Feeling the Heat

How climate change is driving extreme weather in the developing world

Trócaire

Trócaire envisages a just and peaceful world where people's dignity is ensured and rights are respected; where basic needs are met and resources are shared equitably; where people have control over their own lives and those in power act for the common good.

Front cover photo: 'Typhoon Haiyan after moving through the Philippines, November 9th 2013'. (Photo: NASA Goddard Photo/photopin)

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Contents

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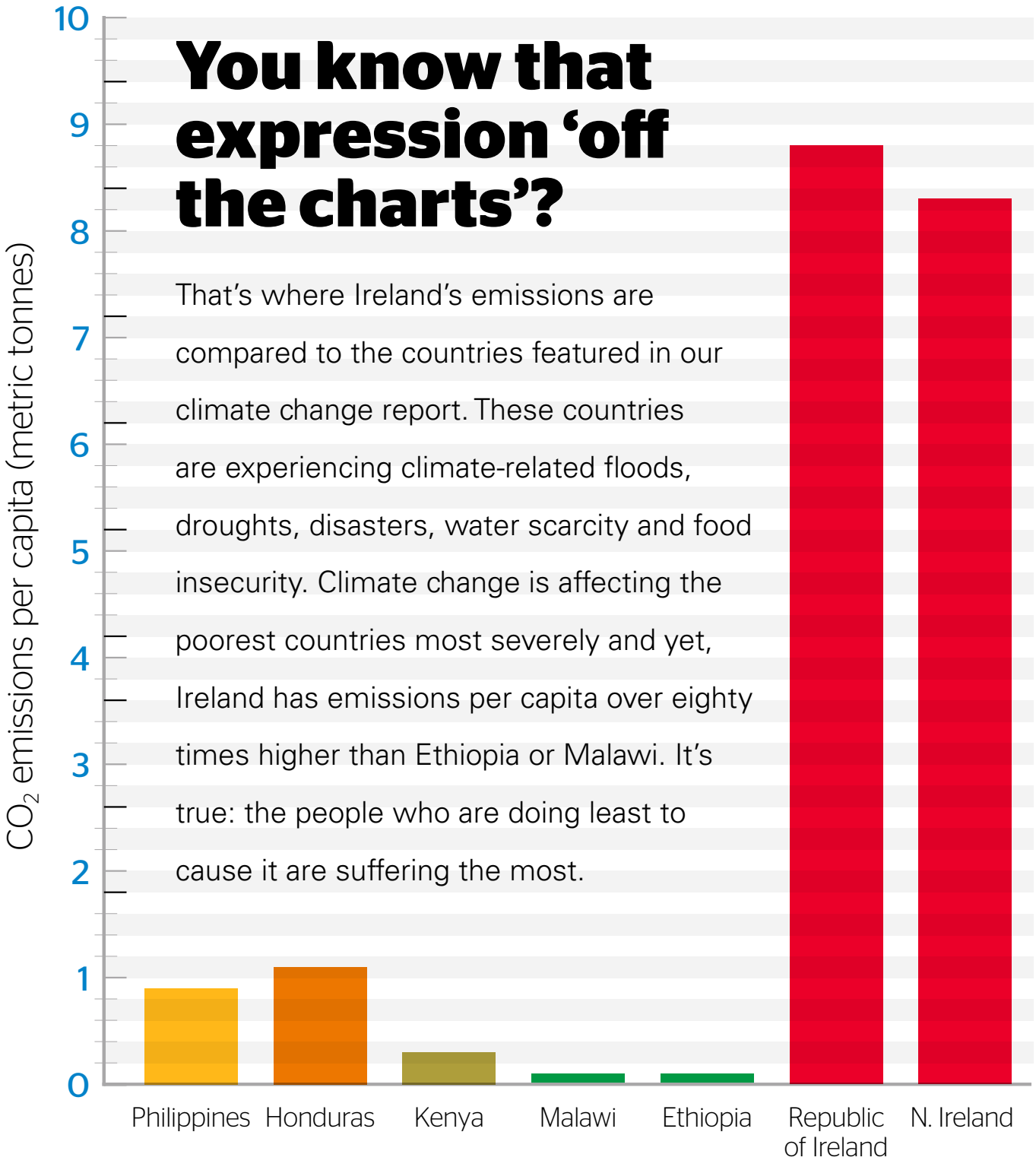
You know that expression 'off the charts'?

That's where Ireland's emissions are compared to the countries featured in our climate change report. These countries are experiencing climate-related floods, droughts, disasters, water scarcity and food insecurity. Climate change is affecting the poorest countries most severely and yet, Ireland has emissions per capita over eighty times higher than Ethiopia or Malawi. It's true: the people who are doing least to cause it are suffering the most.



Sources:

http://data.worldbank.org/indicator/EN.ATM.CO2E.PC

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/322822/20140624_Full_Dataset.xlsx

Foreword

Climate change is the greatest injustice of our time. The people who are doing least to cause it are suffering the most. Those with most power to address it have so far failed us.

People in the developing world are struggling to survive in the face of drought, storms and floods. Rains are becoming more erratic and extreme weather more common. Year after year crops are failing. Families can no longer plan and the hungry season is extending. This is a silent emergency. We cannot continue to tackle poverty in the world without addressing the issue of climate change and helping people to adapt to its impacts.

Trócaire believes it doesn't have to be this way. Together we can tackle the injustice of climate change. We ***can*** make the transition to a more sustainable and equitable world. Food can be produced in ways that are more sustainable and help vulnerable farmers to overcome the impacts of climate change. Clean energy can be produced that is available and affordable for all.

This report, developed in collaboration with the Department of Geography in Maynooth University, brings together the science around climate change and personal experience of communities and organisations seeking to address the injustice underpinning the current situation. Based on the best scientific information available, it puts forward a series of policy proposals which need to be addressed if Ireland is to play its part in addressing climate change.

This is possible if we all stand together. We can speak up, we can consume in more sustainable ways, and we can support Trócaire's work to empower people to adapt to climate change.

2015 will be a historic year. As individuals, as communities, as companies and as governments we must act. Together we are the solution to climate injustice.

Éamonn Meehan

Executive Director, Trócaire

Executive Summary

2015 will be a historic year. It may be the year in which the nations of the world finally agree to an equitable, practical and legally binding agreement on climate change – or it may be, yet again, the year that they fail to do so.

Climate change affects us all. In Ireland*, the Environmental Protection Agency and the Department of the Environment in Northern Ireland have stated that we will likely see both more intense storms and rainfall, and increased water shortages as a result of climate change. However, in Ireland we have sophisticated monitoring systems, contingency plans and a network of social security to lessen hardship. In the developing countries featured in our case studies below, climate change will be added to existing challenges, with far fewer resources to cope with the problems.

Our report looks at five countries: the Philippines, Honduras, Kenya, Malawi and Ethiopia, and reviews the scientific literature in these countries for the effects of climate change, both present and future. Below is a synthesis of our findings of climate change impacts on human well-being and socio-economic development in these countries, followed by a summary of our recommendations.

The state of climate change

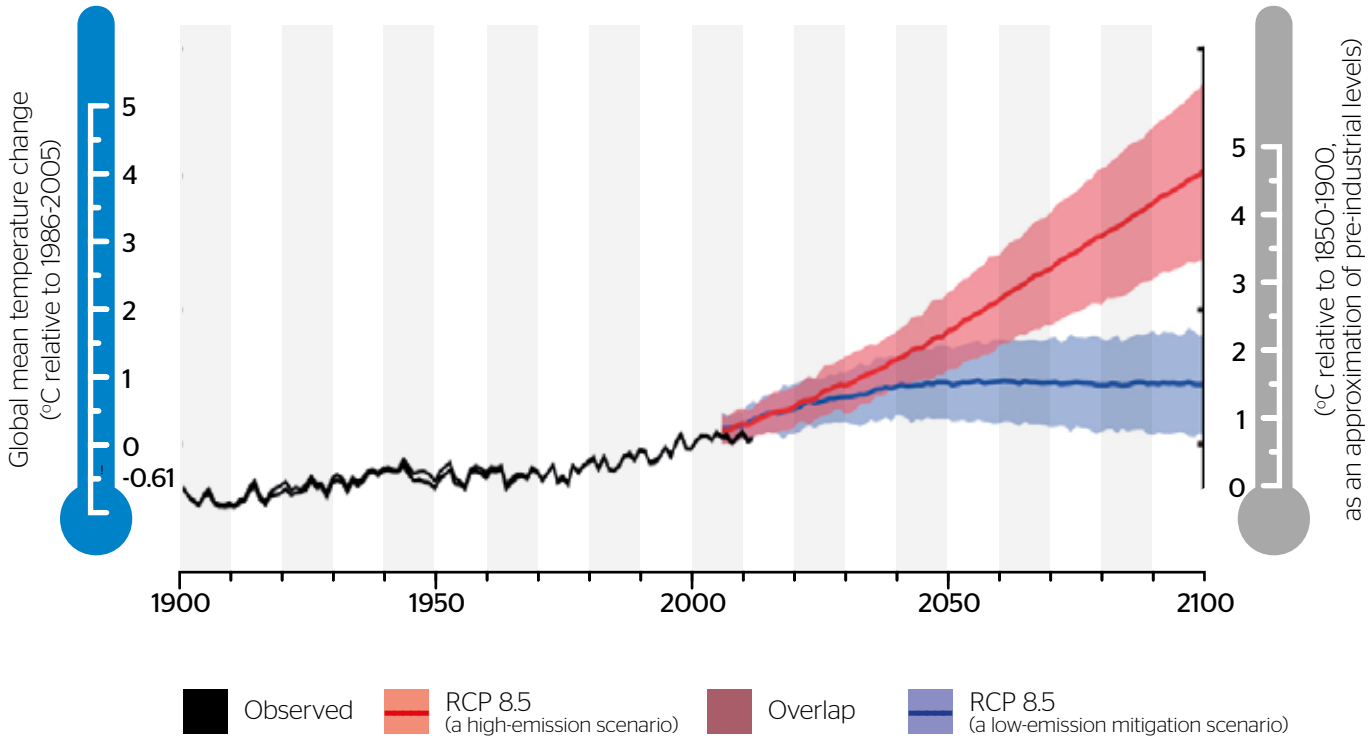
> ***'Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.'***
>
> *IPCC Fifth Assessment Report, Summary Report, 2013.*

Global climate change is having a serious impact on the countries featured in our case studies below. In all of the countries, increases in temperature both during the day and at night are clearly observable. Longer dry seasons and hotter days, leading to greater evaporation losses leads to serious risk of droughts. When rain does fall, it falls more intensely than before, leading to greater risk of floods, damage to crops and risks to human health through water- and vector-borne diseases. As the ocean warms, tropical storms are expected to get stronger. This is a huge concern in those countries already massively affected by tropical storms. In 2013, super typhoon Haiyan killed over 6,000 people in the Philippines and displaced millions more. In the last century, six of the twelve strongest hurricanes in the world impacted Honduras, including Hurricane Mitch which killed 10,000 people in 1998.

* Throughout this report Ireland refers to both the Republic of Ireland and Northern Ireland

Anthony (6) and Patrick (8), water the kitchen garden plants at their home in Meru, which provides the family with extra nutrition. Dry farm land can be seen behind the kitchen garden.

Projected changes in climate



The graph above shows the projected changes in global temperature published by the Intergovernmental Panel on Climate Change (IPCC).[1] The red line shows what would happen to global temperature if we continue with 'business as usual' – no reduction in emissions – and the blue line which would require serious action right now by governments to curb emissions and mitigate the effects of climate change. Although this is known as the 'best case scenario', in reality it is the only scenario in which we can hope to keep global temperatures below a 2˚C increase, the limit which the international community have agreed is necessary to prevent the worst effects of climate change.

In both cases, temperatures will rise for the next couple of decades. However, quite quickly, scenarios begin to diverge, with lowered emissions leading to a levelling off of warming and 'business as usual' leading to a much higher change of temperature, with correspondingly more devastating effects on food security and livelihoods.

For most of the countries featured in the report, the rise in the predicted changes under a 'business as usual' scenario across country case studies are mostly in line with the global mean, with temperature rises in the region of 4°C projected for the end of this century.[2] Malawi and the rest of southern Africa will be particularly badly affected, with an average warming of over 5°C predicted by the end of this century.[3] The effects of rising temperatures will not be felt in the same way everywhere. Developing countries are much more dependent on subsistence agriculture, and have far fewer resources with which to mitigate or adapt to climate change.

