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Climate change and the geographical and institutional drivers of economic development

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July 2015

Centre for Climate Change Economics and Policy
Working Paper No. 223

Grantham Research Institute on Climate Change and the Environment
Working Paper No. 198

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Climate change and the geographical and institutional drivers of economic development

Working paper

Grantham Research Institute on
Climate Change and
the Environment

PRISE
Pathways to resilience
in semi-arid economies

Research for climate–resilient futures

Climate change and the geographical and institutional drivers of economic development

July 2015

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This paper has been produced as part of a series of preliminary papers to guide the long-term research agenda of the Pathways to Resilience in Semi-arid Economies (PRISE) project. PRISE is a five-year, multi-country research project that generates new knowledge about how economic development in semi-arid regions can be made more equitable and resilient to climate change.

Front cover image:
Garden farming in semi-arid regions of Tanzania.

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, and Maria Waldinger. Inputs on the PRISE countries were kindly provided by the research teams at Innovation, Environnement, Developpement Afrique, Sustainable Development Policy Institute, and the Centre for Climate Change Studies at the University of Dar es Salaam. Excellent research assistance was provided by Rossi Abi Rafeh, Veda Narasimhan and Monir Shaikh. Any remaining errors are the sole responsibility of the authors.

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Abstract

The links between climate change, economic development and poverty reduction have gained increasing attention over recent years in both the academic and policy literature. 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. In this regard, 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 power. We focus in particular on the effects in low-income, semi-arid countries, as they are anticipated to suffer disproportionately the most negative effects of climate change. They also tend to have relatively weak economic and political institutions, constraining their ability to cope with climate variability and shocks.

Our review suggests that there are a potentially important set of dynamic interactions and feedback loops between institutions, climate (impacts and vulnerability) and development, which to date have been understudied. Understanding both the direct as well as the indirect effects of climate change is not only fundamental for the design of mitigation and adaptation strategies; whether by addressing the direct impacts of geographical factors, or by addressing their indirect effects on the socio-political environment, mitigation and adaptation strategies are also fundamental as key elements of broader development strategies. Moreover, as climate shocks disproportionally affect the poor, addressing climate-related risks is also a sound strategy in terms of addressing inequality and poverty reduction.

Executive summary

How climate change impacts on growth and development in semi-arid lands

- Climate change has direct implications for economic growth and development for example via its impacts on agricultural output and the effects of extreme weather events. However, climate change could also have important effects on the economy via its influence on conflict, political stability and fiscal sustainability.
- The six case study countries of the *Pathways to Resilience in Semi-arid Economies* (PRISE) project (Senegal, Burkina Faso, Tanzania, Kenya, Pakistan and Tajikistan) may be particularly vulnerable to climate change due to; existing environmental challenges; economic reliance on agricultural output; relatively high poverty rates, particularly in rural areas; financial constraints, including relatively low proportion of the population having access to formal financial services; and weak state capacity.

Adapting to climate change: the role of institutions, governance and finance in climate resilient development

- Institutions matter greatly for economic development. The design of 'good' institutions should take account of local conditions (historical, political and environmental) as well as future challenges, including climate change.
- At the household level, adaptation to climate change can involve efforts to make existing locations, livelihoods and forms of production more resilient to climate risk, *or* reductions in vulnerability through movement of people and changes in economic activity.
- Successful adaptation will need to strike a balance between the two, avoiding locking-in unsustainable practices in locations that are already marginal from an economic perspective, and taking account of broader socio-economic trends (such as population growth and urbanisation).
- Adaptation should be predominantly about risk coping, and supporting efficient risk-taking behaviour, and not just about minimising risk.
- The primary role of government is to facilitate the autonomous adaptation decisions of individual households and businesses, by for example; providing an enabling environment (reducing bureaucracy, providing basic infrastructure); supporting the expansion of financial services (including micro-finance and insurance); and making available necessary information (e.g. on existing climate variability, anticipated climate change and associated coping mechanisms).

1. Introduction

The links between climate change, economic development and poverty reduction have gained increasing attention over recent years in both the academic and policy literature. Climate change can affect the processes of poverty reduction and economic development directly, through modifying relevant natural (geographical) conditions, but also indirectly by altering the socio-political environment within which poverty reduction and development take place. Understanding both the direct as well as the indirect effects of climate change is therefore not only fundamental for the design of mitigation and adaptation strategies but also in the design of broader strategies for poverty reduction and economic development.

In this paper we focus on the 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 driver of relative prosperity, or indirectly by modifying the environmental context in which political and economic institutions evolve. In this regard, 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 power. Our review suggests that there are a potentially important set of dynamic interactions and feedback loops between institutions, climate (impacts and vulnerability) and development, which to date have been understudied.

We focus in particular on the effects in low-income, semi-arid countries. Low-income countries are anticipated to suffer disproportionately the most negative effects of climate change. They also tend to have relatively weak economic and political institutions, constraining their ability to cope with climate variability and shocks. Semi-arid countries are also especially vulnerable to climate change, given the existing environmental challenges they face.

Climate change represents a shift in the distribution of future weather, and can therefore distort both the mean and the variability of economically relevant weather variables, as well as potentially increasing the frequency and intensity of extreme weather events, leading to natural disasters (see e.g. IPCC, 2012). These trends are likely to affect disproportionately the poor and may be especially relevant for regions already facing environmental challenges and stresses (e.g. Samson et al., 2011).

It is important to note from the outset that much of the literature that we review here studies the effects of *existing climatic variability* on factors related to economic development. However, understanding the relationship between existing climate and development is an important first step to understand how anticipated *climate change* might affect development.

In the long run, what matters for economic development is (sustained) economic growth.[1] Much concern has been expressed over the potential effects of climate change on economic development and poverty (e.g. World Bank, 2010; IPCC, 2014). However, the evidence to date has tended to show level effects (i.e. reductions in output, e.g. agriculture) as opposed to growth effects of climate variability and shocks (Tarazona et al., 2014).

Given the extreme disparities that we see around the world in terms of living standards, understanding the fundamental drivers of prosperity becomes one of the most critical issues for both social scientists and policy-makers concerned with poverty reduction and sustainable economic development. But understanding the dynamics of long-run development is not an easy task. Indeed, the debate in the literature about the fundamental drivers of prosperity is an intense and highly contested one. Long-run economic growth is a complex phenomenon that interacts with several social, political and economic dynamics.

There has been extensive theoretical and empirical research on the *proximate* drivers of economic growth. Factor accumulation (mainly of physical and human capital) and technological progress have been identified as the main elements explaining growth differences across countries over time.[2] But trying to understand differences between countries in their rates of factor accumulation and

[1] There is, of course, more to economic development that 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.

[2] There is a long literature on the proximate determinants of cross-country differences in economic growth providing evidence on the role of measures of physical investment and human capital accumulation (see for instance Barro, 1991; 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.

Farmers in Dodoma, a semi-arid region of Tanzania.

technological progress has led to a focus in the literature towards understanding the *fundamental* determinants explaining these differences. In this regard 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). Among these, geography and institutions have probably attracted the most attention, with conflicting positions as to whether one set of determinants trumps the other. 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 in economic development (see for example Sachs, 2003; Glaeser et al., 2004).[3]

The aim of this paper is to set the context for understanding the role of climate change in current development and poverty reduction strategies. We focus on direct effects – analysing geographical determinants of economic development (section 2) as well as on indirect effects – looking at the role of institutions in the process of development (section 3.1 and 3.2). We analyse institutional development, with a focus on conflict and political stability, as a relevant mechanism through which the effects of climate change can operate (section 3.3). We apply this general theory to the six case study countries of the Pathways to Resilience in Semi-arid Economies (PRISE) project for which this paper has been produced: Burkina Faso, Senegal, Tanzania, Kenya, Pakistan and Tajikistan. All six are agricultural-dependent semi-arid countries, facing both development and climate-related policy challenges (see boxes). In section 4, we conclude highlighting the main lessons from our review, policy implications and research gap.

[3] The role of geography has also been analysed within countries (which helps control for the effect of the overall national environment, including national institutions). Nordhaus (2006), for instance, reports statistically and economically significant effects of geographical variables to explain income differences across locations worldwide at a resolution of 1° latitude by 1° longitude. Similarly, Dell et al. (2009) find that geographical variables explain up to a 61 per cent of the variations in incomes at the municipal level across 12 countries in the Americas.

