-industrial levels (see e.g. World
56 Bank, 2013). We know therefore that some adaptation will be required and that
57 development strategies will need to take account of the potential effects of a changing
58
59
60

1
2
3 climate.

4
5 The literature on the economic impacts of climate change has been reviewed elsewhere,
6 most recently in Dell et al. (2014). That review focussed on issues related to identification,
7 crucial to establish reliable estimates of impacts. However, while identifying the magnitude
8 of aggregate impacts is sufficient to motivate mitigation policies, the design of appropriate
9 adaptation and climate-resilient development⁵ strategies will require information on the
10 precise causal mechanisms linking climate and economic outcomes, which is the focus of
11 this review. Often, in the least developed countries, the main strategies to cope with
12 climate change are developed in parallel to national development strategies or poverty
13 reduction strategies (Fankhauser and Schmidt-Traub, 2010). By illustrating potentially
14 important mechanisms of effect from climate change to long-run economic development,
15 we hope our review might also be useful for informing climate-resilient development
16 strategies.
17
18
19
20

21 The remainder of this paper proceeds as follows. In section 2 we focus on direct effects of
22 climate change, analysing geographical determinants of economic development. In section
23 3 we focus on indirect effects. We start by looking at the role of institutions in the process
24 of development (section 3.1 and 3.2). We then analyse institutional development, with a
25 focus on conflict and political stability, as a relevant mechanism through which the effects
26 of climate change can operate (section 3.3). In section 4, we conclude highlighting the main
27 lessons from our review, policy implications and research gaps.
28
29
30
31

32 **2. Geography and development**

33
34
35 Geography clearly matters for development. The spatial distribution of economic activity
36 (globally and within regions, countries, etc.) is far from random. Instead, human
37 settlements and economic activity tend to cluster in particular locations. Some of the
38 earliest towns and cities emerged on flood plains, benefitting from the available fertile soils
39 and favourable climate. Roman and Medieval settlements tended to be based at militarily
40 strategic sites (Michaels and Rauch, 2013). Modern-day economic activity is heavily
41 concentrated on coasts and near (ocean-navigable) rivers, to avail of the gains from trade
42 (Gallup et al., 1999, 2001).
43
44
45

46 The observed relationship between geography and development derives at least partly from
47 differences relating to the fundamental characteristics of locations. For example, high
48 transport costs, due to remoteness from markets, difficult mountainous terrains, or the fact
49 of being land-locked, can significantly reduce the growth potential of countries by reducing
50 trade opportunities (Gallup et al., 1999), investment and technology absorption
51 (Henderson et al., 2001). Many of these factors are fixed (i.e. unchanging over time) and
52 therefore will be unaffected by climate change. However, climate change is likely to result
53 in changing risk profiles. This might have particularly important implications for economic
54 development given the concentration of economic activity in specific locations, particularly
55 on coasts, creating the potential for climate change to have costly impacts.
56
57
58
59
60

1
2
3
4 Geographical differences between locations, even if small, can lead to amplifying
5 differences in the patterns of economic development. According to Galor (2005),
6 variations in economic performance across locations today reflect initial differences in
7 geographical factors and historical accidents manifested in variation in institutional, social,
8 cultural, and political factors. According to New Economic Geography Models, spatial
9 differences in economic development, whether between countries, between regions within
10 countries, or between rural and urban locations, can be explained not just by natural
11 geographical factors (inherent conditions of locations as discussed before) but also by the
12 process of circular causation reinforcing agglomeration and development in initially
13 favoured locations (Krugman, 1991, 1999; Puga and Venables, 1999; Henderson et al.,
14 2001). Geographical factors give some places a head-start that magnifies over time and
15 which helps us explain the vast spatial differences we see today. Hence, aspects of natural
16 geography matter a lot, not because natural features of the landscape lead deterministically
17 to the patterns of spatial development that we observe, but because they inspire self-
18 reinforcing agglomerations (Krugman, 1999). This implies that small differences in terms
19 of geographical characteristics can have long-lasting consequences and create *natural*
20 patterns of divergence between different locations that are difficult to reverse.
21
22
23
24
25

26
27 On the one hand, it seems then that climate should matter a lot given the importance of
28 differences in inherent productivity of locations and the possibility of these being
29 reinforced by agglomeration effects. On the other hand, those same agglomeration effects
30 might mean that future climate changes are unlikely to alter the *relative* spatial distribution
31 of development. However this has important implications for adaptation (and development
32 planning generally). The historical lock-in of spatial development patterns might create
33 excessive exposure to natural hazards. This effect relates to the switching costs that
34 societies would face if they were to change their historical spatial development, with the
35 result that such patterns tend to persist even after substantial and damaging shocks such as
36 war-time bombing (Davis and Weinstein, 2002) and large scale floods (Kocornik-Mina et
37 al. 2015). For example, the fact that the earliest towns and cities emerged on flood plains
38 obviously leaves them vulnerable to flooding risk. In the past, that risk may have been
39 worthwhile to avail of the economic benefits inherent to those locations (in this case soil
40 fertility). However, such location benefits may no longer be economically relevant, creating
41 an excessive or unwarranted exposure to flooding risk. The difficulty of reversing patterns
42 of spatial development therefore reinforces the need to consider future climate risk for
43 development planning. Moreover, as those particular geographical characteristics more
44 suitable for economic development are likely to change over time (for instance as
45 transportation and communication technologies evolve or as economic structure changes)
46 it also implies that sound interventions to foster specific advantages of locations can
47 generate magnified benefits.
48
49
50
51
52

53
54 Urban centres deserve special attention. Cities are the drivers of modern economic growth
55 (i.e. Jacobs, 1985; Glaeser, 2011). With a high concentration of assets (both physical and
56 human) in urban locations, these areas are particularly important in terms of investment,
57 innovation and technological change, all fundamental for economic development.
58
59
60

1
2
3 Disruptions to urban economies might therefore be particularly costly, not just in terms of
4 the direct losses resulting from the destruction of assets, but also the potential knock-on
5 effects for the wider economy and the rate of innovation and productivity growth, which
6 ultimately determine an economy's long-run growth potential. Moreover, in spite of high
7 congestion costs associated with increasing concentration in urban centres,⁶ cities in many
8 developing countries today continue to grow rapidly. While in many countries (like China)
9 this is the natural by-product of structural change and greater opportunities in cities, in
10 other countries (mainly in Sub-Saharan Africa) this happens also due to non-economic
11 factors (Bloom et al., 2008), in particular as people are pushed away from rural areas due to
12 diminishing resources, violent conflicts and in some cases, following natural disasters. In
13 this latter case, there is rapid urbanisation without industrialisation and growth (see for
14 instance Fay and Opal 2000; Kim 2008; Gollin et al. 2014). Climate change represents a risk
15 in this regard as it creates an additional rural push factor driving people into cities (see e.g.
16 Barrios et al., 2006; Henderson et al., 2014), as a result of climatic stress in rural areas. This
17 climate-driven rural push factor adds to inefficient growth of urban areas (mega-cities),
18 especially in places that are ill-equipped to cope with rapidly growing populations.
19 Increasing agglomeration under deficient urban environments has been shown to reduce,
20 rather than to increase, economic growth (Castells-Quintana, 2015). In this regard the
21 provision of the necessary infrastructure arises not just as fundamental in terms of
22 economic growth and development but also in terms of sustainable adaptation.
23
24
25
26
27
28

29 **2.1. Direct effects of climate**

30
31
32 Climate change represents a shift in the distribution of future weather, and can therefore
33 distort both the mean and the variability of economically relevant weather variables, as well
34 as potentially increasing the frequency and intensity of extreme weather events, leading to
35 natural disasters (see e.g. IPCC, 2012). These changes are anticipated to exacerbate existing
36 environmental challenges in poorer countries that already face hotter and more variable
37 weather conditions (Stern, 2007; IPCC, 2013, 2014; World Bank, 2010, 2013), to which
38 they struggle to adapt (e.g. Brooks et al., 2005, Barr et al., 2010).
39
40
41

42 It has often been observed that hotter countries tend also to be poorer (e.g. Gallup et al.,
43 1999). However, in order to establish a causal effect of temperature (or other climatic
44 variable) on income, it is necessary to look at changes over time, in order to isolate the
45 effect of climate from other factors, which happen to be correlated with it. Several recent
46 papers now explicitly focus on temperature changes over time. Looking at worldwide
47 average temperatures and their relationship with economic growth, recent evidence
48 suggests that, on average, a 1°C of global temperature increase reduces growth by 0.9 per
49 cent (Bansal and Ochoa, 2009). This impact is found to be large for those countries that
50 are closer to the Equator and negligible in countries at high latitudes. Looking at country-
51 level temperature shocks, several papers find similarly negative effects on growth from
52 higher temperatures, especially in poor countries (e.g. Dell et al., 2012; Brown et al., 2013).
53 Jones and Olken (2010) find that higher temperatures in poor countries lead to large and
54 negative impacts on the growth of their exports. Examining the industrial breakdown of
55 the impacts of temperature, their findings show negative effects on agricultural exports and
56
57
58
59
60

1
2
3 light manufacturing exports (but little effect on heavy industry or raw materials
4 production). Dell et al. (2012) find an analogous negative impact of higher temperature on
5 industrial output. These findings indicate that climate change will have economic
6 consequences beyond the agricultural sector. These effects might operate, for example, via
7 the effect of temperature on productivity (see Martin et al., 2011; Advaryu et al., 2014), in
8 line with arguments emphasising that factory workers are less productive when it is hot.⁷
9 The negative effects of temperature shocks on economic activity seem to be permanent
10 rather than transitory, substantially affecting the rate of economic growth and not only the
11 level of output, with a 1°C increase in mean temperature in a given year reducing income
12 per-capita by 1.4 per cent (Dell et al., 2012).
13
14
15

16
17 The effect of temperature is also felt in today's developed countries; Deryugina and Hsiang
18 (2014), using within-county variation in temperatures for the last decades, find significant
19 effects of temperature on productivity in the United States – productivity of individual days
20 declines roughly 1.7% for each 1°C increase in daily average temperature above 15°C.
21
22

23 Several other papers focus on (changes in) rainfall patterns as a consequence of a changing
24 climate (e.g. O'Connell and Ndulu, 2000; Barrios et al., 2010; Brown and Lall, 2006; Brown
25 et al., 2013). In the particular case of Africa, a significant decrease in rainfall levels has been
26 observed since the 1960s (Nicholson, 2000, 2001). Given the importance of the agricultural
27 sector in Africa, and the relevance of rainfall for agricultural productivity, this decline
28 might have important consequences for economic growth, as has been suggested by Bloom
29 and Sachs (1998) and Collier and Gunning (1999). Indeed, O'Connell and Ndulu (2000)
30 found significant lower long-run economic growth rates in Africa in those countries with a
31 higher proportion of dry years. Similarly, Barrios et al. (2010), studying the relationship
32 between rainfall and economic growth for 22 African and 38 non-African countries over
33 the period 1960-1990, provide evidence on the adverse effects on economic growth rates
34 of the general decline in rainfall in Africa during recent decades (controlling for effects
35 from temperatures, which they find not to be significant). This effect of rainfall was not
36 found for other developing countries. According to the results of simulations carried out
37 by these authors, if rainfall in Africa had remained at previous levels, the current gap in
38 GDP per capita relative to other developing countries could have been between 15 per
39 cent and 40 per cent lower.
40
41
42
43
44

45 **2.2. Climate change and economic performance: Mechanisms**

46
47

48 A caveat in relation to most of the empirical literature mentioned here is that it tests
49 'reduced form' relationships – i.e. looks directly at the relationship between climate
50 variables (e.g. temperature or rainfall shocks) and economic growth or output, without
51 formally testing the causal mechanisms connecting climate and the economy. Several
52 channels allow for climate change to directly affect economic performance. In what follows
53 we discuss some of the most likely mechanisms.
54
55

