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Coping with climate risk: the role of institutions, governance and finance in private adaptation decisions of the poor

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Working paper

Grantham Research Institute on Climate Change and the Environment

PRISE
Pathways to resilience in semi-arid economies

Research for climate-resilient futures

Coping with climate risk: the role of institutions, governance and finance in private adaptation decisions of the poor

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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:
Woman drawing water in Bahi, a semi-arid area of Tanzania

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Contents

Boxes and tables

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).

Abstract

This paper looks at adaptation from the point of view of households. It asks how political and economic institutions may affect – help or hinder – these adaptation decisions. Climate change represents a change in the (future) distribution of weather. Since the development literature has firmly established the role of weather risk as a source of income volatility for the poor, we review the range of risk-coping mechanisms available to poorer households, with a focus on possible barriers to adaptation. We ask both how government interventions (policies, institutions etc.) affect the set of options available for adaptation and risk coping, and also what these adaptive responses imply for development prospects, and in particular the prospects of the poor and other marginalised groups. We argue that some risk taking is necessary for development and adaptation therefore should be primarily about risk-coping rather than arbitrary attempts to minimise risks. An important consideration for policy-makers, which appears to have been relatively neglected to date in the adaptation literature, is how adaptation and development will interact dynamically over time.

Adaptation to climate risk can occur along two broad dimensions; *in-situ* adaptation seeks to make existing locations, livelihoods and forms of production more resilient to climate risk; *transformational* adaptation, on the other hand, seeks to reduce vulnerability through the movement of people and economic activity across sectors and across space. Political and economic institutions, including access to finance, have the potential to impact dramatically on both forms of adaptation. While the two forms of adaptation appear distinct, they are also related, and indeed should be thought of as two dimensions on which a continuum of adaptation strategies might be mapped, rather than discrete policy options (or alternatives). Some *in-situ* adaptation may be required in order to facilitate transformational change. Poverty-traps (or at least persistent poverty) can prevent transformational change, and this economic stagnation is potentially reinforced by climate change. Those most vulnerable to climate change impacts also lack the resources to move out of agriculture or to migrate to more productive locations. The design of optimal adaptation strategies will involve an appropriate balance of the two forms of adaptation, with the aim of achieving the best long-term development outcomes, while respecting the rights and preferences of affected communities, and at the same time avoiding locking-in future vulnerability.

Section 1

Introduction

While attention is usually focused on the overall adverse exogenous effects of climate change on Africa—the region as a victim of circumstances beyond its influence—it might be more important to consider how capacity to adapt can be enhanced (Collier et al., 2008).

Image:
Women selling sugar cane in Morogoro, Tanzania

In this review, we focus on adaptation as an autonomous response to changing climatic conditions. We explore the barriers to private adaptation of poorer households and other vulnerable groups to climate risk and the policies that can be used to foster successful long-term adaptation strategies. While most attention in the literature on adaptation has focused on policies undertaken by governments (Fankhauser and Soare, 2013), private agents – households, communities and firms – also undertake important initiatives that help to mitigate or adapt to climate change. In fact, it has been argued that adaptation should be primarily a private-sector response (Collier et al., 2008). Forward-looking private-sector actors should be able to respond appropriately to (slowly evolving) change, without government intervention, provided they have "adequate information, appropriate incentives, and an economic environment conducive to investing in the required changes" (Collier et al., 2008). Ensuring these conditions are met is the primary role for government. As we will argue, in many cases this begins with removing impediments to appropriate adaptation. But there is also an appropriate active role for government, for example in responding to market failures, providing public goods (e.g. information, basic infrastructure etc.) and ensuring that development plans take account of (long term) climate risk.

Adaptation can occur along two broad dimensions: the first is *in-situ* adaptation, which seeks to make existing locations, livelihoods and forms of production more resilient to climate change impacts. This might involve, for example, making agriculture more resilient and preventing agricultural (income/production) risk from translating into welfare risk (Hallegatte, 2014). The second is *transformational* adaptation, whereby vulnerability is reduced (resilience is increased) through the movement of people and economic activity across sectors and across space (Collier et al., 2008; Dercon, 2012). This may be seen as part of a longer-term process of economic development, involving for example a shift away from (subsistence, rainfed) agriculture (sectoral transformation) or a movement away from geographically isolated, less productive locations (locational transformation). Political and economic institutions have the potential to impact dramatically on both forms of adaptation.

While the two forms of adaptation appear distinct, they are also related, and indeed should be thought of as two dimensions on which a continuum of adaptation strategies might be mapped, rather than discrete policy options (or alternatives). Some *in-situ* adaptation may be required in order to facilitate transformational change, and there are many intermediate cases. For example, seasonal migration has often been used as a coping mechanism for vulnerable households – a theme we return to in section 3.

"Climate change will increase the uncertainty and risk faced by vulnerable groups such as poorer households."

The resilience literature emphasises that while climate threats are essentially exogenous stressors, the economic and social impacts will depend on a combination of vulnerability, exposure and adaptive capacity (Barr et al., 2010: Bowen et al., 2012; IPCC, 2014). From an economic standpoint, Mendelsohn (2012) has defined adaptation as "any change in behaviour or capital that an actor makes to reduce the harm or increase the gains from climate change". Thus, where adaptive capacity is weak, it is likely both that adverse impacts of climate change will be realised and opportunities missed (Collier et al., 2008).

There are multiple channels available for reducing climatic risk: via lower *exposure*, e.g. by avoiding at-risk locations and activities, or improvements in protective infrastructure; via lower *vulnerability*, e.g. by avoiding disasters through better early warning systems and evacuation plans; or via improved *adaptive capacity*, i.e. improving the risk-coping capacity of the poor in order to avoid production or income volatility translating into consumption volatility and welfare losses. Specific adaptation policies can aim to act on any of these three channels. However, each will also depend on wider development policies and strategies and also, crucially, on broader economic and demographic trends (at regional and global levels) that are largely outside the control of local policy-makers.

In this paper we emphasise the potential for improving adaptive capacity via building the risk-coping capacity of poorer households and other vulnerable groups.

Since climate vulnerability is strongly associated with poverty, one straightforward adaptation strategy is the pursuit of economic growth. Indeed it has been argued that efforts towards adaptation (e.g. foreign aid directed towards climate adaptation projects) would be more effectively spent on pursuing basic development goals, such as education and healthcare (Schelling, 1992, 1997). However, development (in the sense of poverty reduction, improvements in livelihoods and the welfare of vulnerable or marginal groups) and adaptation do not derive automatically from aggregate economic growth. Dercon (2012) points out that the effect on poverty will depend in part on the labour-intensity of growth, and especially the relative demand "for the lower skilled labour that the poor are largely endowed with" (Dercon, 2012, p.5). Thus in many poorer countries, agricultural growth or contraction might have especially strong impacts on poverty. The effects of growth on poverty will also depend on the capacity of poorer households to avail of opportunities generated by aggregate growth via labour mobility both across sectors and across space.

Distinguishing forms of growth (development paths) that are both pro-poor and can increase resilience to climate risk is an important task for policy-makers. It is equally important that policy-makers do not pursue reduced vulnerability at the expense of longer-term development opportunities. Some development trends (e.g. urbanisation and the accumulation of assets in high-productivity, but vulnerable locations; most forms of innovation and entrepreneurial activity) will necessarily involve the accumulation of certain risks. Policy should therefore emphasise managing that risk, and enhancing risk-coping capacity, rather than purely focussing on risk reduction.

Climate change will increase the uncertainty and risk faced by vulnerable groups such as poorer households. An important constraint on adaptation may be aversion to experimentation, which is prominent especially amongst poor households (Bryan et al., 2014). An inherent obstacle for the poor in escaping poverty – especially for those living close to subsistence – is that any failed experiment can have devastating consequences for household finances and welfare. This is one of the most basic examples of poverty trap dynamics, and is reflected in the "poverty as vulnerability" view (Banerjee, 2004) – i.e. "that the poor cannot take advantage of profitable opportunities because they are vulnerable and afraid of losses (Kanbur, 1979; Kihlstrom and Laffont, 1979; Banerjee and Newman, 1991)" (Bryan et al., 2014). Bryan et al. (2014) make the point that this phenomenon can also explain the relatively low adoption and diffusion rates of 'Green revolution' technologies across South Asia, "partly due to low levels of experimentation and the resultant slow learning (Munshi, 2004)". Experimentation within agriculture is further constrained where farm plots are small (e.g. in South Asia the median farm is less than an acre), making division into experimental plots more difficult (Foster and Rosenzweig, 2011 – as cited in Bryan et al., 2014).

Clearly the aversion to experimentation problem presents a key challenge for climate change adaptation, and will affect both *in-situ* and *transformational* adaptation strategies. For example, adaptation in the case of agriculture may require the adoption of new technologies (e.g. drought resistant seed varieties, investment in irrigation or changes in production methods) and learning about new weather (growing) conditions. Similarly diversification activities require entrepreneurial experimentation, while migration strategies often involve

experimentation with seasonal migration or sending a household member to look for work in another location – often a nearby town or city, or even abroad.

Two caveats to the adaptation-as-growth perspective are important to note; one is the effect of growth on poverty, which is ambiguous. While growth has been strongly associated with poverty reduction (see e.g. Dollar and Kraay, 2002)[1], and the correction of market failures leads to greater economic efficiency (in the Pareto sense), as Dercon (2012, p.4) has pointed out "the possibility of efficiency gains only means that the winners in principle would be able to compensate the losers sufficiently given the size of the gains, but such redistribution of gains certainly does not occur automatically." The fact that post-hoc redistribution rarely happens in practice is in part a result of failures of governance and weak institutions.

The second caveat is the possibility of some forms of growth increasing climate risk (Bowen et al., 2012). For example, development initiatives based on climate-sensitive activity (e.g. water-intensive crops) or located in high-risk areas (e.g. the development of flood plains) risk 'locking-in' longer-term vulnerability (Vivid, 2010). In the extreme, any form of *in-situ* adaptation in locations that are already economically or agriculturally marginal, and where conditions are expected to deteriorate, might represent maladaptation. More generally, the allure of possible 'quick-wins'[2] needs to be tempered in development strategies by an acute awareness that spurts of short-run growth are rather easily achieved, while *sustained* long-term growth is considerably more difficult (Broadberry and Gardner, 2013; Easterly, 2006; Easterly et al., 1993; Rodrik, 1999).[3] The former should not be pursued at the expense of the latter.

Ideally, adaptation to climate change should not be viewed as an entirely defensive project. In fact, Collier et al. (2008) argue that 'defensive flexibility' – i.e. the ability to cope with, or at least *survive*, short-run shocks – tends to be relatively well developed in poor, subsistence agriculture and pastoralist settings. The longer-term capacity for *sustained* adaptation to new circumstances (or the adoption of new technologies), by contrast, is often limited in those same settings, in part because poorer households have less capital-intensive technologies; because their economic activities – whether farming or other – tend to operate at relatively small scales (with implications for management practices and the capacity to experiment with new technologies); due to an aversion to experimentation, deriving from precarious livelihoods; and also because they often lack access to credit and other financial services.

Climate change could create opportunities. Or, at the very least, sensible adaptive investments will often overlap with other development objectives, or can be used to promote longer-term development strategies. Strengthening the autonomous adaptive capacity of private agents appears to be the first best way of achieving both adaptation and development goals simultaneously. In some cases, public adaptation actions involve correcting market failures and can carry ancillary benefits (e.g. downstream benefits of soil and water conservation programmes). If adaptation derives primarily from the pursuit of existing development goals, and can also generate ancillary benefits, the question arises as to why such strategies are not already being pursued. The answer may be that many developing countries lack the institutional and governance capacity to effectively correct market failures and to provide adequate public goods; these failures potentially become more costly due to the threat posed by climate change (Vivid, 2010).

In the remainder of this paper we survey the literature on various risk-coping mechanisms available for dealing with climate risk (section 2) as well as the literature that looks at mechanisms involving movements across space and (economic) sectors (section 3). Our discussion focuses on the barriers to autonomous adaptation for poorer households, with specific reference to the appropriate role of government policy in fostering long-term sustainable adaptation. We conclude with a reflection on the policy implications of our discussion and also highlight some open research questions.

[1] This is not universally the case. Periods of rapid growth can of course lead to a widening of (domestic) income inequality and thus an increase in relative poverty. It may also be that aggregate growth is not sufficient to reduce the most extreme (chronic) forms of poverty. However, at a global level, economic growth has been associated with large reductions in absolute poverty (for example in China). This debate over the links between aggregate growth and poverty has spawned an entire literature, which is somewhat beyond the scope of the current paper. The interested reader should refer to (e.g. Ravallion, 2012).

[2] For example, high yield crops that depend on unsustainable water use or that are highly vulnerable to variations in growing conditions. In turn, more resilient crop varieties – or diversification of crops – might be adopted at the expense of reduced yields or market value of output. Such trade-offs need to be made explicit so that costs and benefits can be weighed. More generally, the balance between 'quick wins' and longer term development priorities should also be reflected in setting the appropriate balance between *in-situ* and *transformational* adaptation strategies.

[3] For many of the most vulnerable populations, a sustained period of real income growth would be required to overcome the poverty dynamics highlighted in the literature cited here.

Section 2

In-situ adaptation

Climate change poses a threat to the livelihoods and wellbeing of the poor, via various channels, including its expected impacts on agricultural production, health and the ability to invest in long-term assets including education.

One reason the poor are vulnerable to climate variability and shocks is their reliance on agriculture. Poorer households in urban areas may also be more vulnerable to climate risk as a result of settling in riskier locations (the poor are often priced out of safe areas), with little or no infrastructure and poorly constructed housing. Development and industrialisation mean that citizens in rich countries depend little on weather-contingent production activities and can also use more resources to protect themselves against the direct effects of adverse weather conditions (Fankhauser and McDermott, 2014). Not so for the poor, who aside from being more dependent on weather-sensitive economic activities, and residing in areas of higher climate risk, also tend to be financially constrained. Not only do the poor lack own resources (by definition), but they are also often shut out of credit markets since they lack the collateral required to obtain a loan.

The climatic vulnerability of the poor is further compounded by marginalisation along various dimensions; including gender, ethnic, political and geographic discrimination. For example, the literature on climate impacts appears to show a greater income elasticity of female (relative to male) opportunities and wellbeing, including access to education and health (see e.g. Maccini and Yang, 2009; Henderson et al., 2014) indicating the potential for climate shocks to exacerbate existing gender inequalities.[4]

Political and geographic marginalisation can also play important roles in reducing or exacerbating the effects of climate stress. Globally, poverty is geographically concentrated in locations that are already marginal from a climate and agricultural productivity perspective. For example, a high proportion of Africa's rural poor live in pastoral and agro-pastoral drylands, with poverty in these regions attributed to climate variability and vulnerability to drought (Food and Agriculture Organization (FAO), 2008). Various measures of human well-being have also been found to decline with aridity; e.g. infant mortality, child malnutrition, maternal care, adult literacy and access to education – again, particularly amongst women and girls (UNDP, 2011). Political and geographic isolation is also likely to affect the provision of basic infrastructure, access to markets (transport), financial services, and the under-provision (by both public and private sectors) of basic services including health and education (Anbarci et al., 2005).