2. Direct effects

2.1 Geography and economic development

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

According to some authors, the effects of geography on development can be traced back to the beginnings of civilisation. Biogeographical conditions created a differentiated path for development as far as 11,000 years ago (Diamond, 1997). Certain regions where conditions were favourable (e.g. those with a greater availability of crops and domesticable animals) were the first to develop sedentary agriculture/farming (thus enabling the Neolithic Revolution to take place) and therefore gained a head-start in the emergence of non-food producing classes, specialisation and the accumulation of knowledge and wealth. Among the factors cited, climate, latitude, and landmass favoured biodiversity in terms of crops and animals to be domesticated. Geographical factors also facilitated the spread of skills and knowledge, with Eurasia being particularly favoured in this regard (given its mild climate, large landmass and horizontal orientation). Differences in initial conditions (as far as the onset of the Neolithic Revolution) still matter today, it is argued, as they persisted over time through urban agglomeration effects and/or the colonial dominance of the European nations (see for instance Acemoglu and Robinson, 2012).

Location effects

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

Semi-arid regions in Senegal. © Rajeshree Sisodia/PRISE

While we can identify spatial clustering and local spillovers in the distribution of economic activity, the spread of modern economic growth, and with it modern levels of prosperity, has not occurred uniformly across space. Indeed the relationship between geography (broadly defined) and economic development is not deterministic (Krugman, 1999), but rather is mediated via socio-economic and institutional factors, e.g. urbanisation, trade, colonisation, political regimes and war (Findlay and O'Rourke, 2007).

Second-order geographical factors: Reinforcing differences in initial conditions

Geographical differences between locations, even if small, can lead to amplifying differences in the patterns of economic development. According to Galor (2005), variations in economic performance across locations today reflect initial differences in geographical factors and historical accidents manifested in variation in institutional, social, cultural, and political factors. According to New Economic Geography Models (i.e. Krugman, 1991) similar locations (that are independent of each other) can dramatically diverge over time due to agglomeration forces (and falling transport costs).

Spatial differences in economic development, whether between countries, between regions within countries, or between rural and urban locations, can therefore be explained not just by natural geographical factors (inherent conditions of locations as discussed before) but also by the process of circular causation reinforcing agglomeration and development in initially favoured locations (Krugman, 1999; Puga and Venables, 1999; Henderson et al., 2001). Geographical factors give some places a head-start that magnifies over time and which helps us explain the vast spatial differences we see today. Hence, aspects of natural geography matter a lot, not because natural features of the landscape lead deterministically to the patterns of spatial development that we observe, but because they inspire self-reinforcing agglomerations (Krugman, 1999). This implies that small differences in terms of geographical characteristics can have long-lasting consequences and create *natural* patterns of divergence between different locations that are difficult to reverse.

On the one hand, it seems then that climate should matter a lot given the importance of differences in inherent productivity of locations and the possibility of these being reinforced by agglomeration effects. On the other hand, those same agglomeration effects might mean that future climate changes are unlikely to alter the *relative* spatial distribution of development. However this has important implications for adaptation (and development planning generally). The historical lock-in of spatial development patterns might create excessive (inefficient/sub-optimal) exposure to natural hazards. For example, the fact that the earliest towns and cities emerged on flood plains obviously leaves them vulnerable to flooding risk. In the past, that risk may have been worthwhile to avail of the economic benefits inherent to those locations (in this case soil fertility). However, such location benefits may no longer be economically relevant, creating an excessive or unwarranted exposure to flooding risk. The difficulty of reversing patterns of spatial development therefore reinforces the need to consider future climate risk for development planning, particularly where development is at its early stages. Moreover, as those particular geographical characteristics more suitable for economic development are likely to change over time (for instance as transportation and communication technologies evolve or as economic structure changes) it also implies that sound interventions to foster specific advantages of locations can generate magnified benefits.

Urban centres deserve special attention. Cities are the drivers of modern economic growth (i.e. Jacobs, 1985; Glaeser, 2011). With a high concentration of assets (both physical and human) in urban locations, these areas are particularly important in terms of investment, innovation and technological change, all fundamental for economic development. Disruptions to urban economies might therefore be particularly costly, not just in terms of the direct losses resulting from the destruction of assets, but also the potential knock-on effects for the wider economy and the rate of innovation and productivity growth, which ultimately determine an economy's long-run growth potential.

Congestion effects

Geographical concentration of population and economic activity not only brings agglomeration economies but also congestion costs. 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. Thus, dispersion forces (and further reductions in transport costs) act to limit what would otherwise be never-ending city growth, and eventually lead to convergence between locations, although this will tend to happen only in the long run (Krugman, 1999).

In spite of high congestion costs, cities in many developing countries today continue to grow rapidly, in part due to non-economic factors (Bloom et al., 2008), in particular as

people are pushed away from rural areas due to diminishing resources, violent conflicts and in some cases, following natural disasters. Climate change represents a risk in this regard as it creates an additional rural push factor driving people into cities (see e.g. Barrios et al., 2006; Henderson et al., 2014), as a result of climatic stress in rural areas. This climate-driven rural push factor may lead to inefficient growth of urban areas (mega-cities), especially in places that are ill-equipped to cope with rapidly growing populations. Increasing agglomeration under deficient urban environments has been shown to reduce, rather than to increase, economic growth (Castells-Quintana, 2015). In this regard the provision of the necessary infrastructure arises not just as fundamental in terms of poverty reduction and economic development but also in terms of sustainable adaptation.

2.2 Direct effects of climate

While (some) locational fundamentals won't change in response to climate change, others will – in particular, climate risk. As noted, climate change can distort both the mean and the variability of economically relevant weather variables, as well as potentially increase the frequency and intensity of extreme weather events. These changes are anticipated to exacerbate existing environmental challenges in poorer countries that already face hotter and more variable weather conditions (Stern, 2007; IPCC, 2013, 2014; World Bank, 2010, 2013), to which they struggle to adapt (e.g. Brooks et al., 2005, Barr et al., 2010).

Geographical factors, as we have seen, have a direct effect on living conditions and shape the possibilities societies face to reduce poverty, grow and develop. A long literature has focused on the multiple effects of geography on economic development. In particular, a strong focus has been given to location and climate as fundamental determinants of agricultural productivity, disease burdens and transport costs, all relevant for income levels and income growth (Gallup et al., 1999).

It has often been observed that hotter countries tend also to be poorer (e.g. Gallup et al., 1999). However, in order to establish a causal effect of temperature (or other climatic variable) on income, it is necessary to look at changes over time, in order to isolate the effect of climate from other factors, which happen to be correlated with it. Several recent papers now explicitly focus on temperature changes over time. Looking at worldwide average temperatures and their relationship with economic growth, recent evidence suggests that, on average, a 1°C of global temperature increase reduces growth by 0.9 per cent (Bansal and Ochoa, 2009). This impact is found to be large for those countries that are closer to the Equator and negligible in countries at high latitudes. Looking at country-level temperature shocks, several papers find similarly negative effects on growth from higher temperatures, especially in poor countries (e.g. Dell et al., 2012; Brown et al., 2013). Jones and Olken (2010) find that higher temperatures in poor countries lead to large and negative impacts on the growth of their exports. Examining the industrial breakdown of the impacts of temperature, their findings show negative effects on agricultural exports and light manufacturing exports (but little effect on heavy industry or raw materials production). Dell et al. (2012) find an analogous negative impact of higher temperature on industrial output. These findings indicate that climate change will have economic consequences beyond the agricultural sector. These effects might operate, for example, via the effect of temperature on productivity (see Advaryu et al., 2014; Martin et al., 2011), in line with arguments emphasising that factory workers are less productive when it is hot.[4] The negative effects of temperature shocks on economic activity seem to be permanent rather than transitory, substantially affecting the rate of economic growth and not only the level of output, with a 1°C increase in mean temperature in a given year reducing income per-capita by 1.4 per cent (Dell et al., 2012).