56 *A. Agriculture and labour productivity*

57
58
59
60

1
2
3 Parsons (2014) explains how changes in the temperature can reduce labour productivity.
4 When heat exposure is high, changes in the air temperature not only affect body
5 temperature but also productivity during work time. Physical work activities add surplus
6 heat production to the human body, so when the air temperature is higher than 37 C, the
7 heat transfer goes into the body but at high temperatures and humidity level, and
8 evaporation of sweat in order to reduce the body heat is less effective. In these scenarios,
9 sweating continues but there is no body heat loss via evaporation, leading to a decrease in
10 physical performance. Hence, deteriorating climatic conditions can reduce not only
11 agricultural productivity (Deschenes and Greenstone, 2007; Guiteras, 2009; Schlenker and
12 Lobell, 2010; Feng et al., 2010)⁸ but also labour productivity in industrial sectors that lack
13 efficient cooling systems (Martin et al., 2011; Advaryu et al., 2014; Dunne et al 2013,
14 Zander et al 2015). And low agricultural productivity, for instance due to poor soil quality,
15 lack of fresh water, prevalence of pests, and in general less suitable conditions for the
16 spread and improvement of agriculture, not only reduces agricultural output but it can also
17 retard industrial development (e.g. Diamond, 1997).
18
19
20
21
22

23 Some works have tried to estimate the magnitude of the effect of changes in temperature
24 on labour productivity. Dunne et al (2013) have estimated that during the last few decades,
25 heat stress has reduced labour capacity to 90% during peak months, being the tropical and
26 mid-latitudes regions the most affected areas. However, the impact of these changes will
27 also depend on other factors such as climate sensitivity, future population distributions,
28 CO2 emissions and technological change. Zander et al (2015) highlight the importance of
29 adopting measures to reduce the heat effect. They estimate the costs of absenteeism and
30 work performance due to heat in Australia during 2013/214 and calculate an annual cost of
31 US\$655 per person and around US\$6.2 billions for the Australian workforce (0.33-0.47%
32 of Australian GDP).
33
34
35

36 *B. Disease environments and population dynamics*

37 Second, changing weather patterns might have longer-term development effects by altering
38 disease environments, both via changes in environmental conditions and via the effects of
39 weather patterns on migration and urbanisation patterns. Particularly harsh disease
40 environments, for instance characterised by a high prevalence of malaria (Gallup and
41 Sachs, 2001; Sachs and Malaney, 2002), can significantly reduce productivity in several ways
42 (see also Masters and McMillan, 2001). A harsh environment affects health (Deschenes and
43 Greenstone, 2011) and reduces work capacity and productivity directly (Seppanen et al.,
44 2006; Sudarshan and Tewari, 2014). Diseases also increase child mortality and lower life
45 expectancy, which in turn increases fertility and harms incentives to acquire and accumulate
46 human capital, creating regional-specific patterns of demographic transition, leading
47 ultimately to slower development of regions with unfavourable environmental conditions
48 (Strulik, 2008).
49
50
51
52

53 Climatic conditions can also affect population dynamics and migration patterns, in turn
54 affecting the pace and form of structural change and urbanisation processes (e.g. Barrios et
55 al., 2006; Henderson et al., 2014).⁹ One risk of the concentration of population in urban
56 areas is that urban agglomerations are particularly susceptible to flooding and heat stress,
57
58
59
60

and allow more rapid spreading of diseases such as cholera – especially where basic services such as access to water and sanitation facilities are underprovided.

C. Extreme weather events and the depreciation of capital:

Climate-related shocks, such as extreme weather events, can also depreciate the stock of physical, human and environmental capital (Hochrainer, 2009), and damage key infrastructures (Heltberg et al., 2008). Likewise, climate-related shocks also modify saving and investment decisions, not just of domestic agents (Hallegatte, 2014) but also of potential foreign investors (Escaleras and Register, 2011), affecting both physical as well as human capital accumulation.¹⁰

Looking at the empirical evidence, several papers confirm that natural disasters represent setbacks for economic growth (e.g. Hsiang, 2010; Hsiang and Narita, 2012; Hsiang and Jina, 2014; McDermott et al., 2014). Although it had previously been suggested that disasters could have a positive impact on economic growth (Skidmore and Toya, 2002), recent literature shows that such positive effects would only occur in response to relatively moderate disasters (Loayza et al., 2012). Positive effects might be associated with reconstruction and the opportunity to renew and upgrade installed capital, infrastructure and existence technologies. However, severe disasters, especially those that affect poor countries, are significantly associated with lower economic growth (Raddatz, 2009; Loayza et al., 2012). According to Loayza et al. (2012) different disasters have differentiated effects on growth depending on the economic sector; droughts and storms are found to have the strongest negative effects for agricultural productivity. Given that the elasticity of poverty to growth generated in the agricultural sector is higher than for other sectors of the economy, these disasters can be expected to affect the poor disproportionately.

3. Indirect mechanisms: Climate change and institutional development

There are at least two main reasons to focus on institutional development in the analysis of the effects of climate change. First, the evidence reviewed so far appears to indicate that geography (including locational fundamentals and climate) matters a lot for economic development, particularly in its early stages, but perhaps less so as modern economic growth ‘takes off’. This is also reflected in the empirical evidence on the impacts of climate shocks and disasters, which appear to have important macroeconomic (and growth) impacts in poorer countries, whereas similar events tend not to disrupt the economies of relatively wealthy developed nations. There is thus, perhaps, some threshold of development - in terms of income or institutional quality - below which climate will continue to exert a significant direct influence on economic development.¹¹ In particular, many low-income countries, especially in Sub-Saharan Africa, but also some middle-income countries, have states that are unable to perform minimum functions expected from modern sovereign states. These states are defined as “weak”, “fragile” or even “failed” or “collapsed” (Zartman, 1995; Torres and Anderson, 2004).¹² The combination of weak institutions and a lack of basic economic, financial and physical infrastructure, result in the difficulty faced by many of these poor countries in escaping from poverty (see e.g.

1
2
3 Collier et al., 2008; Dercon, 2012), but also in their relatively low adaptive capacity (see e.g.
4 Fankhauser and McDermott, 2014) and their subsequent economic vulnerability to climate
5 shocks.
6

7
8 Second, there is increasing evidence that beyond direct effects, climate (and geography in
9 general) can also affect the possibilities for development by affecting the socio-political and
10 institutional environment in which development takes place. Climate might have an effect
11 on state fragility itself, for example as a catalyst of conflict or as a factor increasing the
12 extent and intensity of existing conflicts. There is increasing evidence on how geographical
13 factors influence institutional development (Engerman and Sokoloff, 1997; Acemoglu et
14 al., 2001, 2002; Rodrik, 2004; Acemoglu and Robinson, 2012) and the likelihood of conflict
15 (Miguel et al., 2004; Hsiang et al., 2011; Dell et al., 2014).
16
17

18
19 In this section we analyse the role of geography in the socio-political and institutional
20 environment to better understand potential indirect effects of climate change in the process
21 of economic development and economic growth. We focus on institutional capacities and
22 the potential for climate to alter the conditions under which institutions evolve, including
23 the effects of climate on conflict.
24
25

26 27 **3.1. Geography, institutions and development**

28
29 Institutions clearly matter greatly for economic development. The relevance of institutions
30 in the prosperity of nations has been highlighted since the beginnings of modern economic
31 thought - from Smith (1776) to Veblen (1899), Commons (1924), Galbraith (1958), Myrdal
32 (1968) and many others.¹³ Since then our knowledge of how institutions shape and interact
33 with economic development has substantially increased. But our understanding of how
34 institutional arrangements evolve over time and what factors contribute to successful
35 institutional reform in different contexts remains somewhat limited. It appears that
36 geography, broadly defined to include climate, physical geography and resource
37 endowments, may have played an important role in the emergence of modern institutions
38 and the apparently crucial distinction between locations that evolved *extractive* versus
39 *inclusive* institutions. Acemoglu et al. (2001) famously used variation in disease
40 environments to explain the emergence of extractive institutions in some locations (e.g.
41 Africa) and inclusive institutions in others (e.g. North America). It does not automatically
42 follow, however, that *climate change* should have any great influence on the future
43 development of economic and political institutions. Certainly it seems unlikely, barring
44 catastrophic scenarios, that climate change will have any major bearing on institutional
45 arrangements in places with established stable and inclusive regimes.¹⁴ On the other hand,
46 in locations where power, institutions, and the rule of law are more contested – i.e. in
47 fragile states – subtle changes to political incentives resulting from changes in
48 environmental conditions, changes in the value of natural assets, or disputes over resources
49 could generate non-negligible effects on institutional quality.
50
51
52
53
54
55

56
57 Other potential mechanisms from climate (change) to institutional change, discussed in
58 more detail below, include; the reinforcement of existing social and economic inequalities
59
60

1
2
3 due to the unequal distribution of anticipated impacts from climate change; disruptions to
4 long-run investments, including the provision of public goods and services, and human
5 capital investments following weather shocks that reduce output or destroy assets; and
6 disruptions to political stability, in the form of the (at times violent) contesting of power
7 following income shocks. For less developed regions generally, their greater vulnerability to
8 climate change and relatively weak existing institutions could make the threat of climate
9 change more relevant for institutional development. Understanding the emergence of
10 institutions is therefore crucial for understanding the potential role of climate (change) for
11 long-term economic development.
12
13

14
15 In spite of their crucial importance in defining the possibilities for economic development,
16 institutions remain poorly understood. One difficulty is that institutional development is
17 highly endogenous to the evolution of economic life; institutions shape economic
18 development as much as the evolution of economic life shapes the evolution of
19 institutions. A number of studies have attempted to identify causal links from institutional
20 quality (usually looking at measures reflecting the quality of economic institutions) to
21 economic performance and long-run prosperity (Mauro, 1995; Engerman and Sokoloff,
22 1997, 2000; Hall and Jones, 1999; Acemoglu et al., 2001, 2002; Rodrik et al., 2004).¹⁵ But
23 country-wide proxies for institutional quality are far from perfect, and cross-country
24 econometric analysis of the role of institutions on economic development based on these
25 proxies has several limitations and can even be misleading.¹⁶ Likewise, despite the clear
26 association between institutional development and economic development, advocating for
27 single-recipe institutional reforms as a straightforward way of achieving economic
28 development is simplistic and potentially risky (Bates (2006), for example, links political
29 reform to increased likelihood of conflict and violence in Africa).
30
31
32
33
34

35 For poor countries the assessment of institutional quality becomes difficult and policy
36 prescription becomes overwhelming, as most indicators of institutional quality are hardly
37 met. In this context several authors have suggested that countries should focus on
38 achieving “good enough governance” and “second-best institutions”, looking at specific
39 reforms that are essential, feasible, easier to implement, and that take into account the stage
40 of development as well as interactions with initial conditions and context-specific
41 institutional arrangements already in place (Grindle, 2004; Rodrik, 2008). In particular,
42 fostering economic growth and improved economic opportunities for the majority of the
43 population, even under sub-optimal institutional arrangements, has been shown to
44 potentially play a fundamental role in fostering institutional change itself (Rodrik, 2008).¹⁷
45 Societies face a set of “institutional opportunities” which improves as countries emerge
46 from poverty and accumulate human, social and physical capital (Djankov et al., 2003;
47 Glaeser et al., 2004). Climate change not only has a direct impact on economic growth (as
48 shown in section 2), but it also shapes the “institutional opportunities” that each country
49 faces. In this context, climate change should be taken into account in the design of key
50 reforms to spur growth as well as in the design of new, context-specific institutions.
51
52
53
54
55

56 *Instability, conflict and economic development*

57
58
59
60

1
2
3 Instability and persistent (violent) conflict are two of the most worrying and common
4 elements characterising fragile states (Rotberg, 2003), deterring their opportunities for
5 prosperity: conflict and political instability have been found to significantly hamper growth
6 and economic development (Gupta, 1990; Barro, 1991; Knack and Keefer, 1995; Alesina
7 and Perotti, 1996; Easterly and Levine, 1997; Rodrik, 1999; Sala-i-Martin et al., 2004;
8 Butkiewicz and Yanikkaya, 2005).¹⁸ Furthermore, instability and conflict have been
9 identified as a powerful trap for poverty and underdevelopment, leading to lower economic
10 development (Collier, 2007). Underdeveloped countries are in turn more prone to conflict
11 and instability. Indeed, countries in conflict are among the worst Millennium Development
12 Goals (MDGs) performers, frequently regressing on key indicators, with the direct impacts
13 of warfare usually accompanied by a weakened economy and government capacity, leading
14 to lower development prospects, in some cases pushing countries into a downward spiral
15 (UNDP, 2011). However, theories about state formation and failure consider conflict as an
16 integral element of countries' institutional development (see Di John, 2010). Institutions
17 are defined by conflict of interests and the distribution of power within societies. Climate
18 change can alter the economic opportunities of different groups and trigger conflict over
19 natural resources and the distribution of power, therefore likely playing a role in the
20 definition of institutions. It then becomes essential to better understand how climate
21 change affects different groups, and the mechanisms linking these effects to conflict
22 propensity and intensity and institutional development.
23
24
25
26
27
28