Food production

Our global demand for food is rapidly rising, but in many developing countries, crops are failing with increasing frequency due to climate variability and drought. Huge risks are posed to global and regional food security by climate change, particularly if we continue with 'business as usual' emissions. In developing countries, these risks are greatly exacerbated by low levels of investment in small scale farmers, low access to technology, reliance on rain-fed agriculture, and high levels of pre-existing food poverty. For example, in Malawi, 90 per cent of the population are dependent on rain-fed agriculture, 60 per cent of whom are already food insecure on a year-round-basis.[4] By curbing greenhouse emissions, we can substantially lessen the risks of even greater food insecurity. By investing in small scale

farmers, especially women, we can increase people's resilience to climate change and food security.

Access to water

With hotter days and a longer dry season, there is less rain to feed water sources, and greater losses from evaporation. In many countries where access to water is already a struggle, there will be less water to drink, less water to grow crops, and less water to power electricity. When rain does fall, it will often fall more heavily, and when this happens, less of it soaks into the ground where it's most useful for crops – instead, it runs off quickly and may cause flooding. Heavier rainfall also leads to increased sediments and pollutants in fresh water bodies. This is particularly harmful where people do not have access to safe water – in Ethiopia for example, almost half of the population relies on unimproved water sources such as ponds, streams or rivers.[5]

Health

Compared with a future without climate change, the WHO predicts 250,000 additional deaths per year globally from 2030: 38,000 due to heat exposure in elderly people, 48,000 due to diarrhoea, 60,000 due to malaria, and 95,000 due to childhood under-nutrition.[6] Changing climate conditions have been linked to increased epidemics in several of the countries featured here. Rising temperatures have been associated with outbreaks of dengue fever, which struck 12,000 people in Honduras in 2013.[7] In Kenya, climate change is expected to increase malaria in areas where it is already rife, but also to spread into high-altitude areas as a result of rising temperatures.[8] Such communities are more vulnerable due to lack of immunity and preparedness.

Gender

Just as we have seen that climate change will not affect all regions of the world equally, with developing societies particularly badly hit, so will climate change have the worst effects on those with least power within those societies. This includes women, who remain culturally disempowered and under-represented in many communities. The adverse effects of climate change on agriculture will affect women disproportionately – women make up half the agricultural workforce in least developed countries, but own only between 10-20 per cent of the land.[9] Access to water has important gender dimensions, with young girls in particular being more vulnerable to water availability and competition.[10] When natural disasters strike, socio-cultural norms can impact on women's ability to escape. A survey by Oxfam International after the 2004 tsunami found that a disproportionate number of victims were female – up to 80% of those killed in some places were women. The research found that women died because they stayed behind to look after small children or ageing relatives, or because they were unable to swim or climb trees.[11]

However, when women are involved as equal participants in climate-related strategies and coping mechanisms, those strategies are more likely to succeed. Women are more likely to respond to disaster early warning systems, and during Hurricane Mitch, the municipality of La Masica reported no deaths owing to the success of a community preparedness system which involved men and women equally.[12]

Migration

Increased natural disasters, rising sea levels and prolonged droughts are all leading to increased migration and displacement. Typhoon Haiyan forced some 4 million people in the Philippines to leave their homes, approximately 400,000 of whom are still in evacuation centres. In Kenya, sea level rise of just 30 cm will submerge 17 per cent of Mombasa – and the best case scenario indicates a global sea level rise of between 26 and 55 cm by the end of the century.[13] In Ethiopia and Kenya, droughts have contributed to increased rural-urban migration, increasing urban vulnerability.

Economic impacts

Our country profiles show the various ways in which climate change is already having an economic impact, and how it will in the future. In Honduras, hurricanes caused direct and indirect damages of over $5 billion USD over the course of the 20th century, equivalent to 95 per cent of Honduras' GDP in 1998.[14] In the Philippines, the cost of adaptation for agriculture and coastal zones is expected to be about $5 billion/year by 2020 on average.[15] In Kenya, net economic costs of climate

Mtuwa village in Chikwawa, southern Malawi, one of the most vulnerable regions to the impacts of climate change. Credit: Alan Whelan/ Trócaire.

change, including health burdens, energy demand and infrastructure could be equivalent to a loss of almost 3 per cent of GDP each year by 2030.[16] In most developing countries, climate change is likely to raise income inequality and reduce household wealth.

The Stern Report on the economics of climate change estimates that it would be up to 20 times cheaper to prevent further climate change as opposed to dealing with the economic costs of inaction.[17]

Recommendations

If the logic of the Stern Report does not compel us to act, the sheer injustice of the human suffering which is occurring in the case studies featured in our report should.

The poorest women and men are already suffering impacts at current levels and will suffer further as temperatures continue to rise – as they will inevitably do, no matter what we do next. The people who have done least to cause the problem are bearing the brunt of inadequate action to date to both mitigate and support adaptation. They need our support now and into the future.

However, we also have a critical choice to make about what future we want for the youth of today and the next generation. If we act now, urgently and ambitiously, temperatures increases can be contained and will begin to level off. A failure to do so will see global poverty eradication becoming impossible and inequalities spiralling. We have a choice – but we must act now.

The following recommendations set forth what Trócaire believes is needed in order to prevent and respond to the worst effects of climate change. For a detailed list of recommendations see page 36.

1 We must establish a fair, legally binding framework on climate change that keeps global temperature rises as far below 2°C as possible, and ensures that the most vulnerable women and men can adapt to the impacts of climate change.

An international agreement is essential to ensure co-ordinated and collective action – we all need to work together. All eyes are now fixed on the 21st UN Climate Change Conference in Paris in December 2015 (COP21), at which all the nations of the world have committed to negotiating a binding universal agreement on climate change. This action must also be replicated at the national level, with effective climate legislation here in Ireland.

Limiting temperature rises to no more than 2°C above pre-industrial times has been adopted by the international community as the threshold necessary to avoid the most dangerous impacts of climate change. In order to achieve this, policy makers must achieve the 'best case scenario' by adopting ambitious targets and adaptation measures. While the threat of climate change may seem overwhelming, there is broad consensus that responding to it adequately is both achievable and affordable.[18]

The impacts of climate change are already being felt, and even with emission reductions we are 'locked-in' to a certain inevitable amount of future climate change. A just climate agreement must also ensure the provision of sufficient, accessible and additional public finance to support communities to adapt in appropriate ways to the impacts of climate change.

2 We must switch to more sustainable ways of producing and consuming, in particular energy and agriculture.

An emissions framework as above provides the overall limits within which countries can operate. Actually delivering upon the changes necessary to meet these targets requires a transition in the way we produce and consume, particularly in the areas of agriculture and energy. Agriculture accounts for almost a quarter of greenhouse gas emissions globally; in Ireland, this share is even higher. We need to improve our land management so that nutrients are restored to the soil, and to re-examine our diets and the level of waste in food supply chains - the FAO have estimated that up to one-third of food produced for human consumption globally is lost or wasted, from initial agricultural production down to final household consumption.[19] In terms of energy, there is no alternative but to transition to a world free from fossil fuels. In order to contain temperature rises as far below 2˚C as possible, more than two-thirds of current commercially viable fossil fuels will need to remain in the ground.[20] It is critical that policies are designed with adequate social and environmental safeguards to ensure that they do not result in unintended impacts on the rights and resilience of vulnerable communities.

3 We must support and promote sustainable agricultural approaches and secure access to natural resources to ensure that the most vulnerable people can adapt to the impacts of climate change.

As the case studies demonstrate, the impacts of climate change will be felt in the coming decades even with effective action to reduce emissions. It is therefore vital that the most vulnerable people and communities around the world are supported so that they can adapt to these inevitable impacts. The scale and complexity of climate change can sometimes make the task of adaptation extremely difficult – but it is human nature to adapt, even in the face of seemingly insurmountable challenges. The individual stories highlighted throughout our report also demonstrate the resilience of small scale farmers, and how with even small levels of investment in simple technologies such as irrigation systems supported by Trócaire (e.g. see Kenya, page 20 and Ethiopia, page 30) they can flourish. Ensuring that there is sufficient investment in these kind of sustainable approaches to agriculture is a first step to ensuring people can not only survive but thrive in the face of climate change. An enabling policy framework that avoids 'false solutions', supports rather than undermines sustainable agricultural approaches and ensures secure access to natural resources such as land and water is critical.

1: Introduction and Overview

1.1 Setting the scene

Way off target: a decade of missed opportunities

In 2008, Trócaire outlined that a just response to climate change would require tackling both the causes and the consequences of climate change in an equitable way.[21] We have continued to witness how vulnerable communities are at the front-line of the impacts of climate change. They are paying the price for a problem they have not created, and for which they have least resources to cope. The occurrence of extreme weather events such as storms and floods, as well as slower onset events like drought create large scale hardships, such as in the Horn and East of Africa in 2010-11 when in excess of 10 million people faced starvation, or in Malawi in 2012 where more than one and a half million people were in need of food aid. Projections of a future climate with increased greenhouse gases show that such extremes are expected to increase. Extreme climatic events force people living in poverty to sell what little assets they have in order to cope; they reduce the numbers of meals a day, pull children from school to work, engage in dangerous income generating options, or migrate. This leads to a downward spiral in which escaping poverty is impossible, and survival is an ongoing struggle.

The science has continued to harden around the imperative for action. The Fifth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), released in 2013/2014, builds with even greater confidence on earlier scientific assessments and confirms that climate change is happening here, now and everywhere. Action on mitigation and adaptation is more urgent than ever before. It is a challenge that not only requires the right government policies, but one that requires a dramatic shift in the way we live in rich countries – to transition to a greener, low carbon future. It is up to us.

Despite this clear evidence, there have been few signs of significant progress. The commitment made by the international community at the Climate Summit in Cancun in 2010 to keep rises in global temperature to below 2°C above pre-industrial levels is an important milestone. However, we are far off track for making this goal a reality.

The IPCC 5th Assessment Report confirms that despite a growing number of climate change mitigation policies, greenhouse emissions are continuing to rise – and at a higher rate.[22]

There has been a considerable increase in national mitigation planning since 2007, with 67 per cent of global GHG emissions subject to national legislation or strategies by 2012 compared to only 45 per cent in 2007.[23] However, current commitments by countries to reduce their greenhouse gas emissions only amount to between 3-7 gigatonnes of carbon dioxide equivalent emissions below business as usual projections by 2020.[24] This falls significantly short of the 14 gigatonnes that will be necessary to stay within the 2°C target, and even further short of the 18.5 gigatonnes that would be needed to stay within the lower 1.5°C target that many developing countries are calling for in order to ensure their survival.[25]

In order to have a greater than 66% likelihood of not exceeding the 2°C threshold, the IPCC Fifth Assessment Report concluded that a cumulative carbon dioxide equivalent budget of less than 2900 gigatonnes must be respected. Given that, by 2011, 1890 gigatonnes had already been emitted, and that around 50 gigatonnes is currently emitted annually, the remaining budget for 2015 onwards is around 860 gigatonnes. If annual global emissions remain at the current level, this budget will be completely used up in less than 20 years, with one third of it gone after only the next 5-6 years. It goes without saying that the remaining budget to limit warming to 1.5°C is even smaller and exhausted in less time.

If additional efforts are not made to reduce emissions, the global mean surface temperature is expected to rise from 3.7˚C to 4.8˚C by the end of the century.[26] At these temperature rises the impacts of climate change become catastrophic – beyond the limits of adaptation in many cases.

Under the European Union climate and energy package for 2020, the Republic of Ireland has a

20 per cent reduction target in greenhouse gas emissions by 2020. However, the latest figures from the Environmental Protection Agency (EPA) indicate that emissions in the Republic of Ireland, even under best case scenario of implementing all policies and measures, is significantly off-track, with decreases of only 5-12 per cent projected.[27] Even more worryingly emissions in the Republic of Ireland are expected to rise by 12 per cent by the year 2030.[28]

In the UK, the 2008 Climate Change Act introduced a legally binding target to reduce the UK's greenhouse gas emissions to at least 80 per cent below 1990 levels by 2050, with an interim target of a 35 per cent reduction by 2020[a]. However, this Act does not extend to the devolved regions within the UK. Northern Ireland is now the only region in the UK that has not yet introduced a regional climate change Act and is therefore the only administration within the UK without legally binding emission targets. Instead the current Northern Ireland Programme for Government sets out a less ambitious, non legally binding target of a 35 per cent reduction in greenhouse gas emissions by 2025[b]. The latest emission figures from the UK Greenhouse Gas Inventories reveal that Northern Ireland is again the lowest performing region of the UK on emission reductions with only a 16 per cent decrease reported for 2012, compared to the UK average of a 26.5 per cent decrease[c].