Several other papers focus on (changes in) rainfall patterns as a consequence of a changing climate (e.g. O'Connell and Ndulu, 2000; Barrios et al., 2010; Brown and Lall, 2006; Brown et al., 2013). In the particular case of Africa, a significant decrease in rainfall levels has been observed since the 1960s (Nicholson, 2000, 2001). Given the importance of the agricultural sector in Africa, and the relevance of rainfall for agricultural productivity, this decline might have important consequences for economic growth, as has been suggested by Bloom and Sachs (1998) and Collier and Gunning (1999). Indeed, O'Connell and Ndulu (2000) found significant lower long-run economic growth rates in Africa in those countries with a higher proportion of dry years. Similarly, Barrios et al. (2010), studying the relationship between rainfall and economic growth for 22 African and 38 non-African countries over the period 1960-1990, provide evidence on the adverse effects on economic growth rates of the general decline in rainfall in Africa during recent decades (controlling for effects from temperatures, which they find not to be significant). This effect of rainfall was not found for other developing countries. According to

[4] 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.

Cattle herder in Senegalese semi-arid regions. © Rajeshree Sisodia/PRISE

the results of simulations carried out by these authors, if rainfall in Africa had remained at previous levels, the current gap in GDP per capita relative to other developing countries could have been between 15 per cent and 40 per cent lower.

A caveat of most of the empirical literature mentioned here is that it tests 'reduced form' relationships – i.e. looks directly at the relationship between climate variables (e.g. temperature or rainfall shocks) and economic growth/output, without formally testing the causal mechanisms connecting climate and the economy. In what follows we discuss some of the most likely mechanisms.

Climate change and economic performance: Mechanisms

Agriculture and labour productivity

Several channels allow for climate change to directly affect economic performance. In particular, deteriorating climatic conditions can reduce agricultural productivity (Deschenes and Greenstone, 2007; Guiteras, 2009; Schlenker and Lobell, 2010; Feng et al., 2010;)[5] as well as labour productivity in industrial sectors (Martin et al., 2011; Advaryu et al., 2014). Low agricultural productivity, for instance due to poor soil quality, lack of fresh water, prevalence of pests, and in general less suitable conditions for the spread and improvement of agriculture, not only reduces agricultural output but it can also retard industrial development (e.g. Diamond, 1997).

Disease environments and population dynamics

Second, changing weather patterns might have longer-term development effects by altering disease environments, both via changes in environmental conditions and via the effects of weather patterns on migration/urbanisation patterns. Particularly harsh disease environments, for instance characterised by a high prevalence of malaria (Gallup and Sachs, 2001; Sachs and Malaney, 2002), can significantly reduce productivity in several ways (see also Masters and McMillan, 2001). A harsh environment affects health (Deschenes and Greenstone, 2011) and reduces work capacity and productivity directly (Seppanen et al., 2006; Sudarshan and Tewari, 2014).

[5] 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 Fiel, 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).

Diseases also increase child mortality and lower life expectancy, which in turn increases fertility and harms incentives to acquire and accumulate human capital, creating regional-specific patterns of demographic transition, leading ultimately to slower development of regions with unfavourable environmental conditions (Strulik, 2008).

Climatic conditions can also affect population dynamics and migration patterns (as we further discuss in section 3 and in Castells-Quintana et al., 2015), in turn affecting the pace and form of structural change and urbanisation processes (e.g. Barrios et al., 2006; Henderson et al., 2014).[6] One risk of the concentration of population in urban areas is that urban agglomerations are particularly susceptible to flooding and heat stress, and allow more rapid spreading of diseases such as cholera – especially where basic services such as access to water and sanitation facilities are underprovided.

Frequency/intensity of extreme weather events

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 (Hallegate, 2014) but also of potential foreign investors (Escaleras and Register, 2011), affecting both physical as well as human capital accumulation.[7]

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.

Poverty and vulnerability to shocks

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 and/or institutional quality) below which climate will continue to exert a significant direct influence on economic development.

The difficulty faced by many poorer countries in escaping from poverty results from a combination of a lack of basic economic, financial and physical infrastructure, which is often compounded by weak institutions and patterns of governance that restrict the opportunities for economic development (see e.g. Collier et al., 2008; Dercon, 2012). These same factors explain the relatively low adaptive capacity of many poorer countries (see e.g. Fankhauser and McDermott, 2014) and their subsequent economic vulnerability to climate shocks.

In the preceding sections we have focused on the direct impacts of climate change on development. In the next section we turn our attention to indirect impacts.

[6] 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.

[7] 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.

Box 1: Climate exposure, climate change and economic growth in semi-arid countries

Climate change has the potential to harm economic growth via various mechanisms – the most obvious of which is through its anticipated effects on agriculture. The impact of climate change on growth will depend on (i) how dependent countries are on climatic conditions (i.e. in terms of production), (ii) how sensitive they are to climate shocks, and (iii) on their adaptive capacity. Semi-arid countries are especially vulnerable in this regard. The tables in this box show some basic figures on climate dependence, climate trends, and correlations between climate shocks and economic growth for the six case study countries of the Pathways to Resilience in Semi-arid Economies (PRISE) project for which this paper has been produced: Senegal, Burkina Faso, Tanzania, Kenya, Tajikistan and Pakistan.

In terms of climate dependence all the countries considered display a relatively high contribution of agriculture to national GDP and employment, but some of them display a low level of arable land per capita (Pakistan, Tajikistan and Kenya have lower levels than the world average and the low-income countries average). Additionally, per capita water availability in all six countries, except Tajikistan, is lower than the world average and the Sub-Saharan Africa average. Water availability is particularly low (classified as 'absolute scarcity' by Falkenmark (1989) where lower than 500m^3) in Kenya and Pakistan. Furthermore, national aggregates hide significant spatial and temporal distributions of water availability needs. Hence, a significantly low proportion of cultivated land is irrigated (Pakistan is a startling exception with around 70% of cultivated land being irrigated), leaving production to be dependent on rainfall patterns. In relation to this, agricultural production is relatively low in these countries. Average cereal yields, for example, are lower than global averages in all countries and particularly low in the four Sub-Saharan African (SSA) countries.

Table 1: Climate dependence, climate trends, and economic growth

	Agriculture (% of GDP)	Agriculture (% of empl.)	Arable land per capita	Water per capita (m3/yr)	Irrigated land (% of cultivated)	Cereal yield (kg/ha)
Burkina Faso	35.3	85	0.4	781.5	-	1021.9
Kenya	29.9	61.1	0.1	492.5	0	1596.6
Pakistan	24.4	43.8	0.1	312.2	70.2	2650
Senegal	16.7	39.6	0.3	1935.4	0.7	1064.2
Tajikistan	27.2	55.5	0.1	8120.4	14.9	2456.8
Tanzania	27.6	79.3	0.3	1812.1	-	1289.3
SS Africa	14.30		0.3	4417.5		1214.5
Low Income	26.40		0.2	5095.8		1882.9
World	0	32.20	0.2	6123.7		3333.5

Note: Averages 2001-2010 period. Data from World Bank - World Development Indicators

In terms of rainfall trends, the inter-annual rainfall variability expressed as the coefficient of variation is not particularly high, < 20% for most countries, which is comparable to many countries in temperate climate regimes. Annual average rainfall ranges from 310mm in Pakistan to 720mm in Burkina Faso. There is little evidence of linear trends in annual rainfall (expressed as a percentage of long-term average) over the periods 1901-2012 (long-term trend) and 1993-2012 (recent trend), although the recent period shows more substantial trends in Senegal (wetting, roughly 1% per year, a 20% increase over the 20 year period) and Tanzania (drying, roughly 1% per year). However, national level analysis is likely to obscure much larger

Box 1: Continued

localised trends and results are highly sensitive to the period chosen for analysis, particularly in regions with strong multi-annual variability where linear extrapolation of trends is highly inappropriate. Furthermore, annual data also disguise intra-annual variability in the timing of onset, duration frequency and intensity of precipitation. Agricultural production does show an increasing trend (roughly 20% increase/decade) in nearly all cases except Kenya and Tanzania during the recent 1993-2012 period (perhaps influenced by recent drought events / drying trend in East Africa). Livestock production has also increased in all cases, with particularly strong increases in Tajikistan and Senegal over the recent period.