29 **3.2. The (potential) role of climate change**

30
31
32 The possibility of strong and long-lasting effects of climate change and climate-related
33 shocks in the process of development has been analysed in historical perspective (Davis,
34 2002; Fagan, 2005, 2009).
35

36
37 There is evidence that significant changes in climate (temperature and rainfall patterns)
38 already had important societal impacts in the distant past. For instance, Dixit et al. (2014)
39 report a connection between weakening of the Indian summer monsoon and de-
40 urbanisation in India around 4,100 years ago, in a time of severe aridification, which
41 affected several Early Bronze Age populations. Similarly, Pederson et al. (2014) suggest that
42 unusual above-average moisture in central Mongolia promoted high grassland productivity
43 and favoured the formation of Mongol political and military power that facilitated the
44 emergence of the vast 13th century Mongol Empire. Although the changes in temperature
45 and rainfall patterns analysed in these papers occurred before human-induced climate
46 change, the evidence about their impacts reinforces the relevance of changing climatic
47 patterns today.¹⁹
48
49
50

51
52 Looking at modern times, there appears to be some correlation between weather
53 conditions and conflict globally. For instance, drylands are among the most conflict-prone
54 regions of the world. In 2007, 80 percent of major armed conflicts worldwide occurred in
55 drylands (UNDP, 2011). Although such correlations tell us nothing about causation - as in
56 the debate over the relationship between climate and development - there is now a growing
57 empirical literature assessing possible climatic determinants of conflict (see Homer-Dixon,
58
59
60

1
2
3 1991; Dell et al., 2014). It has even been argued that changing climatic conditions can lead
4 to the collapse of societies, as a result of increased conflict associated with environmental
5 stress (Diamond, 2005).
6

7
8 Looking at global patterns, Hsiang et al. (2011) have demonstrated that civil conflicts are
9 indeed associated with climatic variation, based on observations of a relationship between
10 El Niño/Southern Oscillation (ENSO) fluctuations and annual conflict risk. A number of
11 papers link periods of drought with increased conflict (e.g. Couttenier and Soubeyran,
12 2013; Maystadt and Ecker, 2014; and Maystadt et al., 2013). Similarly, Burke et al. (2009)
13 find that hotter years are associated with increased incidence of civil war in Africa in the
14 late 20th century. Hendrix and Salehyan (2012) conclude that rainfall deviations in either
15 direction may be related to conflict, but that violent events are more responsive to heavy
16 rainfall (which may cause subsequent scarcity through the effect of flooding on agricultural
17 yields).
18
19

20
21 Climate change is likely to modify the environmental context and the opportunities
22 available to individuals and societies, potentially reinforcing material inequalities as well as
23 influencing the distribution of power within societies. In this way, climate change can
24 influence not only the probability and intensity of conflict but also institutional
25 arrangements and therefore institutional development. However, empirical evidence in this
26 regard remains limited, with few papers explicitly studying the relationship between climate
27 change and political change. This appears to be a significant research gap.
28
29
30

31 *A. Poverty and income shocks*

32
33 Burke and Leigh (2010) and Bruckner and Ciccone (2011) are among the first to test
34 empirically the relationship between climate and institutional change. Although these works
35 use changes in climatic conditions as an exogenous shock to output, their conclusions seem
36 to support the idea that weather shocks may lead to institutional change; in this case
37 democratisation. In both papers, the mechanism proposed is via output: negative rainfall
38 shocks open a 'window of opportunity' for democratic improvement because it translates
39 into a transitory negative GDP shock and a lower opportunity cost of contesting power. In
40 contrast to these findings, Dell et al. (2012), highlighting a similar mechanism, show that
41 adverse temperature shocks might increase the probability of irregular leader transitions
42 such as coups, resulting in negative impacts on economic growth. They support their
43 results on the previous empirical evidence that riots and protests are more likely in warmer
44 weather (Boyanowsky, 1999) and, in addition, on the idea that economic impacts of higher
45 temperatures might provoke dissatisfied citizens to seek institutional change – in this case
46 with negative results for the economy.
47
48
49
50

51
52 These somewhat contrasting results illustrate the need for a greater understanding of the
53 mechanisms that potentially link climatic conditions to institutional change. The authors
54 cited above emphasise the effects of weather shocks on income, leading to changes in the
55 opportunity cost of contesting power. However, such a mechanism potentially represents a
56 double-edged sword for institutional development; on the one hand, the opportunity to
57 contest power offers a possible 'window of opportunity' for institutional improvement (e.g.
58
59
60

1
2
3 through removal of an autocratic regime). On the other hand, contesting power might
4 involve (violent) conflict, with no guarantee of an improved outcome.
5

6
7 The role of income shocks is also prominent in the literature on climate and conflict. For
8 example, contest models of conflict (e.g. Hirshleifer, 1988, 1989; Garfinkel, 1990;
9 Skaperdas, 1992) highlight the association between poverty and conflict through
10 individuals' incentives to maintain order, and therefore predict higher likelihood of conflict
11 in poorer countries or regions.²⁰ This mechanism underlies many of the empirical studies of
12 climate and conflict to date (see Dell et al., 2014, for a review of this empirical literature).
13 Miguel et al. (2004) were among the first to propose and test the relationship between
14 weather shocks and conflict, finding that negative economic shocks, caused by decreases in
15 the level of rainfall, tend to trigger conflict. Since then, this strand of literature has
16 expanded rapidly, with numerous papers finding significant links between weather variation
17 and conflict. However, these findings have not been uncontroversial, and there remains
18 some uncertainty over the precise causal mechanisms linking climate and conflict and the
19 most relevant climatic variables.
20
21
22
23

24 In a review of the arguments for climate variability to influence conflict through economic
25 growth, Koubi et al. (2012) find no evidence of significant effects of climate variability on
26 growth. Miguel and Satyanath (2011) similarly argue that for the period 2000-2009 there is
27 no strong relationship between rainfall and growth for African countries, implying that
28 rainfall might not be used as an instrument to study the effect of economic shocks on
29 conflict risk. Sarsons (2011) has also found problems using rainfall as a measure of
30 economic shocks. Whereas he supports previous findings in rain-fed districts in India
31 (Bohlken and Sergenti 2010), he argues that in dam-fed districts wages are less sensitive to
32 rain shocks (although he finds that rainfall might still affect conflict through a channel
33 other than income in these districts). Dell et al. (2014) propose different reasons for the
34 diverse findings in the literature: omitted fixed effects, differences in the way both weather
35 and conflict are parameterised, and noisy estimates make it difficult to reach conclusions
36 about the effect of rainfall fluctuation on conflict risk.
37
38
39
40
41

42 According to Chassang and Padro-i-Miquel (2008, 2009) the likelihood of conflict increases
43 after negative shocks while it decreases with the expectations of higher incomes. Hence,
44 lower and volatile growth can lead to higher risk of conflict. As climate-induced income
45 shocks hit the poor in a disproportionate way - as discussed elsewhere in this paper -
46 climate change might affect the likelihood (and severity) of conflict by reinforcing existing
47 poverty dynamics.
48
49

50 For poor countries, climate-induced income shocks have been analysed mostly looking at
51 dynamics in rural areas. Variations in agricultural production and cattle herding are among
52 the most common mechanisms proposed to explain how temperature and rainfall
53 fluctuations might affect conflict risk through income shocks (Miguel et al., 2004; Mehlum
54 et al., 2006; Chaney, 2010; and Ciccone, 2011, for rainfall, and Burke et al., 2009, for
55 temperature). Negative economic shocks driven by the decrease of rainfall levels have been
56 found to increase Muslim-Hindu riots in Indian states (Bohlken and Sergenti, 2010) as well
57
58
59
60

1
2
3 as communal conflict in subnational African regions (Fjelde and von Uexkull, 2012). Using
4 data from East Africa, Raleigh and Kniveton (2012) argue that civil war is more likely in
5 extreme dry conditions whereas wet conditions are more associated with non-state conflict.
6 In a study for Somalia, Maystadt and Ecker (2014) suggest that local livestock markets are
7 the primary channels through which droughts fuel conflict, and that livestock price
8 downturns and losses in herder's income lower resistance to engage in conflict and
9 decrease the opportunity costs of conflict participation.²¹
10
11

12
13 A low opportunity cost of fighting, usually associated with low levels of income per capita,
14 has often been identified as one of the main determinants of the probability of conflict
15 (Collier and Hoeffler, 1998, 2004; Miguel et al., 2004; Besley and Persson, 2008; Collier et
16 al., 2009).²²
17
18

19
20 Negative economic shocks, associated with rainfall, can have long-term effects through
21 mass rebellions. Kung and Ma (2014) suggest that suboptimal rainfall may have triggered
22 peasant rebellions in China (although these shocks might have been overcome by the
23 appearance of Confucianism). In this line Jia (2013) reports that droughts indeed increased
24 the probability of peasant revolts in China by 0.7 per cent.
25
26

27
28 In a similar argument, and looking at long-term trends, Zhang et al. (2007) show how
29 fluctuations of war frequency and population change in the pre-industrial era followed the
30 cycle of temperature change; long-term climate change directly affects land-carrying
31 capacity (agricultural production) and can lead to unrest, conflict, famines and epidemics.
32 Waldinger (2013) also finds a significant relationship between climatic trends and peasant
33 revolt during the French Revolution – with higher summer temperatures and lower winter
34 temperatures associated with increased incidence of revolt. Tol and Wagner (2010) similarly
35 find that colder times were associated with increased conflict in Europe. In a European
36 context (i.e. in a relatively cold climate), periods of colder weather may have resulted in
37 worse growing conditions, and a resultant negative shock to incomes.²³
38
39

40
41 However, income shocks are not the only mechanism that potentially links climate change
42 to institutional change and/or conflict. In the rest of this section, we discuss other
43 potential mechanisms, relying mainly on theoretical arguments, given the lack of empirical
44 work (or very scarce evidence) in this area to date.
45
46

47 *B. Inequalities and the distribution of power*

48
49 The distribution of power also matters for the quality of institutions and governance as
50 well as for conflict. The literature reviewed previously on institutions highlighted the
51 relevance of inequalities and the distribution of power.²⁴ In this literature inequalities
52 appear as critical in the development and persistence of institutions as in any scope for
53 institutional change; when extreme, inequality can become an important obstacle for
54 successful institutional reform, but it is also true that inequality might have been one
55 relevant factor behind political revolution, for instance in the extension of the franchise in
56 the 19th century in several European countries (Acemoglu and Robinson, 2000; Przeworski,
57 2009; Aidt and Franck, 2015). The literature on conflict has also highlighted the role of
58
59
60

1
2
3 distribution; Acemoglu and Robinson (2001, 2010) model elites as competing with the
4 poor for control of the state and bargaining to accommodate the rest of the society by
5 extending the voting franchise in periods when there are real threats of revolt. Ray (2009)
6 models the emergence of conflict based on the impossibility to arrange transfers that satisfy
7 all groups. His model predicts a high likelihood of conflict in divided societies - either by
8 class, geography, religion, or ethnicity. Ethnic polarisation (rather than fractionalisation)
9 has also been highlighted as a significant determinant of conflict; in societies where a large
10 ethnic minority faces an ethnic majority severe conflict is more likely to arise (Montalvo
11 and Reynal-Querol, 2005).²⁵ Thus, where climate change is expected to reinforce existing
12 inequalities, this could have knock-on effects for the quality of institutions and ultimately
13 conflict.
14
15
16
17
18
19