Furthermore, when responses are designed without a focus on how actions impact on the most vulnerable men and women, they not only fail to put us on a transformative pathway to more sustainable ways of life, but also risk exacerbating existing vulnerabilities for some of the world's poorest people including their rights to resources such as land and water. For example, EU policies including the Renewable Energy Directive and the Fuel Quality Directive have resulted in an increased demand for biofuels. Meeting the targets set has been estimated to require an area between 4.7-7.9 million hectares of new land – an area roughly the size of Ireland, to be converted to biofuel production.[29] The impact of such policies has included the reallocation of resources to fuel rather than food production, and increases in land grab, including cases of forced evictions. Mitigation policies must be designed with adequate social and environmental safeguards, with particular attention to the human rights of vulnerable people.

Developed countries have already committed to mobilise $100 billion USD per year by 2020 in new and additional long-term finance to support adaptation and mitigation in developing countries. They have also established the delivery mechanism for a significant portion of that funding, in the form of a Green Climate Fund. However to actually deliver upon this commitment the international community must establish a clear, transparent and accountable process to scale up public climate finance commitments to at least $100 billion USD per year by 2020 as additional to ODA.

As part of the global agreement in Paris, all developed countries within their intended 'nationally determined contributions' must provide information on their planned climate finance provisions.

Turning the tide: from missed chances to real opportunities

Despite a series of missed opportunities over the past seven years, 2015 provides leaders – in Ireland and internationally, with a series of opportunities to put us on a pathway to a more equitable and sustainable future. In Ireland critical choices will be made on climate legislation, departmental adaption strategies and on national sectoral policies in the areas of energy and agriculture, and specific recommendations on this can be found at the end of this report. Internationally, 2015 will be a milestone year, as three international processes coincide to set the frame for human development in the coming decades. The three processes are: the negotiation of the second Hyogo Framework for Action in disaster risk reduction in March, the agreement of a new set of Sustainable Development Goals (SDGs) at the UN General Assembly in September, and the negotiation of a new global agreement on climate change at COP21 in Paris in December. Together, these agreements will shape what is possible in terms of sustainable development and poverty reduction in the coming decades. They will determine the targets for emission reductions, the vision of what sustainable development,

a UK National Archives (2008) Climate Change Act http://www.legislation.gov.uk/ukpga/2008/27/contents

b Northern Ireland Executive (2011) Northern Ireland Programme for Government 2011-2015 http://www.northernireland.gov.uk/pfg-2011-2015-final-report.pdf

c Northern Ireland Department of the Environment (2014) The latest emission figures in the Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland, 1990-2012 10 June 2014 - Latest data show 16% drop in NI greenhouse gas emissions from 1990 to 2012 | Northern Ireland Executive

including adaptation looks like, and establish the financial and resourcing commitments that will be necessary to translate goals into practice. The case studies outlined in this report, from the Philippines, Ethiopia, Honduras, Malawi and Kenya illustrate the human imperative to make the urgent changes required in order to avoid reversing decades of development, and instead build and sustain peaceful, prospering and just societies into the future.

1.2 About the case studies

This report provides a comprehensive review of observed changes in climate, climate change projections and impacts in five of Trócaire's programme countries: the Philippines, Honduras, Kenya, Malawi and Ethiopia. The report reviews over 150 publications on recent research, predominantly from peer reviewed international scientific journals to provide an up to date overview of our emerging knowledge on how climate change is likely to unfold in some of the most vulnerable countries in the world. This work therefore provides a solid scientific evidence base for understanding the impacts and uncertainties of climate change in each of the aforementioned countries. Where limited information is provided, this indicates a gap in the available scientific data. For each country an in-depth profile is provided with the following structure:

- An introduction and overview of the country's particular vulnerabilities with regard to climate change.
- Evidence on observed climate variability and change
- Scientific information on projected changes in climate from regional and national level studies in each country.
- Assessment of impacts in key sectors including; food production, water resources, human health, migration and economic impacts. Issues of gender are also considered.

1.3 How to read the case studies

The 5th Assessment of the Intergovernmental Panel on Climate Change (IPCC) published in 2013/2014 provides the most comprehensive assessment of our understanding of climate change to date, and much of the global and regional data contained in this report draws upon it. It is important to understand how projections of climate impacts work, and the latest IPCC projections are derived, in order to read and interpret this report.

Global climate models, which represent current understanding of the global climate system are used to project future changes in climate. Future scenarios of greenhouse gases are used as input to these models to explore how differing global concentrations of greenhouse gases are likely to affect important climatic variables such as temperature and precipitation.

There are a large number of different climate models, and different models give different results - this gives rise to uncertainty in projections. Given the importance of understanding future impacts to society studies usually employ a number of different models (ensembles) so that a good handle can be obtained on ranges of future change. Models agree that increases in greenhouse gases will result in increases in temperatures. However, the specific amount of warming expected for an equivalent increase in greenhouse gases varies between models. Changes in rainfall and extreme events are more difficult to capture and are associated with greater ranges of potential change in the future. In order to give a best estimate averages across different models are usually taken to represent a central estimate across the ranges of change projected by different models.

The different scenarios in the 5th IPCC Assessment Report are based on greenhouse gas emissions in the atmosphere, known as Representative Concentration Pathways (RCPs). While four different scenarios were examined in the IPCC report, we have concentrated here on the two most extreme. At one end, the 'business as usual' scenario (RCP 8.5) represents high emissions, where no policy changes to reduce emissions have taken place. At the other, if ambitious greenhouse gas reductions are achieved, CO2 emissions stay at current levels until 2020, and then decline and become negative by 2100. This is the low emissions 'best case scenario'.

2: The Philippines

In brief: With over 7,000 islands and affected by El Niño, the Philippines is extremely vulnerable to natural disasters and erratic agricultural production due to climate variability.

Right Now: In 2013, Typhoon Haiyan claimed 6,000 lives.

Future climate change risks: Eroded coastlines and coral reefs; increased risk of tropical storms.

Emissions of CO_2 per capita: 0.9 metric tons – **approximately nine times less than Ireland**

2.1 Introduction

The Philippines is classified as one of the least developed countries in the world, ranked at 117 out of 187 countries on the 2014 Human Development Index. Over half of its population live in poverty.[30] As population rates grow, people are increasingly constrained to living and farming in areas not suitable for settlement and agriculture such as on riverbanks and mountain slopes, thereby exacerbating the damage caused by extreme weather events and climate change.[31]

The Philippines has always been susceptible to variations in ocean temperature and rainfall, due to the El Niño effect. According to the 2013 Climate Change Vulnerability Index, the Philippines ranked 9th most at risk country in the world and as early as 2012, the Asian Development Bank (ADB) released a study stating that "50.3% of the country's land area is economically at risk from multiple hazards such as floods, typhoon, and earthquakes. This means some 81.3% of the country's population or around 76.6 million Filipinos are prone to economic impacts brought by natural disasters."[32]

Indeed, in recent years the country has seen an increase in both frequency and intensity of extreme weather events.[33] In 2011, a study highlighted the early recognition of the increased potential for disasters as a matter of urgent concern.[34] Two years later, super typhoon Haiyan devastated the Philippines, killing over 6,000 people and displacing millions of families.

In addition to the direct impact on human life, and the costs of response and recovery, such extreme events seriously impact the country's natural ecosystems that are major sources of livelihoods and development.[35] Over seven thousand islands make up the nation of the Philippines, of which some 2,000 islands are inhabited. Rising sea levels are projected to result in agricultural land loss[36] and destruction of coral reef ecosystems, on which many Filipinos are dependent for coastal protection, subsistence fisheries and tourism.[37]

Future projections of climate indicate that the Philippines is expected to experience a significant rise in temperature and increased rainfall variability, with the highest increases projected to occur in major agriculture regions.[38] Climate change therefore presents a systemic challenge to the country's efforts to address poverty and realise sustainable development.[39]

As a nation, the Philippines is acutely aware of the threats which climate change poses to their people's well-being. A national Climate Change Commission was established in 2009 in the Philippines as an independent government agency. In the aftermath of typhoon Haiyan, the Climate Change Commission delegation to the UN Climate Change Summit in Warsaw pleaded with the international community to *'take drastic action now to ensure that we prevent a future where super typhoons are a way of life'*, and to *'stop calling events like these natural disasters'* because *'It is not natural when science already tells us that global warming will induce more intense storms.'*[40] The commission's message is representative of a general awareness and activism on climate change and Disaster Risk Reduction in the Philippines, where local organisations and networks strive to raise these issues at a national and more global level.

2.2 Observed Climate Variability and Change

There is an increase in observed mean

temperatures in the Philippines of 0.64°C from 1951-2010.[41] The increases in temperature were greater in the latter half of that period, and 1998 and 2010 were the warmest years since 1951 in the Philippines.[42] The country is experiencing an increased number of hot days and a decreasing number of cold nights.[43]

The El Niño effect causes year to year variations in rainfall and large variability in extreme precipitation in the Philippines.[44] Increasing trends in the number of "no rain" days have been observed over western Philippines.[45] The total southwest monsoon rainfall has declined significantly over the last 50 years, with time series analysis showing rates of decrease ranging from 0.026 per cent to 0.075 per cent per decade in the western half of the country.[46] For all of the Philippines, significant drying trends in the dry season are observed which may cause droughts while a wetting tendency is observed during the wet season which may increase risk of flooding potential.[47] Households have perceived changes in climate including an increase in rainfall variability, rising sea levels and an increase in the intensity and frequency of storm events.[48]

2.3 Projections of Future Climate Change

Figure 1 shows the projected changes in annual temperature for south-east Asia to the end of the 21st century. Temperature increases are predicted for all scenarios of greenhouse gas emissions examined, with the rate of temperature increase diverging after mid-century. If greenhouse emissions are not decreased – the 'business as usual' RCP 8.5 scenario – an average warming of approximately 4°C is predicted, with some models indicating temperature increases above 5°C. The best case scenario (RCP2.6), which would require an ambitious global agreement to reducing emissions, shows an average warming of approximately 1°C by the end of the century.

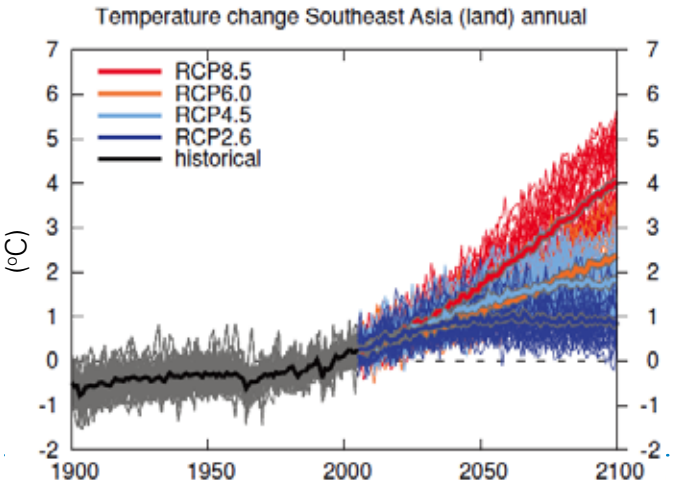


Figure 1 Projected changes in annual temperature relative to 1986-2005 under different greenhouse gas emissions pathways for south-east Asia. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin lines denote a single model projection; thick lines show the mean simulation for multiple climate models.[49]

Lengthening of seasonal dry periods, and an increasing frequency of droughts are likely under the 'business as usual' scenario. Longer wet and dry periods would have implications for food production, coastal system services including fisheries,[50] human settlement and health, livelihoods and socio-economic development.

Country level studies for the Philippines project a mean annual temperature increase of 0.9 to 1.1°C by the 2020s, and 1.8 to 2.5°C by 2050 under a medium high emissions scenario (SRES2).[51] These climate projections further indicate that a reduction in rainfall in most parts of the country during the summer season is expected. Yet, the country is expected to experience increases in both the frequency and intensity of extreme daily rainfall events.[52]

2.4 Food Production and Climate Change

Climate change poses significant risks for food security in the Philippines, particularly for agriculture and fisheries. Under current conditions natural climate variability has a large impact on agricultural productivity with the effects of El Niño being felt in various sectors of the economy: agriculture, environment, water resources, energy and health. The agricultural sector is most vulnerable to drought and changes in the southwest monsoon rainfall.[53] About thirteen million hectares of agricultural area produce a wide

A destroyed house on the outskirts of Tacloban on Leyte island. This region was the worst affected by the typhoon, causing widespread damage and loss of life. Caritas is responding by distributing food, shelter, hygiene kits and cooking utensils.

variety of fruits, grains and vegetables. More than half of this area is devoted to rice and corn, the Filipino staple foods. Corn and rice producing areas are vulnerable to El Niño.[54]

Coastal resources are highly vulnerable in the Philippines. Over 60 per cent of the population live by the coast, with the majority of these people depending on agriculture and fisheries for food and livelihoods.[55]

Resources on the coast will likely be severely impacted by global warming, particularly coral reefs which underpin fisheries in the country.