Table 2: Rainfall trends, cereal yields and livestock production

	Average annual rainfall (mm)	Annual rainfall trend, 1961-2012 & 1993-2012		Annual trend of cereal yield, 1961-2012 & 1993-2012		Annual trend of livestock production, 1961-2012 & 1993-2012	
Burkina Faso	720	-0.09	0.18	2.10	2.35	3.82	6.97
Kenya	641	0.02	0.06	0.53	-0.02	2.76	5.52
Pakistan	310	0.12	-0.03	2.25	3.05	5.00	8.76
Senegal	643	-0.25	1.04	1.49	3.22	4.83	9.12
Tajikistan	484	0.20	0.39	-	10.47	3.80	5.69
Tanzania	419	0.08	-1.05	1.35	-0.29	2.35	2.87

In parallel to rainfall patterns, some of the considered countries display increasing trends in temperatures. In Pakistan, mean, maximum and minimum temperatures have risen 0.47°C, 0.87°C and 0.48°C, respectively, from 1960 to 2007. Pakistan was the third country most adversely affected by climate extremes in 2011, and one of the major climate related risks in the country is the increasing frequency of floods; from 2010 to 2014 Pakistan suffered heavily from consecutively flooding. In September 2011, for instance, a massive flood swept across the province of Sindh resulting in the death of 360 people, with 5.3 million people affected as well as 1.7 million acres of arable land inundated. In Senegal, climate models indicate that by 2050 the annual average temperature will raise from +1 to +1.9 C, and rainfall will fall from 1 to 10% annually, compared to the 1961-90 period. An increase in drought frequency of 20-30% in the Northwest area of the country is also expected.[1]

Climate trends are associated with projected reductions in agricultural production capacities. Wheat is the staple food for most Pakistanis, and is grown all over the country. In Pakistan, reductions of wheat production (8% and 6%) under A2 and B2 IPCC scenarios are projected for semi-arid and arid plans, which contribute to 42% to 47% of national wheat production, respectively. The Pakistan Institute of Development Studies (PIDE) projects impacts of climate change on major agriculture crops in arid and semi-arid plains (wheat, rice, cotton and sugarcane). For cotton and sugarcane the loss in production up to 2030 would be 13.29% to 27.98% and 13.56% to 40.09%, respectively, with an increase in temperature between 10C and 20C.[2]

[1]Figures for Pakistan come from Zaman et al. (2009) and Harmeling and Eckstein (2012). Projections for Senegal come from Gaye et al. (1998).
[2] See also Iqbal et al. (2009) for projections on yields for Pakistan.

3. Indirect mechanisms: Climate change and institutional development

Beyond direct effects (discussed above), geography can also affect the possibilities for development by affecting the socio-political environment in which development takes place. Geographical factors can significantly influence institutional development (Engerman and Sokoloff, 1997; Acemoglu et al., 2001, 2002; Rodrik, 2004; Acemoglu and Robinson, 2012) and the likelihood of conflict (Miguel et al., 2004; Hsiang et al., 2011; Dell et al., 2014). In this section we analyse the role of geography in the socio-political environment to better understand potential indirect effects of climate change in the process of economic development and poverty reduction. We focus on institutional capacities and the potential for climate to alter the conditions under which institutions evolve, including the effects of climate on conflict.

3.1 Fragile states and climate change

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). "Fragile" states have been defined as those having very weak policies, institutions and governance (World Bank). "Failed" states have been defined as those incapable of sustaining themselves as members of the international community (Helman and Ratner, 1993), and/or where the central government loses the monopoly on the means of violence (Ignatieff, 2002).[8] State fragility and failure has been associated with the failure of development strategies and the persistence of poverty in many countries (see for instance Torres and Anderson, 2004; Bates, 2008).

The "fragility" of the state, including weak governance and deficient institutions, is also relevant in the analysis of the effects of climate change on development for at least two main reasons. On the one hand, as outlined above, fragile states are more vulnerable to climate shocks. The macro impacts of a changing climate will be felt most strongly in poorer (fragile) states (Dell et al., 2014). On the other hand, climate might have an effect on state fragility itself, for example as a critical catalyst of conflict or as a factor increasing the extent and intensity of existing conflicts. In this line, climatic conditions can also play a significant role in institutional change and institutional development (as we discuss below), representing an important indirect channel of effect from climate to (long-run) development.

3.2 Geography, institutions and development

Good institutions and economic development go hand in hand. The relevance of institutions in the prosperity of nations has been highlighted since the beginnings of modern economic thought. As Adam Smith (1776) noted, a regular administration of justice, secured property and enforced contracts are essential for commerce and manufactures to flourish. As highlighted by Veblen (1899), not only do institutions shape human behaviour but any possibilities for a sound understanding of economic life has to take place considering the political and social systems within which economic life is embedded. Moreover, as institutions underline economic activity, understanding institutional differences helps us understand inequalities between rich and poor nations. Understanding institutional development is thus critical to understanding economic development (as highlighted in Commons, 1924; Galbraith, 1958; and Myrdal, 1968, among many others).

Two prominent views on the role of institutions in explaining prosperity have recently been synthesised in Acemoglu and Robinson (2012) and Besely and Persson (2011). According to Acemoglu and Robinson (2012), in the long-run "countries differ in their economic success because of their different institutions, understood as 'the rules influencing how the economy works, and the incentives that motivate people'." A society can have extractive or inclusive institutions, and the extractive or inclusive nature of these institutions relates to both economic as well as political institutions. The emergence of one of these two forms of institutions, according to the Acemoglu and Robinson argument, depends at least partly on geographical factors, in terms of available resources and climatic conditions. Extractive economic institutions are characterised by the exploitation of the majority by the elite, with few incentives for innovation, and are associated with extractive political institutions

[8] Our purpose is not to review the literature on "fragile" states in depth. See Di John (2010) for a good review of this literature.

where the concentration of power resides in the few that constantly shape rules in their favour, and a very limited participation by the rest. By contrast inclusive economic institutions are characterised by secure property rights, the provision of public services that guarantees a level playing field, and inclusive markets, as well as by incentives that encourage innovation and investment. Inclusive economic institutions are thus associated with *creative destruction* as well as with pluralism in the political process and the respect and enforcement of rules. According to the authors, most African countries, as well as many other developing countries in other regions of the world, have developed over time highly extractive institutions, which represent a key factor holding back their economic development, and in some extreme cases driving whole countries into failed states.

Similarly, Besley and Persson (2011) explain the existence of development clusters around the world, combining effective state institutions, the absence of political violence, and high per capita incomes. They focus on the role of fiscal and legal capacity and political stability as the three pillars of prosperity based on Smith's (1776) idea of peace, easy taxes and a tolerable administration of justice, as the requirements for economic development. Underdevelopment is thus due to misallocation of resources caused by a lack of incentives due to weaknesses in the underlying institutional framework. Hence, similarly to Acemoglu and Robinson's argument, the lack of effective state institutions is what keeps countries in poverty and outside these development clusters.[9]

Institutions clearly matter greatly for economic development. However, our understanding of how institutional arrangements evolve over time and what factors contribute to successful institutional reform remains somewhat limited. It appears that geography, broadly defined to include climate, physical geography and resource endowments, may have played an important role in the emergence of modern institutions and the apparently crucial distinction between locations that evolved *extractive* versus *inclusive* institutions. For example, Acemoglu et al. (2001) famously used variation in disease environments to explain the emergence of extractive institutions in some locations (e.g. Africa) and inclusive institutions in others (e.g. North America).

It does not automatically follow, however, that *climate change* should have any great influence on the future development of economic and political institutions. Certainly it seems unlikely, barring catastrophic scenarios, that climate change will have any major bearing on institutional arrangements in places with established stable and inclusive regimes.[10] On the other hand, in locations where power, institutions, and the rule of law are more contested – i.e. in fragile states – subtle changes to political incentives resulting from changes in environmental conditions, changes in the value of natural assets, or disputes over resources could generate non-negligible effects on institutional quality.

Other potential mechanisms from climate (change) to institutional change, discussed in more detail below, include; the reinforcement of existing social and economic inequalities due to the unequal distribution of anticipated impacts from climate change; disruptions to long-run investments, including the provision of public goods and services, and human capital investments following weather shocks that reduce output or destroy assets; and disruptions to political stability, in the form of the (at times violent) contesting of power following income shocks.

For less developed regions generally, their greater vulnerability to climate change (see Box 1) and relatively weak existing institutions (see Box 3) could make the threat of climate change more relevant for institutional development. Understanding the emergence of institutions is therefore crucial for understanding the potential role of climate (change) for long-term economic development.