[4] Existing patterns of discrimination against women can also be exacerbated by climatic stress, via income shocks (as noted in Dell et al., 2014). For example, the murder of "witches" – typically elderly women – in Tanzania has been found to increase in response to extreme rainfall events (Miguel, 2005); the frequency of witch trials also increased in response to cold weather in 16th-18th century Europe; and dowry killings were found to be higher during recent periods of low rainfall in India (Sekhri and Storeygard, 2011).

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 Sub-Saharan Africa average. Water availability is particularly low (classified as 'stressed' 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

Countries/regions	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 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. 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

Countries/regions	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 change 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.[5]

Climate trends are associated with projected reductions in agricultural production capacities. Wheat is the staple food for most of Pakistanis, 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.[6]

In-situ adaptation to climate risk will involve some combination of reducing vulnerability (through improved infrastructure, information, new technologies/crops etc.) and improved risk-coping capacity. The rest of this section looks at various risk-coping mechanisms and how these are mediated by government policies and institutions.

In this section, we take a look at the specific risk-coping strategies employed by poor households in attempting to avoid weather risk translating into welfare risk (Hallegatte, 2014), and how these depend on economic and political institutions, with a view to highlighting opportunities for government (both local and national) to ameliorate those risks.

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

Box 2: Climate change and poverty in semi-arid countries

Climate vulnerability is strongly associated with poverty. This is especially true in still largely rural/agricultural societies. Climate change poses a threat to the livelihoods and wellbeing of the poor via various channels, including its expected impacts on agricultural production, health and the ability to invest in long-term assets including education. Lower income and assets in turn increases the poor's vulnerability to climate change.

Many of the world's poorest people live in areas that are already marginal from a climate and agricultural productivity perspective, and many of these areas are precisely those suffering more from climate change. For example, a high proportion of Africa's rural poor live in pastoral and agro-pastoral drylands, with poverty in these regions attributed to climate variability and vulnerability to drought. Natural disaster risk has also been shown to be associated with poverty at multiple geographical scales and the poor appear particularly vulnerable to extreme weather events and climatic shocks.[7]

As the Table below shows, the six semi-arid countries in which we focus are still predominantly rural, with climatic conditions expected to be highly relevant for living conditions. In terms of climatic conditions, annual average rainfall is relatively low in the six countries, Pakistan being the country with the lowest average rainfall (310mm) and Burkina Faso being the country with the highest (720mm). Beyond rainfall, all 6 countries are affected by extreme climatic events. Kenya and Tajikistan, in particular, display a high impact of droughts, floods and extreme temperatures, with more than 5% of total population being affected (injured, left homeless, requiring immediate assistance or being displaced or evacuated) per year on average between 1990 and 2009. In five out of the six countries, poverty rates (at $2 a day in PPP) exceed 50% of total population. In the six countries poverty rates among the rural population are on average more than 5 % higher than poverty rates for the total population.

Table 3. Poverty, climatic conditions and rural population

Countries/regions	Rural Pop (%)	Poverty headcount ratio at $1.25	Poverty headcount ratio at $2	Rainfall (annual average in mm)	Droughts, floods, extreme temp. (% pop, average 1990-2009)
Burkina Faso	71.81	44.46	72.56	720	1.25
Kenya	75.22	43.37	67.21	641	6.48
Pakistan	62.14	12.74	60.19	310	1.06
Senegal	59.92	34.06	55.22	643	0.60
Tajikistan	73.38	5.92	27.69	484	5.38
Tanzania	69.80	43.48	87.87	419	1.50
SS Africa	63.35	46.80	69.87		
South Asia	67.81	24.50	66.71		
World	47.00	14.50	-		

Note: Data for poverty rates and natural disasters come from the World Bank - World Development Indicators. Data for 2013 or closest available year. Poverty rates for Kenya are for 2005. For rainfall we use CRU CY country average time series for 1901–2012 updated in Harris et al. (2014).

[7] See FAO (2008) and Albala-Bertrand (1993), and Kellenberg and Mobarak (2008).

In Pakistan, the poorest districts have been identified as precisely those with higher food insecurity and higher vulnerability to floods.[8]

In Burkina Faso rainfall patterns and temperatures have also been identified as the two climatic parameters which have the greatest impact on resources and the country's main sectors of activity: agriculture, livestock farming, and forestry. Indeed, changes in rainfall patterns and temperatures have led to a net decrease in water availability, a decline in the biomass potential, and a drastic reduction and deterioration of the pasture land. This severely affected rural areas where 50.7% of populations live below the poverty threshold, against 19.9% in urban areas. In rural areas, the global level of incidence of poverty doesn't reflect the regional disparities. With an estimated incidence of poverty of 68.1% and 62.2% respectively, the regions of the north and east, which coincide essentially with Burkina's arid and semi-arid lands, are the regions most affected.[9]

Finally, in Senegal, the three of the main economic sectors (agriculture, livestock and fishery) are extremely vulnerable to climate change. Droughts cycles and temperature rise in the country have impacted on the productivity/production of these sectors. As a significant number of vulnerable people work in these sectors, climate change intensifies poverty, especially in rural areas, even if national trends show a decrease in the incidence of poverty. It was observed that the inland areas of the country (which coincide with the agricultural, pastoral and fishery zones) are the most affected, with the highest incidence of poverty - above 60% in Ziguinchor, Kolda, Kaolack and Diourbel.[10]

[8] See for instance Naveed and Ali (2012) on multidimensional poverty; Khan and Salman (2012) on Spatial Mapping of Human Vulnerability Index and 2010 Floods of Pakistan; or Suleri and Haq (2009) on Food Insecurity in Pakistan.
[9] See Ministère de l'Environnement et du Cadre de Vie [Burkina Faso] (2007) and République du Burkina Faso (2010).
[10] See Ministère de l'Environnement et de la Protection de la Nature [Sénégal] (2006), Agence nationale de la Statistique et de la Démographie (2013) and Ministère de l'Economie et des Finances [Sénégal] (2004) and Oxfam (2009).

2.1. Infrastructure

The anticipated impacts of climate change on the poor will depend on the interaction of the severity of the climatic stress and the exposure, vulnerability and adaptive capacity of the societies affected. For example, projections of climate change impacts on agricultural productivity depend heavily on assumptions about, among other things, the degree of future climate change and the local adaptive responses of affected people and societies. From the perspective of this review, it is the latter adaptive responses – subject to a greater degree of control by developing country governments than global emissions pathways – that are of primary interest.

Optimal crop growth depends on the right combination of ambient temperatures and water availability.[11] Man-made (and natural) irrigation, and to a lesser extent temperature control techniques (e.g. using greenhouses) can reduce dependence on the weather (see e.g. Schlenker et al., 2005; Fishman, 2011; on the importance of the distinction between irrigated and rain-fed agriculture for anticipated climate impacts on yields).[12] However, where the infrastructure for these is lacking, farm production is dependent on receiving the right amount of rain, at the right time, along with temperatures conducive to growth. Climate change will alter both the mean and the distribution of temperatures and precipitation.[13]

Various studies have highlighted the under-provision of irrigation and other farm inputs in the African context. For example, fertilizer use in Africa has stagnated since 1980, while in Asia and Latin America it has risen tenfold over the same period (Cooper et al., 2013), while just four per cent of agricultural land in Africa is irrigated compared to 18 per cent globally (Yu et al., 2010).[14] This weak adaptive capacity, and the expectation of significant negative physical impacts of climate change for dryland regions (Christensen et al., 2007), has led to projections of substantial declines in crop yields.[15] It is worth noting that growth (or contraction) of agricultural production has a disproportionately large impact on poverty, compared with changes in output from other sectors (Valdés and Foster, 2010; Dercon, 2012).

The significance of irrigation in reducing vulnerability of agriculture to weather shocks highlights the role of basic infrastructure in enabling adaptation to climate risk, as demonstrated in a number of recent empirical studies: For example, Burgess et al. (2011) find that weather and mortality remain closely related in post-independence India, but this relationship only exists in rural areas where agricultural yields, wages and prices are adversely affected by hot and dry weather. Similarly, Burgess and Donaldson (2010) show that rainfall shortages affect productivity and led to famine in Colonial India, but this rainfall-famine relationship was considerably attenuated after the arrival of railroads in a district. Jayachandran (2006) also shows that wages of rural workers are more responsive (i.e. vulnerable) to rainfall shocks in districts with fewer banks or higher migration costs. These studies emphasise geographic isolation as a constraint on adaptive capacity, and the consequent role of transport infrastructure in increasing the flexibility of the local economy, for example by improving trade and migration opportunities. The evidence in Jayachandran (2006) also highlights the role of access to finance in risk coping – the subject of the next section.

A lack of access to basic infrastructure (e.g. energy and sanitation) might represent an important barrier to the adaptation options available to the poor – especially women and girls, since the burden of domestic activities tends to fall disproportionately on them (UNDP, 2011).

The provision of basic infrastructure (transport, energy and sanitation) represents an obvious role for government, and a first step in creating an 'enabling environment' for autonomous adaptation. Governments might also support capital-intensive investments (e.g. in irrigation), which may not strictly be public goods, but where investment is constrained by lack of resources. However, public investment in infrastructure projects raises the thorny issue of decision-making under (deeply) uncertain climate change (see e.g. Stainforth et al., 2007a,b). Such uncertainty represents an additional motivation for policy-makers to prioritise building adaptive capacity, in particular economic flexibility of vulnerable groups, above defensive infrastructure investments (e.g. flood defences), which are much more subject to concerns about uncertainty (see e.g. Watkiss et al., 2014; McDermott, 2015).

Much of the basic infrastructure we refer to here (e.g. electricity, sanitation and transport

[11] Combined with soil quality and other inputs such as fertilizer, farm labour etc.
[12] The availability of irrigation depends on a combination of capital owned by farmers, e.g. small irrigation systems, and (public) water infrastructure, e.g. water reservoirs and irrigation canals.
[13] Also, potentially the timing of rainfall.
[14] Both as cited in Henderson et al. (2014). Low fertilizer use might actually represent a rational response to unreliable water supply, in the form of high rainfall variability and low provision of irrigation, since the returns to fertilizer use depend on the timing of watering during the cropping cycle.
[15] For example, Henderson et al. (2014) cite a range of papers projecting crop yields in Africa declining by 8-15 per cent by mid-century and by more than 20 per cent (and as much as 47 per cent) by 2090.

infrastructure) will be required regardless of climate change and will likely contribute to building resilience under a range of plausible climate scenarios. However, an important caveat to this view is that any infrastructure provision represents a form of commitment to a specific location. There is also a role for government in ensuring that capital intensive (and thus by definition, longer-term) investments are based on sustainable resource use (e.g. water), taking account of anticipated future climate trends. To this end, it is important that government policies do not distort information in the form of market signals. For example, government subsidies on scarce resources (including water) might deter vulnerable households from making timely and efficient adaptation decisions. Since information – e.g. on existing climate variability and anticipated climate change – is another form of public good, there is clearly a role for government in providing information as a further element of creating an enabling environment for (successful and efficient) adaptation. We return to this theme later in the paper.

2.2. Access to finance

Poor households by definition lack own resources, but also often lack access to formal financial services, constraining their ability to cope with risk.

Box 3. Access to finance in semi-arid countries

Access to finance is still very limited in many poor and developing countries. Limited access to financial products, such as credit, saving opportunities, transaction facilities and insurance, not only constrains economic growth and poverty reduction but also hinders adaptation to climate change, as discussed in the main text. The following table displays some basic indicators on formal finance penetration in the six semi-arid countries of our focus: Senegal, Burkina Faso, Tanzania, Kenya, Tajikistan and Pakistan.

As the figures show, the percentage of population with an account at a formal financial institution remains very limited (even compared with regional averages). Only in Kenya more than 40% of the adult population have an account (but still significantly below the world average of around 50%). In all remaining countries the figure does not reach the 20% mark. Significant differences by gender and geographical location are also present. In Pakistan, for example, less than 3% of adult females have an account (compared to 10% of adult males). The percentage of rural population with an account is at least half that of urban population in most of these countries. Regarding commercial bank branches, in the best case (Pakistan) the number is still very low, with less than 9 branches per 100,000 adults and compared with a world average of more than 13.

In terms of getting credit the situation does not appear much better, although Kenya scores relatively highly on this indicator. New technologies arise as an interesting tool to provide financial services including transaction facilities. The use of mobile phones to pay bills seems already quite well developed in Kenya and Tajikistan, but remains an almost unexplored opportunity in Burkina Faso and Senegal.

When looking at small firms, Sub-Saharan Africa countries display relatively high values of small firms having an account in formal institutions – over 96% in the case of Burkina Faso. By contrast, in Pakistan just over half of small firms have a formal bank account.

In Tanzania, the government has undertaken an effort to formalise property rights aimed at among other things, increasing access to credit by poor/rural households, which would allow farmers to utilise their land as collateral to buy new seeds, fertilizers and so on, and therefore help them to adapt to climate change.

Table 4. Finance penetration indicators

	Accounts at a formal institution							
Countries/regions	total	female	rural	urban	Commercial bank branches	Getting credit	Mobile phone use to pay bills (%)	% of Small enterprises with account
Burkina Faso	13.35	10.81	11.78	35.44	-	43.8	0.29	96.78
Kenya	42.34	39.18	37.9	75.95	5.17	87.5	13.43	84.96
Pakistan	10.31	2.95	7.22	15.38	8.74	62.5	1.50	54.02
Senegal	5.82	5.45	4.59	9.00	-	43.8	0.24	80.78
Tajikistan	2.54	2.14	1.67	9.93	6.67	12.5	25.65	81.06
Tanzania	17.26	13.82	14.22	40.57	1.95	43.8	5.49	84.64
South Asia	32.96	25.02	31.32	37.53	8.29		2.05	76.71
SS Africa	24.03	21.47	20.48	37.89	3.43			84.47
World	50.49	46.61	44.13	59.6	13.51			75.83

Note: Accounts are % of population aged 15+. Commercial bank branches are per 100,000 adults. Getting credit is measured from 0 to 100 as distance to the "frontier" (100 being the best performing). Small enterprises are defined as from 5 to 9 employees. Data for 2011 or closest year.

A lack of financial reserves makes the poor vulnerable to income shocks – with consequences for health, education, investment, productivity – and ultimately in danger of falling into poverty traps (see Skoufias et al., 2011, for a review of the literature on the poverty impacts of climate change and the role of finance in coping with these impacts). Financially constrained households cope with risk in non-efficient ways, both *ex-ante* and *ex-post*. *Ex-ante* they either hold low-return liquid assets (Rosenzweig and Binswanger, 1993) or diversify productive activities. Liquid financial assets often carry negative real interest rates, and real liquid assets either have high costs of storage, such as grain, or are themselves vulnerable to climatic shocks: notably, during a drought the price of livestock will decline owing to synchronised pressures to sell (Dercon, 2002). Engaging in several productive activities deprives households of the benefits from scope and specialisation. *Ex-post* financially constrained households adapt by drawing on savings (Paxson, 1992); selling productive assets (Deaton, 1992); increasing labour supply, which on aggregate reduces wages (Kochar, 1999); sending children to work rather than to school (Jacoby and Skoufias, 1997); or engaging in informal expensive borrowing (Banerjee and Duflo, 2011). These informal risk management strategies are associated with increased poverty, lower investment and lower growth (Elbers et al., 2007).