Sea levels are forecast to rise and some low-lying islands may be completely submerged.[56]

Climate variability also impacts heavily on fisheries. In El Niño years, when the Pacific Ocean warms, fish move to colder waters in search of food. An increase in the occurrence of El Niño events would therefore impact fish catch. Fish catch, which tends to be lower during dry (summer) months than during rainy months, will also be affected by the projected lengthening of the dry seasons.[57] Coastal flooding, coastal erosion, saltwater intrusion and drought may exacerbate food insecurity and habitat degradation in coastal regions, for example in Manila Bay.[58] Among the various socioeconomic groups in the Philippines, poor coastal families, specifically small scale fishermen and shellfish gatherers are the most vulnerable to these impacts, followed by the enterprising poor and the self-employed. Women within these socioeconomic groups are particularly vulnerable to food insecurity impacts.[59]

As noted above, increasing temperatures are expected to negatively impact on coral reefs, an important resource in small tropical islands and a source of well being for many island communities. Reefs play a significant role in supplying sediment to island shores and in dissipating wave energy thus reducing the potential foreshore erosion.[60] Coral reefs also provide habitat for a host of marine species upon which many island communities are dependent for subsistence foods, and underpin beach and reef-based tourism and economic activity. There is clear evidence that climate change will kill off living coral and consequently fishing production.[61] The impact of climate change in the Philippines could therefore lead to more malnutrition, higher poverty levels, and possibly, heightened social unrest and conflict in certain areas in the country due to loss of land.

It only took a few seconds to destroy a lifetime's work.

Gerardo and Jovita Amantillo were both at home when Typhoon Haiyan struck on November 8th, 2013. The couple, both aged 74, had been warned that a bad storm was on its way but nothing had prepared them for the intensity of what they faced.

The winds had been battering their home for several hours when suddenly the waves crashed down all around them, destroying their home and leaving Gerardo and Jovita fighting for their lives.

The strength of the waves carried Gerardo and Jovita out of their home. They survived only by clinging to the neighbour's roof – almost three metres off the ground.

"We held on to the roof," says Gerardo. "The only reason the roof was not blown away was because there were so many of us lying on it. After around two hours the winds died down and the water receded. Our house was completely gone."

Miraculously, they received only superficial wounds to their legs but were otherwise unharmed. However, sitting on Ormoc pier waiting for a boat to take them off Leyte island, which was the worst affected region of the Philippines, the couple has just one small bag of possessions. Everything else was lost.

"We stayed with neighbours for a few nights but we plan on living with our son for the next few months," says Gerardo. "I do not know when we will be able to move back."

Across the Philippines over 4 million people were displaced by Typhoon Haiyan. Approximately 400,000 are living in evacuation centres, with the rest sheltering with friends or family.

Trócaire is offering shelter and food to people who lost their homes, but also rebuilding affected areas so as people like Gerardo and Jovita can look forward to the day when they can return home.

2.5 Access to Water

Freshwater supply in small island environments continues to present challenges and in all previous IPCC reports fresh water supply in small islands has remained highly vulnerable.[62] Watersheds and river catchments are highly sensitive to rainfall variations. In the Philippines, rivers on volcanic and granitic islands have limited storage for water. In addition rivers on porous limestone and low atoll islands have minimal surface runoff and water rapidly percolates into the groundwater. Therefore, the projected changes in rainfall, with longer dry seasons and more intense rainfall in the wet season, are expected to create severe water shortages and stress both in quantity and quality. Increases in rainfall variability and longer dry periods will affect the amount of water in dams which provide irrigation services to farmers, especially those in rain fed areas, thereby, limiting agricultural production. The Fifth Assessment Report of the IPCC indicates that stress on water due to heavy rain and increases in temperature will increase the risk of diarrheal diseases among the resource poor.[63]

The effects of climate change on domestic water supply are compounded by governance and infrastructure challenges in the Philippines, adversely affecting access to safe water, especially in the rural areas. Although the joint Monitoring Programme for Water Supply and Sanitation indicates that access to improved water sources is being achieved and access to sanitation is on track, the country's water quality is greatly compromised.[64] Surface water and groundwater quality is deteriorating rapidly. Major pollution sources for surface and coastal waters in terms of Biological Oxygen Demand (BOD) load are point sources. Among non-pollution sources, agricultural runoff is the major source of pollution.[65] More intense rainfall will increase nutrient washout from agricultural land.

2.6 Gender

It is clear that climate variability has rapidly become a serious threat to human society and well being in the Philippines.[66] The country often experiences climate-related disasters, and both men and women have developed adaptation strategies that make them resilient to extreme weather events.[67] Available evidence shows that men and women adapt to flooding according to their traditional roles but women have extra new

roles and burdens in addition to farming roles and managing daily household welfare.[68] Contemporary studies indicate that often men occupy freer spaces in society, enabling them to cope with and recover from disasters much more easily than women, who occupy enclosed private spaces without windows of opportunity to adapt.[69] Even in their productive roles, women struggle to cope with and recover after disasters because they are marginalised in governance structures and have unequal access to entitlements as compared to male counterparts.[70]

In the Philippines women lack resources and power and usually take up roles that make them less mobile.[71] Although in the Philippines there is some transformation that may help women cope with climate related extreme events, literature shows that culturally, they continue to have less power over family finances and other assets.[72] There is gender bias in power and decision-making that limits engagement in community development and politics by women, and is exacerbated by many cultural restrictions on mobility and education.[73] Women in the countryside have lower incomes and are more likely to be economically dependent which compromises their adaptive capacity.[74]

Following disasters, the vulnerabilities of poor women are exacerbated, leaving them more at risk to the threat of trafficking. According to anecdotal evidence, there is an increase in human trafficking in the wake of disasters.

2.7 Migration

Literature indicates that the Filipinos have always migrated seeking employment globally. With future climate change projections and intensifying disasters, however, migration is likely to increase. Weather related disasters have forced huge numbers of Filipinos to leave their homes. Gerardo and Jovita Amantillo, featured in the story opposite were just two of the 4 million displaced by Typhoon Haiyan. Following disasters, many Filipinos have migrated to seek employment and support their families through remittances as a way of coping.

Internal migration in the Philippines is driven by socio-economic factors. The general trends of migration show that poor people move away from areas of high risk, especially into cities. Urban-rural migration is common, with people moving into cities where services and infrastructure are more developed.[75] This is exacerbated by the impact of climate variability on the agricultural sector. Crop and livestock producers abandon agriculture because of decreasing yields and migrate to urban areas to seek new job opportunities.[76] These shifts in population result in additional pressures on already under-resourced and vulnerable urban areas, particularly in mega cities.

2.8 Health

Globally, the effects of climate change on human health will be both direct and indirect, and are expected to exacerbate existing health risks, especially in the most vulnerable communities where the burden of disease is already high.[77] Direct impacts of climate change on health in the Philippines relate to increased incidences of floods and droughts, and also typhoons. Incremental increases in temperatures and changing rainfall regimes could trigger adverse health impacts; in particular, the outbreak and spread of water-based and vector-borne diseases leading to higher morbidity and mortality. For example, in addition to the direct loss of life caused by Typhoon Haiyan in the Philippines, the storm was also associated with waterborne illnesses.[78]

2.9 Economic impacts

Between 1998 and 2009 12.1 million were exposed to extreme weather events, with damages accounting for a 23.9 per cent loss in GDP.[79]

Under a medium high emissions scenario, losses of up to 2.2 per cent of GDP are projected annually by 2100 due to climate change impacts on agriculture.[80] Projected losses are well above the world's projected mean GDP loss of 0.6 per cent each year by 2100 due to market impact alone. Losses connected to agriculture could reach 5.7 per cent of GDP and 6.7 per cent of the GDP if catastrophic risks are also taken into account.

2.10 Looking to the future

The future for the Philippines looks challenging - eroding coast lines and destruction of coral reefs leading to loss of livelihoods, increased risk of typhoons which already cause widespread destruction on a regular basis, and increased risk of climate variability with serious implications for

agricultural production.

Even with these seemingly overwhelming challenges, there is hope. Philippines Climate Change Commissioner Naderev 'Yeb' Saño says:

'Climate change is our opportunity to make the Philippines a better nation. Even if it is a huge problem, it still has a positive side to it because it can change the way we govern our country… This is a war and we will survive because there is no choice.'[81]

With the help of the global community, the Philippines can avoid the worst effects of climate change, and adapt to the challenges which will inevitably arise. In partnership with Caritas Philippines and linking with Irish missionaries and other local partners, Trócaire worked in the Philippines for forty years before transitioning out of the country in 2012. However, following typhoon Haiyan and the Irish public's generosity, which provided over €3m to support victims of the typhoon, Trócaire is, once again, assisting Filipino communities to cope with their current situation, and to build strength and resilience against future crises.

Immediately after the typhoon, Trócaire supported partners across the worst hit areas in the Visayas to provide food, essential household items, essential hygiene-maintenance supplies, cash grants, emergency shelter kits and psychosocial assistance. Through these partners and as part of a broader Caritas response, Trócaire reached over 300,000 people.

Today, Trócaire and partners have moved from an emergency response to an early recovery and rehabilitation response with the aim of leaving the Philippines with stronger and more disaster-resilient communities. This is being done by ensuring communities re-establish their lives and create a better future by building safe and disaster resilient homes, schools, sanitary facilities and livelihoods. Trócaire and partners are ensuring mitigation of future risk is inbuilt into the recovery effort and that the capacities of communities and local organisations are also strengthened. Meanwhile, advocacy initiatives to tackle underlying vulnerabilities within disaster-prone areas are being encouraged and supported.

The scene on Ormoc pier, Leyet island, as people try to leave the island following the devastating typhoon, November 2013.

2.11 Summary of Findings

The Philippines is experiencing hotter days and fewer cold nights, with overall mean temperatures increasing by 0.64°C over the past fifty years. Increasing trends in the number of "no rain" days have been observed over western Philippines while significant decreasing trends are evident in the total southwest monsoon rainfall in the western half of the country.

Significant warming is predicted for the region of south east Asia. With unabated emissions an average warming of approximately 4°C is simulated across all models by the end of the century. Rainfall projections for the region show a large range of changes over the coming century, with the direction of change uncertain. Country level studies indicate a reduction in rainfall in most parts of the country during the dry season and an increase in rainfall during the monsoon seasons.

The country is expected to experience increases in both the frequency and intensity of extreme daily rainfall events. Lengthening of seasonal dry periods, and an increasing frequency of droughts are projected for the region. These more intense wet seasons and longer dry seasons may have serious implications for food production, coastal system services including fisheries, human settlement and health, livelihoods and socio-economic development.

Under a medium high emissions scenario, an estimated loss of up to 2.2 per cent of gross domestic product (GDP) is projected annually by 2100 due to climate change impacts on agriculture.

Climate change poses significant risks for food security in the Philippines, particularly for agriculture and fisheries. Under current conditions natural climate variability has a large impact on agricultural productivity with the effects of El Niño being felt in various sectors of the economy. The agricultural sector is most vulnerable to drought and changes in the southwest monsoon rainfall.

Projected changes in rainfall are expected to create severe water shortages and stress both in quantity and quality. Increases in rainfall variability and longer dry periods will affect the amount of water in dams which provide irrigation services to farmers, especially those in rain fed areas.

The effects of climate change on human health will be both direct and indirect, and are expected to exacerbate existing health risks, especially in the most vulnerable communities where the burden of disease is already high. Direct impacts of climate change on health in the Philippines relate to an increased incidence of floods and droughts. Increases in temperatures and changing rainfall regimes could trigger adverse health impacts; in particular, the outbreak and spread of water-based and vector-borne diseases leading to higher morbidity and mortality.

Research asserts that women are disproportionately impacted by disasters, severe weather events, and climate change because of cultural norms and the inequitable distribution of roles, resources, and power, especially in developing countries. In the Philippines there is gender bias in power and decision-making that limits engagement in community development and politics by women, and is exacerbated by many cultural restrictions on mobility and education.

Migration and relocation are important coping mechanisms for communities living in disaster vulnerable areas. The projected impacts of climate change on agriculture and coastal resources may influence migration. Following weather related disasters many Filipinos have migrated to seek employment and support their families through remittances as a way of coping. With future climate change projections and intensifying disasters, migration as adaptation is likely to increase.

3: Honduras

In brief: Highly vulnerable to extreme weather events, including tropical hurricanes.

Right Now: currently rated the worst-affected country in the world by extreme weather events.

Future climate change risks: Increased water scarcity and contamination, reduced staple food production yields.