Understanding the link between institutions and economic growth

In spite of their crucial importance in defining the possibilities for economic development, institutions remain poorly understood. One difficulty is that institutional development is highly endogenous to the evolution of economic life; institutions shape economic development as much as the evolution of economic life shapes the evolution of institutions. A number of studies have attempted to identify causal links from institutional quality (usually looking at measures reflecting the quality of economic institutions) to economic performance and long-run prosperity (Mauro, 1995; Engerman and Sokoloff, 1997, 2000; Hall and Jones, 1999; Acemoglu et al., 2001, 2002; Rodrik et al., 2004).[11] But

[9] See Jennings (2013) for a more thorough review and comparison of the two approaches described here.

[10] 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.

[11] 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

country-wide proxies for institutional quality are far from perfect (see Box 3). Cross-country econometric analysis of the role of institutions on economic development based on these proxies has several limitations and can even be misleading. Research using micro-data, which allows exploiting variation within-countries, has been proposed to better study institutional change (Pande and Udry, 2005).[12] Likewise, despite the clear association between institutional development and economic development, advocating for single-recipe institutional reforms as a straightforward way of achieving economic development is simplistic and potentially risky (Bates (2006), for example, links political reform to increased likelihood of conflict and violence in Africa).

Box 2: Defining and measuring (good) institutions

Institutions are generally understood as "the rules of the game" (as considered by Coase, 1960; Williamson, 1975; North, 1989, 1990; Ostrom, 1990; and the New Institutional Economics). "Institutions are rules, enforcement characteristics of rules, and norms of behaviour that structure repeated human interaction" (North, 1989). Institutions can be understood to embody all those elements regulating the interactions between the individuals of a given society, from the legal to the economic and social framework (North, 1990). Institutions include both formal - *de jure* - and informal rules - *de facto* (including codes of conduct and standards of behaviour). Furthermore, individuals have to believe in the norms and consider them just in order to live up to them, making values, culture, ideology and religion, also fundamental determinants of institutional frameworks. Two central but interrelated sets of elements ultimately define institutions: property rights and transactions costs, on the one hand, and incentives, on the other hand. Good institutions have thus been considered as those set of rules governing property rights and transaction costs that allow for efficient allocation of resources, greater specialisation and trade to take place (Coase, 1960; Besley, 1995), as well as for adequate economic incentives (North, 1982, 1990) fostering hard work, investment and risk taking. As good institutions define possibilities for increased prosperity, inappropriate incentives can lead to low technology adoption, low innovation, rent seeking, myopic decision-making and corruption (Acemoglu and Robinson, 2012; Olken and Pande, 2012).

Several indicators are regularly used to proxy for the quality of institutions, with some focused on formal institutions and others on informal ones. Formal institutions relate to the degree of democracy, electoral laws, judicial independence and other political characteristics of societies. Informal institutions, by contrast, look at how laws are enforced. Common indicators range from indices of *expropriation risk*, *repudiation of contract by government*, *corruption in government*, *quality of bureaucracy* and *rule of law* (International Country Risk Guide), *contract enforceability*, *nationalisation potential*, *bureaucratic delays* and *infrastructure quality* (Business Environment Risk Intelligence), *civil liberties* (Freedom House), *polity2* (a measure of democracy, Polity IV), and indices of *corruption* (Transparency International), to measures of *revolutions*, *coups* and *political assassinations* (Gastil Institute). All of these indicators for institutional quality aim at reflecting political as well as economic institutions, are usually measured at the country level by international agencies, and are increasingly present in country performance reports. Good performance in these indicators tends to be correlated with good performance in terms of economic outcomes including investment and economic growth (Knack and Keefer, 1995; Mauro, 1995; Hall and Jones, 1999; Rodrik, 1999).

However, since these indicators measure different dimensions of institutions they can lead to different conclusions about the relevance of institutions (Wooddruff, 2006). Each of the indicators mentioned above only partially and imperfectly measures some dimension of institutional quality, and while some indicators are highly correlated others may not be. Additionally, scores in most typical indicators of institutional quality have a significant share of subjectivity and have been criticised as being conceptually unsuitable to establish causality

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.

[12] 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.

Box 2: Continued

from institutions to growth (Glaeser et al., 2004). Furthermore, universal indicators cannot be taken as completely defining institutional quality of a given country. According to many authors, institutions develop differently according to initial conditions, and what can be considered 'good' institutions is likely to be context-specific. Universal measures of institutions do not consider context- specific. Universal measures of institutions do not consider context-specific advantages or disadvantages of particular institutional characteristics. In this regard a universal definition of good institutions is not just unrealistic but also inadequate (Chang, 2001; Rodrik et al., 2004; Grindle, 2004). The goal for policy makers (and donors) is to find feasible and successful reforms that, for specific conditions, set economic and institutional development into motion. In the conditions of semi-arid countries these reforms should consider the challenges of climate change.

From optimal to good enough institutions

Defining institutions is not straightforward and has become a topic of extensive research and debate (see Box 2). A long and increasing list of desirable institutional characteristics means not only that the assessment of institutional quality becomes difficult but also that policy prescriptions become overwhelming, especially for poor countries where most indicators of institutional quality are hardly met. Instead, it has been suggested that countries should focus on achieving "good enough governance" (Grindle, 2004) and "second-best institutions" (Rodrik, 2008), looking at specific reforms that are essential, feasible, easier to implement, that have been proven to be successful in unleashing economic growth and reducing poverty, and that take into account the stage of development as well as interactions with initial conditions and context-specific institutional arrangements already in place.[13] By modifying the environmental context, climate change can be one key factor defining institutional arrangements and should also be taken into account in the design of new, context-specific, institutions.

As noted by Chang (2001), Grindle (2004) and Rodrik (2008), 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. Furthermore, societies face a set of "institutional opportunities" which improves as countries emerge from poverty and accumulate human, social and physical capital (Djankov et al., 2003; Glaeser et al., 2004). But these institutional opportunities also depend on the opportunities and challenges that the environmental context poses. The challenge for developing countries, especially the poorest ones, lies therefore in identifying key reforms that are successful for spurring growth without the need for high institutional quality as a prerequisite. That includes reforms that take into account the challenges of climate change.

Fostering institutional change and poverty reduction

Institutional change is crucial for economic development as well as for poverty reduction. But major institutional reform is neither likely

[13] As Rodrik highlights, best-practice (or 'optimal') institutions are, almost by definition, non-contextual. Such generically defined institutions are unhelpful for policy-makers and reformers. Moreover, developing countries tend to face various resource constraints, making the case for pursuing second-best institutions more relevant.

Box 3: Institutional quality in semi-arid countries

The Country Policy and Institution Assessment (CPIA) is a diagnostic tool sponsored by the World Bank that is intended to capture the quality of a country's policies and institutional arrangements. They have five different measures and each of them is ranked between 1 and 6. The main variable is the Public Sector Management and Institutions indicator, which is an average of the five measures.

In terms of the six PRISE countries, their performance seems to be above the average for Sub-Saharan Africa. Variation within the group shows a division between the African countries (Senegal, Burkina Faso, Tanzania, and Kenya) and the Asian ones (Tajikistan and Pakistan). In general the African countries appear to perform slightly better on these indicators of institutional quality when compared with the two Asian countries of study and with the Sub-Saharan Africa average. While there is not a great deal of variance among the group, Burkina Faso appears to be the country with marginally the best institutions, according to this measure.

Table 3: Institutional Quality Indicators (1=low to 6=high)

	Public Sector Management and Institutions[1]	Policies & Institutions for Environment Sustainability[2]	Quality of Budgetary & Financial Management[3]	Efficiency of revenue Mobilization[4]	Quality of Public Administration[5]	Transparency, Accountability & Corruption in Public Sector[6]
Senegal	3.6	3.5	3.5	4	3.5	3.5
Burkina Faso	3.7	3	4.5	4	3.5	3.5
Tanzania	3.4	3.5	3.5	4	3	3
Kenya	3.4	3	3.5	4	3.5	3
Tajikistan	3	2.5	3.5	3	3.5	2.5
Pakistan	3	2.5	3.5	3.5	3	2.5
Sub-Saharan Africa	**2.9**	**2.8**	**3**	**3.4**	**2.8**	**2.7**

Source: World Bank.