20 21 *C. Resources, incentives and information*

22 It has been suggested that geography (including climate) matters in the choice of economic
23 policy itself (Gallup et al., 1999). The logic is that the political economy of policy formation
24 depends on the incentives faced by policy-makers. Where growth prospects are weak, the
25 incentive to pursue pro-growth, inclusive economic policies may be weaker than the
26 incentive to pursue 'extractive' type policies that produce short-term benefits for those in
27 power. Alternatively, the decline of aggregate output can diminish government revenues,
28 making the state invest less in state capacity and security. In any case, climatic conditions,
29 by modifying the growth prospects of poorer nations, might also lead to endogenously
30 worse economic policies.
31
32
33

34 This reasoning is similar in spirit to some of the *resource curse* literature, where natural
35 resources have been identified as playing a role in conflict risk (e.g. Fearon and Laitin,
36 2003). Natural resource revenues represent a bigger (and more easily appropriable) prize in
37 case of success and also a source of finance for fighting activities. Besley and Persson
38 (2008) also highlight the role of the nature of the prize and how it will be distributed given
39 institutional constraints, the technology for fighting and the likely allocation of power in
40 the absence of an insurgency. As a consequence, not only does conflict diminish state
41 capacity, but it is only when political institutions provide insufficient checks and balances
42 or enough protection for those excluded from power that other determinants of conflict,
43 such as climate, aid or external shocks, become significant determinants increasing the
44 likelihood of conflict (Besley and Persson, 2009).
45
46
47
48

49 Sachs and Warner (2001) show how natural resource countries tend to miss-out on export-
50 led growth. Natural resources can also make the government less accountable to the
51 population (as relying on natural resource extraction rather than on taxation). This suggests
52 a further political-economy risk associated with climate change; i.e. that climate finance
53 flows to developing countries could make their governments less politically accountable.
54
55

56 Another related set of conflict models looks at the problem of commitment (Walter, 1997;
57 Garfinkel and Skaperdas, 2000; Powell, 2006; McBride and Skaperdas, 2007). According to
58
59
60

1
2
3 these models civil war is more likely to occur when there are limits to conflict resolution
4 and contract enforcement along with a high probability of a shifting distribution of power.
5 The distributional effects of climate change might therefore play a role in contributing to
6 the risk of civil conflicts.
7

8
9 Economic inequalities (Fearon, 2007) and frustration (Davies, 1962; Gurr, 1971; Paige,
10 1975; Scott, 1976; Petersen, 2001; looking at agrarian revolutions in the 1960s and 1970s)
11 clearly play a strong motivating role in many conflicts. However, nonmaterial incentives,
12 including grievances and vengeance, might better describe proximate explanations of
13 conflict (Roemer, 1985; Wood, 2003). Climate change might also play a role here when
14 grievances over resources (e.g. water, access to land, grazing rights etc.) are generated by
15 changing environmental conditions.
16

17
18 Finally, recent literature distinguishes between motivation of conflict and feasibility of
19 conflict. On the one hand, motivation can be driven by root causes, whether historical,
20 political or socio-economic, with poverty, inequality and political exclusion being
21 commonly discussed in this regard. Feasibility, on the other hand, may be driven by
22 circumstances distinct to motivation, and has been the focus of several authors (Hirshleifer,
23 2001; Collier and Hoeffler, 2004; Weinstein, 2005; Collier et al., 2009). According to these
24 authors, conflict will be more likely to occur where it is financially and militarily feasible,
25 and this in turn is likely to depend on a combination of geographic and demographic
26 factors, as well as on the presence of an ineffective state.
27
28
29

30 31 *D. Migration and human capital*

32 One important way in which climate shocks can increase the likelihood of conflict is by
33 inducing migration. In fact, one of the main security challenges brought about by climate
34 change (through increasing the frequency and severity of climate-related natural disasters as
35 well as through affecting natural resources and weather conditions) is the rise in mass
36 migrations. Mass waves of 'climate refugees' are regularly cited as one of the potential risks
37 of runaway (unabated) climate change. For example, Myers and Kent (1995) forecast 150
38 million environmentally-induced refugees by 2050 (although according to Gemenne (2011)
39 these estimates appear to lack empirical support). While the numbers may be speculative,
40 the risks are not so easily dismissed. It is notable that the security/military community takes
41 these threats seriously, and conducts its risk assessments on the basis of considering
42 multiple plausible future scenarios. For instance, according to the Campbell et al. (2007)
43 report, the disappearance of low lying coastal lands could conceivably lead to massive
44 migrations - potentially involving hundreds of millions of people - and trigger major
45 security concerns and spike regional tensions.²⁶
46
47
48
49

50
51 Regardless of its impacts on the number of future migrants, climate change also has the
52 potential to alter the quality of migration patterns (Jäger et al., 2009). While the
53 displacement of people following natural disasters is typically temporary, over short
54 distances and along well established routes (McMichael et al., 2012), climate change has the
55 potential to generate extreme events, or combinations of events, that would overwhelm
56 existing coping mechanisms, leading to larger-scale, longer-term and longer-distance
57
58
59
60

migrations that are likely to be less organised or planned. These irregular and/or unexpected migrations pose the greatest threat to stability and security (Foresight, 2011).

Hidalgo et al. (2010) examine the link between weather conditions and conflict looking at land invasions. Exploring municipal-level data from 1988 to 2004 in Brazil and using rainfall variation as a proxy of adverse economic shocks, they find that these shocks cause the rural poor to invade large landholdings. Nevertheless, their findings exhibit considerable heterogeneity by land inequality and land tenure systems. In highly unequal municipalities, negative income shocks (measured as climate shocks) cause twice as many land invasions as in municipalities with average land inequality.

In section 2.2 we saw potential direct effects of climate change on the disease environment. Another potential risk is the threat to human health posed by large-scale population movements: “[T]he health risks posed by climate-related population movements are likely to become a major source of human suffering, disability, and loss of life—an outcome that, currently, appears more likely than the much-debated possibility of increased violent conflict or state failure (Kolmannskog, 2008).” – McMichael et al. (2012, pp.646-7). But these are not distinct (separate) threats. On the contrary, migration, disease patterns and violent conflict interact in complicated ways, and potentially reinforce each other. In the context of agriculturally-marginal semi-arid zones of West-Central Africa, Miller (1982) documents historical links between climate change and patterns of settlement and migration, with an emphasis on the effects of climate induced scarcity on migration, disease, and migration-induced conflict.

Finally, and as mentioned before, the opportunities for institutional development depend on levels of human capital (Djankov et al., 2003; Glaeser et al., 2004). Thus, another mechanism through which climate change can deter institutional development is, of course, by hindering human capital accumulation.

E. *Extreme weather events*

Few papers explicitly focus on the link between natural *disasters* and conflict. Although this literature is not extensive, some writings on environmental security and “political ecology” provide useful arguments for understanding how natural disasters might impact societies and how these events might affect conflict risk through their impacts on social variables, such as migration, as well as on economic variables. Nel and Righarts (2008) use data for 187 political units for the period 1950-2000 to explore this question and find that natural disasters significantly increase the risk of violent civil conflict both in the short and medium-term, particularly in low- and middle-income countries that have high levels of inequality, mixed political regimes, and sluggish economic growth. However, these conclusions appear to be contradicted by Slettebak (2012) who finds that countries that are affected by natural disasters have a lower risk of civil war. Different explanations are given: one explanation comes from the *sociology of crisis* and is related to the idea that people tend to unite in adversity. Another explanation suggests that disasters provide an opportunity for governments to display both their competence and incompetence, so the negative effect of disasters on conflict can be read as a way used by the government to improve

1
2
3 their popularity, reducing the pool of potential recruits for insurgent organisations. Among
4 this group of literature, Bergholt and Lujala (2012) find that natural disasters have a
5 negative effect on economic growth, but this does not translate into an increased risk of
6 conflict.
7
8
9

10 **4. Conclusion and policy implications**

11
12 In this paper we have studied the role of climate change in the process of long-term
13 economic growth and development, reviewing the literature on the determinants of
14 economic development and analysing the role that climate change can potentially have in
15 this regard. We have looked at both potential direct and indirect effects of climate change,
16 focusing on implications for low-income countries. This broad approach allows us to
17 better understand in an integrated way the different effects of climate change on long-term
18 development and frame the adaptation discussion in terms of climate-resilient economic
19 development, as well as identifying policy implications. In particular we have analysed the
20 role of geography and institutions, with a focus on conflict and instability, in the process of
21 development. In each case we have looked at possible effects of climate change and
22 climate-related shocks, as well as at the empirical evidence on these effects and existing
23 gaps in the literature.
24
25
26
27
28

29 Looking at the direct effect of climate, we have described how climate change can affect
30 the processes of long-run economic growth and development in different ways.
31 Additionally, we have analysed how, given unequal anticipated effects across rich and poor
32 countries, climate change can potentially reinforce both spatial inequalities and poverty trap
33 dynamics. We have also described the potentially important effects of climate change on
34 economic development through its indirect effects on the socio-political and institutional
35 environment. First, climate change can alter the context within which institutional
36 development takes place. Second, given its significant role in the likelihood and intensity of
37 conflict, changing climatic conditions can also affect the socio-political stability of
38 countries.
39
40
41
42

43 The evidence reviewed confirms distinct effects of climate shocks across rich and poor
44 countries; the macro impacts of a changing climate will be felt more strongly in poorer, and
45 especially in fragile, states. At the same time, it is in these same countries where the indirect
46 effects of climate change become most relevant, potentially reinforcing institutional fragility
47 and in turn vulnerability to climate shocks. Our analysis also highlights the need to take
48 account of the interaction of climate change (risk) with other development trends (e.g. in
49 the case of rapid urbanisation, increasing exposure to urban disasters, etc.) for the design of
50 sound adaptation strategies and development plans.
51
52
53

54 Two main policy implications arise from our review. First, it has become evident how
55 adaptation strategies to climate change are fundamental not just on their own right, but
56 also as key elements of broader poverty-reduction and development strategies. Moreover,
57 as climate shocks disproportionately affect the poor, addressing climate-related risks is also a
58
59
60

1
2
3 sound strategy in terms of inequality and poverty reduction. Second, given their
4 interactions, both geographical and institutional factors need to be considered in the design
5 and successful implementation of strategies for both poverty reduction and economic
6 development. Not only do geographical factors affect institutional dynamics, but the
7 institutional framework is also likely to condition the way geographical factors influence the
8 evolution of poverty and economic development. Especially close attention is warranted
9 for institutional development in geographically challenged countries (such as those with
10 extreme and variable weather conditions, climate-associated epidemic diseases, etc.) where
11 these interactions are expected to be strongest.
12
13

14
15 Finally, from our analysis many relevant questions for further research can be identified.
16 Regarding direct effects of climate change on economic development, the main
17 outstanding questions relate to identifying the precise causal mechanisms through which
18 climate shocks impact on the economy. The policy implications of the current literature are
19 mainly on the mitigation side – identifying negative economic impacts of climate
20 vulnerability and shocks motivates efforts to minimise future climate change. However, in
21 order to make policy-relevant conclusions for adaptation strategies future work should aim
22 at better understanding of mechanisms and a move beyond reduced form estimation.
23 Significant research gaps also remain regarding the potential indirect effects of climate
24 change for economic development, via effects on the overall socio-political environment.
25
26
27

28
29 Our review suggests that there are a potentially important set of dynamic interactions and
30 feedback loops between institutions, climate (impacts and vulnerability) and development,
31 which to date have been understudied. However, we first need to improve our
32 understanding of socio-political dynamics, where our knowledge still remains limited. In
33 what refers to institutions, there is still a lot to learn about institutional change as well as its
34 role in economic development (causal effects, context-specific institutional characteristics,
35 feasibility of optimal institutions, etc.). Understanding the role of specific institutions in
36 given contexts, and how institutions evolve and adapt in the face of major challenges,
37 becomes even more relevant to understand the effects of major shocks such as those
38 brought about by climate change.
39
40
41

42
43 Most empirical evidence on socio-institutional effects of a changing climate relates to
44 (violent) conflict, but there are also potentially important mechanisms via other socio-
45 cultural factors, institutional elements (including informal institutions, such as contract
46 enforcement, trust and cooperation), political economy (incentives), accountability of
47 political classes, the potential role of aid flows (including climate finance), many of which
48 to date remain under-studied. In this way, it becomes critical, for instance, to understand
49 how climate change will affect the political economy of governance (i.e. the domestic
50 distribution of political power) and policy formation in challenged countries, or how
51 institutional design should take account of climate risks, including concrete
52 recommendations for development planning.
53
54
55

56
57 In sum, what seems clear from our analysis is that the effects of climate change, whether
58 direct or indirect, seem of central relevance for sustainable economic development,
59
60

especially for poor countries, and in particular for those with fragile states. But our understanding of these effects remains limited. The topic clearly deserves further research.