Relaxing credit/financial constraints on the poor could help them not only to cope better with exogenous risk, but also to take on riskier (and theoretically, more efficient) investments (e.g. Hill and Viceisza, 2012; Mobarak and Rosenzweig, 2013; Galarza and Carter, 2011; Cai et al., 2009). A number of authors provide micro-evidence on the positive effects of financial expansion to increase households' income and consumption, and therefore to reduce poverty (Burgess and Pande, 2005; Karlan and Zinman, 2010; Kaboski and Townsend, 2012). Improved access to finance – as a means of coping with greater risk and escaping poverty – could therefore represent an important instrument for adapting to climate change (Hecht, 2008; Ward et al., 2008; Agrawala and Carraro, 2010; MCII, 2012, 2013; among others).

However, expanding access to finance for poor or vulnerable households is far from easy (Agrawala and Carraro, 2010; World Bank, 2013a). Not only do they lack collateral, many vulnerable groups such as pastoralists also tend to live in geographically isolated locations, making market access problematic and provision of services relatively unattractive to the private sector. Microfinance can be a possible remedy. By definition, microfinance schemes rely on small-scale transactions but potentially for many customers; there is therefore a need for service providers to find cost effective means of reaching a broad customer base. Communications technology could facilitate such a process (see e.g. King, 2012).

For financial services to be provided to the poor in a sustainable way, profitability for private providers has to be attained. For microfinance to make a real difference, it therefore has to become both attractive and affordable for poor individuals at the same time as profitable and financially sustainable for providers (Clarke and Grenham, 2013). From the user's perspective, there are also question marks over the usefulness of microfinance, since it may predominantly benefit those with an *a priori* propensity to become entrepreneurs (Banerjee et al., 2015). A second issue relates to the design of microfinance schemes; the commonly used joint liability schemes might have the benefit of delivering high repayment rates, but this could also discourage risk-taking, making investment in high-return activities less likely (Fisher, 2013).

There are also limitations to the effectiveness of financial instruments in coping with risks, particularly when shocks recur with relative frequency, repeated borrowing could simply result in greater indebtedness.[16] Differences in the nature, reach, frequency and impact of climate shocks, call for different strategies. Access to finance can be a useful tool for adaptation to some, but not all, climate-related shocks (MCII, 2012). In particular, when shocks have low frequency but high impact, financial services, such as credit, savings and insurance, can play a key role in poor households' adaptation to climate change. When shocks have higher frequency the need for large-scale intervention, for instance investments in infrastructure, may become necessary.

A final question mark relates to the external validity of existing findings in relation to microfinance schemes; can the success stories be scaled up and replicated in other settings? Further research is required, in particular on the specifics of how microfinance can best be implemented to deliver maximum benefits for the poor.

[16] Frequent shocks that affect large numbers of households, depressing the local economy, could also result in micro-finance initiatives themselves becoming indebted or even bankrupt, particularly where these schemes are not well diversified geographically.

2.3. Remittances

An alternative source of finance for many developing countries and poorer households is remittances from family members living in domestic towns and cities or abroad. Remittances are increasingly used as a means of coping with climate shocks (Yang, 2008; Yang and Choi, 2007; Arezki and Brückner, 2012). International remittances have been on an increasing trajectory in recent years, gaining greater attention in the academic literature as a result (Clemens, 2011). International remittances represent significant sources of investment for many developing countries (up to a quarter in Sub-Saharan Africa, according to Arezki and Brückner, 2012). The scale of remittances now far exceeds aid flows to developing countries, and is equivalent to total private debt and portfolio equity flows, although to date there is little evidence of any effect of remittances on aggregate economic growth (Clemens and McKenzie, 2014).
Regardless of the effect of remittances on growth, they can play a key role in providing finance alternatives when internal financial markets are underdeveloped, and "migration and remittances clearly have first-order effects on poverty at the origin, on the welfare of migrants and their families, and on global GDP" (Clemens and McKenzie, 2014).

Remittances can either work as an alternative source of credit for investment – and therefore react to productivity shocks – or as insurance to smooth income and consumption, and therefore react to income shocks. In semi-arid regions, climate induced shocks (such as variation in rainfall) represent an important productivity as well as income shock. Arezki and Brückner, (2012) show that when financial development is low, remittances react positively to productivity shocks, induced by improved rainfall, i.e. they are pro-cyclical, encouraged by high-return investment opportunities. However, when financial development increases, remittances seem to react in a counter-cyclical way to smooth consumption in the face of income shocks (also due to changes in rainfall). This finding suggests that although remittances potentially act to fill a financing gap in developing economies, in reality they are most likely to play a complementary role to other sources of finance, and their effectiveness (and reach) is dependent on the development of the (domestic) financial sector.

2.4. Insurance

Many traditional, poorer communities have highly developed informal schemes for coping with individual risks, such as episodes of ill health (as in the 'defensive' flexibility noted by Collier et al., 2008). However, the covariant nature of climate risk renders these informal neighbourhood schemes inadequate for coping with climate shocks.

One instrument for dealing with income shocks resulting from climate variability and change is insurance. In the absence of transaction costs, insurance offers an efficient response to climate risk (Collier et al., 2008), particularly where combined with risk mitigation. Microinsurance, in particular, not only allows for better risk management but, by increasing creditworthiness of individuals, it can also promote investments in productive assets that might be riskier but also of higher return (MCII, 2013).[17] An additional feature of insurance schemes might be a commitment effect, which for example savings schemes generally lack; that is, insurance would only pay out following a weather shock (or loss of output) whereas savings might be drawn down to cover other fluctuations in income or household expenses.[18]

However, there are numerous challenges to implementation of an effective weather insurance scheme. Aside from the standard insurance problems of moral hazard and adverse selection, insuring against weather risk also faces the additional challenge of coping with covariant (regional) as opposed to individual shocks. From the demand side there are also challenges to deal with (see e.g. Hecht, 2008): For example, limits on time and other resources necessary to obtain or use information (e.g. about climate risk) may cause people to disregard those risks. Perceived or real budget constraints may also deter poorer households from paying for insurance, while people also tend to view insurance as an investment rather than as a hedge against loss, leading to underinsurance.

Providing traditional *indemnity insurance*, in which the claim payment depends on the policyholder's loss, against weather risk faces the familiar moral hazard problem, which might be particularly strong in the context of the type of business activities engaged in by many poorer households. For example, in a (rural) agriculture setting, observing the effort of many small policyholders can become very expensive. Similarly, in urban areas many poorer households depend on small-scale activities and the informal economy – where business is often not conducted at a fixed

[17] The MCII (2013) report describes the major components of a risk management framework including risk identification, risk reduction, financial protection, preparedness, and post-disaster reconstruction.

[18] Of course it is debatable whether this should be viewed as an advantage or disadvantage of insurance schemes in the context of credit-constrained households.

location – observing effort and loss assessment may become virtually impossible.

An alternative might therefore be *indexed insurance* products (Clarke and Grenham, 2013), where claim payments are triggered by for example rainfall dropping below some predefined threshold, which is expected to cause agricultural output losses. Indexed insurance can overcome the problems of moral hazard and adverse selection, while reducing the cost of monitoring. It can also be sold to many households relatively easily, increasing the customer base for the insurer, and also facilitate accelerated claim payments, which can be of major importance for poor households.

However, there are a number of drawbacks to indexed insurance. For one thing, indexed insurance is simply a hedge against risk and does not necessarily foster adaptation. Furthermore, indexed insurance schemes require good historical data on climate (and its impacts on output) and that these data are a good guide to future weather distribution and associated losses (Collier et al., 2008) – which is a challenge in the best of circumstances, but particularly so under uncertain climate change and using the spotty climate data available in many developing countries.

According to Clarke and Grenham (2013), a combination of indemnity and indexed insurance can offer a solution. Local community indemnity-based mutual insurance groups can provide protection from individual shocks (with the community playing the role of controlling moral hazard and adverse selection), while indexed insurance can provide protection to the mutual against aggregate shocks (like climate-related shocks) by transferring the risk to reinsurers: "The key issue is ensuring that … local insurers can transfer risks to international markets at low cost to avoid being overexposed to adverse experience in the area where they operate" (Clarke and Grenham, 2013). These authors also highlight four key initiatives required to support the provision of (micro)insurance against climate risk: 1) Government involvement, by providing more information about the benefits of insurance, nudging individuals towards the purchase of insurance, and regulating the market while providing technical assistance and support for long-term investments; 2) supranational involvement in the form of reinsurance; 3) a move from hazard-based indices, such as weather indices, to sample output-based indices, which allows for a closer correlation between losses and payments; and 4) complementary insurance to local governments and firms, as in the aftermath of a crisis the poor might benefit more from the continued provision of public services and employment opportunities than from personal insurance.

Providing access to insurance is more complex and difficult than providing other financial services, such as credit (MCII, 2013). To date, successful (micro)insurance schemes that have been implemented have mostly relied on government funding. The challenge for government then becomes one of attempting to facilitate, but not substitute, (micro)insurance provision by private insurance providers. There is also a question mark over the cost of insuring against climate risk, particularly in low-income environments.

It has been suggested that insurers can help society to adapt to the impacts of climate change, by promoting the effective limitation and management of risks from extreme weather-related hazards (Wilbanks and Romero Lankao, 2007) and by facilitating "the creation of new markets and services that will help to solve the climate change problem" (Hecht, 2008, p. 1585). However, the effect of insurance on risk-taking behaviour is unclear.

Ward et al. (2008) suggest three main channels through which insurance can help to promote efforts to adapt. The first of these examples relates to the provision of information about reducing vulnerability, and therefore improving insurability, of properties. The second relates to financial incentives, whereby insurers can provide discounts or make insurance conditional on efforts to mitigate the impacts of extreme weather. The final example emphasises the role of partnerships with policy-makers to establish maximum thresholds of acceptable risk, and actions to remain below those thresholds. In spite of the theoretical benefits, empirical evidence remains limited; for example, Surminski and Oramas-Dorta (2013), in a study of 27 flood insurance schemes in developing countries, find that only a small proportion (less than 40 per cent of the schemes studied) have either a direct or indirect association with risk reduction beyond risk transfer.

An important question is; does insurance lead to more or less risk taking? Perhaps more important again is the normative question; *should* insurance lead to more or less risk-taking? If paying actuarially fair premiums, then insurance is "efficient" in the sense of providing a risk-coping mechanism, while still ensuring that agents internalise risks (and their costs). Subsidised insurance schemes, on the other hand, could lead to inefficient risk-taking behaviour and sub-optimal levels of adaptation. Both the positive and normative questions raised here appear deserving of further attention from researchers.

2.5. Social Safety Nets

While greater access to financial services (both credit facilities and insurance products) can potentially help the poor to cope with climate risk, practical constraints on both the supply and demand sides, as discussed above, are likely to lead to the under-provision/under-utilisation of such services, at least in the near term. Social safety net schemes offer an alternative, publicly funded, form of insurance against climate risk.

Box 4. Social safety net schemes in semi-arid countries

In this information box, we provide examples of various social safety net schemes in operation in our six countries, with a particular focus on schemes that may be relevant for responding to climate shocks and for improving the resilience of poorer households.

a. Senegal

The Government of Senegal has usually responded to the multiple shocks of the last decades, including the drought in 2002-2003 and an economic crisis in 2008-2009, with direct financial support to farmers and with general assistance to the rural population. Responses to weather shocks such as interest rate subsidies and debt forgiveness have at times been inefficient: they are often poorly targeted since they have benefited mainly larger rural producers and those with access to credit systems. After the increase in fuel and food prices during the economic crisis, the government responded with fiscal measures such as subsidies on basic foodstuffs, gas and electricity. This quick response was very expensive (absorbing one-tenth of all public spending in 2008) and not efficiently targeted (only 7-8% of the beneficiaries were in the poorest quintile, showing that most of the benefits went to non-poor). Based on the World Bank's report "Senegal: Social Safety net Assessment" (2013b), in 2011 a dozen social safety net programmes were in place in Senegal. These programmes range from free school lunches and food assistance and support to the elderly and disabled, to two pilot conditional cash transfer programmes. Although social protection programmes have grown in the country during the last decade, there are still many challenges to overcome in order to protect the poor or respond to shocks, for instance by increasing the coverage of existing programmes and simplifying the targeting criteria and mechanisms. Senegal has implemented a national programme releasing grants of 25,000 francs FCA per term to the poorest families. This programme has just started but is already planning to support 250,000 households by 2017.

b. Burkina Faso

The landlocked country is characterised by scarcity of natural resources and high rates of population growth. Its economy is still highly vulnerable to adverse shocks (environmental, social and economic), despite the structural reforms and macroeconomic policies that governments have tried to implement. In 2008 the annual review of the country's poverty reduction strategy revealed that all these efforts had not translated into poverty reduction. The main constraints on poverty reduction relate to recurring food crises, rapid demographic growth and some severe floods that the country regularly experiences. This vulnerability to adverse shocks has increased the demand for social safety net programmes. A World Bank study in 2004 found that Social Safety nets in Burkina Faso were extremely inefficient mainly due to limited coverage, a heavy dependence on external financing and a lack of organisation within different ministries. Between 2008 and 2011, different types of social safety net programmes have been implemented. Among them, there are three pilot cash transfer programmes, which rely exclusively on external funding. Food transfers are the main form of social safety net programmes in the country, accounting for around 69% of the total spending in these programmes between 2005 and 2009. These food transfers include: targeted subsidised food sales, targeted free food distribution, nutrition programmes and school feeding programmes. The government has also introduced universal subsidies to mitigate the effect of high food and fuel prices. However, and despite efforts to improve the scope and coverage of social safety net programmes, these remain limited and most interventions are small in scale and do not reach the poorest and most in need. According to the last report of the World Bank (2011), on average and excluding fuel subsidies, spending on social safety net programmes was only about 0.6% of GDP between 2005 and 2009, while around 20% of the population is food-insecure and lives permanently in poverty. The programme of fuel subsidies is very expensive and has a limited impact on the poorest decile. Besides, most of the financing of social safety net programmes comes from external and ad hoc resources.