[1] CPIA public sector management and institutions cluster average: includes property rights and rule-based governance, quality of budgetary and financial management, efficiency of revenue mobilisation, quality of public administration, and transparency, accountability, and corruption in the public sector.
[2] CPIA property rights and rule-based governance rating: assesses the extent to which private economic activity is facilitated by an effective legal system and rule-based governance structure in which property and contract rights are reliably respected and enforced.
[3] CPIA quality of budgetary and financial management rating: assesses the extent to which there is a comprehensive and credible budget linked to policy priorities, effective financial management systems, and timely and accurate accounting and fiscal reporting, including timely and audited public accounts.
[4] CPIA efficiency of revenue mobilisation rating: assesses the overall pattern of revenue mobilisation – not only the de facto tax structure, but also revenue from all sources as actually collected.
[5] CPIA quality of public administration rating: assesses the extent to which civilian central government staff is structured to design and implement government policy and deliver services effectively.
[6] CPIA transparency, accountability, and corruption in the public sector rating: assesses the extent to which the executive can be held accountable for its use of funds and for the results of its actions by the electorate and by the legislature and judiciary, and the extent to which public employees within the executive are required to account for administrative decisions, use of resources, and results obtained.

to be easy and fast nor necessarily successful. Successful and sustainable institutional change is most likely to rely on dynamics taking place within societies, rather than imposed from abroad. The probabilities of institutional change increase as countries have more educated populations, but they also increase when the persistence of institutions has previously been challenged (Collier, 2007). Similarly, North (1990) has suggested population and technological change, as well as changes in the costs of information, as important determinants of institutional change.

Fostering economic growth and improved economic opportunities for the majority of the population, even under sub-optimal institutional arrangements, can also play a fundamental role in fostering institutional change (as in Asia – see Rodrik, 2008). Similarly, steps towards political empowerment of the poor can also initiate a positive dynamic for change (as in Brazil –

Box 3: Continued

Besley and Persson (2011) have proposed an alternative measure of the quality of national institutions, focusing on the extractive and productive capabilities of the state. Their 'state capacity' index combines a measure of fiscal capacity (the government's ability to levy income tax) with a measure of legal capacity (the government's ability to enforce financial contracts). This state capacity variable is then combined with measures of political violence and income in what these authors refer to as the "Pillars of Prosperity index".

In terms of our countries of interest, we can see from the table below that their overall index values appear to be moderately high, at between 0.5 and 0.6 on a scale of 0 to 1. This partly reflects relatively high peacefulness ratings, with all bar Tajikistan scoring 0.9 or higher on this measure. In terms of state capacity, the scores are considerably lower, particularly so for Pakistan, Senegal and Burkina Faso. Perhaps not surprisingly, our six target countries also have relatively low incomes, with Tanzania the poorest among the group, according to these data. Tajikistan appears something of an outlier, with lower levels of peacefulness but higher state capacity. Pakistan is the richest of the six countries of study, but also has the lowest level of state capacity, according to this measure. It is interesting to note that, at least for our six countries of interest, there is not a clear correlation between the three constituent variables that make up the Pillars of Prosperity index: higher peacefulness scores do not necessarily imply higher income or state capacity, and similarly richer countries do not necessarily have higher state capacity and more peace.

Table 4: Pillars of Prosperity Index (0=low to 1=high)

	Index Value[1]	Peacefulness[2]	State Capacity[3]	Income[4]
Senegal	0.516	1	0.243	0.304
Burkina Faso	0.502	1	0.263	0.242
Tanzania	0.557	1	0.504	0.166
Kenya	0.612	0.984	0.531	0.321
Tajikistan	0.59	0.625	0.78	0.366
Pakistan	0.508	0.903	0.205	0.416

Source: Besley and Persson (2011).

[1] The overall index value is calculated as an average assigning equal weight to the three variables: peacefulness, state capacity and income.
[2] Peacefulness measures the absence of repression and civil war. The data come from the Armed Conflict Dataset from 1976 to 2004 and from Banks (2005) from 1976 to 2005.
[3] State capacity is an average of fiscal capacity and legal capacity. Fiscal capacity relates to the government's ability to levy income tax. This variable is based on IMF data (share of income tax in total government revenue). Legal capacity relates to the government's ability to enforce contracts in financial markets. Data for this variable come from the World Bank (index of contract enforcement in the Doing Business Survey).
[4] Income is the logarithm of GDP per capita in 2005 constant international prices. It is scaled between 0 and 1 by deducting the minimum in the sample from each country's income level and then dividing by the full sample range.

see Grindle, 2004). In both cases inequalities appear as critical in the persistence of institutions as in any scope for institutional change.[14] Inequality tends to be highly correlated with institutional development, but also, when extreme, inequality can become an important obstacle for successful institutional reform (Acemoglu and Robinson, 2010, 2012; Stiglitz, 2012; Krugman, 2012; Piketty, 2014).[15]

Small changes in the incentives of policy-makers, politicians and service providers can also have substantial effects. One area of major relevance in this regard is public services provision (as the World Bank highlights). Most Sub-Saharan African and many Asian countries still display worryingly low levels of access to basic services (as access to water, electricity and improved sanitation facilities), and

[14] In fact in Engerman and Sokoloff (1997, 2000) 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.

[15] 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). But it is also true that inequality might have been one relevant factor behind political revolution, in particular the extension of the franchise in the 19th century, in England and other developed countries (Acemoglu and Robinson, 2000).

this situation tends to be associated with bad governance and the incentives faced to provide broad public goods (Keefer and Khemani, 2005). Careful understanding of the motivations and the constraints of each actor (poorer households/individuals, civil servants, taxpayers, elected politicians, and so on) can lead to policies and institutions that are better designed, and less likely to be perverted by corruption or dereliction of duty (Banerjee and Duflo, 2011).

Conflict and economic development

As several of the reviewed studies about institutions and development highlight, institutions are defined by conflict of interests and the distribution of power within societies. Climate change can alter the economic opportunities of different groups (as described previously) and trigger conflict over natural resources and the distribution of power, therefore likely playing a role in the definition of institutions. But inequalities can deter institutional change, when ruling elites are sufficiently strong, as they can bring unrest and conflict. Both the persistence of bad institutions and higher social unrest and the possibility of violence deter the opportunities for prosperity in poorer countries.[16]

Conflict and political instability have been found to significantly hamper growth and economic development (Gupta, 1990; Barro, 1991; Knack and Keefer, 1995; Alesina and Perotti, 1996; Easterly and Levine, 1997; Rodrik, 1999; Sala-i-Martin et al., 2004; Butkiewicz and Yanikkaya, 2005).[17] Furthermore, instability and conflict have been identified as a powerful trap for poverty and underdevelopment, leading to lower economic development (Collier, 2007). Underdeveloped countries are in turn more prone to conflict and instability. Indeed, countries in conflict are among the worst Millennium Development Goals (MDGs) performers, frequently regressing on key indicators, with the direct impacts of warfare usually accompanied by a weakened economy and government capacity, leading to lower development prospects, in some cases pushing countries into a downward spiral (UNDP, 2011).

State formation, state failure and conflict

A brief look to the theories on state formation and "failure" allows us to better understand indirect effects of climate change. Particularly useful for our focus, these theories also allow us to consider conflict as an integral element of countries' institutional development, and where there is a potential relevant role for climate change. Instability and persistent (violent) conflict are two of the most worrying and common elements characterising fragile states (Rotberg, 2003). Following Di John (2010), who reviews the concepts, causes and consequences behind failed states, up to five sets of "big ideas" regarding state formation, "state failure" and conflict can be identified. The first idea relates to the view of the state as pre-requisite for development, where clientelism, corruption and patrimonial states are anti-developmental and therefore trigger violent reactions. The second is the liberal view according to which liberalisation and democracy promote peace, and where conflict and war therefore represent "development in reverse". Third, functionalist theories consider clientelist and patrimonial states as purposefully constructed by elites to promote their interests. Accordingly, conflict and war has to be examined in relation to its *functions* and not (only) in relation to its causes, as there can be large benefits derived from violence and war. Finally, in a related way, in the *resource curse* literature war can be seen as an outcome of conflict over the control of resource wealth, leading to state breakdown.

3.3 The (potential) role of climate change

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

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

[16] Ethnic favouritism has been identified as a factor 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).

[17] 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.

Mangroves in Senegal. © Rajeshree Sisodia/PRISE

relevance of changing climatic patterns today.[18]

Climate change, conflict and institutional change

Looking at modern times, there appears to be some correlation between weather conditions and conflict globally. For instance, drylands are among the most conflict-prone regions of the world. In 2007, 80 percent of major armed conflicts worldwide occurred in drylands (UNDP, 2011). Although such correlations tell us nothing about causation - as in the debate over the relationship between climate and development - there is now a growing empirical literature assessing possible climatic determinants of conflict (see Dell et al., 2014). Homer-Dixon (1991) also provides one of the first reviews on the relationship between environmental changes and acute conflict). It has even been argued that changing climatic conditions can lead to the collapse of societies, as a result of increased conflict associated with environmental stress (Diamond, 2005).