Emissions of CO_2 per capita: 1.1 metric tons – **almost eight times less than Ireland**

3.1 Introduction

In global terms, Central America and Honduras are hotspots for adverse climate change impacts, consistently ranking highly on global assessments of climate change vulnerability. Honduras is one of the poorest countries in Central America. Currently, about one million households live below the poverty line.[82] Poverty is greatest in rural areas and closely related to land scarcity and governance of land distribution. Less than 2 per cent of farmers own more than 40 per cent of farmland and an estimated 300,000 families are landless.

Like the Philippines, Honduras is vulnerable to extreme weather events, including tropical storms. Taking into account casualties and GDP losses, Honduras was the worst-affected country in the world by the impacts of extreme weather events in the period from 1993 to 2012.[83] Over these 20 years, at least 65 extreme weather events occurred in Honduras, leading to annual economic losses of over 2.6 per cent of GDP.[84] Six of the twelve strongest hurricanes of the 20th Century impacted Honduras, the most notable being Hurricane Mitch in 1998 resulting in more than 10,000 deaths, devastation of the country's infrastructure and drinking water network and extensive crop losses.[85]

Vulnerability to extremes has consistently increased over recent years as a result of pervasive and structural poverty, extremely high levels of inequality in terms of income distribution, the impacts of persistent extreme events and limited access to critical infrastructure and basic services such as water supply.

3.2 Observed climate variability and change

Honduras has seen increases in the number of warm days and decreases in the number of cold days.[86] Extremely warm temperatures occur more frequently while extremely cold temperature events have decreased.[87] There have not been significant increases in the total amount of rainfall, but rainfall is intensifying, with more wet and very wet days.[88] This leads to risks of both floods and droughts, as more of the total rainfall falls as extreme events. Drought conditions affect Honduras with high frequency with negative social and economic impacts. Rural populations in central and southern Honduras are frequently subjected to food insecurity due to drought conditions linked to El Niño. Further warming and changes in the intensity and variability of precipitation may pose a serious threat to biodiversity, water resources and related socio-economic sectors for Honduras and throughout Central America.[89]

3.3 Projections of future climate change

Figure 1 shows the changes in annual temperature and precipitation for Central America. Under a 'business as usual' scenario, with no reduction in emissions, the average projection is for temperature increases of approximately 4°C by the end of the century. Some individual models show increases of up to 6°C above current temperatures. With ambitious reductions in global emissions the central estimate of warming is approximately 1°C with projections from individual models ranging from slight increases to increases of up to 2°C by the end of the century.

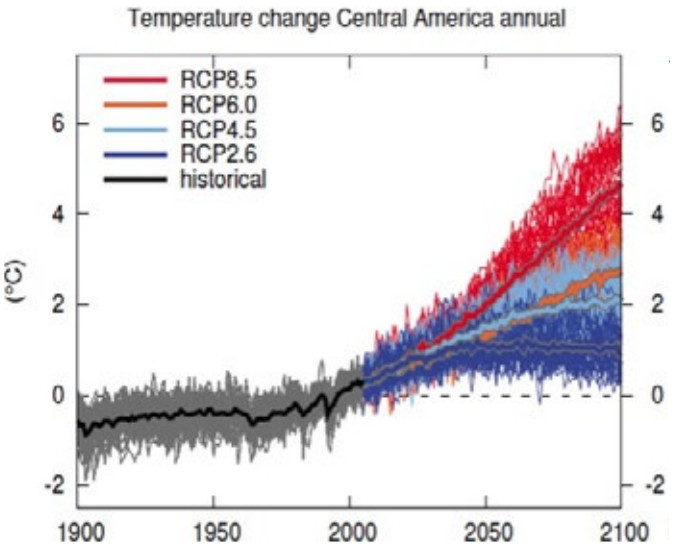


Figure 1 Projected changes in annual temperature relative to 1986-2005 under different greenhouse gas emissions pathways for Central America. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin lines denote a single model projection; thick lines show the mean simulation for multiple climate models. (Source; IPCC, 2014)

Decreases in rainfall are expected throughout Central America under business as usual scenarios – by as much as 40 per cent according to some projections. Large reductions in rainfall during the rainy season are projected, with negative impacts for the regions high value ecosystems.[90]

Droughts are very likely to intensify and become more prolonged in the 21st century in Central America, due to reduced rainfall and/or increased evapotranspiration.[91] Such changes in dryness will have implications for crop production on which the economy of Honduras is heavily dependent. Increases in sea surface temperatures in the region are likely to affect monsoonal rainfall upon which agriculture, water and energy depends. Projected sea level rise will compound the impacts of tropical storms where storm surges have been associated with great loss during past events. Increases in intense rainfall events will also increase the likelihood of mudslides, debris flows and slope failures to which there is high exposure and vulnerability in many parts of Honduras.[92]

One study looks at coping with climate variability and change in the city of La Ceiba in Honduras, highlighting the high risks associated with flooding due to lack of city drainage infrastructure, river flooding from the Rio Cangrejal and flooding from heavy rainfall and storm surges associated with hurricanes.[93] An increase of 13 per cent in the volume of heavy rainfall is associated with high emissions for the 2050s which would result in increasingly common flood flows by about 60 per cent. With more intense hurricanes the flow of the Rio Cangrejal could increase by one-third during storms. Projected rapid development in coastal zones is also likely to increase the risks of sea level rise and storm surges.[94]

Boy wades through flood water in northern Honduras, 2011.

3.4 Food Production and Climate Change

Maize and beans are the core components of diets and culture in Honduras with most smallholder farmers engaged in production of these crops. Overall yields are low. Land degradation coupled with climate change and limited access to credit and basic services are likely to adversely impact agriculture in Honduras. Across El Salvador, Guatemala, Honduras and Nicaragua, losses in the gross production value of maize of $120 million USD are expected by 2025.[95] These losses are expected for all global emissions scenarios, since the beneficial effects of reduced emissions would not be seen until after 2050. Maize is highly sensitive to water shortages with decreases in rainfall and more intense and prolonged drought likely to be problematic for agriculture.

Without adaptation and mitigation further losses in production will pose challenges to the food security of many of the rural poor. All parts of the country are expected to experience yield losses in excess of at least 10 per cent by 2020.[96]

Beans are very sensitive to drought conditions and temperature extremes, especially night time temperatures which reduce flowering and overall production. With temperature rises of just 2˚C by the end of the century, bean production in Honduras could be reduced by more than 20 per cent. Rural households will have an especially hard time coping with climate change where infrastructure (equipment and roads) is inadequate, access to natural resources (water and land) is limited, financial resources are scarce, and social capital is very weak.[97]

Losses from maize production in Honduras could amount to 120,000 tonnes annually, valued at $40 million USD by 2025.[98]

A further study estimated the sensitivity of maize and beans, and small-scale cultivation of these staple crops, to projected increases in temperatures and reductions in rainfall.[99] Their results indicate significant reductions in yields with climate change. Maize yields are expected to decrease by 4 per cent by 2025, and by 12 per cent by 2050, compared with 2000. Average bean yields are expected to decrease by 11 per cent by 2025 and 32 per cent by 2050. Yields in lowland areas were more affected by increasing temperatures. Increasing instability of rainfall patterns will render agricultural planning more difficult and crop losses more probable.[100]

3.5 Access to water

Water resources in Honduras are already threatened by overexploitation, as well as by contamination from diverse sources that include waste, agricultural drainage, surface runoff and mining leachates.[101] Access to treated drinking water is limited in many rural parts of Honduras. In urban areas, particularly in the capital Tegucigalpa, population growth as a result of rural-urban migration is increasing pressures on water supply where water rationing is in effect throughout the year.

Current pressures are likely to be exacerbated with climate change, leading to severe water scarcity. Reductions in annual rainfall, particularly in the northwest and southeast of the country pose

Edwin Ramos is a carpenter, a farmer and an activist

He thinks each of these activities is equally important; farming feeds his family, carpentry provides an income, while being a member of a local cooperative provided him with an opportunity to own his own land.

In the Aguan region, it is rare for people to own their own land. Edwin got some land through a collective of campesino groups that negotiated ownership rights to local land from the state. Gaining access to this land has made all the difference and means he can raise pigs and grow crops such as yuca, pineapple and beans. Edwin knows that having a variety of ways of earning a living is important in a region as vulnerable to weather extremes as the Aguan Valley.

When Hurricane Mitch hit in 1998 Edwin worked on the plantations and had little to support him when the work stopped as a result of the hurricane. In 2005 when Hurricanes Beta and Gama hit, Edwin still worked on the plantations but because he had some land by then he had some food stored up which helped get his family through the difficult times. By 2008, Edwin had his carpentry business, pig and crops which meant he was in an even better position if a storm hit. He says 'We usually get by much better during storms if we have stored maize and beans'. Having some land of his own has afforded Edwin and his family a more secure future in the face of an uncertain climate.

significant challenges for water supply. For the second half of this century, runoff which is critical for replenishing rivers may reduce by as much as 30 per cent in dry seasons with significant knock on effects for water supply, particularly in urban areas.[102] For the Lempa River basin, one of the largest basins in Central America, covering portions of Guatemala, Honduras and El Salvador research has shown that future climate projections (increase in evaporation and reduction in precipitation) imply a reduction of 20 per cent in inflows to major reservoirs in this system with a potential reduction in hydropower capacity of up to 53 per cent by 2070-2099.[103]

3.6 Gender

Research suggests that, given the opportunity, women are more likely to receive and act on early warnings.[104] The power of involving women in disaster response is illustrated by the story of the municipality of La Masica which reported no deaths following Hurricane Mitch, unlike other municipalities in the northern Atlantida department.[105] Six months before the disaster, a community emergency preparedness plan had been put in place, and the community had decided that men and women should participate equally in all hazard management activities. When Mitch struck, women participated alongside men in all aspects of the relief operations – including stepping in when men abandoned continuous monitoring of the early warning system.[106] Women in La Masica reported a lower incidence of depression following the disaster, most likely because of their active role.[107]

3.7 Migration

Increases in land scarcity, coupled with displacement following extreme events are currently changing migration patterns in parts of Honduras. Where temporary migration was the norm, in building resource bases before returning to rural villages, contemporary trends are showing more permanent migration driven by changing power structures around land tenure, economic decline and extreme weather events.[108]

3.8 Health

Apart from the danger of loss of life associated with increased flooding and storms, rising temperatures and increases in rainfall intensity have implications for the spread of vector-borne diseases. The aftermath of Hurricane Mitch saw outbreaks of malaria, dengue fever and cholera. Climate variability and change more generally have also been linked to outbreaks of dengue fever in Honduras.[109] In 2013, Honduras declared a national state of emergency in response to an outbreak of dengue fever which affected over 12,000 people.

3.9 Economic impacts

In Honduras, financial losses due to disasters over the past 30 years are estimated at 4.7 billion USD, representing approximately 50 per cent of losses throughout Central America.[110] Over the 20th century hurricanes caused direct and indirect damages to Honduras of over $5 billion USD, equivalent to 95 per cent of Honduras' GDP in 1998.[111] Impacts of such extreme events are felt most strongly by the poor. Studies in the aftermath of Mitch indicate that among rural households greatest losses were experienced through loss of crops, household assets and loss of wages or income. Relief amounted to less than one-tenth of the losses incurred by households.[112] Such extreme events can push households into poverty traps from which recovery can be difficult, and can greatly weaken their capacity to deal with future extremes.[113]

3.10 Looking to the future

Climate variability has always presented challenges in Honduras, and climate change is expected to greatly intensify these problems. The World Bank estimates that 62 per cent of the territory of Honduras and 92 per cent of the total population are at risk of two or more natural hazards, placing it in the world's top ten countries at risk from natural disasters.[114] However, by strengthening communities and providing effective response, such as in La Masica where women and men worked together during Hurricane Mitch, resilience to climate related extremes can be improved.

In Honduras, Trócaire is focused on helping local farming communities build sustainable food production systems. These are designed with

Constantino Varela of the community Cuatro Esquinas, southern Honduras, shows how water from an irrigation system is helping his crops grow.

climate change in mind, and aim to reduce the risk and potential impact of disasters. Trócaire also works to promote access to land and other natural resources for communities who are facing resource exploitation and expropriation. Having access to natural resources is essential to ensure that communities can build a secure and resilient livelihood in the face of climate change. This work includes legal support for land titling, and supporting human rights defenders to protect community land, water and forest rights. Advocacy on policies including climate change policy and resource rights is a core part of the programme, including in conjunction with other countries in the region. Trócaire recently worked with other NGOs to fund a regional meeting of civil society organisations in Central America, which produced an advocacy paper ahead of the next Climate Change Conference in Lima in December 2014.