The World Bank report (2011) concludes that few of the programmes that are running at the moment assist the chronic poor by providing them with regular and predictable transfers. Most of the existing interventions are short-term projects that are implemented during periods of shocks and focused on particular geographic areas. There are not systematic programmes that are aimed to assist the poor and vulnerable people.

c. Tanzania

During the last years, Tanzania has experienced high rates of economic growth fostered by economic liberalisation and important macroeconomic policies. In addition to this, the public sector has expanded, improving public services: primary enrolment rates have increased and under-five mortality rates have substantially decreased. However, decreases in poverty have been marginal. Many Tanzanians live close to the poverty line and there are large disparities between the incomes of the poorest and the poor in general, suggesting that there is a group of "ultra-poor" who are particularly vulnerable and would stand to benefit most from social transfers. This group is more vulnerable to food price inflation and to any negative shock to the national economy. The most common of these are: unexpected crop price movements and prolonged droughts. Given the large number of poor, the large differences within this group, and limited available resources, it is important that safety net programmes be well-targeted and efficiently distributed. While there are some notable safety net programmes running in Tanzania, reports suggest that the impact on poverty has been limited; most of them cover only a small portion of the poor and in many cases do not reach those targeted.

Currently, six main transfer programmes are operating. The first one is a support scheme for orphans and vulnerable children that is financed by external aid. This programme seems to work well, but the unit cost is high and benefits to children are low compared to the costs. The second one is a programme of subsidised food distribution (or free food) by the government. There is little information available about the actual beneficiaries or whether they reach the poorest people. However, the programme covers almost a third of the country. The third programme is a school feeding programme which is concentrated in food-insecure districts. Some studies show that it has some positive impact on learning and attendance, but the benefits appear modest relative to costs. There are also two public employment schemes, one for cash and one for food. These are very small and are run by local governments. The main drawback of these two programmes is that they provide only once-off benefits to households, so that their impact on poverty reduction is limited. Finally, there is a national agricultural input voucher scheme. This programme is the largest single transfer programme in the country and provides vouchers for seed and fertilizer to small farmers. Although it was proposed as a productivity-enhancing scheme, the characteristics of targeted households and the important benefits they receive (relative to costs), may make it attractive as a longer-term productive safety net programme.

d. Pakistan

Pakistan has several social security nets with notions of providing assistance to the poor for managing short-term risk and calamity and to some extent catering long-term disabilities. Broadly these can be grouped in to five major categories: 1) Social Security (programmes for public and private employees for old age benefits, cash and in-kind support, provident fund, health services, etc.); 2) Social Assistance (cash and in-kind support programmes for the poor, women, and needy); 3) Labour Market Programmes (programmes for unemployed labour); 4) Micro and area-based safeguards (small loans programmes for poor and women); and 5) Child Protection and Health Services (food and health support for the children in poorest household).

Frequent occurrence of floods and droughts has led to climate-related safety nets. The 2010 floods in Pakistan submerged over 100,000 sq km of land and displaced nearly 10% of the country's population over a vast geographical area. Even the semi-arid lands in KPK, Punjab and Sindh were inundated with water incurring total agriculture losses of almost $1840 million (Government of Pakistan, 2012). The Citizen Damage Compensation Programme (CDCP) was the first social protection programme in Pakistan that was integrated with Disaster Risk Reduction as a response to the great floods of 2010. Also known as the 'Watan Card', the CDCP, instituted through the country's National Registration and Database Authority (NADRA), is a two phased unconditional cash transfer aimed at helping the flood-affected families for early recovery and to rejuvenate the local economy. The CDCP has offered a model framework for preparing a National Disaster Response Action Plan for early recovery phase, using cash transfers as the main instrument.

Case study: the 'Benazir Income Support Programme (BISP)':

The BISP is the single largest poverty alleviation programme in Pakistan launched in 2007-08 for direct and speedy relief to the underprivileged sections of society. A cash transfer of Rs. 1000/month were initially distributed to eligible families, which has then increased to Rs.1200/month. Similarly the number of beneficiaries has raised from 1.7 million families in 2008-09 to 5.25 million in 2013-14. The two

significant features of this programme which ensures transparency and accountability are 1) the process of identification of beneficiary families by using Nationwide Poverty Scorecard Survey and application of Proxy Means Test status of the household (ranges from 0-100) and; 2) Benazir Smart Cards and Mobile Phone Banking for delivering payments. The later factor provides new dimensions in relief and support programmes. After testing and piloting this mobile phone banking system, about 78% of families are now receiving payments through this mechanism. The programme is considered to yield many benefits by providing financial assistance to the poorest of the poor. But the programme also helped to identify some 7.7 million families living below cut-off score of 16.17 and created a large-scale socio-economic data base for 27 million households, including GPS coordinates of all the underprivileged and poor households across Pakistan, which provides additional information than can be crucial in planning and decision-making not only for poverty reduction and provision of public services but also for effective response to climate change related disasters.

For those most vulnerable to climate risk, inadequate access to market services is likely to be particularly acute. Social safety nets may therefore form an important part of a broader poverty reduction strategy that helps among other things to redistribute income to the poorest and most vulnerable, to enable households to make better investments and to help them to manage risk, particularly when faced with unexpected shocks (Grosh et al., 2008). One important caveat to the use of social safety net schemes as (public) insurance against climate risk is that their availability might reduce incentives to adapt or reduce vulnerability. This concern reinforces the importance of the careful design of such schemes, so that they support efficient risk-taking – i.e. risks and investments that are productivity enhancing.

The 2010 World Development report argued that the creation and reinforcement of social safety nets is critical to adapting to the impacts of climate change (World Bank, 2010). Bangladesh is a good example of how social safety nets can be implemented in a poor country. One of the recommendations discussed in the report highlights the use of existing safety net programmes that can be ramped up after shocks occur, as opposed to creating new programmes specifically for disasters (World Bank, 2010).

For emergencies, the most common type of transfer is the in-kind programme. Yet, there is evidence that in cash safety net programmes, e.g. those implemented in Somalia and Swaziland, have had a positive impact during emergencies (Pelham et al., 2011). Even during conflict periods in Somalia, evidence shows that cash could be delivered and distributed safely and is less prone to diversion than food transfers (Majid, 2007). Cash payments have often been used in social welfare programmes and in emergency responses (as insurance and as relief) in developed countries. However, their implementation in developing countries may take time and more regulation and monitoring due to weaker institutions and enforceable laws.

The advantages of cash transfers are related to their potential positive externalities in terms of stimulating local markets whereas the negative side is that cash is particularly susceptible to changes in the market and increases the risk of inflation (Pelham et al., 2011). Cash provides more flexibility and choices to participants whereas transfers in kind are more rigid and have a limited use. In kind transfers such as food have a more direct impact on consumption, whereas cash has a direct impact on asset accumulation. Cash is also more empowering since decision-making power is transferred directly to households. This benefit can be magnified when disadvantaged groups, such as women or the elderly, receive the cash directly. This has been the case in Swaziland, where women have benefited directly from cash transfers (Pelham et al., 2011). In terms of maximising household choice, cash gives more decision options and allows households to decide how best to allocate their resources. However, it is common to observe that households decide to meet other urgent needs (e.g. paying debts), with the result that programme objectives, such as health and education, remain unaffected (Bailey, 2008). A further drawback of cash payments during a period of crisis – e.g. following a natural disaster – is that markets may be (temporarily) disrupted so that providing cash is not sufficient to ensure that affected people are able to access food and other essential supplies.

In terms of their applicability to climate risk, there is evidence that conditional cash transfer programmes in Central America

have been able to help participants and to protect children from being taken out of school and used as a risk coping strategy after a shock (de Janvry et al., 2006). Ethiopia has also implemented a productive safety net programme since 2008, which aims to meet transient food insecurity as well as responding to longer-term needs. In this programme, more than eight million employees are paid with food and/or cash in return for work on community-based public works activities for up to 6 months (Pelham et al., 2011).

Studies evaluating these social safety net schemes have demonstrated their success in increasing school enrollment rates, raising household consumption and improving preventive health. However, there are still gaps in the literature on these programmes' evaluation. The replicability under different conditions and their long-term effectiveness in preventing the inter-generational transmission of poverty remain unanswered questions (Rawling, 2004).

2.6. Information

Most adaptation – and certainly the autonomous adaptation of private individuals and firms – will depend on informed decisions by individuals. Actors will respond appropriately to changing conditions when they have adequate information, appropriate incentives and an environment conducive to investing in required changes. However, acquiring information may be costly for individuals. On efficiency grounds, governments should intervene only when markets do not work properly.[19] Lack of information is an important market failure, particularly in smallholder agriculture where incentives to free-ride are strong, resulting in under-provision of information by the private market. This explains why governments usually provide agricultural extension services. The information deficit problem is intensified when there is a need for adaptation (Collier et al., 2008).

The most relevant forms of information for climate change adaptation relate to existing climate variability, future climate change, potential impacts and available adaptation strategies (Yohe, 1991). In the case of agriculture, important information requirements include, but are not limited to, information to support the adoption of more suitable crops, alternative planting techniques, irrigation methods, crop rotation etc. (Collier et al., 2008). In an urban context, resilient development would be fostered for example through the public provision of information on urban flooding risk. This information is particularly important for ex-ante adaptations that need to be made in advance of the actual climate change (Mendelson, 2000). Empirical work in development economics confirms that farmers who are better informed about farming practices and climate change are more likely to adapt (successfully) and experience, on average, higher productivity and output (Di Falco et al., 2011).

Relevant information for adaptation decisions might also go beyond making existing modes of production more resilient, to include information that facilitates *transformative* adaptation; for example, information on job opportunities for migrants and on local opportunities for diversification and entrepreneurial activities for those who wish to remain. Governments might also intervene to encourage long-term investment (e.g. in education, health and productive assets) or to improve access to credit for small borrowers, since imperfect information may prevent small borrowers from obtaining credit to finance adaptive investments (Fankhauser et al., 1999).

Information flows are also important for preventing climatic shocks from translating into social or economic disasters. Amartya Sen (1981) famously argued that famines do not occur in democracies with a free press. While famines are typically triggered by adverse weather conditions leading to failed harvests, the translation of these conditions into a famine depends on institutional and governance failures – including inadequate information flows.

Although the literature seems to highlight the importance of information for adaptation, there remain some important knowledge gaps. In particular, the literature does not distinguish between different types of information failures, such as asymmetric or imperfect information. These distinct forms of information failure may affect in different ways how individuals make their decisions to adapt. Furthermore, the usability of information – and its widespread dissemination – is just as important for successful autonomous adaptation as the availability of information.

2.7. Incentives and property rights

In addition to providing information, a key role for governments in creating an enabling environment for adaptation is to ensure that private sector actors have the incentive to adapt. In many cases, this means that governments commit *not* to act, in order to avoid creating moral hazard by for example trying to insulate households and firms from risk. Governments that react quickly to

[19] Government intervention might also be motivated by equity concerns, as in redistributive taxation systems or initiatives aimed specifically at vulnerable or marginalised groups.

any adverse shock may produce perverse incentives for private actors, in particular weakening the incentive to reduce exposure to risk (Deressa and Hassan, 2010). However, getting incentives right is not just a matter of committing not to act. Another crucial component in creating the right incentives for adaptation is the allocation and enforcement of property rights.

The evolution of property rights and their effect on important variables like productivity, investment, output, access to credit among others is an important issue in the development economics field and has been seen as a key precondition for economic growth. There are two important channels through which property rights affect efficiency of resource allocation: limiting expropriation and facilitating market transactions. The former includes enhancing investment incentives by limiting expropriation risk and reducing the need to divert private resources to protect property. The latter includes facilitating trade in assets and improving collateralizability of assets, which at the same time facilitates credit transactions (Besley, 1995).

Numerous papers have studied the question of whether secure property rights improve investment incentives. For example, Besley (1995), studying the effect of property rights in Ghana, finds that investment is increased by better land rights. Also in Ghana, Goldstein and Udry (2008) find that farmers without political power are less confident of their rights and therefore tend to leave their land fallow for shorter periods compared to those who hold political power. These results have important implications in terms of loss in profits per unit of land. Such findings are also suggestive of an important role for property rights in adapting to climate change, given that successful adaptation will require consideration of the long-term sustainability of investments and resource use.

In a historical context, Hornbeck (2010) shows that improved property rights, via the introduction of barbed wire fencing, led to significant agricultural development of the American Plains in the late nineteenth century. Counties that experienced the greatest improvement in security of property rights were found to have significantly higher farmland values and productivity.
Improved property rights have also been shown to increase labour supply of urban slum dwellers in Peru via reduced need for guard labour freeing up household labour time to be used more efficiently in the labour market (Field, 2007). Similarly, Galiani and Schargrodsky (2010) find that allocating land titles to squatters in Argentina substantially increased housing investment, reduced household size and enhanced the education of their children compared to a control group. Improved property rights can also affect access to finance (e.g. Besley et al., 2012; Wang, 2008).

This literature suggests that improving property rights could have important benefits for poorer households, affecting both their vulnerability to climate risk and their ability to adapt to it. Weak property rights in developing countries might therefore represent a barrier to adaptation.

In the case of environmental capital and natural resources – e.g. water resources, fisheries, grazing lands and forests – property rights are often poorly defined, or operate under a mixture of private and communal property rights, leading to collective action problems, including the classic 'tragedy of the commons' result of overexploitation (Hardin, 1968). In theory, this further reinforces the case for assigning (private) property rights over natural resources, in order to avoid unsustainable use. However, this may not be feasible where privatisation would conflict with traditional rights and practices; for example those of pastoralist communities. A recent literature on cooperative resource management suggests that the tragedy of the commons can be avoided if cooperative arrangements follow some key design principles; e.g. clearly defining the identity of the group and boundaries of the resource; proportional rewards to effort of group members; collective agreement over rules of the group; monitoring, graduated sanctions and simple and fair conflict resolution mechanisms (see Wilson et al., 2013). This literature even suggests that 'social norms' enforced by the community can be more effective and have greater staying power than externally imposed systems of monitoring and sanction, in fostering sustainable resource use (see e.g. Ostrom, 2000).

Section 3

Transformational Adaptation

If the productivity of some locations or activities suffers as a result of climate change, then an obvious response is to relocate capital and labour to relatively more productive or less risky locations and sectors (Collier et al., 2008). This is also part of the broader development agenda – the standard path of economic development involves structural transformation of the economy, with an accompanying shift from rural to urban or coastal locations (see e.g. Dercon, 2012; Lewis, 1954; Harris and Todaro, 1970).[20]

As noted, translating aggregate growth into poverty reduction is not automatic; aside from the labour-intensity and skill-bias of growth, any effect on poverty reduction is also contingent on the mobility of the poor, both across sectors and across space, and their resulting capacity to avail of the opportunities generated by aggregate growth (Dercon, 2012). This mobility can be facilitated, or indeed constrained, by political and economic institutions; for example, Africa's relative fragmentation both in terms of national borders and ethnic groups, and the number of landlocked countries, act as an effective constraint on movement (Collier et al., 2008; Diamond, 1997).

In this section we discuss migration and sectoral transformation as alternative adaptation strategies in response to climate risk. Migration – particularly temporary or seasonal migration – has long been used as an important risk-coping strategy of poorer households. However, migration is costly and there are numerous barriers to migration, especially for poorer households who are often most vulnerable to climate risk. The inability to migrate thus represents an important, and relatively neglected, policy concern. In the context of climate change, migration also carries risks. For example, there is the risk of disorderly or reactive migration in response to climate shocks, potentially leading to disruptions of economic activity and in some cases conflict. A further risk is that internal migration – particularly the rapid urbanisation currently occurring in many developing countries – whether driven by economic or environmental forces, will place additional strain on scarce resources (e.g. infrastructure and housing) in receiving locations, potentially increasing the vulnerability of migrants to climate risk.