References

- Acemoglu, D., Johnson, S. and Robinson, J. (2001). The colonial origins of comparative development: an empirical investigation. *American Economic Review*, 91(5), 1369-1401.
- Acemoglu, D., Johnson, S. and Robinson, J. (2002). Reversal of fortune: geography and institutions in the making of the modern world income distribution. *Quarterly Journal of Economics*, 117(4), 1231-1294.
- Acemoglu, D. and Robinson, J. (2000). Why did the west extend the franchise? Democracy, inequality, and growth in historical perspective. *Quarterly Journal of Economics*, 115(4), 1167-1199.
- Acemoglu, D. and Robinson, J. (2001). A theory of political transitions. *American Economic Review*, 91(4), 938-963.
- Acemoglu, D. and Robinson, J. (2010). The role of institutions in growth and development. *Review of Economics and Institutions*, 1(2), 1-33.
- Acemoglu, D. and Robinson, J. (2012). *Why Nations Fail: the Origins of power, Prosperity, and Poverty*. New York: Crown Publishing group.
- Adams, R (2004) Economic growth, inequality and Poverty: Estimating the growth elasticity of Poverty, *World Development* 32(12), 1989-2014.
- Advaryu, A., Kala, N. and Nyshadman, A. (2014). *The light and the Heat: Productivity co-benefits of Energy-saving Technology*. Unpublished manuscript.
- Aidt, T., and Franck, R. (2015). Democratization under the threat of Revolution: evidence from the great reform act of 1832. *Econometrica*, 83(2), 505-547.
- Alesina, A. and Perotti, R. (1996). Income distribution, political instability, and investment. *European Economic Review*, 40, 1203-1228.
- Ashraf, Q. and Galor, O. (2011). *Cultural diversity, geographical isolation, and the origin of the wealth of nations*, NBER Working Paper no. 17640. Cambridge MA: National Bureau of Economic Research.
- Ashraf, Q. and Galor, O. (2013). The “Out of Africa” hypothesis, human genetic diversity, and comparative economic development. *American Economic Review*, 103(1), 1-46.
- Banerjee, A., Kumar, S., Pande, R. and Su, F. (2011). *Do informed voters make better choices? Experimental evidence from urban India*. Unpublished manuscript.
- Bansal, R. and Ochoa, M. (2009). *Temperature, Growth and Asset Prices*. Duke University Working Paper. Durham NC: Duke University.
- Barr, R., Fankhauser, S. and Hamilton, K. (2010). Adaptation investment: a resource allocation framework. *Mitigation and Adaptation Strategies for Global Change*, 15(8), 843-858.
- Barrios, S., Bertinelli, L., and Strobl, E. (2006). Climate change and rural-urban migration: The case of Sub-Saharan Africa. *Journal of Urban Economics*, 60, 357-371.
- Barrios, S., Bertinelli, L. and Strobl, E. (2010). Trends in rainfall and economic growth in Africa: A neglected cause of the African growth tragedy. *Review of Economics and Statistics*, 92(2), 350-366.
- Barro, R. (1991). Economic growth in a cross section of countries. *Quarterly Journal of Economics*, 116(2), 407-443.
- Bates, R. (2006). Institutions and development. *Journal of African Economies*, 15(1), 10-61.
- Bergholt, D. and Lujala, P. (2012). Climate-related natural disasters, economic growth and armed civil conflict. *Journal of Peace Research*, 49(1), 147-162.
- Besley, T. and Persson, T. (2008). Wars and state capacity. *Journal of the European Economic Association*, 6(2-3), 522-530.
- Besley, T. and Persson, T. (2009). Repression or civil war? *American Economic Review: Papers and Proceedings*, 99(2), 292-297.

- 1
2
3 Besley, T. and Persson, T. (2011). *Pillars of Prosperity: The Political Economics of Development Clusters*. Princeton:
4 Princeton University Press.
- 5 Blattman, C. and Miguel, E. (2010). Civil war. *Journal of Economic Literature*, 48(1), 3-57.
- 6 Bloom, D. E., Canning, D. and Fink, G. (2008). Urbanization and the wealth of nations, *Science (New York,*
7 *N.Y.)*, 319(5864), 772-5.
- 8 Bloom, D. E. and Sachs, J. (1998). Geography, demography and economic growth in Africa, *Brookings Papers*
9 *on Economic Activity*, 2, 207-273.
- 10 Bohlken, A. and Sergenti, T. (2010). Economic growth and Ethnic Violence: an empirical investigation of
11 Hindu-Muslim Riots in India, *Journal of Peace Research*, 47(5), 589-600.
- 12 Boyanowsky, E. (1999). Violence and aggression in the heat of Passion and in Cold Blood: The Ecs-TC
13 syndrome. *International Journal of Law and Psychiatry*, 22(3), 257-71.
- 14 Broadberry, S., and Gardner, L. (2013). Africa's growth prospects in a European mirror: A historical
15 perspective. CAGE-Chatham House Series, No.5, February 2013.
- 16 Brooks, N., Adger, W. N. and Kelly P. M. (2005). The determinants of vulnerability and adaptive capacity at
17 the national level and the implications for adaptation. *Global Environmental Change*, 15, 151-163.
- 18 Brown, C. and Lall, U. (2006). Water and economic development: The role of variability and a framework for
19 resilience. *Natural resources forum*, 30, 306-317.
- 20 Brown, C., Meeks, R., Ghile, Y. and Hunu, K. (2013). Is water security necessary? An empirical analysis of the
21 effects of climate hazards on national-level economic growth. *Philosophical transactions of the Royal Society*
22 *A*, 371.
- 23 Brückner, M. and Ciccone, A. (2011). Rain and the democratic window of opportunity. *Econometrica*, 79(3),
24 923-947.
- 25 Burke, P. and Leigh, A. (2010). Do output contractions trigger democratic change? *American Economic Journal:*
26 *Macroeconomics*, 2(4), 124-57.
- 27 Burke, M., Miguel, E., Shanker, S., Dykema, J. and Lobell, D. (2009). Warming increase the risk of civil war in
28 Africa. *Proceedings of the National Academy of Sciences*, 106(49), pp.20670-74.
- 29 Butkiewick J. and Yanikkaya, H. (2005). The impact of sociopolitical instability on economic growth: Analysis
30 and Implications. *Journal of Policy Modeling*, 33(3), 371-391.
- 31 Campbell, K. M., Gullledge, J., McNeill, J. R., Podesta, J., Ogden, P., Fuerth, L., Woolsey, R. J., Lennon, A. T.
32 J., Smith, J., Weitz, R. and Mix, D. (2007). *The Age of Consequences: The Foreign Policy and National Security*
33 *Implications of Global Climate Change*. Washington DC: Center for Strategic and International Studies and
34 Center for a New American Security.
- 35 Castells-Quintana, D. (2015). Malthus living in a slum: Urban concentration, infrastructures and economic
36 growth. *Journal of Urban Economics* (forthcoming).
- 37 Castells-Quintana, D. and Royuela, V. (2014a). *Tracking positive and negative effects of inequality on long-run growth*.
38 IREA Working Paper no. 2014/01. Barcelona: Research Institute of Applied Economics.
- 39 Castells-Quintana, D. and Royuela, V. (2014b). Agglomeration, inequality and economic growth. *Annals of*
40 *Regional Science*, 52(2), 343-366.
- 41 Chaney, E. (2010). *Revolt on the Nile: Economic shocks, Religion and Institutional Change*. Harvard Working Paper.
42 Cambridge MA: Harvard University.
- 43 Chang, H. (2001). *Institutional development in developing countries in an historical perspective: lessons from developed countries*
44 *in earlier times*. Unpublished manuscript.
- 45 Chassang S. and Padro i Miquel, G. (2008). *Conflict and deterrence under Strategic Risk*. NBER Working Paper, no.
46 13964. Cambridge MA: National Bureau of Economic Research.
- 47 Chassang, S. and Padro-Miquel, G. (2009). *Strategic risk, civil war and intervention*. Unpublished manuscript.
- 48 Ciccone, A. (2011). Economic shocks and civil conflict: A comment. *American Economic Journal: Applied*
49 *Economics*, 3(4), 215-227.
- 50 Clarke, G. (1995). More evidence on income distribution and growth. *Journal of Development Economics*, 47, 403-
51 427.
- 52
53
54
55
56
57
58
59
60

- 1
2
3 CNA Corporation (2007). *National Security and the Threat of Climate Change*. Arlington: CNA Corporation.
- 4 Collier, P. (2007). *The Bottom Billion: Why the Poorest Countries are Failing and What Can Be Done About it*. Oxford:
5 Oxford University Press.
- 6 Collier, P., Conway, G. and Venables, T. (2008). Climate change and Africa. *Oxford Review of Economic Policy*,
7 24(2), 337-353.
- 8 Collier, P. and Gunning, J. W. (1999). Why has African grown slowly? *Journal of Economic Perspectives*, 13(3), 3-
9 22.
- 10 Collier, P. and Hoeffler, A. (1998). On the economic causes of civil war. *Oxford Economic Papers*, 50, 563-573.
- 11 Collier, P. and Hoeffler, A. (2004). Greed and grievance in civil war. *Oxford Economic Papers*, 56, 563-595.
- 12 Collier, P., Hoeffler, A. and Rohner, D. (2009). Beyond greed and grievance: feasibility and civil war. *Oxford*
13 *Economic Papers*, 61, 1-27.
- 14 Commons, J. (1924). *Legal foundations of Capitalism*. New York: Macmillan.
- 15
16 Couttenier, M. and Soubeyran, R. (2013). Drought and civil war in sub-Saharan Africa. *The Economic Journal*,
17 124(575), 201-244.
- 18
19 Davies, J. (1962). Toward a theory of revolution. *American Sociological Review*. 27(1), 5-19.
- 20
21 Davis, M. (2002). *Late Victorian holocausts: El Niño famines and the making of the third world*. Taylor and Francis:
22 London.
- 23
24 Davis, D.R. and D.E. Weinstein (2002). Bones, bombs and break points: The geography of economic activity.
25 *The American Economic Review*, 92(5), 1269-1289.
- 26
27 Dell, M., Jones, B. and Olken, B. (2009). Temperature and income: Reconciling new cross-sectional and panel
28 estimates. *American Economic Review*, 99(2), 198-204.
- 29
30 Dell, M., Jones, B. and Olken, B. (2012). Temperature shocks and economic growth: Evidence from the last
31 half a century. *American Economic Journal: Macroeconomics*, 4(3), 66-95.
- 32
33 Dell, M., Jones, B. and Olken, B. (2014). What do we learn from the weather? The new climate-economy
34 literature, forthcoming *Journal of Economic Literature*.
- 35
36 Dercon, S. (2012). *Is green growth good for the poor?* World Bank Policy Research Working Paper no. 6231.
37 Washington DC: World Bank Group.
- 38
39 Deryugina, T. and Hsiang, S. (2104). Does the environment still matter? Daily temperature and income in the
40 United States. NBER Working Paper no. 20750. Cambridge MA: National Bureau of Economic
41 Research.
- 42
43 Deschenes, O. and Greenstone, M. (2007). The economic impacts of climate change: Evidence from
44 agricultural output and random fluctuations in weather. *American Economic Review*, 97(1), 354-381.
- 45
46 Deschenes, O. and Greenstone, M. (2011). Climate change, mortality, and adaptation: evidence from annual
47 fluctuations in weather in the U.S. *American Economic Journal: Applied Economics*, 3(4), 152-185.
- 48
49 Di John, J. (2010). The concept, causes and consequences of failed states: A critical review of the literature
50 and agenda for research with specific reference to Sub-Saharan Africa. *European Journal of Development*
51 *Research*, 22(1), 10-30.
- 52
53 Diamond, J. (1997). *Guns, Germs, and Steel: The Fates of Human Societies*. New York: W.W. Norton.
- 54
55 Diamond, J. (2005.) *Collapse: How Societies Choose to Fail or Succeed*. New York: Viking.
- 56
57 Dixit, Y., Hodell, D. A. and Petrie, C. A. (2014). Abrupt weakening of the summer monsoon in northwest
58 Indian 4100 yr ago, *Geology*.
- 59
60 Djankov, S., Glaeser, E. L., La Porta, R., Lopez-de-Silanes, F. and Shleifer, A. (2003). The new comparative
61 economics. *Journal of Comparative Economics*, 31(4), 595-619.
- 62
63 Do, Q. and Iyer, L. (2006). *An empirical analysis of Civil conflict in Nepal*. Center on Institutions and Governance
64 Working Paper no.12. Berkeley: University of California.
- 65
66 Dube, O. and Vargas, J. F. (2013). Commodity price shock and Civil conflict: Evidence from Colombia.
67 *Review of Economic Studies*, 81(2), 1384-1421.