3.11 Summary of Findings

The occurrence of extreme warm maximum and minimum temperatures has increased while extremely cold temperature events have decreased. Despite the large spatial variability in precipitation change, observations indicate that although no significant increases in the total amount are found, rainfall events are intensifying and the contribution of wet and very wet days are enlarging

Simulations of future climate over the coming century indicate temperature increases under all greenhouse gas concentration pathways. Decreases in rainfall are expected throughout Central America under unabated emissions scenarios. There is high confidence that droughts will intensify and become more prolonged. Increases in sea surface temperatures in the region are likely to affect monsoonal rainfall upon which agriculture, water and energy depends. Projected sea level rise will compound the impacts of tropical cyclones where storm surges have been associated with great loss during past events.

Under climate change, an increasing frequency and intensity of climate extremes, together with greater climatic variability will increase the social, economic and environmental risks posed by disasters in Honduras.

Economic losses associated with extreme events are likely to be high in Honduras. Financial losses for the country due to disasters over the past 30 years are estimated at 4.7 billion USD, representing approximately 50 per cent of losses throughout Central America. Over the 20th century hurricanes caused direct and indirect damages to Honduras of over $5 billion USD, equivalent to 95 per cent of Honduras' GDP in 1998.

Maize is highly sensitive to water shortages with decreases in rainfall and more intense and prolonged drought likely to be problematic for agriculture. All parts of the country are expected to experience maize yield losses in excess of 10 per cent by 2020. Beans, the other staple crop is also likely to be negatively impacted. Increasing instability of rainfall patterns will render agricultural planning more difficult and crop losses more probable.

Honduras faces considerable water scarcity challenges in the near future. Current water supply is affected by high levels of land degradation and deforestation with current pressures likely to be exacerbated with climate change. Reductions in annual rainfall, particularly in the northwest and southeast of the country pose significant challenges for water supply. Reductions in rainfall will likely imply a reduction in inflows to major reservoirs with a potential reduction in hydropower capacity.

Very little research has been conducted on the health implications of climate change in Honduras. Increases in the intensity or frequency of extreme events would be associated with direct and indirect impacts on health. Research has also shown linkages between climate variability and outbreaks of Dengue fever in Honduras.

Research suggests that, given the opportunity, women are more likely to receive and act on early warnings. The equal participation of women in hazard management activities in one community yielded positive results during Hurricane Mitch where, unlike neighbouring municipalities, no deaths were recorded and a lower incidence of depression was reported following the disaster.

In Honduras, issues of land tenure and access to resources influence adaptive migration patterns. Increases in land scarcity, coupled with displacement following extreme events is currently changing migration patterns in parts of Honduras. While this is not directly associated with climate change per se, increases in extreme events will add complexity to migration patterns.

4: Kenya

In brief: Vulnerable to frequent droughts in some regions, flooding likely in others.

Right Now: Endemic severe droughts have left communities struggling to cope with repeated shocks to their livelihoods.

Future climate change risks: A sea level rise of just 0.3 metres would render 17 per cent of Mombasa uninhabitable.

Emissions of CO_2 per capita: 0.3 metric tons – **almost thirty times less than Ireland**

4.1 Introduction

Kenya's socio-economic development is already highly susceptible to climate variability and climate-related extreme events.[115]Agriculture accounts for 67 per cent of employment, and 30 per cent of the total population are pastoralists in semi-arid areas. Approximately 85 per cent of the land area is classified as arid or semi-arid, dependent on short rainy seasons for water.[116]If, as the science indicates, we can expect longer dry seasons and more rainfall falling in shorter periods of time, the effect on water availability and quality will be severe.

Climate change projections indicate that yields of staple crops of maize and beans will decline over the coming decades and that Kenyans will face increasingly serious food security issues in the next 40 years due to water stress and droughts in semi-arid regions. In other parts of the country, more extreme rainfall events makes flooding likely, which will also impact on crop and livestock production.[117] Both droughts and floods are expected to increase in frequency and result in the displacement of communities and migration of pastoralists resulting in conflicts over natural resources. In particular, areas in which agriculture is currently marginal and dominated by pastoralism are the most vulnerable to changing climatic conditions. Each disaster takes its toll on community resilience and adaptive capacity, making successive disasters increasingly difficult to contend with.

4.2 Observed Climate Variability and Change

Evidence of climate change is 'unmistakeable' according to Kenya's government, citing rainfall that has become irregular and unpredictable, extreme and harsh weather that is now the norm, and some regions experiencing frequent droughts during the long dry season while others experiencing severe floods during the short rains.[118]Kenya's National Climate Change Response Strategy highlights that observed temperature trends between 1960-2006 show general warming over land locations except for the coastal zone that shows cooling trends. The minimum temperature has risen by 0.7 – 2.0 °C and the maximum by 0.2 – 1.3 °C, depending on the season and the region. In areas near the Indian Ocean, maximum temperatures have risen much like in other areas but minimum temperatures have either not changed or become slightly lower.[119]

The Fourth and the Fifth Assessment Reports of the Intergovernmental Panel on Climate Change point to the occurrence of extreme precipitation changes over Eastern Africa such as droughts and heavy rainfall.[120]Kenya has been vulnerable to precipitation extremes events: 2003 was the wettest in 70 years in some parts of Kenya. The years 2003-2006 were marked by drought with the country receiving only 50 per cent of expected rainfall. Early 2010 saw serious flooding after weeks of heavy rainfall and was identified as the worst flood in more than a decade. Drought conditions between 2008-2011 badly affected pastoralist communities in the north east of Kenya, where some 70 per cent of livestock died.[121]

Research has indicated that there has been an increase in seasonal mean temperature in many areas of Kenya over the last 50 years.[122] In addition, warming of the near surface temperature and an increase in the frequency of extreme warm events has been observed for countries bordering

the western Indian Ocean between 1961 and 2008.[123]The frequency of dry years is increasing while rainfall has declined significantly since the mid-1970s. In particular, reductions in rainfall and increases in the frequency of dry years threaten critical surplus crop growing areas in central Kenya. If such trends continue the amount of prime arable land could diminish substantially.[124]

4.3 Projections of Future Climate Change

With continued emissions of greenhouse gases, global climate models show warming projected for all seasons in all regions of Kenya, except for coastal regions.[125]Results for Kenya show that, compared to the 1961-1990 average, a medium high emissions scenario produces warming of around 4°C by the end of the century in both seasons.[126] This is consistent with projections from the most recent IPCC report, which indicate considerable warming for the region of east Africa, with the degree of warming greatest for higher greenhouse gas emissions pathways (Figure 1). Under a business as usual scenario, with no policy changes to reduce global emissions, the average warming across all models shows temperature increases of approximately 4.5°C by the end of the century. When the range of projections from individual models is examined, some show temperature increases approaching and exceeding 6°C by the same period. Under ambitious global greenhouse gas emission reductions (represented by RCP2.6) temperatures are expected to increase by approximately 1°C by the end of the century, however, even under this ambitious scenario increases in mean annual temperature above current conditions still approach 2°C for some models.

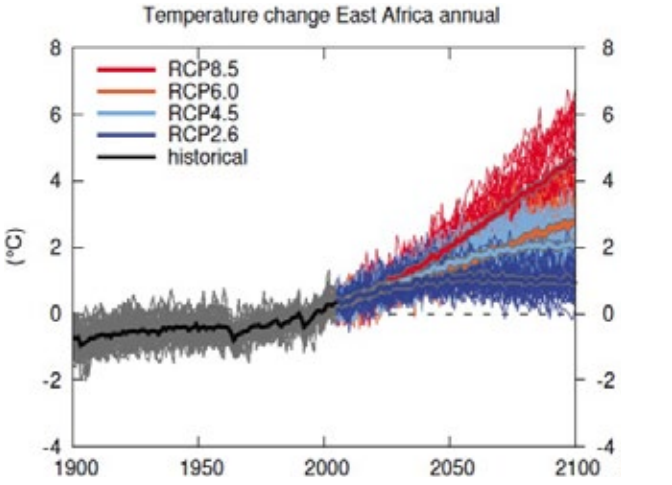


Figure 1 Projected changes in annual temperature relative to 1986-2005 under different greenhouse gas emissions pathways for East Africa. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin lines denote a single model projection; thick lines show the mean simulation for multiple climate models. (Source; IPCC, 2014)

It is uncertain whether total rainfall will increase or decrease but, in common with other regions, it is expected that rain is more likely to fall as extreme events. Kenya is projected to experience increases in heavy precipitation with high certainty alongside an increase in the number of extreme wet days by the mid-21st century.[127] Increases in rainfall extremes are likely to translate into greater flood and drought risks nationally affecting disaster management and local livelihoods.

Sea level rise presents a significant risk to Kenya's second largest city Mombasa which is also the region's largest sea port. The city has very high levels of poverty.

Sea level rise of only 0.3 metres would submerge an estimated 17 per cent of Mombasa, with large areas becoming uninhabitable due to flooding, or will become agriculturally unsustainable due to salt water flooding.[128]

Impacts of sea level rise on Mombasa are likely to be felt nationally and across the region due to its strategic economic importance. The most recent IPCC report indicates that over the period 1901-2010 global mean sea level rose by approximately 0.19 metres.[129] Under all greenhouse gas emissions scenarios sea level will continue to rise over the coming century. For the most ambitious scenario (RCP2.6) sea level rise by the end of the century relative to the period 1981-2005 will likely

be 0.26-0.55 metres. For the unabated emissions scenario, estimated sea level rise for 2100 is 0.52 – 0.98 metres.[130]

4.4 Food Production and Climate Change

In Kenya climate change is having far reaching negative effects on the already precarious food security situation for both crop cultivators and pastoralists.[131] In recent years droughts have become frequent, reducing production of maize, the staple food crop, sugarcane and coffee, worsening Kenya's food security.[132]

Extreme precipitation events including drought have the ability to create poverty traps. For instance, crop failures in 2009 placed an estimated 10 million Kenyans at risk of hunger, malnutrition and starvation.[133] The FAO has reported that in 2011 maize production in the Eastern Province of Kenya dropped by 8 per cent due to a poor harvest caused by early cessation of the 2011 short rains, attributed to changing climatic conditions.[134] At the other end of the spectrum, increases in floods are expected to exert considerable impacts on food security, for example, heavy rains in 2002 caused floods on farms and mudslides, which forced tens of thousands to leave their homes in Kenya. Such extremes of drought and deluge are likely to increase over the coming century.

Climate change is expected to increase agricultural pests and diseases, particularly ticks and tick-borne diseases in East Africa.[135] Changing weather patterns could expand the distribution of ticks causing animal disease in particular Theileriosis (East Coast Fever) disease, which causes anaemia and skin damage that expose cattle to secondary infections.[136] Ticks and tick-borne diseases will specifically exacerbate the growing food insecurity among the pastoral community in Kenya.[137]

4.5 Access to water

Rising temperatures, associated increases in evaporation losses and changes in rainfall, together with increases in the frequency and magnitude of extreme events are expected to impact negatively on water resources in eastern Africa.[138] In Kenya water supplies are projected to be affected by increases in temperature and local variability of precipitation.[139] Most water for domestic use and other uses is derived from rivers whose recharge depends on rainfall.[140] Extreme climate change events are already changing the water cycle that in turn affects water availability and runoff and thus may affect the recharge of rivers across Kenya.[141]

Kenya's per capita water availability is very low and likely to decrease with climate change in combination with population growth and environmental degradation.[142] At the present time, 35 per cent of people are reliant on drinking from unimproved water sources such as ponds, streams and rivers that are often contaminated.[143]Meanwhile, water demand is predicted to rise by 2020.[144]

Access to water is most difficult in arid and semi-arid regions of Kenya where livelihoods are derived from livestock keeping. Any reductions in surface run-off are likely to impact negatively on pastoral livelihoods through drying of water sources.[145] These losses are likely to be exacerbated by climate variability and change over the coming decades and, consequently, increase pressure on water resources.[146]

4.6 Gender

Kenya has made considerable advances in both climate change strategy, and gender mainstreaming – but there is very little overlap between the two.[147] Gender considerations in climate change policy are rare – despite evidence of the ways in which climate change is affecting women in particular. Changes in water availability under climate change are likely to exacerbate existing burdens on women in relation to water collection. Women are more affected when the quantity of water and/or its accessibility changes. Research also shows the extra burden carried by women in the aftermath of disasters deteriorate women's adaptive capacity in Kenya.[148]

A study of pastoralists in the remote Turkana province of Kenya clearly shows the gender dimension to climate-change related conflict and food insecurity. Women are particularly vulnerable in times of conflict, being less likely to flee during raids given their responsibility towards their children.[149]If a woman survives and her husband does not, she has poorer customary rights to the land, water and livestock.

Thiga Nanuaga is still getting used to seeing green fields again.