Finally, we turn to sectoral transformation and diversification out of agriculture in particular, with a focus on how government policies can support this transformation. For example, the ability of poorer households to transition out of agriculture into other sectors will depend *inter alia* on labour market flexibility and the absorptive capacity of the non-farm economy. First, we briefly revisit the idea of location-based inequality.

3.1. Location-based inequality

There remains some debate over the 'fundamental' sources of economic growth and prosperity (see further discussion in Castells-Quintana et al., 2015). While a number of authors link the global distribution of income to environmental factors, including climate (e.g. Gallup et al., 2001), this view has been challenged by the institutionalists (e.g. Acemoglu et al., 2001, 2002; Rodrik et al., 2004). Regardless of whether geography (climate and location) can explain differences in development across countries, it is clear that we can identify certain characteristics of locations that make them relatively low or high productivity. These include;

- transport costs (associated with being landlocked, ruggedness of the terrain, changes in climatic or vegetation conditions; see e.g. Diamond, 1997)
- access to (drinking) water and fuel
- disease burdens (Sachs and Malaney, 2002 ; Strulik, 2008)
- agricultural productivity (Costinot et al., 2014)
- labour productivity (e.g. as a result of heat stress; see Martin et al., 2011; and Advaryu et al., 2014)

Productivity differences between locations (e.g. rich vs poor countries) have been shown to derive primarily from location-based productivity differences, as opposed to differences in the productivity of workers (Hall and Jones, 1999; Clark, 1987). This finding is supported by empirical work on the earnings of migrants, which tends to find that migrants achieve gains from migration that are roughly equivalent to the wage gap between origin and destination labour markets, while accounting for selection effects (e.g. McKenzie et al., 2010; Clemens, 2010).[21]

Climate change is likely to increase the challenges faced in lower-productivity locations – i.e. those that are already hot, dry, landlocked, suffering from disease burdens, with relatively low agricultural productivity and highly variable rainfall (see e.g. Samson et al., 2011). Thus climate change can be expected to reinforce existing location-based inequalities, and as a consequence give further momentum to the dynamics and incentives that drive economic

[20] Dercon (2012) points to the example of China, where "in the last two decades, poverty reduction was accompanied by large migration … with well over 170 million people moving into cities from rural areas since 1990."

[21] As cited in Clemens, 2011.

migrants towards urban and coastal locations.

Spatial externalities – e.g. increasing returns to scale linked to location and agglomeration effects (Fujita and Dapeng, 2001) – imply that existing inequalities between locations will continue to diverge, regardless of the effects of climate change (Dercon, 2012). This divergence, potentially exacerbated by the effects of climate change, creates the possibility of spatial traps, with persistent poverty in poorer locations (Ravallion and Jalan, 1997; Gallup et al., 1999). In the extreme – where existing conditions are sufficiently bad, or climate change impacts prove to be especially negative – some marginal areas may no longer be capable of sustaining dense populations and associated economic activity. That means, for some locations, any form of *in-situ* adaptation may represent maladaptation.

This creates an important challenge for policy-makers. In general, the thrust of our argument in this paper is that the role of government in fostering climate-resilient development is to provide an enabling environment for autonomous (private) adaptation. In this sense, policy-makers do not have to attempt to predict for every community, location and economic activity, when the threshold beyond which *in-situ* adaptation becomes maladaptation, might be reached. However, as we have already noted, geographic isolation can act as a constraint on the adaptive capacity of poorer households, for example as a result of a lack of basic infrastructure, and difficulties accessing markets and financial services. In certain circumstances then – particularly in setting priorities for investment in such public infrastructure projects – policy-makers will need to take account of the risk of maladaptation in the form of locking in unsustainable development paths.

3.2. Migration

Migration as a risk-coping mechanism

Migration is a traditional risk-coping mechanism. Numerous studies identify human mobility as an important coping mechanism in response to environmental shocks (e.g. Laczko and Aghazarm, 2009; Wisner et al., 2004; Ellis, 2000; Jonsson, 2001; Naude, 2010; Marchiori et al., 2012, 2013; Henry et al., 2004; Parnell and Walawege, 2011).[22] Within-country migration also has the potential to generate significant welfare gains (Dercon, 2012); as a result of permanent relocation of labour from less to more productive locations (e.g. from isolated, rural hinterlands, to high-productivity, coastal, urban locations); and in other cases where temporary or seasonal migration is used as a mechanism for coping with uncertain income flows, resulting from adverse weather conditions and other external shocks (e.g. Laczko and Aghazarm, 2009; Wisner et al., 2004; Ellis, 2000; Marchiori et al., 2013).[23]

In some areas these traditional patterns of coping have changed in recent decades due to rapidly changing socio-economic and environmental conditions (Jäger et al., 2009). Climate change is likely to alter the character of migration patterns, and may act as a constraint on the migration opportunities of the most vulnerable populations, for example where the ability to accumulate wealth is negatively affected (Government Office for Science [UK], 2011). Gray and Mueller (2012a) similarly find that while "mobility can serve as a post-disaster coping strategy, it does not do so universally, and disasters in fact can reduce mobility by increasing labor needs at the origin or by removing the resources necessary to migrate."

Constraints to migration are both financial, e.g. credit constraints and transport costs; and informational, e.g. knowledge, networks, and education (see e.g. Munshi, 2003; Hatton and Williamson, 2006; Gray and Mueller, 2012a). People who want to leave their village/region/country can only do so if they have the necessary financial means and access to networks that support migration (Jager et al., 2009). Institutional factors will also affect both the ability to migrate (e.g. due to requirements for permits, e.g. in China), and the success of that migration. For example, Collier et al. (2008) point out that where tenure/land rights systems are based on traditional or ancestral claims, access to land may be problematic for newly arrived migrants. Policy barriers in destination countries also act as a major constraint to international migration – as evidenced by the 13.6 million applications for just 50,000 visas allocated by the US Diversity Visa Lottery (Clemens, 2011).

The element of risk/uncertainty associated with migration is compounded for those already living close to subsistence, for whom failure could be catastrophic (Bryan et al., 2014). Bryan et al. (2014) also argue that "it is important for individuals to experience migration for themselves," since "they cannot learn about returns from others" (p3).[24]

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[22] As cited in Gray and Mueller (2012a) and Henderson et al. (2014).

[23] Cited in Gray and Mueller (2012a) and Henderson et al. (2014).

[24] These authors further suggest that "such frictions may be part of what keeps workers in agriculture despite the persistent productivity gap between rural agriculture and urban non-agriculture sectors (Gollin et al., 2002; Caselli, 2005; Restuccia et al., 2008; Vollrath, 2009; Gollin et al., 2011; McMillan and Rodrik, 2011)." – Bryan et al. (2014, p3).

Given the costs involved in migration – the requirement of various forms of capital; whether human, financial or social[25] – a pertinent concern for development policy is that "populations who experience the impacts of environmental change may see a reduction in the very capital required to enable a move" (Government Office for Science [UK], 2011). Dercon (2012) similarly raises the concern that climate change could restrict migration opportunities for the rural poor, where incomes are negatively affected by climate change potentially leading to 'poverty-trap' type processes, "in which populations may remain trapped in marginal and vulnerable areas (Black et al., 2011; Government Office for Science [UK], 2011)". This 'trapped' population – potentially millions of people who will be *unable* to move away from vulnerable locations – "is likely to represent just as important a policy concern as those who do migrate" (Government Office for Science [UK], 2011). The worst effects of climate change on migration, from a development perspective, may be "to reduce populations' ability to move on their own terms" (Gemenne, 2011a, p189).

Climate-induced migration

Of course migration also carries risks, particularly in the context of climate change. While economic and other socio-cultural variables are the primary determinants of population movements, climatic factors can also play a role (Maxwell and Soule, 2011).[26] Evidence on the number of people displaced annually by natural disasters, and extreme weather events in particular, has led to fears of mass waves of 'climate refugees' as representing one of the potential risks of unabated climate change.[27] For example, Myers and Kent (1995) forecast 150 million environmentally-induced refugees by 2050. However, these estimates appear to lack empirical support (Gemenne, 2011b; François, 2011), and therefore remain somewhat speculative.

Migration across borders or ethnic groups, especially where that migration is irregular or unanticipated, can also lead to conflict, with negative consequences both for aggregate growth, and in many cases especially sorry consequences for the poor and other marginalised groups, including women (Collier et al., 2008; Government Office for Science [UK], 2011).[28]

In reality, as noted in the previous section, it is often not the most vulnerable, or those directly affected by climate shocks, that are most likely to move (Gray and Mueller, 2012a; Ó Gráda and O'Rourke, 1997), while there appears to be relatively little evidence on *cross-border* migration in response to climate shocks (Beine and Parsons, 2013; Boustan et al., 2012; Drabo & Mbaye, 2011; Gray & Mueller, 2012b; Hornbeck, 2012). Instead most climate-induced migration is likely to occur within countries, and predominantly involving movements from rural to urban locations (see e.g. Marchiori et al., 2012; Barrios et al., 2006; Henderson et al., 2014).

[25] "Migration often selects for individuals with above-average access to human, social, and financial capital" – Gray and Mueller, 2012a, p1

[26] For example, Turner (2012) finds that population in US counties responds to environmental shocks due to hurricanes and earthquakes.

[27] Globally, flood events alone have displaced 22 million people *per year* since 1985, according to data from the Dartmouth Flood Observatory.

[28] Collier et al. (2008) cite examples of conflict in Darfur and Cote d'Ivoire as being related to migration.

Box 5. Climate change, migration and urbanisation in semi-arid countries

Increasingly harsh climatic conditions, especially in already vulnerable and agriculturally dependent regions, put additional stress on the poor. In some cases the only viable adaptation alternative is to leave. But migration is neither cheap nor easy and, by reducing household's wealth, climate change can further constrain the mobility of the poor and the risk associated with migration. Furthermore, migration can be a risky adaptation strategy not only at the individual but also at the aggregate level. Mass migration can entail significant effects on specific ecosystems and even increase vulnerability to climate change. Likewise, in the case of rural-urban migration, the pressure from new urban dwellers increases the challenges for sustainable urban development in cities where living conditions are far from optimal and where the supply of basic services and infrastructure may be unable to keep pace with rising demand.

The Table below presents some basic facts about population dynamics, including growth, density, migration, urbanisation and urban concentration trends, in our six countries (Burkina Faso, Kenya Pakistan, Senegal, Tajikistan and Tanzania).

As the figures show, population growth remains relatively high in what are already relatively densely populated countries (especially Pakistan) putting additional pressure on (natural and man-made) resources. According to the figures, urban population growth significantly exceeds total population growth in all six countries, suggesting that internal migration is likely driven mostly towards urban centres. Thus, despite still being relatively rural, these countries are experiencing a process of rapid urbanisation. Furthermore, all six countries also display a high level of urban concentration, with a large proportion of the urban population living in the country's largest city (more than half in the case of Senegal). These are large agglomerations of several million inhabitants (more than 15 in Karachi, Pakistan) growing at a fast pace and bringing relevant risks for sustainable development. In Burkina Faso, Kenya and Tanzania access to improved sanitation facilities, for instance, only covers half or less of the urban population. In fact, a large proportion of urban dwellers in these countries lives in slums without access to basic services.

In terms of international migration, for the six countries considered the total number of emigrants significantly exceeds the total number of immigrants. Emigration of tertiary educated people, in particular, is notably high in four of these countries (Kenya, Senegal, Pakistan and Tanzania), indicating a likely problem of human capital flight ("brain drain"). In Kenya over 38% of tertiary educated people leave the country.

Migration and rapid urbanisation in semi-arid countries, including those analysed here, is most likely not just a result of the natural process of structural change associated with economic development, but also a consequence of challenging climatic conditions pushing households away from their rural environments. In this regard, climate-induced migration can be a direct consequence of reduced economic opportunities (for example from lower agricultural yield), but also the consequence of climate-induced conflict or inadequate institutional frameworks.

In the 70s and 80s in Senegal, frequent droughts and soil degradation distinctly reduced yields from agriculture causing an "under-employment" of farmers and urban migration towards Dakar where migrants mainly occupied the low areas of the capital most vulnerable to flooding. In the 90s, the slowing down of the agricultural, pastoral and forestry sectors, led to more migration from young people which notably led to the anarchical set up of stalls blocking the streets of the capital and causing riots between ambulant vendors in 2007. International mobility has become an increasingly preferred option. In the fishery sector, for instance, there has been growing movement towards other African countries, in particular those bordering Senegal, in the hope for better catches and more opportunities for seasonal jobs. The situation worsened with a new type of illegal emigration towards Europe, in particular Spain, with the phenomenon of the "death boats", called « Barçà wala Barsakh » (meaning Barcelona or death), which has become the option of last resort for many young people working in those sectors greatly impacted by climate change, as fisheries, agriculture and livestock.[29]

[29] For more on the impacts of droughts in Senegal see Lackzo and Aghazarm (2009), Diané (2009) and Sall (2010). For more on emigration see Thiam and Crowley (2014) and Tall and Tandian (2010).

Table 5: Population, urbanisation and migration

Countries/regions	Population density	Population growth (%)	Urban pop (%)	Urban population growth (%)	Internal Migration
Burkina Faso	61.90	2.84	28.19	5.87	
Kenya	77.93	2.69	24.78	4.35	
Pakistan	236.28	1.65	37.86	2.80	
Senegal	73.41	2.92	43.08	3.62	
Tajikistan	58.64	2.45	26.62	2.65	
Tanzania	55.60	3.03	30.20	5.39	
SS Africa	39.67	2.70	36.65	4.11	
South Asia	350.16	1.31	32.19	2.60	
World	54.92	1.16	53.00	2.07	

Countries/regions	Population in largest city (% of urban pop)	Access to improved sanitation (% of urban pop)	Population in slums (% of urban pop)	Net migration (total)	Emigration of tertiary educated (%)
Burkina Faso	49.95	50.40	59.40	-125000	2.56
Kenya	33.00	31.30	54.80	-50000	38.52
Pakistan	22.61	71.80	47.50	-1634420	12.70
Senegal	53.72	67.10	38.10	-99996	17.19
Tajikistan	35.69	93.60	-	-99999	0.61
Tanzania	30.77	24.90	66.40	-150000	12.09
SS Africa	28.83	40.69			12.59
South Asia	11.57	61.11			5.35
World	16.40	79.31			5.40

Note: Data from the World Bank - World Development Indicators. Data for 2013 or closest year. For slums data is for 2005 from UN-Habitat

Urbanisation

Demographic trends are one of the key determinants of vulnerability and exposure to future climate change. This is likely to be particularly relevant for semi-arid regions of Africa and Central Asia, where existing climatic conditions create challenging environments for sustaining rural livelihoods, resources per capita (including water, energy, food and finance/capital) are relatively scarce and rapid population growth is anticipated over the coming decades.