- 1
2
3 Dunne J.P, Stouffer, R and John J (2013) Reductions in labour capacity from heat stress under climate
4 warning, *Nature Climate Change*, 3, 563-566.
- 5 Easterly, W. (2007). Inequality does cause underdevelopment: insights from a new instrument. *Journal of*
6 *Development Economics*, 84, 755-776.
- 7 Easterly, W. (2006). Reliving the 1950s: the big push, poverty traps, and takeoffs in economic development.
8 *Journal of Economic Growth*, 11, 289–318
- 9
10 Easterly, W. and Levine, R. (1997). Africa’s growth tragedy: Policies and ethnic divisions. *Quarterly Journal of*
11 *Economics*, 112(4), 1203-50.
- 12 Easterly, W. and Levine, R. (2003). Tropics, germs, and crops: how endowments influence economic
13 development. *Journal of Monetary Economics*, 50(1), 3-39.
- 14 Engerman, S. and Sokoloff, K. (1997). Factor Endowments, Institutions, and Differential Paths of Growth
15 among New World Economics. In S. Haber, ed. *How Latin America Fell Behind*. Stanford CA: Stanford
16 University Press.
- 17 Engerman, S. and Sokoloff, K. (2000). History lessons: Institutions, factor endowments, and paths of
18 development in the new world. *Journal of Economic Perspectives*, 14(3), 217-232.
- 19 Escaleras, M. and Register, C. A. (2011). Natural disasters and foreign direct investment. *Land Economics*,
20 87(2), 346-363.
- 21 Fagan, B. (2005). *The long summer: How climate changed civilization*. New York: Basic Books.
- 22 Fagan, B. (2009). *Floods famines and emperors: El Nino and the fate of civilisations*. New York: Basic Books.
- 23 Fankhauser, S. and McDermott, T. K. J. (2014). Understanding the adaptation deficit: Why are poor countries
24 more vulnerable to climate events than rich countries? *Global Environmental Change*, 27, 9-18.
- 25 Fankhauser, S and Schmidt-Traub (2010). From adaptation to climate-resilient development: the costs of
26 climate-proofing the Millennium Development Goals in Africa, Policy Paper, Grantham Institute.
- 27 Fay, M., Opal, C., 2000. Urbanization without growth: a not-so-uncommon phenomenon. World Bank Policy
28 Research Working Paper 2412.
- 29 Fankhauser, S. and Tol, R. S. J. (2005). On climate change and economic growth. *Resource and Energy*
30 *Economics*, 27(1).
- 31 Fearon, J. (2007). Economic development, insurgency and civil war, In: E. Helpman, ed. 2008. *Institutions and*
32 *Economic Performance*. Cambridge: Harvard University Press. 292-328.
- 33 Fearon, J. and Laitin, D. (2003). Ethnicity, insurgency and civil war. *American Political Science Review*, 97(1), 75-
34 90.
- 35 Feng, S., Kruege, A. and Oppenheimer, M. (2010). Linkages among climate change, crop yields and Mexico’s
36 cross-border migration. *Proceedings of the National Academy of Sciences*, 107(32), 14257-62.
- 37 Ferraz, C. and Finan, F. (2011). Electoral accountability and corruption: evidence from the audits of local
38 governments. *American Economic Review*, 101(4), 1274-1311.
- 39 Fjelde, H., and von Uexkull, N. (2012). Climate triggers: rainfall anomalies, vulnerability and communal
40 conflict in Sub-Saharan Africa. *Political Geography*, 31(7), 444–453.
- 41 Fosu, A., Bates, R. and Hoeffler, A. (2006). Institutions, governance and economic development in Africa:
42 and overview. *Journal of African Economies*, 15(1), 1-9.
- 43 Furuya, J. and Koyama, O. (2005). Impacts of climate change on world agricultural product markets:
44 Estimation of macro yield functions. *Japan Agricultural Research Quarterly*, 39, 121-134.
- 45 Galbraith, J. (1958). *The Affluent Society*. Boston: Houghton Mifflin.
- 46 Gallup, J. and Sachs, J. (2001). The economic burden of malaria. *American Journal of Tropical Medicine and*
47 *Hygiene*, 64(1), 85-96.
- 48 Gallup, J., Sachs, J. and Mellinger, D. (1999). Geography and economic development. *International Regional*
49 *Science Review*, 22(2), 179-232.
- 50 Gallup, J., Sachs, J. and Mellinger, D. (2001). The geography of poverty and wealth. *Scientific American*.
- 51
52
53
54
55
56
57
58
59
60

- 1
2
3 Galor, O. (2005). From stagnation to growth: Unified growth theory, in: P. Aghion and S. Durlauf, ed.
4 *Handbook of Economic Growth*. Oxford and Amsterdam: Elsevier, North-Holland. 171-293.
- 5 Garfinkel, M. (1990). Arming as a strategic investment in a cooperative equilibrium. *American Economic Review*,
6 80(1), 50-68.
- 7 Garfinkel, M. and Skarpedas, S. (2000). Conflict without misperceptions or incomplete information: How the
8 future matters. *Journal of Conflict Resolution*, 44(6), 793-807.
- 9
10 Gartzke, E. (2012). Could climate change precipitate peace? *Journal of Peace Research*, 49(1), 177-192.
- 11 Gemenne, F. (2011). Why the numbers don't add up: a review of predictions and forecasts for
12 environmentally-induced migration. *Global Environmental Change*, 21, 41-49.
- 13 Glaeser, E. (2011). *The Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier,*
14 *and Happier*. London: Penguin Books.
- 15 Glaeser, E., La Porta, R., Lopez-De-Silanes, F. and Shleifer, A. (2004). Do institutions cause growth? *Journal of*
16 *Economic Growth*, 9, 271-303.
- 17
18 Gollin, D., Jedwab, R., Vollrath, D., 2014. Urbanization with and without industrialization, Institute for
19 International Economic Policy Working Papers 2014-01.
- 20 Foresight: Migration and global environmental change (2011). Final project report. Government Office for
21 Science, London.
- 22
23 Grindle, M. (2004). Good enough governance: poverty reduction and reform in developing countries.
24 *Governance*, 17(4), 525-548.
- 25 Guiteras, R. (2009). *The impact of climate change on Indian agriculture*. Working Paper. College Park: University of
26 Maryland.
- 27 Gupta, D. (1990). *The Economics of Political Violence*. New York: Praeger.
- 28
29 Gurr, T. (1971). *Why Men Rebel*. Princeton and Oxford: Princeton University Press.
- 30 Hall, R. and Jones, C. (1999). Why do some countries produce so much more output per worker than others?
31 *Quarterly Journal of Economics*, 114(1), 83-116.
- 32 Hallegatte, S. (2014). *Economic resilience: definition and measurement*. World Bank Development Research Group
33 Policy Research Working Paper no. 6852. Washington DC: World Bank Group.
- 34 Hallegatte, S., M. Bangalore, L. Bonzanigo, M. Fay, T. Kane, U. Narloch, J. Rozenberg, D. Treguer, and A.
35 Vogt-Schilb (2016). *Shock Waves: Managing the Impacts of Climate Change on Poverty*. Climate Change and
36 Development Series. Washington, DC: World Bank. doi:10.1596/978-1-4648-0673-5.
- 37
38 Hausmann, R., Pritchett, L., & Rodrik, D. (2005). Growth Accelerations. *Journal of Economic Growth*, 10(4),
39 303-329.
- 40 Heltberg, R., Siegel, P. and Jorgenson, S. L. (2008). Addressing Human Vulnerability to Climate Change:
41 Towards a No Regrets Approach. *Global Environmental Change*, 19(1), 89-99.
- 42 Henderson, J. V., Shalizi, Z. and Venables, A. (2001). Geography and development. *Journal of Economic*
43 *Geography*, 1, 81-105.
- 44 Henderson, J. V., Storeygard, A. and Deichmann, U. (2014). *50 years of urbanization in Africa*. World Bank
45 Policy Research Working Paper no. 6925. Washington DC: World Bank Group.
- 46
47 Hendrix, C. and Salehyan, I. (2012). Climate change, rainfall, and social conflict in Africa. *Journal of Peace*
48 *Research*, 49(1), 5-50.
- 49 Hidalgo, D., Naidu, S., Nichter, S. and Richardson, N. (2010). Economic determinants of land invasions.
50 *Review of Economics and Statistics*, 92(3), 505-523.
- 51
52 Hirshleifer, J. (1988). The Analytics of continuing conflict. *Synthese*, 76(2), 201-233.
- 53
54 Hirshleifer, J. (1989). Conflict and rent-seeking success functions: Ratio vs. Difference Models of relative
55 success. *Public Choice*, 63(2), 101-112.
- 56
57 Hirshleifer, J. (2001). *The dark side of the force: Economic Foundations of Conflict Theory*. Cambridge: Cambridge
58 University Press.
- 59
60