The 65-year-old farmer has lived his whole life near to the village of Chuka in the Tharaka district of central Kenya, but increased drought over recent years was making it more difficult to survive.

Farmers in this region have traditionally relied on two rainy seasons each year. With no other way of getting water to their land, the rain was vital if crops were to grow. When the rains came, farmers could grow enough food to sustain their families through the dry period. When the rains did not come, however, people went hungry.

"We had to wait for the rain for our crops to grow," explains Thiga. "The rains are disappearing so it was getting more difficult every year. Life was very hard. We experienced hunger very often."

Thiga, who lives with his wife, Alice, and their two young children, received a lifeline earlier this year when his farm was connected to a Trócaire-funded irrigation project which brings water directly from a river to over 1,400 farms in the area. The irrigation project means that people are no longer reliant on the rain for their crops.

"The irrigation has made a big difference," he says, proudly displaying his thriving crops. "We don't have to wait for the rain any more so we can plant all year round. We are growing crops throughout the year."

The irrigation project has transformed this community. However, across Kenya millions of farmers are still reliant on rain to grow crops. With rains becoming more erratic and less predictable, hunger is on the rise.

"The rains are getting less by the year," says Thiga. "When I was young there was plenty of rain but not anymore. It is going to be very difficult for people who do not have irrigation. I do not know how they will continue."

4.7 Migration

Rural-urban migration in Kenya is accelerated during periods of drought such as in 2008-2011.[150]During these drought conditions many pastoralists migrated to peri-urban areas increasing significantly their vulnerability and dependency on food aid.[151]

For pastoralists, migration is influenced by livestock deaths and acute food shortage due to depletion of pasture and water for livestock. For example, during the severe droughts in 2000, the Maasai pastoralists moved as far as the slopes of Mount Kenya (approximate distance of 29 km) and the Aberdare ranges (approximate distance of 38 km) in search of pasture and returned to their base afterwards.[152]Conflicts that are sparked by dwindling pasture and water resources also contribute to migration. In the event that - pastoralists lose their herd, they often migrate to peri-urban and urban areas to seek alternative livelihoods. Research shows that migration has increased school drop-outs significantly with school going children migrating with families in search of food, water and pasture for their livestock.[153] An increased incidence of droughts under climate change is likely to increase rural-urban migration and exacerbate urban vulnerability.

4.8 Health

Malaria is a major cause of death in Kenya and has a large negative impact on farm labour. Women and children are particularly vulnerable.

Consensus is growing in Kenya that the malaria epidemic is connected to changing climate conditions.[154]

Highland areas, especially in East Africa, will likely experience increased malaria epidemics as temperatures increase and areas above 2,000m, with temperatures currently too low to support

malaria transmission are affected.[155]One study of Wajir County in Kenya showed that extreme climate events were associated with a large malaria epidemic in 1997/1998 and 2006/2007, resulting in high admissions to Wajir Hospital and a weekly malaria incidence of 40–55 cases per 1000 population per week in all persons and children.[156]

Research also argues that climate change is expected to increase stunting among children in the country.[157] The poorest people that depend on locally grown crops will disproportionately suffer with increased health risks likely to compromise labour needed for crop and livestock production. Rift Valley fever (RVF) epidemics in Kenya are associated with precipitation and temperature.[158]Projected climate change could further exacerbate its incidence and spread. In 2006–2007 uninterrupted rainfall and the worst flooding in the county for over 50 years, was linked to an outbreak of RVF in the county.[159]

4.9 Economic impacts

Climate change impacts in Kenya could threaten past development gains and constrain future economic progress. Periodic floods and droughts cause major macro-economic costs and reductions in economic growth. Future climate change will likely lead to additional and potentially very large economic costs. Additional net economic costs (on top of existing climate variability) could be equivalent to a loss of almost 3 per cent of GDP each year by 2030 in Kenya.[160]Costs include potential threats to coastal zones (sea-level rise), health burdens, energy demand, infrastructure, water resources, agriculture and loss of ecosystem services. While the costs of adaptation are only emerging, an initial estimate of immediate needs for addressing current climate as well as preparing for future climate change for Kenya is $500 million / year (for 2012).[161] The cost of adaptation by 2030 will increase: an upper estimate likely to be in the range of $1 to 2 billion / year.[162]

4.10 Looking to the future

As droughts occur with greater and greater frequency in Kenya, continuous preparedness and adaptation measures are needed for communities to be able to cope. Trócaire's programme in Kenya works to build community resilience, which involves improving management of natural resources, community-managed disaster risk reduction, protection of the environment and advocating for favourable policies, including climate change policies. The programme focuses on improving food security, promoting the sustainable management of natural resources for improved livelihood security and advocating for policies, laws and institutions that support sustainable livelihoods. Recent successes include increasing the diversity of livelihoods and food groups, reducing the distance to water and establishing and working with community-based groups, such as Natural Resource Management and Community Managed Disaster Risk Reduction committees, and linking them to government structures and systems. The picture above shows Thiga Nanuaga's green fields- his farm was connected to a Trócaire-funded irrigation project benefiting 1,400 farms in his area.

Kenya is moving in the right direction in creating an enabling environment to respond to climate change, and Trócaire partners are active participants in this process. Partners have contributed to developments in Climate Change Policy, the Community Land Policy and the Forest Act, which are integral to ensuring people can access the natural resources such as land and forestry that they need to build resilience and sustainable livelihoods.

An irrigated field stands beside land that has not received irrigation. The increasingly erratic nature of rainfall in central Kenya means that farmers are struggling to survive without irrigation.

4.11 Summary of Findings

There has been an increase in seasonal mean temperature in many areas of Kenya over the last 50 years. An increase in the frequency of extreme warm events has been observed for the region between 1961 and 2008. Observational evidence shows that the frequency of dry years is increasing while rainfall has declined significantly since the mid-1970s.

Warming is projected for all seasons in all regions of Kenya, except for coastal regions. Under a business as usual scenario, the average warming across all models shows temperature increases of approximately 4.5°C by the end of the century. Sea level rise presents a significant risk to Kenya's second largest city Mombasa which is also the region's largest sea port.

Kenya is projected to experience increases in heavy precipitation with high certainty alongside an increase in the number of extreme wet days by the mid-21st century. Increases in rainfall extremes are likely to translate into rising flood and drought risks for Kenya with implications for disaster management, development planning and local livelihoods.

Net economic costs of climate change could be equivalent to a loss of almost 3 per cent of GDP each year by 2030 in Kenya. Costs include potential threats to coastal zones (sea-level rise), health burdens, energy demand, infrastructure, water resources, agriculture and loss of ecosystem services. While the costs of adaptation are only emerging, an initial estimate of immediate needs for addressing current climate as well as preparing for future climate change for Kenya is $500 million / year.

In Kenya climate change is having far reaching negative effects on the already precarious food security situation for both crop cultivators and pastoralists. Climate change is expected to increase agricultural pests and diseases, particularly ticks and tick-borne diseases in East Africa.

Rising temperatures, associated increases in evaporation losses and changes in rainfall, together with increases in the frequency and magnitude of extremes events will impact negatively on water resources. In Kenya water supplies are expected to be affected by increases in temperature and local variability of precipitation.

Consensus is growing in Kenya that the malaria epidemic is connected to changing climate conditions. Highland areas, especially in East Africa, will likely experience increased malaria epidemics as temperatures increaseand areas above 2,000m, with temperatures currently too low to support malaria transmission are affected

There is very little overlap between climate change strategies and gender mainstreaming policies in Kenya. Women are particularly badly affected by water shortages, disasters, and climate change-induced conflict in Kenya.

Rural-urban migration in Kenya is accelerated during periods of drought such as in 2008-2011. Conflicts that are sparked by dwindling pasture and water resources contribute to migration. An increased incidence of droughts under climate change is likely to increase rural-urban migration and confound urban vulnerability.

5: Malawi

In brief: Temperature rises which exceed global averages are set to exacerbate poverty in an already vulnerable country.

Right Now: 92 per cent of Malawians rely on rain-fed sources of water, which are heavily impacted by floods and droughts.

Future climate change risks: Rising temperatures, increased risk of drought, and late onset of rains will affect food production and increase food poverty.

Emissions of CO_2 per capita: 0.1 metric tons – **approximately eighty times less than Ireland**

5.1 Introduction

In Malawi climate change is a threat to economic growth, long-term prosperity, as well as the livelihoods of an already vulnerable population.[163] Ninety per cent of the population are dependent on rain-fed agriculture, 60 per cent of whom are food insecure on a year-round-basis.[164]Climate sensitive rain-fed agriculture is a major contributor to the national gross domestic and foreign exchange earnings and supports the livelihoods of over 80 per cent of Malawians who are involved in primary and secondary agricultural activities.[165]

Climate extremes and weather events severely erode the resilience and adaptive capacity of individuals and communities via declining yields and food security. UNICEF (2013) indicates that flood conditions, especially in the south of the country can result in food insecurity with significant impacts on the livelihoods of poor people in rural areas.[166] More than 15 per cent of the population were affected by floods in the 2012/13 rainy season. In addition to floods, in the last few decades Malawi has experienced droughts during the 1978/79, 1981/82, 1991/92 and 1993/94 crop growing seasons. Therefore Malawi is highly vulnerable to climate change under even modest temperature increases. Over the coming decades increased climate variability and extreme events, compounded by lack of human and technological capacity to mitigate and adapt to climate change will increase the vulnerability of chronically and transiently poor households, heavily dependent on rain fed agriculture.

5.2 Observed Climate Variability and Change

Temperature data across Malawi indicates an increase in temperatures of 0.9°C between 1960 and 2006 at an average rate of 0.21°C per decade.[167] The increase in temperature has been most rapid in December-February (mid-summer) and slowest during September-November (early summer).[168] Observations in Malawi are consistent with Sub-Saharan Africa and global trends.[169] In terms of temperature related extremes the frequency of hot days and hot nights has increased in all seasons. The average number of hot days increased by 30.5 days per year between 1960 and 2003, particularly in summer. The average number of hot nights increased by an additional 41 days over the same period.[170]

Analysis of trends in monthly rainfall across Malawi indicates that most regions have experienced decreasing but non-significant rainfall trends over the period 1960-2006. Decreases are evident for annual and seasonal rainfall and for the months of March to December, while slight increases are evident for the highest rainfall months of January and February.[171] Again, this points to a tendency for rain to fall more intensely, with negative impacts for food production and access to water. Decreases in annual runoff and increases in evaporation losses have also been found over the period 1971-2000[172] indicating that decreasing rainfall has practical significance in that Malawi has become more water limited in recent decades.

5.3 Projections of future climate change

Land surface warming in southern Africa is likely to exceed the global mean increase, under all greenhouse gas emissions pathways.[173] By the end of the century temperature increases under business as usual indicate an average warming of over 5oC across all models for southern Africa –with some models indicating a temperature increase of over 6oC. Such changes would be very difficult to adapt to. Under a best case scenario a mean temperature increase of just over 1oC is projected, with some models showing increases in excess of2oC.

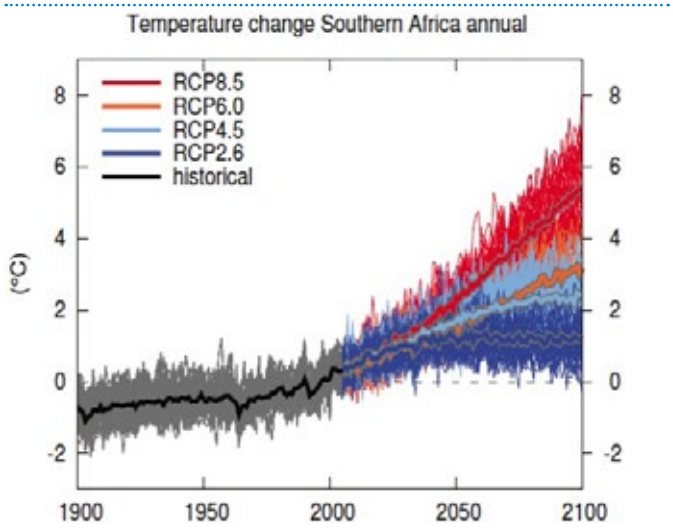


Figure 1 Projected changes in annual temperature relative to 1986-2005 under different greenhouse gas emissions pathways for southern Africa. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin lines denote a single model projection; thick lines show the mean simulation for multiple climate models(Source; IPCC, 2014)

While there are large uncertainties in future rainfall projections, decreases in rainfall are likely, particularly by the end of the century. Greater decreases are associated with higher greenhouse gas emissions. Substantial increases in drought are expected under a business as usual scenario. Soil moisture drying is expected with increased surface temperatures so that surface drying is likely by the end of the century. Decreases in runoff and increased evaporative losses are also projected. These, combined with projected longer dry periods may have serious implications for food production. Countries with a single rainy season, such as Malawi, are expected to experience a delay in onset of precipitation with possible implications for agriculture, which will impact negatively on maize production.[174]

At country level, projections indicate substantial increases in the frequency of hot days and nights. By the end of the century the number of consecutive dry days is projected to increase, as is the percentage of total rainfall falling as extreme bursts. The duration of hot events (maximum period greater than 5 days with temperatures greater than 1961-90 average) is likely to increase substantially under the higher emissions scenario. For each extreme indicator the magnitude of change is greater with higher levels of greenhouse gas emissions.[175]

5.4 Food Production and Climate Change

In southern Africa, agricultural production, including access to food, is projected to suffer negative impacts for several important crops.[176]

Because of underdeveloped agriculture systems, yields in sub-Saharan Africa are projected to decrease by as much as 50 per cent over the century while crop net revenues could fall by as much as 90 per cent by 2100, with small-scale farmers being the most affected.