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

[18] 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.

"[N]egative rainfall shocks open a 'window of opportunity' for democratic improvement because it translates into a transitory negative GDP shock and a lower opportunity cost of contesting power […] However, such a mechanism potentially represents a double-edged sword for institutional development."

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

Poverty and income shocks

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

These somewhat contrasting results illustrate the need for a greater understanding of the mechanisms that potentially link climatic conditions to institutional change. The authors cited above emphasise the effects of weather shocks on income, leading to changes in the opportunity cost of contesting power. However, such a mechanism potentially represents a double-edged sword for institutional development; on the one hand, the opportunity to contest power offers a possible 'window of opportunity' for institutional improvement (e.g. through removal of an autocratic regime). On the other hand, contesting power might involve (violent) conflict, with no guarantee of an improved outcome.

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

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

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

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

For poor countries, climate-induced income shocks have been analysed mostly looking at dynamics in rural areas. Variations in agricultural production and cattle herding are among the most common mechanisms proposed to explain how temperature and rainfall fluctuations might affect conflict risk through income shocks (Miguel et al., 2004; Mehlum et al., 2006; Chaney, 2010; and Ciccone, 2011, for rainfall, and Burke et al., 2009, for temperature). Negative economic shocks driven by the decrease of rainfall levels have been found to increase Muslim-Hindu riots in Indian states (Bohlken and Sergenti, 2010) as well as communal conflict in subnational African regions (Fjelde and von Uexkull, 2012). Using data from East Africa, Raleigh and Kniveton (2012) argue that civil war is more likely in extreme dry conditions whereas wet conditions are more associated with non-state conflict. In a study for Somalia, Maystadt and Ecker (2014) suggest that local livestock markets are the primary channels through which droughts fuel conflict, and that livestock price downturns and losses in herder's income lower resistance to engage in conflict and decrease the opportunity costs of conflict participation.[20]

A low opportunity cost of fighting, usually associated with low levels of income per capita, has often been identified as one of the main determinants of the probability of conflict (Collier and Hoeffler, 1998, 2004; Miguel et al., 2004; Besley and Persson, 2008; Collier et al., 2009).[21]

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

In a similar argument, and looking at long-term trends, Zhang et al. (2007) show how fluctuations of war frequency and population change in the pre-industrial era followed the cycle of temperature change; long-term climate change directly affects land-carrying capacity (agricultural production) and can lead to unrest, conflict, famines and epidemics. Waldinger (2013) also finds a significant relationship between climatic trends and peasant revolt during the French Revolution – with higher summer temperatures and lower winter temperatures associated with increased incidence of revolt. Tol and Wagner (2010) similarly find that colder times were associated with increased conflict in Europe. In a European context (i.e. in a relatively cold climate), periods of colder weather may have resulted in worse growing conditions, and a resultant negative shock to incomes.[22]

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

Inequalities and the distribution of power

The distribution of power also matters for the quality of institutions and governance as well as for conflict. For example, Acemoglu and Robinson (2001, 2009) model elites as competing with the poor

[20] 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).

[21] 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.

[22] Clearly, in hotter climates periods of higher temperatures might be expected to create more difficult growing conditions.

for control of the state and bargaining to accommodate the rest of the society by extending the voting franchise in periods when there are real threats of revolt. The literature reviewed previously on institutions also highlighted the distinction between highly unequal extractive type institutions versus more inclusive regimes (Besley and Persson, 2011; Acemoglu and Robinson, 2012). Similarly, Ray (2009) models the emergence of conflict based on the impossibility to arrange transfers that satisfy all groups. His model predicts a high likelihood of conflict in divided societies - either by class, geography, religion, or ethnicity. Ethnic polarisation (rather than fractionalisation) has also been highlighted as a significant determinant of conflict; in societies where a large ethnic minority faces an ethnic majority severe conflict is more likely to arise (Montalvo and Reynal-Querol, 2005). Thus, where climate change is expected to reinforce existing inequalities, this could have knock-on effects for the quality of institutions and ultimately conflict.

Resources, incentives and information

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

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

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

Another related set of conflict models looks at the problem of commitment (Walter, 1997; Garfinkel and Skaperdas, 2000; Powell, 2006; McBride and Skaperdas, 2007). According to these models civil war is more likely to occur when there are limits to conflict resolution and contract enforcement along with a high probability of a shifting distribution of power. The distributional effects of climate change might therefore play a role in contributing to the risk of civil conflicts.

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

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

Migration and human capital

One important way in which climate shocks can increase the likelihood of conflict is by inducing migration. In fact, one of the main security challenges brought about by climate change (through increasing the frequency and severity of

Box 4: Conflict in semi-arid countries

According to data presented in the previous box (*institutional quality*), the six PRISE countries all score relatively highly on an index of 'peacefulness'. However, there have been various episodes of civil-unrest over recent years, albeit often localised rather than nationwide. Here we survey some of these events, with a focus on the causes of the disputes.

Burkina Faso

Burkina Faso gained independence from France in 1960, being still relatively poor and prone to droughts, as we have seen. Although it experienced a series of military coups during 1980s, it is currently a stable country. Thus, the 2000s was a politically stable decade, but the country experienced a series of protests prompted by rising food, fuel and transportation costs. The riots took place in the cities of Bobo-Dioulasso, Banfora and Ouhigouy. The severe droughts during these years also affected grazing land and led to some disputes over land ownership between farmers. Some of the riots turned violent and spread to the capital, Ouagadougou. According to estimates from the Ministry of Animal Resources, approximately 4000 conflicts between crop and livestock farmers occurred in Burkina Faso between 2005 and 2011, causing dozens of deaths.

Kenya

Kenya gained independence from Great Britain in 1963. According to the statistics of the ACLED data set, it is considered the seventh most violent country with over 3,500 politically violent events between 1997 and 2013. The levels of conflict in Kenya during this period are comparable to those observed in Uganda and South Africa. However, the type of violence is markedly different. Unlike Uganda, Kenya has experienced violence that is categorized as "low grade violence", "communal conflict" and "electoral violence" instead of the outright civil war experienced by Uganda. Kenya's type of conflict includes battles, violence against civilians, and rioting and protesting, and show important regional variations in the types, tactics and perpetrators of political violence. Nairobi has the highest levels of riots and protests. Electoral cycles coincide with some conflict peaks, but in general, Kenya experiences overlapping conflicts and multiple types and actors that have shaped the nature of conflict.

Senegal

Between 1997 and 2010, the ACLED data set reported 101 events involving protests and riots in Senegal. Most of the events involved opposition, students and women protesting for their rights or for political reasons. Only three protests during this period where related to high living costs, food and fuel prices. Changing rainfall patterns have led to the degradation of the ground vegetation and especially fodders, which means that the areas which used to be reserved for pastoral activities are being abandoned in favour of other areas which until now have been used for agriculture. This cohabitation between farmers and herdsmen has caused many conflicts in Senegal especially in the groundnut basin. In the fishery sector, the increasing scarcity of halieutic resources, caused notably by the rise in temperatures, changes in coastal upwelling and acidification of surface water (Diop, 2007), leads to more and more conflicts between actors or between communities (Le Roux et Noël, 2007), as it was recently the case in Ngaparou, Yoff, Gorée, Soumbédioune, which caused significant human and material damages. In sum, the drying of watering holes, the decrease in farmable lands, food shortages, scarcity of forestry resources, and so on, are all drivers which will, with most probability, exacerbate conflicts in Senegal.

Tanzania

Although Tanzania has not experienced intrastate armed conflict, the country has participated in conflict in neighbouring countries, in particular in Ugandan intrastate armed conflict. Between 1997 and 2010, ACLED registered 98 protests and riots in the country. There is high variation in terms of location of these

Box 4: Continued

events, with protests spread over the entire country. In rural areas pastoral migrations have become a key concern; already in 1997 the Agricultural and Livestock Policy warned about an increase in farmer-herder conflicts due to free movement by pastoralists, and the Rural Development Strategy of 2001 noted the negative consequences of pastoralists' actions through migration, causing land degradation through overgrazing, land use conflicts and the spread of animal diseases. As climatic conditions become harsher, migration is expected to increase leading to higher probability of conflict.