- 1
2
3 Hochrainer, S. (2009). *Assessing the Macroeconomic Impacts of Natural Disasters – Are There Any?* World Bank
4 Policy Research Working Paper no. 4968. Washington DC: World Bank Group.
- 5 Homer-Dixon, T. (1991). On the threshold: Environmental changes as causes of acute conflict. *International*
6 *Security*, 16(2).
- 7 Hsiang, S. M. (2010). Temperatures and cyclones strongly associated with economic production in the
8 Caribbean and Central America. *Proceedings of the National Academy of Science*, 107(35), 15367-72.
- 9 Hsiang, S. M. and Jina, A. (2014). *The casual effects of environmental catastrophe on economic growth*. NBER Working
10 Paper no. 20352. Cambridge MA: National Bureau of Economic Research.
- 11 Hsiang, S. M., Meng, K. C. and Cane, M. A. (2011). Civil conflicts are associated with the global climate.
12 *Nature*, 476, 438–441.
- 13 Hsiang, S. M. and Narita, D. (2012). Adaptation to cyclone risk: Evidence from the global cross-section.
14 *Climate Change Economics*, 3(2).
- 15 Intergovernmental Panel on Climate Change (IPCC). (2012). *Managing the risks of extreme events and disasters to*
16 *advance climate change adaptation*. New York: Cambridge University Press.
- 17 IPCC (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment*
18 *Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University
19 Press.
- 20 IPCC (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the*
21 *Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York:
22 Cambridge University Press.
- 23 Jacobs, J. (1985). *Cities and the Wealth of Nations*. New York: Random House USA.
- 24 Jäger, J., Frühmann, J., Günberger, S. and Vag, A. (2009). *Environmental Change and Forced Migration Scenarios*
25 *Project Synthesis Report*. EACH-FOR Paper.
- 26 Jennings, C. (2013). Institutions and Prosperity. *European Journal of Political Economy*, 29, 252-258.
- 27 Jia, R. (2013). Weather shocks, sweet potatoes and peasant revolts in historical China. *The Economic Journal*,
28 124, 92-118.
- 29 Jones, B. and Olken, B. (2010). Climate shock and exports. *American Economic Review*, 100(2), 454-459.
- 30 Khan, H (1999) Sectoral growth and Poverty Alleviation: a multiplier decomposition technique applied to
31 South Africa, *World Development* 27(3): 521-530.
- 32 Kim, S., 2008. Spatial Inequality and Economic Development: Theories, Facts and Policies, Working Paper
33 No. 16, Commission on *Growth and Development*.
- 34 Knack, S. and Keefer, P. (1995). Institutions and economic performance: cross-country tests using alternative
35 measures. *Economics and Politics*, 7(3), 207-227.
- 36 Kocornik-Mina, A., T.K.J. McDermott, G. Michaels and F. Rauch (2015). *Flooded Cities*, London, Centre for
37 Economic Policy Research Discussion Paper No. 11010 (December).
- 38 Kolmannskog, V. O. (2008). *Future floods of refugees. A comment on climate change, conflict and forced migration*. Oslo:
39 Norwegian Refugee Council.
- 40 Koubi, V., Bernauer, T., Kalbhenn, A. and Spilker, G. (2012). Climate variability, economic growth and civil
41 conflict. *Journal of Peace Research*, 49(1), 11-22.
- 42 Krugman, P. (1991). *Geography and Trade*. Cambridge MA: MIT Press.
- 43 Krugman, P. (1999). The role of geography in development. *International Regional Science Review*, 22(2), 142-161.
- 44 Krugman, P. (2012). *End this depression now!* London: Norton.
- 45 Kung, J. and Ma, C. (2014). Can cultural norms reduce conflicts? Confucianism and peasant rebellions in
46 Qing China. *Journal of Development Economics*, 111, 132-149.
- 47 Loayza, N., Olaberria, J. and Christiaensen, L. (2012). Natural disasters and growth: Going beyond the
48 averages. *World Development*, 40(7), 1317-36.
- 49 Loayza, N and Raddatz C (2010). The composition of growth matters for poverty Alleviation, *Journal of*
50 *Development Economics*, 93(1): 137-151.
- 51
52
53
54
55
56
57
58
59
60

- 1
2
3 Lobell, D. and Field C. B. (2007). Historical effects of temperature and precipitation on California crop
4 yields. *Climate Change*, 81, 187-203.
- 5 Martin, R., Muuls, M. and Ward, A. (2011). The Sensitivity of UK Manufacturing Firms to Extreme Weather
6 Events. Supporting Research for: CCC, 2011. *Adapting to climate change in the UK – Measuring progress*.
7 London: Climate Change Committee.
- 8 Masters, W. A. and McMillan, M. S. (2001). Climate and scale in economic growth. *Journal of Economic Growth*,
9 6, 167-186.
- 10 Mauro, P. (1995). Corruption and growth. *Quarterly Journal of Economics*, 110(3), 681-712.
- 11 Maystadt, J. and Ecker, O. (2014). Extreme weather and civil war: does drought fuel conflict in Somalia
12 through livestock price shocks? *American Journal of Agricultural economics*, 1-26.
- 13 Maystadt, J., Ecker, O. and Mabiso, A. (2013). *Extreme weather and civil war in Somalia: Does drought fuel conflict
14 through livestock price shocks*. IFPRI Discussion Paper no. 01243. Washington DC: International Food
15 Policy Research Institute.
- 16
17 McBride, M. and Skarpedas, S. (2007). Explaining conflict in low-income countries: Incomplete contracting
18 in the shadow of the future. In: M. Gradstein and K. Konrad, ed. *Institutions and Norms in Economic
19 Development*. Cambridge and London: MIT Press. 141-162.
- 20 McDermott, T. K. J., Barry, F. and Tol, R. S. J. (2014). Disasters and Development: Natural Disasters, Credit
21 Constraints and Economic Growth. *Oxford Economic Papers*, 66(3), 750-773.
- 22
23 McMichael, C., Barnett, J. and McMichael, A. J. (2012). An ill wind? Climate change, migration, and health.
24 *Environmental Health Perspectives*, 120(5), 646-654.
- 25 Mehlum, H., Miguel, E. and Torvik, R. (2006). Poverty and Crime in 19th century Germany. *Journal of Urban
26 Economics*, 59(3), 370-388.
- 27 Michaels, G. and Rauch, F. (2013). *Resetting the urban network: 117-2012*. University of Oxford Department of
28 Economics Discussion Paper no.684. Oxford: Oxford University.
- 29 Miguel, E. and Satyanath, S. (2011). Re-examining economic shocks and civil conflict. *American Economic
30 Journal: Applied Economics*, 3(4), 228-232.
- 31 Miguel, E., Satyanath, S. and Sergenti, E. (2004). Economic shocks and civil conflict: an instrumental
32 variables approach. *Journal of Political Economy*, 112(4), 725-753.
- 33
34 Miller, J. C. (1982). The significance of drought, disease and famine in the agriculturally marginal zones of
35 West-Central Africa. *The Journal of African History*, 23(1), 17-61.
- 36 Montalvo, J. and Reynal-Querol, M. (2005). Ethnic polarization, potential conflict, and civil wars. *American
37 Economic Review*, 95(3), 796-816.
- 38 Myers, N. and Kent, J. (1995). Environmental exodus: An emergent crisis in the global arena. Washington
39 DC: Climate Institute.
- 40 Myrdal, G. (1968). *Asian Drama: An inquiry into the Poverty of Nations*. New York: Pantheon Books.
- 41 Nel, P. and Righarts, M. (2008). Natural disasters and the risk of violent civil conflict. *International studies
42 Quarterly*, 52(1), 159-185.
- 43
44 Nicholson, S. (2000). The nature of rainfall variability over Africa on time scales of decades to millennia.
45 *Global and Planetary Change*, 26(1-3), 137-158.
- 46 Nicholson, S. (2001). Climatic and environmental change in Africa during the last two centuries. *Climate
47 Research*, 17, 123-144.
- 48
49 Nordhaus, W. (2006). Geography and macroeconomics: New data and new findings. *Proceedings of the National
50 Academy of Science*, 103(10), 3510-17.
- 51 O'Connell, S. A. and Ndulu, B. J. (2000). *Africa's growth experience, a focus on sources of growth*. Working Paper.
- 52
53 Oppenheimer, M., M. Campos, R. Warren, J. Birkmann, G. Luber, B. O'Neill, and K. Takahashi, 2014:
54 Emergent risks and key vulnerabilities. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part
55 A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the
56 Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D.
57 Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel,
58 A.N. Levy, S. MacCracken,

- 1
2
3 P.R. Mastrandrea, and L.L. White (eds.]. Cambridge University Press, Cambridge, United Kingdom and New
4 York, NY, USA, pp. 1039-1099.
- 5 Paige, J. (1975). *Agrarian Revolution: Social Movements and Export Agriculture in the Underdeveloped World*. New
6 York: Macmillan, Free Press.
- 7 Pande, R. and Udry, C. (2005). Institutions and Development: A View from Below. In: R. Blundell, W.
8 Newey and T. Persson, eds. *The Proceedings of the 9th World Congress of the Econometric Society*. Cambridge:
9 Cambridge University Press. 349-403.
- 10 Parsons K (2014) *Human Thermal Environments. The effects of hot, moderate and cold temperatures on human health,*
11 *comfort and performance*, Taylor and Francis, London.
- 12 Pederson, N., Hessel, A. E., Baatarbileg, N., Anchukaitis, K. J. and Di Cosmo, N. (2014). Pluvials, droughts,
13 the Mongol empire, and modern Mongolia. *PNAS*, 112(12), 4375–4379.
- 14 Petersen, R., 2001. *Resistance and Rebellion: Lessons from Eastern Europe*. Cambridge, New York and Melbourne:
15 Cambridge University Press.
- 16 Piketty, T. (2014). *Capital in the Twentieth-First Century*. Cambridge MA: Harvard University Press.
- 17 Powell, R. (2006). War as a commitment problem. *International Organization*, 60(1), 169-203.
- 18 Puga, D. and Venables, A. (1999). Agglomeration and economic development: Import substitution vs. trade
19 liberalization. *The Economic Journal*, 109(455), 292-311.
- 20 Przeworski, A. (2009). Conquered or granted? A history of suffrage Extension. *British Journal of Political Science*,
21 39(2), 291-321.
- 22 Ravallion, M (1995) Growth and Poverty: Evidence for developing countries in the 1980s, *Economic Letters*,
23 48, 411-417.
- 24 Raddatz, C. (2009). The wrath of God: Macroeconomic costs of natural disasters. World Bank Policy
25 Research Working Paper. Washington DC: World Bank Group.
- 26 Raleigh, C. and Kniveton, D. (2012). Come rain or shine: an analysis of conflict and climate variability In East
27 Africa. *Journal of Peace Research*, 49(1), 51-64.
- 28 Ray, D. (2009). *Remarks on the initiation of costly conflict*. Presented at the Yale University Workshop on
29 Rationality and Conflict, New Haven.
- 30 Rodrik, D. (1999). Where did all the growth go? External shocks, social conflict, and growth collapses. *Journal*
31 *of Economic Growth*, 4(4), 385-412.
- 32 Rodrik, D. (2004). *Normalising Industrial Policy*, World Bank Commission on Growth and Development
33 Working Paper no. 3. Washington DC: World Bank Group.
- 34 Rodrik, D. (2008). Second-best institutions. *American economic Review: Papers and Proceedings*, 98(2), 100-104.
- 35 Rodrik, D., Subramanian, A. and Trebbi, F. (2004). Institutions rule: the primacy of institutions over
36 geography and integration in economic development. *Journal of Economic Growth*, 9(2), 131-165.
- 37 Roemer, J. (1985). Rationalizing revolutionary ideology. *Econometrica*, 53(1), 85-108.
- 38 Rose, S, Abbas, S, Ali M and Azeem M (2013) Growth-Poverty linkages: does sectoral composition matter
39 for Pakistan? *World Applied Sciences Journal*, 21(6), 915-919.
- 40 Rotberg, R. (2003). *When States Fail: Causes and Consequences*. Princeton: Princeton University Press.
- 41 Sachs, J. (2003). *Institutions don't rule: A refutation of institutional fundamentalism*. NBER Working Paper no. 9490.
42 Cambridge MA: National Bureau of Economic Research.
- 43 Sachs, J. and Malaney, P. (2002). The economic and social burden of malaria. *Nature*, 415(6872), 680–685.
- 44 Sachs, J. and Warner, A. (2001). The curse of natural resources. *European Economic Review*, 45, 827-836.
- 45 Sala-i-Martin, X., Doppelhofer, G. and Miller, R. (2004). Determinants of long-run growth: a Bayesian
46 averaging of classical estimates (BACE) approach. *American Economic Review*, 94(4), 813-835.
- 47 Samson, J., Berteaux, B. J. and Humphries, M. M. (2011). Geographic disparities and moral hazards in the
48 predicted impacts of climate change on human populations. *Global Ecology and Biogeography*, 20(4), 532–
49 544.
- 50 Sarsons, H. (2011). *Rainfall and Conflict*. Unpublished manuscript.
- 51
52
53
54
55
56
57
58
59
60