The rapid population growth forecast for developing regions will be further concentrated due to continuing urbanisation. Urbanisation can offer improved opportunities; by reducing economic dependence on the weather; through agglomeration economies; and by providing better access to trade and financial services (see e.g. UNDP, 2011). However, urbanisation also carries risks. When urbanisation is dominated by precarious living standards, urban residents become more sensitive and less able to cope with shocks associated with these risks.

The recent rapid urbanisation of developing countries appears to have been driven more by rural push factors (Lipton, 1977; Bates, 1981; Bairoch, 1988; Barrios et al., 2006), and natural urban growth (Jedwab et al., 2014), rather than urban pull factors associated with industrialisation and economic development. In particular, climate stress in rural areas has been shown to be driving internal migration towards urban areas (Henderson et al., 2014).

Where urban expansion is occurring most rapidly – in less developed countries – housing and infrastructure, including basic water and waste management services, are often provided in haste, inadequately, or not at all, leaving inhabitants at the mercy of the elements (Anbarci et al., 2005). An estimated one billion people worldwide live in slums with 2 billion expected before 2030 (UN-Habitat). In sub-Saharan Africa almost 80 per cent of the urban population lives in slums, lacking access to basic services such as clean water, sanitation facilities and electricity (Castells-Quintana, 2015). Slum populations in this region are growing at a rate that will see them double every 15 years.[30]

Rapid urbanisation, particularly in large agglomerations as is the case today, poses great challenges for sustainable development, in particular the provision of adequate basic infrastructure and shelter/housing (World Bank, 2011). Furthermore, rapid urbanisation can also increase vulnerability to climate change. While the shift away from agriculture generally reduces economic dependence on the weather, the mass movement of (still relatively poor) people into urban areas will involve essentially shifting risk from one location (and type) to another. Urban areas are particularly susceptible to flooding and heat stress, for example, as well as the more rapid spreading of diseases such as cholera – especially where water and waste infrastructure is underprovided. According to the Foresight report (Government Office for Science UK, 2011), by 2060 there could be an additional 114-192 million people living in flood plains in urban areas in Africa and Asia (relative to the year 2000). Additionally, as cities tend to be located in (low-lying) coastal areas they are at risk from sea-level rise.

In developing countries then a major challenge is how to accommodate safely the additional millions, who wish to live in economically vibrant urban locations. Reducing the number of casualties from disasters needs to be a high priority for governments and international donors, and quick wins in this area might be achieved through improved early warning and emergency response systems. In the longer term, investments in improved (resilient) infrastructure, taking account of disaster risk, will also be required. Long term development planning should also consider urban disaster risk and how exposure (particularly to flooding) might be minimised, without constraining development opportunities. This might involve development of secondary cities (with lower climate risk), although such strategies will depend on the degree of agglomeration economies already accumulated in existing (risky) urban locations – in other words the degree of path dependence or historical lock-in already committed to.

3.3. Sectoral/Structural transformation

In creating policies to support adaptation and development under climate change, an important consideration is the potential shift in comparative advantage. As we have noted, yields for various crops may be threatened by shifts in temperature and rainfall patterns resulting from climate change. One obvious adaptive response is to reduce the weather-dependence of agriculture through irrigation schemes. These are most likely to be successful in yielding returns on the investment in areas with good market access and suitable soils, since irrigation in these regions could "enable production of high-

[30] Figures from UN-Habitat, cited in Marx et al. (2013).

value crops as well as intensified food crops" (UNDP, 2011). Other areas – e.g. remote, sparsely populated drylands, as in parts of West Africa – may have a comparative advantage in large-scale livestock production (UNDP, 2011). However, as we have argued previously, for some areas declining/worsening (climatic) conditions could make any support for agriculture a form of maladaptation. Instead, policies to identify opportunities and enable diversification out of agricultural production should be sought.

Although diversification away from agriculture tends to go 'hand-in-hand' with economic development (Vivid, 2010), in the context of developing countries, there are a number of constraints to this process.[31] Creating a business environment that enables diversification and (ultimately) a structural transformation of the economy is one of the great challenges for development policy, potentially made more pressing by the threat of climate change.

Diversification as adaptation

It has been shown that under drier conditions, rural households in Africa shift their labour out of farm activities – to non-farm employment in the case of men, and out of the labour force entirely in the case of women (Henderson et al., 2014). This suggests that sectoral shifts in employment, where opportunities are available, could become an important means of adaptation to climate change. Indeed, there is plenty of evidence to suggest that income diversification and non-farm employment can act as important adaptation strategies for households facing climate-related income volatility (e.g. Bryan et al., 2014).

Policy support may be required to increase the opportunities available in non-farm employment, whether locally or via migration (as discussed above), to ease movement of workers between sectors (and across space), and to address the barriers to non-farm employment, for rural women in particular. For example, a lack of basic energy and sanitation services (such as electricity, running water etc.) in many rural parts of the developing world results in domestic duties becoming a major drain on household time, the burden of which tends to fall disproportionately on women (UNDP, 2011).

As Collier et al. (2008) have argued, "a policy priority in responding to climate change should be to raise the factor absorption capacity of the non-agricultural sectors". But how best can this be achieved? There appears to be renewed interest among some authors in industrial policy as a means of fostering structural change (e.g. Rodrik, 2004; Hausmann and Rodrik, 2006; as cited in Vivid, 2010). The standard market failures - collateral constraints, asymmetric information, learning-by-doing spillovers and coordination failures – do indeed justify some forms of government intervention.[32] There is also an argument to be made for infant-industry protection, where industrial sectors exhibit economies of scale.[33] However, the standard concerns about such policies – question marks over the ability of governments to successfully 'pick winners' and, perhaps more importantly, 'let the losers fail' (Rodrik, 2014) – are likely exacerbated in developing countries where the business and regulatory environment is less than ideal. These challenges are further complicated by uncertainty over future climate change and its likely effects on comparative advantage – making interventionist policies, particularly those that give support to one industry or sector over others, all the more risky.

If the conditions for establishing competitive industries are lacking, then protectionist policies are likely to prove wasteful at best, and self-defeating at worst, resulting in uncompetitive protected industries draining government resources, forcing higher prices on consumers, and ultimately failing to achieve any long-term, sustainable structural change. With that danger in mind, protectionist industrial policies should not be considered without accompanying efforts to improve the conditions required for the development of competitive manufacturing (and other) industries. Priority areas (for government policy) should focus on getting the basics right in providing an enabling environment for the growth of industry.

The first requirement is infrastructure. As noted above, the burden of household activities – especially acute where basic energy and sanitation infrastructure is absent – can act as a barrier to participation in the (non-farm) workforce, especially for women. Collier et al. (2008) also highlight unreliable electricity and expensive telecommunications as impediments to business. They cite the successful development of light manufacturing (textiles) in Bangladesh and telecommunication services in India as examples of industrial development leading to lower sensitivity to weather shocks in these vulnerable countries. This diversification was enabled by improvements in the provision of basic infrastructure services. Similarly, the development of the rural non-farm sector in China has been credited with providing "employment and income to millions of people whose labour is no longer needed in farming". The

[31] "There are market and information failures that prevent agents and countries from taking advantage of risk-minimisation strategies." Vivid, 2010, p.30

[32] A further motivation might relate to concerns about regional inequalities.

[33] Such strategies have been cited as part of the success of Asian economies during the late 20th century (e.g. Collier, 2006 – cited in Vivid, 2010).

most effective investments in rural (dryland) western parts of China were apparently in agricultural research and development, education, roads and electricity (Fan et al., 2002 – as cited in UNDP, 2011).

A second, complementary requirement is removing the regulatory barriers to the free movement of labour and the establishment of new enterprises. Collier et al. (2008) again highlight the relevance of these issues as "appropriate responses to the threat of climate change", which remain relatively neglected by the literature to date. A note of caution here is warranted; our discussion above on urbanisation highlights the need for adequate infrastructure provision, and appropriate land use and zoning policies, to avoid increasing the vulnerability to climate risk of urban migrants.

As noted elsewhere in this review weak institutional capacity represents a barrier to adaptation in developing countries. A notable example of this is the poor performance of most African countries on the World Bank's *Doing Business* survey indicators, "implying that all tradable activities, other than those which depend upon locationally specific advantages, are liable to be uncompetitive" (Collier et al., 2008). Reducing the regulatory and bureaucratic burden associated with establishing (and closing) businesses (Collier and Goderis, 2008), should be viewed as important adaptive responses to the threat of climate change.

Section 4
Implications for research and policy

In this paper, we have reviewed the literature on how specific institutional, governance and finance arrangements can promote the reduction of vulnerability and risk-coping at the level of individuals, including households, communities and vulnerable groups (such as women, low-income households and marginalised groups). In drawing lessons from this literature, we distinguish between two forms of adaptation; *in-situ* adaptation, which seeks to make existing locations, livelihoods and forms of production more resilient to climate change impacts, and *transformational* adaptation, which seeks to reduce vulnerability through the movement of people and economic activity across sectors and across space. Political and economic institutions, including access to finance, have the potential to impact dramatically on both forms of adaptation.

While we believe this distinction is useful, we also note that the two forms of adaptation should be thought of as two dimensions on which a continuum of adaptation strategies might be mapped, rather than discrete policy options (or alternatives). In many cases, some form of *in-situ* adaptation – i.e. building resilience and risk-coping capacity of vulnerable groups – will be required before *transformational* adaptation can take place.

Most of the adaptation literature has tended to focus on *in-situ* forms of adaptation. However, successful adaptation strategies should include elements of both forms. For example, in locations that are already marginal from an economic or environmental perspective, *in-situ* adaptation strategies might lock in unsustainable practices. There is also a general risk that adaptation tends to be reactive in nature, for example in response to extreme weather events. While the 'defensive flexibility' to cope with shocks might be relatively well developed amongst vulnerable groups, more efficient adaptation – i.e. that would build longer term resilience and sustained prosperity – needs to take account of broader development or socio-economic trends (such as population growth and urbanisation) as well as gradual (and in some cases permanent) changes in climate. We have highlighted a number of institutional and financial constraints to efficient anticipatory (or transformative) adaptation.

Of course there may also be behavioural issues in relation to risk perceptions (as discussed briefly in our section on weather insurance) that prevent people from making efficient adaptation decisions.

Economic development generally involves the accumulation of certain types of risk (whether through movement towards high productivity, but vulnerable locations such as coastal areas, or through the adoption of new technologies and entrepreneurial activity more generally). Adaptation therefore should be predominantly about risk coping, and supporting efficient (i.e. productivity-enhancing) risk-taking behaviour, and not just about arbitrary attempts to minimise risk. This distinction speaks to the appropriate balance between efforts to reduce exposure and vulnerability, and efforts to improve adaptive capacity.

While the primary role of government is in providing an enabling environment for autonomous private adaptation, by for example providing the right incentives, 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), we also identify cases of market failures and externalities where public adaptation may be appropriate.

Box 6 Emerging research questions

- What can we learn from case studies in semi-arid lands about the optimal design and combination of micro-finance, micro-insurance and social safety net schemes, with climate risk in mind?
- Testing external validity: Can micro-finance success stories be replicated in other settings (e.g. in semi-arid lands), and scaled-up to the regional or national level?
- Identify the practical financing needs of adaptation actors (e.g., farmers, water companies), barriers to finance and type of finance they have access to (e.g. bank loans, remittances, savings, micro-credit)
- Analysis of how local informal institutions (e.g. traditional or communal property rights) affect adaptation decisions of the rural poor in semi-arid lands and how different modes of governance affect delivery.

We have argued that policy-makers should prioritise building the adaptive capacity and economic flexibility of vulnerable and marginalised groups. This follows from a general view of adaptation as occurring primarily through autonomous action of private individuals and households, and is further reinforced by uncertainty over future climate change and impacts.

However, we have also noted that under certain circumstances investment in hard defensive infrastructure projects will also be required. This might be justified, for example, where shocks occur with relatively high frequency – rendering financial or insurance type mechanisms unfeasible – and affect areas with existing high density of economic activity, or some other location-specific features such as cultural or historical significance, making retreat or relocation unacceptable.

Bibliography

Acemoglu, D., Johnson, S. and Robinson, J., 2001. The Colonial Origins of Comparative Development: An Empirical Investigation. The American Economic Review, 91(5), pp.1369-1401.

Acemoglu, D., Johnson, S. and Robinson, J., 2002. Reversal of fortune: geography and institutions in the making of the modern world income distribution. Quarterly Journal of Economics, 117(4), pp.1231-1294.

Agence nationale de la Statistique et de la Démographie, 2013. Deuxième enquête de suivi de la pauvreté au Sénégal (ESPS-II 2011). Dakar: Agence nationale de la Statistique et de la Démographie.

Agrawala, S. and Carraro, M., 2010. Assessing the role of microfinance in fostering adaptation to climate change. OECD Environmental Working Paper no. 15. Paris: Organisation for Economic Co-operation and Development.

Albala-Bertrand, J. M., 1993. Political economy of large natural disasters: With special reference to developing countries. Oxford: Clarendon Press.

Anbarci, N., Escaleras, M. and Register, C. A., 2005. Earthquake fatalities: The interaction of nature and political economy. Journal of Public Economics, 89(9-10), pp.1907-1933.

Arezki, R. and Brückner, M., 2012. Rainfall, financial development, and remittances: Evidence from Sub-Saharan Africa. Journal of International Economics, 87, pp.377-385.

Bailey, S., 2008. Cash transfer for disaster risk reduction in Niger: A feasibility study. London: Overseas Development Institute.

Bairoch, P., 1988. Cities and Economic Development: From the Dawn of History to the Present. Chicago: The University of Chicago Press.

Banerjee, A., 2004. The two poverties. In: S. Dercon, ed. Insurance against Poverty. Oxford: Oxford Scholarship.

Banerjee, A. and Duflo, E., 2011. *Poor Economics: A radical Rethinking of the way to fight Global Poverty*. London: Penguin.

Banerjee, A., Duflo, E., Glennerster, R. and Kinnan, C., 2015. The miracle of microfinance? Evidence from a randomized evaluation. *American Economic Journal: Applied Economics*, 7(1), pp.22-53.

Banerjee, A. and Newman, A., 1991. Risk-bearing and the theory of income distribution. *Review of Economic Studies*, 58(2), pp.211-235.

Barrios, S., Bertinelli, L. and Strobl, E., 2006. Climate change and rural-urban migration: The case of Sub-Saharan Africa. *Journal of Urban Economics,* 60(3), pp.357-371.

Bates, R., 1981. *Market and States in Tropical Africa: The Political Basis of Agricultural Policies*. Berkeley: University of California Press.

Beine, M. and C. Parsons, 2013. *Climatic Factors as Determinants of International Migration*. International Migration Institute and Oxford University Working Paper no. 70. Oxford: IMI and Oxford University.

Besley, T., 1995. Property rights and investment incentives: Theory and evidence from Ghana. *Journal of Political Economy*, 103(5), pp.903-937.