Pakistan

According to the UCDP categories of organised violence, Pakistan has experienced interstate (with India), intrastate, non-state and one-sided categories.[1] In addition to this, the country experiences frequent communal riots and receives large numbers of refugees each year. These are spread throughout the country. During the years 2007 and 2009, ACLED registered around 1168 riots and protests in the country. Different actors and political forces, including Talibans, Mehsud Tribesmen, Jamiat Ulema-e-Islam, Muttahida Qaumi Movement and Political Militia, supported some of these protests. The aim of these protests includes mainly political and economic motives such as political arrest and deaths, human rights, high prices, land disputes and tribal boundaries.

[1] Interstate conflict is defined as a conflict between two or more governments. Intrastate conflict is a conflict between a government and a non-governmental party, with no interference from other countries. Non-state conflict is defined as the use of armed force between two organised armed groups, neither of which is the government of a state, which results in at least 25 battle-related deaths in a year. One-sided violence is defined as the use of armed force by the government of a state or by a formally organised group against civilians which results in at least 25 deaths in a year.

climate-related natural disasters as well as through affecting natural resources and weather conditions) is the rise in mass migrations. Mass waves of 'climate refugees' are regularly cited as one of the potential risks of runaway (unabated) climate change. For example, Myers and Kent (1995) forecast 150 million environmentally-induced refugees by 2050 (although according to Gemenne (2011) these estimates appear to lack empirical support). While the numbers may be speculative, the risks are not so easily dismissed. It is notable that the security/military community takes these threats seriously, and conducts its risk assessments on the basis of considering multiple plausible future scenarios. For instance, according to the Campbell et al. (2007) report, the disappearance of low lying coastal lands could conceivably lead to massive migrations - potentially involving hundreds of millions of people - and trigger major security concerns and spike regional tensions.[23]

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

Hidalgo et al. (2010) examine the link between weather conditions and conflict looking at land invasions. Exploring a rich municipal-level data set 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

[23] 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

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

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.

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

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,

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 their popularity, reducing the pool of potential recruits for insurgent

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-

organisations. Among this group of literature, Bergholt and Lujala (2012) find that natural disasters have a negative effect on economic growth, but this does not translate into an increased risk of conflict.

Ultimately the sources of conflict are many and complex. However, the discussion in this section has highlighted a number of mechanisms through which climate (change) might be expected to influence both the frequency and severity of conflict. We have also seen the dependence of conflict on institutional quality – and in turn the damaging consequences of conflict for governance. There would thus appear to be a potentially important set of dynamic interactions (and feedback loops) between institutions, climate (impacts and vulnerability) and conflict, which to date have been understudied. This represents an important research gap in understanding the potential (indirect) implications of climate change for sustaining economic development over the long-term.

Tajikistan landscape. © Timur Mustaev

4. Conclusion and policy implications

In this paper we study the role of climate change in the process of long-term economic development and poverty reduction, reviewing the literature on the determinants of economic development and analysing the role that climate change can potentially have in this regard. This broad approach allows us to better understand in an integrated way the different effects of climate change on long-term development and frame the adaptation discussion in terms of climate-resilient economic development, as well as identifying policy implications. In particular we have analysed the role of geography and institutions, with a focus on conflict and instability, in the process of development. In each case we have looked at possible effects of climate change and climate-related shocks, as well as at the empirical evidence on these effects and existing gaps in the literature.

Main lessons

Climate change can affect the processes of poverty reduction and economic development in many different ways. Climate change modifies natural (geographical) conditions relevant in the process of economic development. As reviewed, the literature has already identified significant effects of climate change on economic growth working through multiple channels. Given unequal anticipated effects across rich and poor countries, climate change potentially reinforces both spatial inequalities and poverty trap dynamics. But climate change also has potentially important effects on economic development through its indirect effects on the socio-political environment within which poverty reduction and development take place. First, climate change can alter the context within which institutional development takes place. Second, given its significant role in the likelihood and intensity of conflict, changing climatic conditions can also affect the socio-political stability of countries.

The evidence reviewed confirms distinct effects of climate shocks across rich and poor countries; the macro impacts of a changing climate will be felt more strongly in poorer, and especially in fragile, states. At the same time, it is in these same countries where the indirect effects of climate change become most relevant, potentially reinforcing institutional fragility and in turn vulnerability to climate shocks.

Our analysis also highlights the need to take account of the interaction of climate change (risk) with other development trends (e.g. in the case of rapid urbanisation, increasing exposure to urban disasters, etc.) for the design of sound adaptation strategies and development plans.

Policy implications

Whether by addressing the direct impacts of geographical factors, or by addressing their indirect effects on the socio-political environment, adaptation strategies to climate change are fundamental not just on their own right, but also as key elements of broader poverty-reduction and development strategies. Moreover, as climate shocks disproportionally affect the poor, as we have seen, addressing climate-related risks is also a sound strategy in terms of inequality and poverty reduction.

Given their interactions, both geographical and institutional factors need to be considered in the design and successful implementation of strategies for poverty reduction and economic development. Not only do geographical factors affect institutional dynamics, but the institutional framework is also likely to condition the way geographical factors influence the evolution of poverty and economic development. Especially close attention is warranted for institutional development in geographically challenged countries (such as those with extreme and variable whether conditions, climate-associated epidemic diseases, etc.) where these interactions are expected to be strongest.

Research gaps

From our analysis many relevant questions for further research can be identified. Regarding direct effects of climate change on economic development, as reviewed in section 2, the main outstanding questions relate to identifying the precise causal mechanisms through which climate shocks impact on the economy. The policy implications of the current literature are mainly on the mitigation side – identifying negative economic impacts of climate vulnerability and shocks motivates efforts to minimise future climate change. However, in order to make policy-relevant conclusions for adaptation strategies future work should aim at better understanding of mechanisms and a move beyond reduced form estimation.

Box 5: Emerging research questions

- How does climate change affect the political economy of governance (i.e. the domestic distribution of political power) and policy formation in semi-arid lands?
- How does adaptation operate across municipal/local jurisdictions and how do institutional, economic and social factors transcend administrative boundaries?
- How should (optimal) institutional design take account of climate risk, including concrete recommendations for development planning?
- Do climate shocks affect informal institutions – e.g. does contract enforcement (or enforcement of other legal instrument) respond to climate shocks?

Significant research gaps also remain regarding the potential indirect effects of climate change for economic development, via effects on the overall socio-political environment. However, we first need to improve our understanding of socio-political dynamics, where our knowledge still remains limited. In what refers to institutions, there is still a lot to learn about institutional change as well as its role in economic development. Not only is it not clear what defines good institutions or whether institutions are a cause or consequence of economic development, as we have seen, but there are many other relevant issues related to institutions for which we still have very limited knowledge. For example the search for key context-specific institutional characteristics more relevant for poverty reduction has just recently started. Open questions remain regarding the feasibility of optimal institutions or the need for "easier" alternatives, the scope for international cooperation and intervention, and the relevance of institutional capacity in rapidly changing contexts. Understanding the role of specific institutions in given contexts, and how institutions evolve and adapt in the face of major challenges, becomes even more relevant to understand the effects of major shocks such as those brought about by climate change. It becomes critical, for instance, to understand how climate change will affect the political economy of governance (i.e. the domestic distribution of political power) and policy formation in challenged countries, or how institutional design should take account of climate risks, including concrete recommendations for development planning. Likewise, a further area that has been relatively neglected to date is in understanding how climate shocks might affect informal institutions, such as contract enforcement, trust and cooperation.

Most empirical evidence on socio-institutional effects of a changing climate relates to (violent) conflict, but there are also potentially important mechanisms via other socio-cultural factors, institutional factors, political economy/incentives, accountability of political classes, the potential role of aid flows (including climate finance), many of which to date remain under-studied.

What seems clear from our analysis is that the effects of climate change, whether direct or indirect, seem of central relevance for sustainable economic development, especially for poor (and semi-arid) countries, and in particular for those with fragile states. But our understanding of these effects remains limited. The topic clearly deserves further research.

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This work was carried out under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA), with financial support from the UK Government's Department for International Development (DfID) and the International Development Research Centre (IDRC), Canada. The views expressed in this work are those of the creators and do not necessarily represent those of DfID and IDRC or its Board of Governors.

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