- 1
2
3 Schlenker, W. and Lobell, D. (2010). Robust negative impacts of climate change on African agriculture. *Environmental Research Letters*, 5(1).
- 4
5 Scott, J. (1976). *Moral Economy of the Peasant: Rebellion and Subsistence in Southeast Asia*. New Haven and London: Yale University Press.
- 6
7 Seppanen, O., Fisk, W. and Lei, Q. (2006). *Effect of temperature on task performance in office environment*. Berkeley: Lawrence Berkeley National Laboratory.
- 8
9
10 Skaperdas, S. (1992). Cooperation, conflict, and power in the absence of property rights. *American Economic Review*, 82(4), 720-739.
- 11
12 Skidmore, M. and Toya, H. (2002). Do natural disasters promote long-run growth? *Economic Inquiry*, 40(4), 664-667.
- 13
14 Slettebak, R. (2012). Don't blame the weather! Climate-related natural disasters and civil conflict. *Journal of Peace Research*, 49(1), 163-176.
- 15
16 Smith, A. (1776). *An Inquiry into the Nature and Cause of the Wealth of Nations*. London: Methuen & Co.
- 17
18 Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., and Miller, H.L. (eds). (2007). *Contribution of Working Group I to the Fourth Assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, U.K.
- 19
20
21 Steinbruner, J., Stern, P. and Husbands, J. (2013). *Climate and Social Stress: Implications for Security Analysis*. Washington DC: The National Academies Press.
- 22
23 Stern, N. (2007). *The Economics of Climate Change. The Stern Review*. Cambridge: Cambridge University Press.
- 24
25 Stiglitz, J. (2012). *The price of Inequality: How today's Divided Society Endangers our Future*. New York: W. W. Norton.
- 26
27 Strulik, H. (2008). Geography, health, and the pace of demo-economic development. *Journal of Development Economics*, 86(1), 61-75.
- 28
29 Sudarshan, A. and Tewari, M. (2014). *The economic Impacts of temperature on Industrial Productivity: Evidence from Indian Manufacturing*. ICRIER Working Paper no. 278. New Delhi: Indian Council for Research on International Economic Relations.
- 30
31
32 Tol, R. S. J. and Wagner, S. (2010). Climate change and violent conflict in Europe over the last millennium. *Climatic Change*, 99, 65-79.
- 33
34 Torres, M. and Anderson, M. (2004). *Fragile States: Defining Difficult Environments for Poverty Reduction*. PRDE Working Paper no. 1. London: Department for International Development.
- 35
36 United Nations Development Programme (UNDP). (2011). *The Forgotten Billion: MDG achievement in the drylands*. New York: United Nations Development Programme.
- 37
38 United States Agency for International Development (USAID) (2014). *Climate-Resilient Development. A framework for understanding and addressing climate change*. Washington: USAID Global Climate change Office.
- 39
40
41
42 Veblen, T. (1899). *The Theory of the Leisure Class: An Economic Study of Institutions*. London: MacMillan.
- 43
44 Waldinger, M. (2013). *The effect of climate change on Economic Growth: Evidence from the little ice age, 1500–1750*. LSE Economic History Working Paper. London: London School of Economics and Political Science.
- 45
46 Walter, B. (1997). The critical barrier to civil war settlement. *International Organization*, 51(3), 335-364.
- 47
48 Weinstein, J. (2005). Resource and the information problem in rebel recruitment. *Journal of Conflict Resolution*, 49(4), 598-624.
- 49
50 Wood, E. (2003). Civil wars: What we don't know. *Global Governance*, 9(2), 247-261.
- 51
52 World Bank. (2010). *World Development Report 2010: Development and Climate Change*. Washington DC: World Bank Group.
- 53
54 World Bank. (2013). *World Development Report*. Washington DC: World Bank Group.
- 55
56 Wyndham, C. H. (1969). Adaptation to heat and cold. *Environmental Research*, 2(5-6), 442-469.
- 57
58 Young, A. (1995). The tyranny of numbers: confronting the statistical realities of the East Asian growth experience. *Quarterly Journal of Economics*, 110, 641-680.
- 59
60

Zander, K, Botzen W, Oppermann E, Kjellstrom T and Garnett S (2015) Heat Stress causes substantial labour productivity loss in Australia, *Nature Climate Change*, 5, 647-651.

Zartman, W. (1995). Introduction: Posing the problem of state collapse. In: W. Zartman, ed. *Collapsed State: The Disintegration and Restoration of Legitimate Authority*. Boulder: Lynne Rienner. 1-11.

Zhang, D., Brecke, P., Lee, H., He, Y. and Zhang, J. (2007). Global climate change, war, and population decline in recent human history. *PNAS*, 104(49), 19214-19.

Notes:

¹ There is a long literature on the proximate determinants of cross-country differences in economic growth providing evidence on the role of capital accumulation (see for instance Barro, 1991; Young, 1995; Sala-i-Martin et al., 2004). Other variables commonly (and robustly) identified to be associated with economic growth include innovation and technology, measures of life expectancy, fertility, and economic specialisation, as well as geographical and institutional variables.

² Attention has variously focused on several potential deep-rooted determinants of development, including cultural differences (Ashraf and Galor, 2011), biogeographical factors (Diamond, 1997), geographical factors (Gallup et al., 1999, 2001; Easterly and Levine, 2003, among others), institutions (Acemoglu et al., 2001, 2002; Rodrik et al., 2004; Besley and Persson, 2011 and Acemoglu and Robinson, 2012), and most recently even genetic characteristics (Ashraf and Galor, 2013).

³ The available evidence suggests that both geographical and institutional factors act as driving forces for economic development, with some authors arguing that geography produces most of its impact through its effect on institutional development (e.g. Acemoglu et al., 2001; Rodrik, 2004). Even controlling for (national level) institutions, however, geographical factors still seem to play a significant and direct role (see for example Sachs, 2003; Glaeser et al., 2004). The significant role of geography has also been analysed *within* countries (i.e., Nordhaus 2006, Dell et al. 2009).

⁴ A sustained rate of economic growth has the potential to transform economies and lift millions out of chronic poverty. Of course, growth does not automatically translate into poverty reduction in the short-run, and for all members of society. Empirical estimates of the relationship between growth and poverty vary depending on the data used (Ravallion, 1995, Adams, 2004) and the composition and size of economic growth (Khan, 2009, Loayza and Raddatz, 2010 and Rose et al, 2013).

⁵ Climate-resilient development is defined as ensuring that societies and different groups within them are able to cope with climate variability and to adapt to future climate change, trying to preserve development gains and to reduce the damages (USAID, 2014).

⁶ Agglomeration in large urban centres, for instance, not only raises prices but also increases challenges related to transportation, pollution, social cohesion and the provision of adequate public services.

⁷ The physiological response of human beings to temperature has been documented from heat studies in the lab (e.g. Wyndham, 1969). Such effects might be mitigated by a more widespread adoption of air-conditioning. As always, the ultimate impacts of climate will depend not just on the level of exposure but also on the sensitivity and adaptive capacity of affected regions and societies.

⁸ While there might be possible benefits from higher temperatures in some regions due to short-term bio-productivity increases, negative effects of global warming on agriculture, due not just to higher temperatures but also to higher climatic fluctuations, appear to outweigh such benefits (Furuya and Koyama, 2005; Lobell and Field, 2007). For developing regions, the anticipated effects of climate change are expected to be particularly challenging from a socio-economic perspective (see e.g. Samson et al., 2011).

⁹ Barrios et al. (2006) and Henderson et al. (2014) report a significant link between climate and urbanisation in Sub-Saharan Africa, which appears especially strong in arid regions. The mechanism is through reduced incomes (from agriculture) following periods of reduced moisture availability.

¹⁰ Fankhauser and Tol (2005) have suggested, using model simulations, that the indirect (dynamic) impacts of climate change on growth, via lower capital accumulation, could be larger than direct levels effects on output.

¹¹ Several papers show that growth spurts and collapses are more common than simple 'convergence' or deterministic growth paths *a la* neoclassical growth theory (Rodrik 1999; Hausmann et al. 2005; Easterly 2006). Broadberry et al. (2013) argue that there is some threshold in terms of income and institutional development beyond which growth becomes more secure, but below which countries remain vulnerable to shocks.

¹² See Di John (2010) for a good review of the literature on "fragile" states.

¹³ There are two prominent vies about on the role of institutions. First, based on Smith's (1776) idea of peace, easy taxes, and a tolerable administration of justice, as the requirements for economic development, Besley and Persson (2011) focus on the role of fiscal and legal capacity and political stability as the three pillars of

prosperity. Second, Acemoglu and Robinson (2012) explain how in the long run countries differ in their economic success because of their different institutions, either of extractive or inclusive nature. See Jennings (2013) for a more thorough review and comparison of these two approaches.

¹⁴ Except to the extent that mitigation efforts and global climate negotiations might influence domestic politics. However, this is a distinct type of effect – likely operating on the political/ideological make-up of government, as opposed to affecting the fundamental quality of institutional and governance arrangements.

¹⁵ In all these papers the aim is to identify a causal effect of institutions on economic development, typically by using instrumental variables estimations. While Mauro (1995) uses ethnolinguistic fragmentation to instrument for corruption, as proxy for institutional quality, the rest of the papers tend to rely on geographical variables as instruments for institutional variables. Hall and Jones (1999) rely on distance from the Equator, and Acemoglu et al. (2001) on settler mortality rates (in turn determined by disease environment given by geographic characteristics and climate). Engerman and Sokoloff (2000) argue that factor endowments (mainly in terms of soils, climate, mineral resources and availability of cheap and organised labour) determined inequalities in the structures of production and social organisations, which translated into persistent institutional arrangements perpetuating over time.

¹⁶ Pande and Udry (2005) explain the limitations of cross-country approaches to analyse the effect of institutions on economic development. These limitations mainly relate to the coarseness of institutional measures and instruments, omitted variables, and heterogeneous treatment effects, all of which might lead to significant upward biases of the effect of institutions on long-run growth.

¹⁷ As noted by several authors, today's developed countries did not need perfect institutions for industrialisation to take place; while some key reforms were essential many other good governance characteristics came along with the process of development (Chang, 2001; Grindle, 2004; and Rodrik 2008).

¹⁸ The concept and measure of instability varies across studies. While some authors focus more on violent conflict, others consider broader measures of socio-political instability also taking into account social unrest and government stability or lack of it.

¹⁹ In a reversal of circumstances, Pederson et al. (2014) report the 21st century drought in central Mongolia as being the hottest drought in the last 1,112 years.

²⁰ Blattman and Miguel (2010) provide a comprehensive review of war's (economic) causes and consequences, identifying several distinct approaches to modeling the origins of conflict.

²¹ Weather shocks may increase food prices, typically leading to more frequent uprisings and riots. Depending on the circumstances and for specific locations, however, weather shocks might offset current food insecurity and help lower the risk of local conflict (Gartzke, 2012).

²² Indeed, previous evidence supports the idea of decreased output and rural productivity lowering the opportunity cost of engaging in conflict and increasing the returns to violence. In a study of the Colombian civil conflict, Dube and Vargas (2013) present evidence that steep declines in coffee prices and increases in oil prices reduced workers' wages and increased their propensity to join armed groups. Likewise, Do and Iyer (2006) find a strong correlation between civil conflict and poverty and lower levels of human capital, which they consider is a proxy for opportunity costs.

²³ Clearly, in hotter climates periods of *higher* temperatures might be expected to create more difficult growing conditions.

²⁴ See Acemoglu and Robinson (2010, 2012), Besley and Persson (2011), Stiglitz (2012), Krugman (2012), and Piketty (2014). In Engerman and Sokoloff (1997, 2000), for instance, the argument rotates around inequality: "bad institutions" are the consequence of unequal structures of production and social organisations (as those implemented in Latin America after colonisation). Inequalities and bad institutions are in this sense two sides of the same coin, reinforcing each other and becoming persistent over time. Higher inequalities are generally associated with worse institutions (see Castells-Quintana and Royuela, 2014a), and are in fact considered as a relevant handicap for long-run economic growth (Clarke, 1995; Easterly, 2007; Castells-Quintana and Royuela, 2014b, among others)

²⁵ Ethnic favouritism has been identified as a factor also behind inequalities in many African and Asian countries, and represents a clear example of the reinforcing feedbacks between political and economic inequality, as well as of its negative outcomes (for instance, Fosu et al., 2006, found that the existence of ethnically biased interest groups is associated with sub-optimal provision of public goods). But Banerjee et al. (2011) bring some optimism showing how information about candidates in India can lead voters towards more conscious voting and away from relying solely on ethnicity. Increased audits and electoral accountability has led to similar results in Brazil (Ferraz and Finan, 2011).

²⁶ Other reports highlighting security risks of mass migrations include the *National Security and the Threat of Climate Change* report (CNA Corporation, 2007), the US Department of Defence 2010 *Quadrennial Defense Review*, and the *Climate and Social Stress: Implications for Security Analysis* (Steinbruner et al., 2013) report.