Besley, T., Burchardi K. and Ghatak M., 2012. Incentives and de Soto effect. *Quarterly Journal of Economics*, 127, pp.237-282.

Black, R., Bennett, S. R., Thomas, S. M. and Beddington, J. R., 2011. Climate change: Migration as adaptation. *Nature,* 478, pp.447-449.

Boustan, L. P., Kahn, M. E. and Rhode, P. W., 2012. Moving to Higher Ground: Migration Response to Natural Disasters in the Early Twentieth Century. *American Economic Review: Papers & Proceedings*, 102(3), pp.238–244

Bowen, A., Cochrane, S. and Fankhauser, S., 2012. Climate change, adaptation and economic growth. *Climate Change,* 113, pp.95-106.

Broadberry, S. and Gardner, L., 2013. *Africa's growth prospects in a European mirror: A historical perspective*. London: Chatham House.

Bryan, G., Chowdhury S. and Mobarak A., 2014. Under-investment in a profitable technology: The case of seasonal migration in Bangladesh. *Econometrica*, 82(5), pp. 1671-1748.

Burgess, R., Deschenes, O., Donaldson, D. and Greenstone, M., 2011. Weather and death in India. Tilburg University Working Paper. Tilburg: Tilburg University.

Burgess, R. and Donaldson, D., 2010. Can openness mitigate the effects of weather shocks? Evidence from India's famine era. *The American Economic Review* ,100(2), pp.449-453.

Burgess, R. and Pande, R., 2005. Do rural banks matter? Evidence from the Indian social banking experiment. *The American Economic Review* 95(3), pp. 780-795.

Cai, H., Chen, Y., Fang, H. and Zhou, L., 2009. *Microinsurance, trust and economic development: evidence from a randomized Natural Field Experiment*. NBER Working Paper no. 15396. Cambridge MA: National Bureau of Economic Research.

Caselli, F., 2005. Accounting for Cross-Country Income Differences. In: P. Aghion and S. Durlauf, eds. *Handbook of Economic Growth*. Amsterdam: Elsevier. pp. 679–741.

Castells-Quintana, D., 2015. *Malthus living in a slum: Urban concentration, infrastructures and economic growth*. AQR-IREA Working Papers no. 2015/06. Barcelona: Regional Quantitative Analysis Group.

Castells-Quintana D., Lopez-Uribe, M. and McDermott, T. K. J., 2015. *Climate change and the geographical and institutional drivers of economic development*. PRISE Working Paper. London: Grantham Research Institute on Climate Change and the Environment

Christensen, J. H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R. K., Kwon, W.-T., Laprise, R., Magaña Rueda, V., Mearns, L., Menéndez, C. G., Räisänen, J. Rinke, A., Sarr, A. and Whetton, P., 2007. Regional Climate Projections. In: S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, eds. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press.

Clark, G., 1987. Why Isn't the Whole World Developed? Lessons from the Cotton Mills. *The Journal of Economic History*, 47(01), pp. 141-173.

Clarke, D. and Grenham, D., 2013. Microinsurance and natural disasters: Challenges and options. *Environmental Science and Policy,* 27(Supplement 1), pp.S89-S98.

Clemens, M. A., 2010. *The Roots of Global Wage Gaps: Evidence from Randomized Processing of U.S. Visas*. Center for Global Development Working Paper no. 212. Washington DC: Center for Global Development.

Clemens, M. A., 2011. *Economic and Emigration: Trillion-Dollar Bills on the sidewalk?*, Center for Global Development Working paper no.264. Washington DC: Center for Global Development.

Clemens, M. A. and McKenzie, D., 2014. *Why don't remittances appear to affect growth?*, World Bank Policy Research Working Paper no. 6856. Washington DC: World Bank Group.

Collier, P., 2006. Africa: Geography and growth, *Federal Reserve Bank of Kansas City TEN*. Kansas City: Federal Reserve Bank of Kansas City.

Collier, P., Conway, G. and Venables, T., 2008. Climate change and Africa. *Oxford Review of Economic Policy,* 24(2), pp.337-353.

Collier, P. and Goderis, B., 2008. *Commodity prices, growth and the natural resource curse: reconciling a conundrum*. MPRA paper no. 17315. Munich: University Library of Munich.

Cooper, P. J. M., Stern, R. D., Noguer, M. and Gathenya, J. M., Jäger 2013. Climate Change Adaptation Strategies in Sub-Saharan Africa: Foundations for the Future. In: B. R. Singh, ed. *Climate change – Realities, impacts over ice cap, sea level and risks*. Rijeka: Intech.

Costinot, A., Donaldson, D. and Smith, C. B., 2014. *Evolving Comparative Advantage and the Impact of Climate Change in Agricultural Markets: Evidence from 1.7 Million Fields around the World*. NBER Working Paper no. 20079. Cambridge MA: National Bureau of Economic Research.

De Janvry, A., Sadoulet, E., Solomon, P. and Vakis, R., 2006. *Uninsured risk and Asset Protection: Can Conditional cash transfer programs serve as safety nets?* World Bank Social Protection Discussion Paper 0604. Washington DC: World Bank Group.

Deaton, A., 1992. *Understanding consumption*, Oxford: Oxford University Press.

Dell, M., Jones, B. and Olken, B., 2014. What do we learn from the weather? The new climate-economy literature. *Journal of Economic Literature.* (forthcoming).

Dercon, S., 2002. Income risk, coping strategies and safety net., *The World Bank Research Observer*, 17(2), pp.141-166.

Dercon, S., 2012. *Is green growth good for the poor?* World Bank Policy Research Working Paper no. 6231. Washington DC: World Bank Group. Deressa, T. and Hassan, R., 2010. Economic impact of climate change on crop production in Ethiopia: evidence from Cross-section measures. *Journal of African Economies,* 18(4), pp.529-554.

Di Falco, S., Veronesi, M. and Yesuf, M. 2011. Does adaptation to climate change provide food security? A micro-perspective from Ethiopia. *American Journal of Agricultural Economics,* 93(3), pp. 829-846.

Diamond, J., 1997. *Guns, Germs, and Steel: The Fates of Human Societies*. New York: W.W. Norton.

Diané, L., 2009. *Migrations régulières et irrégulières : défis, retombées et implications politiques au Sénégal*. Genève: Organisation Internationale pour les Migrations.

Dollar, D. and Kraay, A., 2002. Growth is good for the poor. *Journal of Economic Growth,* 7, pp.195-225.

Drabo, A. and Mbaye, L., 2011. *Climate Change, Natural Disasters and Migration: An Empirical Analysis in Developing Countries*. IZA Discussion Paper no. 5927. Bonn: Institute for the Study of Labor.

Easterly, W., 2006. *The White's Man Burden: Why the West's Effort to Aid the Rest Have Done So Much Ill and So Little Good*. Oxford: Oxford University Press.

Easterly, W., Kremer, M., Pritchett, L. and Summers, L. H., 1993. Good policy or good luck? Country growth performance and temporary shocks. *Journal of Monetary Economics*, 32(3), pp.459-483.

Elbers, C., Gunning, J. W., and Kinsey, B., 2007. Growth and Risk: Methodology and Micro Evidence. *World Bank Economic Review*, 21, pp.1-20.

Ellis, F., 2000. *Rural livelihoods and diversity in developing countries.* Oxford: Oxford University Press.

Food and Agriculture Organization, 2008. *Water and the rural Poor: Interventions for improving livelihoods in sub-Saharan Africa*. Rome: Food and Agriculture Organization.

Fan, S., Zhang, L. and Zhang, X., 2002. *Growth, inequality, and Poverty in rural China: The role of Public investments*. International Food Policy Research Institute Research Report no. 125. Washington DC: International Food Policy Research Institute.

Fankhauser, S. and McDermott, T. K. J. 2014. Understanding the adaptation deficit: Why are poor countries more vulnerable to climate events than rich countries? *Global Environmental Change*, 27, pp.9-18.

Fankhauser, S., Smith, J. and Tol, R., 1999. Weathering climate change: some simple rules to guide adaptations decisions. *Ecological Economics,* 30, pp.67-78.

Fankhauser, S. and Soare, R., 2013. An economic approach to adaptation: illustrations for Europe. *Climate Change*, 118(2), pp.367-379.

Field, E., 2007. Entitled to work: Urban property rights and labour supply in Peru. *Quarterly Journal of Economics*, 122(4), pp.1561-1602.

Fisher, G., 2013. Contract structure, Risk Sharing and Investment Choice. *Econometrica,* 81(3), pp.883-939.

Fishman, R. M., 2011. *Climate change, rainfall variability, and adaptation through irrigation: Evidence from Indian agriculture*, Columbia University Working Paper. New York: Columbia University.

Foster, A. D. and Rosenzweig, M. R., 2011. *Are Indian Farms Too Small? Mechanization, Agency Costs and Farm Efficiency*. Working Paper.

François, G., 2011. Why the numbers don't add up: A review of estimates and predictions of people displaced by environmental changes. *Global Environmental Change,* 21, pp.S41–S49.

Fujita, M., and Dapeng, H., 2001. Regional disparities in China 1985-1994: the effects of globalization and economic liberalization. *The annals of regional science,* 35(1), pp.3-37.

Galarza, F. and Carter, M., 2011. *Risk Preferences and Demand for Insurance in Peru: a field experiment*. Working Paper no. 11-08. Lima: Universidad del Pacifico.

Galiani, S. and Schargrodsky, E., 2010. Property rights for the poor: effect of land titling. *Journal of Public Economics*, 94, pp.700-729.

Gallup, J., Sachs, J. and Mellinger, A., 1999. Geography and economic development. *International Regional Science Review*, 22(2), pp.179-232.

Gallup, J., Sachs, J. and Mellinger, A., 2001. Geography Datasets. Cambridge MA: Centre for International Development at Harvard University.

Gaye, A. T., Dabo, E. M. F., Sall, S. M., Sambou, E. and Fongang, S., 1998. Scénarios de changements climatiques pour des études d'impacts sur l'agriculture et les zones côtières du Sénégal, contribution à la communication initiale Sénégal à la CCNUCC. Dakar: Ministère de l'Environnement.

Gemenne, F., 2011a. How they became the human face of climate change. Research and policy interactions in the birth of the 'environmental migration' concept. In: E. Piguet, A. Pecoud, and P. De Guchteneire, eds. *Migration and Climate Change*. Cambridge and Paris: Cambridge University Press/UNESCO.

Gemenne, F., 2011b. Why the numbers don't add up: a review of predictions and forecasts for environmentally-induced migration. *Global Environmental Change,* 21, pp.41-49.

Goldstein, M. and Udry, C., 2008. The profits of power: Land rights and agricultural investment in Ghana. *Journal of Political Economy*, 116(6), pp.981-1022.

Gollin, D., Lagakos, D. and Waugh, M. E., 2011. *The Agricultural Productivity Gap in Developing Countries*. Leonard N. Stern School of Business Working Paper no. 11-14. New York: New York University.

Gollin, D., Parente, S. and Rogerson, R., 2002. The Role of Agriculture in Development, *American Economic Review: Papers and Proceedings*, 92(2), pp.160–164.

Government Office for Science [UK], 2011. *Foresight: Migration and Global Environmental Change - Final Project Report*. London: Government Office for Science.

Government of Pakistan, 2012. Economic Survey of Pakistan 2011-12. Islamabad: Ministry of Finance, Government of Pakistan.

Gray, C. and Mueller, V., 2012a. Drought and population mobility in rural Ethiopia. *World Development*, 40(1), pp.134-145.

Gray, C. and Mueller., V., 2012b. Natural disasters and population mobility in Bangladesh. *Proceedings of the National Academy of Science*, 109 (16), pp.6000–6005.

Grosh, M., Ninno, C. del and Ouerghi, A., 2008. *For protection and promotion: the design and implementation of effective safety nets*, Washington: World Bank.

Hall, R. and Jones, C., 1999. Why do some countries produce so much more output per worker than others? *Quarterly Journal of Economics,* 114(1), pp. 83-116.

Hallegatte, S., 2014. *Economics Resilience: Definition and Measurement*. World Bank Policy Research Working Paper no. 6852. Washington DC: World Bank Group.

Hardin, G., 1968. Tragedy of the commons. *Science,* 162(3859), pp.1243-1248.

Harmeling, S. and Eckstein, D., 2012. *Global Climate Risk Index 2013*. Bonn: Germanwatch.

Harris, I., Jones, P. D., Osborn, T. J. and Lister, D. H., 2014. Updated high-resolution grids of monthly climatic observations–the CRU TS3. 10 Dataset. *International Journal of Climatology*, *34*(3), pp.623-642.

Harris, J. and Todaro, M., 1970. Migration, unemployment and development: a two-sector analysis. *The American Economic Review*, 60(1), pp.126-142.

Hatton, T. and Williamson, J., 2006. *What determines immigration's impact? Comparing two global centuries*. NBER working paper no. 12414. Cambridge MA: National Bureau of Economic Research.

Hausmann, R. and Rodrik, D., 2006. *Doomed to Choose: Industrial Policy as Predicament*. Working Paper. Cambridge MA: Center for International Development at Harvard University.

Hecht, S., 2008. Climate change and the transformation of risk: insurance matters. *UCLA Law Review*, 55(6).

Henderson, J. V., Storeygard, A. and Deichmann, U., 2014. *50 years of urbanization in Africa*, - Examining the Role of Climate Change. World Bank Development Research Group Policy Research Working Paper no. 6925. Washington DC: World Bank Group.

Henry, S., Schoumaker, B. and Beauchemin, C., 2004. The impact of rainfall on the first out-migration: A multi-level event-history analysis in Burkina Faso. *Population and Environment,* 25, pp.423-460.

Hill, R. and Viceisza, A., 2012. A field experiment on the impact of weather shocks and insurance on risky investment. *Experimental Economics*, 15(2), pp.341-371.

Hornbeck, R., 2010. Barbed wire: Property rights and agricultural development. *Quarterly Journal of Economics*, 125(2), pp.767-810.

Hornbeck, R., 2012. The enduring impact of the American dust bowl: Short and long-run adjustments to environmental catastrophe. *The American Economic Review,* 102(4), pp.1477-1507.

Intergovernmental Panel on Climate Change (IPCC), 2014. Climate Change 2014: Mitigation of Climate Change. In: O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J. C. Minx, eds. *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press.

Iqbal, M. M.., Hussain, S. S., Goheer, M. A., Sultana, H., Salik, K. M., Mudasser, M. and Khan, A. M., 2009. *Climate change and wheat production in Pakistan: calibration, validation and application of CERES-Wheat model*. GCISC-RR-14. Islamabad: Global Change Impact Studies Centre.

Jacoby, H. and Skoufias, E., 1997. Risk, financial markets, and human capital in a developing country. *Review of Economic Studies,* 64, pp.311-335.

Jäger, J., Frühmann, J., Günberger, S. and Vag, A., 2009. *Environmental Change and Forced Migration Scenarios Project Synthesis Report*. EACH-FOR Paper.

Jayachandran, S., 2006. Selling Labor Low: Wage Responses to Productivity Shocks in Developing Countries. *Journal of Political Economy*, 114(3).

Jedwab, R., Christiansen, L. and Gindelsky, M., 2014. *Demography, urbanization and development: Rural push, urban pull and… urban push?* Unpublished manuscript.

Kaboski, J. and Townsend, R., 2012. The impact of credit on village economies. *American Economic Journal of Applied Economics,* 4(2), pp.98-133.

Kanbur, R., 1979. Of Risk Taking and the Personal Distribution of Income. *Journal of Political Economy*, 87 (4), pp.769–797.

Karlan, D. and Zinman, J., 2010. Expanding credit access: Using Randomized supply decisions to estimate the impacts. *The Review of Financial Studies,* 23, pp.433-464.

Kellenberg, D. K. and Mobarak, A. M., 2008. Does rising income increase or decrease damage risk from natural disasters? *Journal of Urban Economics,* 63, pp.788-802.

Khan, F. A. and Salman, A., 2012. A simple human vulnerability index to climate change hazards for Pakistan. *International Journal of Disaster Risk Science*, 3(3), pp.163-176.

Kihlstrom, R. and Laffont, J., 1979. A General Equilibrium Entrepreneurial Theory of Firm Formation Based on Risk Aversion. *Journal of Political Economy*, 87(4), pp.719–748.

King, M., 2012. *Is mobile banking breaking the tyranny of distance to bank infrastructure? Evidence from Kenya*. IIIS discussion Paper no. 412. Dublin: Institute for International Integration Studies.

Kochar, A., 1999. Smoothing consumption by smoothing income: hours-of-work response to idiosyncratic agricultural shocks in rural India. *Review of Economic and Statistics,* 81(1), pp.50-61.

Laczko, F. and Aghazarm, C., 2009. *Migration, Environment and Climate Change: Assessing the Evidence*. Geneva: International Organisation for Migration.

Lewis, W. A., *1954. Economic Development* with *Unlimited Supplies of Labour. The Manchester School,* 22, pp.139-191.

Lipton, M., 1977. *Why Poor People Stay Poor: Urban Bias in World Development*. Cambridge MA: Harvard University Press.

Maccini, S. and Yang, D., 2009. Under the weather: Health, schooling, and economic consequences of early-life rainfall. *American Economic Review*, 99(3), pp.1006-1026

Majid, N., 2007. *Alternative interventions in insecure environments: the case of cash in southern Somalia*. Humanitarian Exchange no. 37. London: Overseas Development Institute.

Marchiori, L., Maystadt, J. F. and Schumacher, I., 2012. The impact of weather anomalies on migration in sub-saharan Africa. *Journal of Environmental Economics and Management,* 63(3), pp.355-374.

Marchiori, L., Maystadt, J. F. and Schumacher, I., 2013. *Is environmentally-induced income variability a driver of migration? A macroeconomic perspective*. IPAG Business School Working Paper no. 2013-017. Paris: IPAG Business School.

Martin, P., Mayer, T. and Mayneris, F., 2011. Spatial concentration and firm-level productivity in France. *Journal of Urban Economics,* 69, pp.182-195.

Marx, B., Stoker, T., and Tavneet, S., 2013. The economics of slums in the developing world. *Journal of Economic Perspectives,* 27(4), pp.187-21.

Maxwell, J. T. and Soule P. T., 2011. Drought and other driving forces behind population change in six rural counties in the United States. *Southeastern Geographer,* 51(1), pp.133-149.

McDermott, T. K. J., 2015, Sustainable wealth creation in a changing climate. In: S. Surminski, ed. Forthcoming. *The economic benefits of disaster risk management*. Washington DC: World Bank Group.

McKenzie, D., Gibson J. and Stillman, S., 2010. How important is selection? Experimental vs Non-Experimental measures of the income gains from Migration. *Journal of the European Economic Association,* 8(4), pp.913-945.

McMillan, M., and Rodrik D., 2011. *Globalization, Structural Change and Productivity Growth*. NBER Working Paper no. 17143. Cambridge MA: National Bureau of Economic Research.

Mendelsohn, R., 2012. The Economies of Adaptation to Climate Change in Developing Countries. *Climate Change Economics*, 3(02).

Miguel, E., 2005. Poverty and witch killing. *The Review of Economic Studies,* 72(4), pp.1153-1172.

Ministère de l'Economie et des Finances [Sénégal], 2004. *La pauvreté au Sénégal : de la dévaluation de 1994 à 2001-2002*. Dakar: Ministère de l'Economie et des Finances.

Ministère de l'Environnement et du Cadre de Vie [Burkina Faso], 2007. *Programme d'action national d'adaptation à la variabilité et aux changements climatiques*. Ouagadougou: Ministère de l'Environnement et du Cadre de Vie.

Ministère de l'Environnement et de la Protection de la Nature [Sénégal], 2006. *Plan d'Action National pour l'Adaptation aux Changements Climatiques*. Dakar: Ministère de l'Environnement et de la Protection de la Nature.

Mobarak, A. M. and Rosenzweig, M. R., 2013. Informal Risk Sharing, Index Insurance, and Risk Taking in Developing Countries. *American Economic Review*, 103(3), pp.375-380.

Munich Climate Insurance Initiative (MCII), 2012. *Insurance solutions in the context of climate change-related loss and damage: Needs, gaps, and roles of the Convention in addressing loss and damage.* Policy brief No. 6. UNU-EHS Publication Series.

Munich Climate Insurance Initiative (MCII), 2013. *Climate risk adaptation and insurance. Reducing vulnerability and sustaining the livelihood of low-income communities.* Report No. 13. UNU-EHS Publication Series.

Munshi, K., 2003. Networks in the modern economy: Mexican migrants in the US labour market. *The Quarterly Journal of Economics,* 118(2), pp.549-599.

Munshi, K., 2004. Social learning in a Heterogeneous population: Technology diffusion in the Indian Green Revolution. *Journal of Development Economics,* 73(1), pp.185-213.

Myers, N. and Kent, J., 1995. *Environmental Exodus: An emergent Crisis in the Global Arena*. Washington DC: Climate Institute.

Naude, W., 2010. The determinants of migration from Sub-saharan African countries. *Journal of African Economies*, 19(3), pp.30-356.

Naveed, A. and Ali, N., 2012. *Clustered Deprivation: District Profile of Poverty in Pakistan*. Islamabad: Sustainable Development Policy Institute.

Ó Gráda, C. and O'Rourke, K., 1997. Migration as Disaster Relief: Lessons from the Great Irish Famine. *European Review of Economic History,* 1, pp.3-25.

Ostrom, E., 2000. Collective actions and the evolution of social norms. *Journal of Economic Perspectives*, 14(3), pp.137-158.

Oxfam, 2009. *Analyse du contexte de la pauvreté au Sénégal*. Dakar: Oxfam.
Parnell, S. and Walawege, R., 2011. Sub-saharan African urbanisation and global environmental change. *Global Environmental Change,* 21, pp.512-520.

Paxson, C., 1992. Using weather variability to estimate the response of savings to transitory income in Thailand. *The American Economic Review,* 82(1), pp.15-33.

Pelham, L., Clay, E. and Braunholz, T., 2011. *Natural Disasters: What is the role for social safety nets*. World Bank Social Protection and Labour Discussion Paper no. 1102. Washington DC: World Bank Group.

Ravallion, M., 2012. Why don't we see poverty convergence? *American Economic Review*, 102(1), pp.504-23

Ravallion, M. and Jalan, J., 1997. *Spatial poverty traps?* World Bank Policy Research Paper no. 1862. Washington DC: World Bank Group.

République du Burkina Faso, 2010. *Stratégie de Croissance Accélérée et du Développement Durable du Burkina Faso*. Ouagadougou: République du Burkina Faso.

Restuccia, D., Yang, D. T. and Zhu, X., 2008. Agriculture and Aggregate Productivity: A Quantitative Cross-Country Analysis. *Journal of Monetary Economics*, 55, pp.234–250.

Rodrik, D., 1999. Where Did All the Growth Go? External Shocks, Social Conflict, and Growth Collapses. *Journal of Economic Growth*, 4, pp.385–412.

Rodrik, D., 2004, *Normalising Industrial Policy,* World Bank Commission on Growth and Development Working Paper no. 3. Washington DC: World Bank Group.

Rodrik, D., 2014. Green industrial policy. Oxford Review of Economic Policy, 30(3), pp.469-491.

Rodrik, D., Subramanian, A. and Trebbi, F., 2004. Institutions rule: the primacy of institutions over geography and integration in economic development. *Journal of Economic Growth,* 9(2), pp.131-165.

Rosenzweig, M. and Binswanger, H., 1993. Wealth, weather risk and the composition and profitability of agricultural investments. *The Economic Journal,* 103(416), pp.56-78.

Sachs, J. D. and Malaney, P., 2002. The economic and social burden of malaria. *Nature*, 415(6872), pp.680–685.

Sall, M., 2010. L'informel à Dakar: Ubac ou régulateur de l'insécurité urbaine? *Revue de Géographie du Laboratoire Leïdi*, 8, pp. 47-62.

Samson, J., Berteauz, B. J. and Humphries, M. M., 2011. Geographic disparities and moral hazards in the predicted impacts of climate change on human populations. *Global Ecology and Biogeography*, 20(4), pp.532–544.

Schelling, T., 1992. Some economics of global warming. *American Economic Review* 82, pp.1–14.

Schelling, T., 1997. The cost of combating global warming: Facing the tradeoffs. *Foreign Affairs*, 76(6), pp.8–14.

Schlenker, W., Hanemann, W. M. and Fisher, A. C., 2005. Will U.S. Agriculture Really Benefit from Global Warming? Accounting for Irrigation in the Hedonic Approach. *American Economic Review*, 95(1), pp.395-406.

Sekhri, S. and Storeygard, A., 2011. *The impact of climate variability on crimes against women: Dowry deaths in India*, Tufts University Working Paper. Medford: Tufts University.

Skoufias, E., Rabassa, M. and Olivieri, S., 2011. *The poverty impacts of climate change: A review of the evidence*. World Bank Policy Research Working Paper no. 5622. Washington DC: World Bank Group.

Stainforth, D., Allen, M., Tredger, E. and Smith, L., 2007a. Confidence, uncertainty and decision- support relevance in climate predictions. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences,* 365(1857), pp.2145–2161.

Stainforth, D., Downing, T. E., Washington, R. and Lopez, A., 2007b. Issues in the interpretation of climate model ensembles to inform decisions. *Philosophical Transactions of the Royal Society A,* 365, pp.2163–2177.

Strulik, H., 2008. Geography, health, and the pace of demo-economic development. *Journal of Development Economics*, 86(1), pp.61-75.

Suleri, A. Q. and Haq, S., 2009. *Food Insecurity in Pakistan*. Islamabad: Sustainable Development Policy Institute.

Surminski, S. and Oramas-Dorta, D., 2013. Flood insurance and climate adaptation in developing countries. *International Journal of Disaster Risk Reduction*. Article in Press.

Tall, S. M. and Tandian, A., 2010. *Regards sur la migration irrégulière des Sénégalais : vouloir faire fortune en Europe avec des pirogues de fortune*. CARIM Analytic and Synthetic Notes no. 2010/50. Florence: European University Institute.

Thiam, M. T. and Crowley, J., 2014. *Impact des changements environnementaux sur les migrations humaines. Étude de cas : Sénégal et Côte d'Ivoire*. Paris: UNESCO.

Turner, G., 2012. *Natural disasters, Risk Expectations and Population growth: a study of US counties since 1850*, Working Paper.

United Nations Development Programme (UNDP), 2011. *The Forgotten Billion: MDG achievement in the drylands*. New York: United Nations Development Programme.

Valdés, A. and Foster, W., 2010. Reflections on the role of agriculture in pro-poor growth. *World Development*, 38(10), pp. 1362–1374.

Vivid, 2010. *Promoting Economic Growth when the Climate is Changing*. London: Vivid Economics and DFID.

Vollrath, D., 2009. How important are dual economy effects for aggregate productivity? *Journal of Development Economics*, 88(2), pp.325-334.

Wade., R., 1994. *Village Republics, Economic conditions for collective action in South India*. Cambridge: Cambridge University Press.

Wang, S. Y., 2008. *Credit constraints, job mobility and entrepreneurship; Evidence from a property reform in China*. New York University Working Paper. New York: New York University.

Ward, R., Herweijer, C., Patmore, N. and Muir-Wood, R., 2008. The role of insurers in promoting adaptation to the impacts of climate change. *The Geneva Papers,* 33, pp.133-139.

Watkiss, P., Hunt, A. and Savage, M., 2014. *Early VfM Adaptation Toolkit: Delivering value-for-money adaptation with iterative frameworks & Low-regret options*. [pdf] Available at: http://www.evidenceondemand.info/early-vfm-adaptationtoolkit-delivering-value-for-money-adaptation-with-iterative-frameworks-and-low-regret-options

Wilbanks, T. and Romero Lankao, P., 2007. Industry, settlement and society. In: M. L. Parry, O. F. Canziani, J. P. Paultikof, P. J. van der Linden and C. E. Hanson, eds. *Climate Change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth assessment Report of the Intergovernmental Panel on climate Change*. Cambridge: Cambridge University Press. pp.357-390.

Wilson, D. S., Ostrom, E. and Cox, M. E., 2013. Generalizing the core design principles for the efficacy of groups. *Journal of Economic Behavior and Organization*, 90S, pp.S21-S32.

Wisner, B., Blaikie, P., Cannon, T. and Davis, I., 2004. *At Risk: Natural Hazards, People's Vulnerability and Disasters*. London: Routledge.

World Bank, 2010. *World Development Report 2010: Development and Climate Change*. Washington DC: World Bank Group.

World Bank, 2011. *Building resilience to disasters – Delivering results. Global Facility for Disaster Reduction and Recovery Annual Report 2011*. Washington DC: World Bank Group.

World Bank, 2013a. *World Development Report*. Washington DC: World Bank Group.
World Bank, 2013b. Republic of Senegal: Social Safety Net Assessment. Washington DC; World Bank Group.

Yang, D. and Choi, H., 2007. Are remittances insurance? Evidence from rainfall shocks in the Philippines, *The World Bank Economic Review.* 21(2), pp.219-248.

Yang, D., 2008. Coping with disaster: The impact of hurricanes on international financial flows, 1970-2002. *The BE Journal of Economic Analysis and Policy,* 8(1).

Yohe, G., 1991. Uncertainty, climate change and the economic value of information: and economic methodology for evaluation the timing and relative efficacy of alternative response to climate change with application to protecting developed property from greenhouse induced sea level rise. *Policy Sciences*, 24, pp.245-261.

Yu, W., Alam, M. and Hassan, A., 2010. *Climate Change Risks and Food Security in Bangladesh*. Oxford: Earthscan.

Zaman, Q., Mahmood, A., Rasul, G. and Afzaal, M.., 2009. *Climate Change Indicators of Pakistan*. Pakistan Meteorological Department Technical Report no. PMD-22/2009. Islamabad: Pakistan Meteorological Department.

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