This would adversely affect food security and exacerbate poverty and malnutrition.

In Malawi smallholder farmers account for 78 per cent of the cultivated land and generate about 75 per cent of Malawi's total agricultural output. Average farm size is approximately 1.12 hectares, however, more than 72 per cent of smallholders farm less than 1 hectare. The vast majority of farmers rely on rain fed production with little capacity to invest in irrigation. Small farm size is driven by a high density population with Malawi being the third most densely populated country in sub-Saharan Africa (2.3 rural people per hectare of agricultural land).[177] Maize is by far the dominant crop produced in Malawi, occupying more than 70 per cent of available agricultural land and is critically important to the livelihoods of the majority of Malawians. Over the last two decades, maize productivity has been erratic due to weather variability, declining soil fertility, limited use and uptake of technologies and market failures.[178]

It's 5am in Kanyera village, central Malawi, and the first thing on everyone's mind is water.

Eliyeta Muyeye (32) and her daughter, Enestina (9), make the one kilometre round trip every morning to fetch water for their family of six. When they get there, there is usually up to six people waiting in line. As heat and dust sweeps over Kanyera, Eliyeta and Enestina return home two hours later, laden with their precious cargo.

"I don't like carrying water," says Enestina. "It's very far and it's heavy to carry. I have neck pains. When I have to get water in the morning, there is a queue so I wait and I am late for school. I love school but I didn't do well in my exams. I've been failing because I didn't know how to read and write. The time I spend getting water would be better used to study."

Kanyera is at the epicentre of the global water crisis. Every day these women and children carry the weight of this crisis from the trickling Kamboni river to their homes, back and forth.

"Life is hard here because we have difficulty with water," says Stephen Muyeye (38), Eliyeta's husband. "The water we drink is contaminated. It's not clean. It's not treated. It's where animals drink and even pass waste – dogs, pigs, goats all drink from the water.

"If we drink it we get sick. We go to the hospital and they tell us that we have dysentery from drinking the water. The hospital gives us medication and it takes a week to work. But it's difficult to cure as we go back and drink the same water, so we can't ever say that we are cured."

And it's not just drinking water that's affected. The water crisis has caused a perennial food crisis.

Stephen and Eliyeta farm a ½ acre of land growing sweet potatoes, maize, and tomatoes. They have no irrigation system and rely entirely on the rain and adjacent river to water the crops. Inevitably, their one annual harvest only feeds them for seven months, leaving a hungry period of five long months. "Between November and March we have no food," says Stephen. "We work on other people's land as labourers during this time. We get paid maize, sometimes a tin, sometimes a bag. I know it's something to do with climate change. We don't have enough rain water."

In terms of agricultural production, the most serious weather events have been dry spells, seasonal droughts, intense rainfall, riverine floods and flash floods. Each cropping season Malawian famers experience localised dry spells which can significantly impact on food production.[179] With climate change, shifting planting dates will exacerbate challenges in growing maize and other crops. Seasonal dry spells and drought can occur at critical stages of crop development often during flowering.[180] Flooding has also severely disrupted food production in several districts of the country. The most vulnerable groups are rural communities, especially women, children, female-headed households and the elderly, for example in 2012/2013 rainy season 12 districts experienced floods which flooded smallholder farmers across the country. In addition, the 2012/13 agricultural season was characterized by a two to three week delayed start of season in the southern and central regions, erratic rainfall, and an early cessation of rainfall in the surplus central and northern areas. During such conditions the poorest households can spend 75 per cent of their income on market purchases for food at exorbitant prices.[181]

In addition to direct impacts of climate change on specific crops, the impacts of climate change on food production are expected to be compounded by underlying poverty. Extreme climate events can influence poverty by affecting agricultural productivity and raising food prices that are critical to poor households.

A study assessing the consequences of extreme weather events under a medium high emissions scenario on the number of people entering

poverty, found that for the coming century Malawi has among the highest proportion of the population entering poverty in the wake of extreme events.[182] This study finds that following extreme climatic events under a changed climate large productivity declines of approximately 75 per cent may be expected. Such reductions in grain for Malawi with extreme events are not unrealistic as during the severe drought of 1991-92 productivity decreased by between 50 and 65 per cent.[183]

5.5 Access to water

The story above gives some insight into the real impact of Malawi's water crisis. Currently 92 per cent of Malawians rely on water sources, largely surface water sources,[184] which are dependent on rainfall recharge and are highly impacted by projected droughts and floods.[185] For example, the 2012/2013 floods in Karonga and other districts were reported to have damaged water pipe networks and boreholes. Water sources such as unprotected boreholes, springs, ponds, streams and rivers were contaminated.[186] In addition to droughts, soil erosion due to surface run-off is a serious environmental problem causing sedimentation.[187]Increases in rainfall intensity following longer dry spells are likely to increase erosion and sedimentation rates. With reductions in rainfall, reductions in surface runoff are likely to impact negatively on groundwater recharge and consequently contribute to drying of boreholes across the country. Currently Malawi is losing about MKW8.8 billion (approx. €16.5 million) due to water connected economic losses[188] and these losses are likely to be exacerbated by climate variability and change over the coming decades. In the future, climate change is expected to impact negatively on water resources in southern Africa through rising temperatures, associated increases in evaporation losses and changes in rainfall, together with increases in the frequency and magnitude of extremes events.[189]In Malawi projected water supplies are affected by increases in temperature and local variability of precipitation.[190] This is compounded by rapid population growth which leads to increased water demand especially in the urban areas thereby putting pressure on water supplies.

River flows could drop by 10 per cent in the Zambezi basin by the end of 21st century which feeds major rivers in Malawi.[191]

For the Shire catchment, increases in extremes of flooding and drought are likely to increase the vulnerability of river basin communities and river-based infrastructure such as hydro-electric power and drinking water plants. Droughts are expected to have greater impacts on the changing water levels on Lake Malawi and the Shire River. For Lake Malawi, it is estimated that water levels will drop in tandem with decreases in rainfall and increases in evaporation. Consequently water supply and hydro-electric power generation in southern Malawi, especially Blantyre city and surrounding districts are likely to be negatively impacted.[192]

5.6 Gender

Exposure and sensitivity to climate risks vary between men and women with men having more opportunities than women to adapt to climate change through diversifying livelihoods away from subsistence agriculture. In Malawi women represent the larger proportion of the poorest people and are highly dependent on local natural resources.[193] Therefore they are more likely to be vulnerable to climate variability and change than men because of social and cultural contexts that determine access to resources and the division of labour. Within agriculture, women tend to hold responsibility for growing food crops while men are more likely to grow cash crops such as cotton or tobacco. Men are also more likely to be involved in small businesses such as production and selling of charcoal. In Malawi, men and women are differently affected by climate change and climate variability related disasters because women are already considered as marginalized in socioeconomic, institutional, cultural engagements and political participation.[194]In addition, educational access is unequal between boys and girls with girls educated to master domestic chores while boys are encouraged to attend schools. For instance, UNICEF indicates that at secondary level, girls' enrolment remains lower than that of boys with dropout rate for girls being high because of the extra burden they take at household level.[195]

5.7 Migration

Internal migration in Malawi is primarily linked to growing land pressure due to rapid population growth. Malawi is facing social conflicts arising from the highly unequal access to land and high rural population density.[196] Inequality in land

distribution, land degradation, rural tensions, and land market failures which the country is facing impact heaviest on the rural poor and on women in particular. Although there is no direct study to link rural-urban migration to climate change, some studies are showing that economically active populations are migrating into urban areas in pursuit of education and developing alternative livelihoods.[197]

5.8 Health

Direct impacts of climate change on health in Malawi relate to an increased incidence of floods and droughts. Such extremes are associated with higher rates of infant mortality due to malnutrition and chronic illness associated with malaria, cholera and diarrhoea.

The incidence of malaria is expected to increase and spread to previously cool zones as temperature increases.[198]

Malawi also has a high incidence of HIV/AIDs which poses a serious threat to development. Estimates indicate that over 14 per cent of Malawians between the ages of 15-49 are HIV positive. The high incidence of HIV/AIDS increases individual and community vulnerability to climate change and extreme events and decreases agricultural productivity due to frequent and prolonged illness.

5.9 Economic impacts

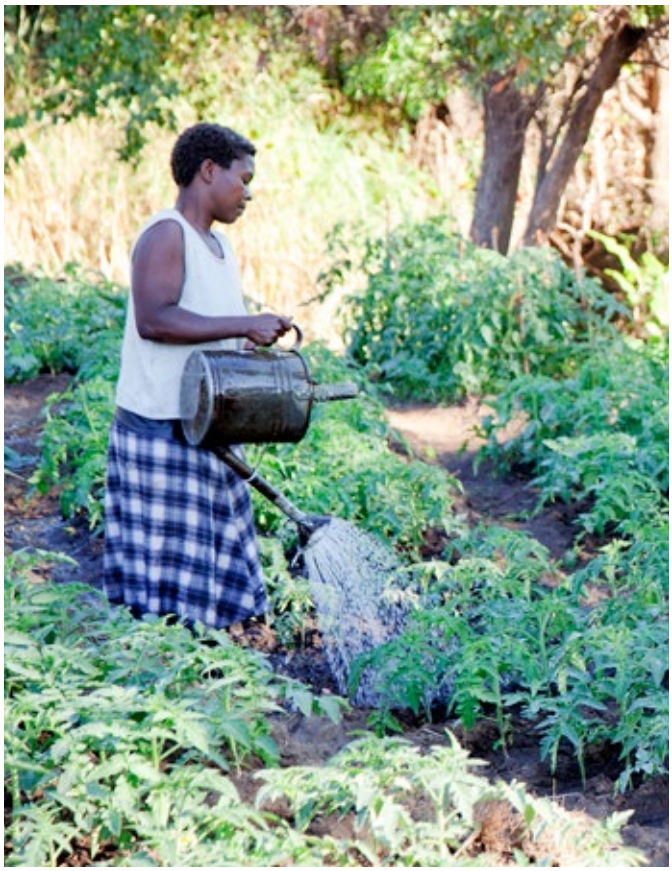
Climate change will reduce agricultural production and output in sectors linked to agriculture. Following extreme events the number of people entering poverty as a result of impacts on agriculture is likely to increase. Climate sensitive rain-fed agriculture is a major contributor to the national gross domestic and foreign exchange earnings and is likely to be adversely affected by increasing temperatures and increased occurrence of drought.

5.10 Looking to the future

The challenges in Malawi are huge. Food insecurity already affects more than half of the population, and water scarcity and quality are a constant problem. Malawi's case also illustrates the urgent need to address emissions levels promptly and dramatically, as a 'business as usual' scenario would see Malawi experiencing temperature rises of up to 5˚C or more.

Trócaire's programme in Malawi focuses on increasing people's food and water security, through building resilience to climate change and climate variability. Farmers are supported to engage in small scale irrigation that can triple their harvests from one to three times annually. Integrated Water Resource Management supports agricultural production, including the adoption of new technologies and the promotion of existing but under-used approaches. Currently only 23 per cent of potentially irrigable land in Malawi receives irrigation, and only 11 per cent of smallholder farming. Crop diversification using high yield and drought resistant seed varieties also help increase resilience to climate change.

The programme has also worked to influence the policy context in Malawi, in particular Disaster Risk Reduction and Climate Change policies by creating the opportunity for poor farmers to present their priorities to the decision makers through national networks and fora. Trócaire is currently working to create an opportunity for wider stakeholders to influence the contents of the Meteorological Policy, National Adaptation Programme of Action (NAPA) and National Adaptation Plans (NAP) in Malawi.



Eliyeta Muyeye (32) watering her crops in Dedza, Malawi, 2013.

5.11 Summary of Findings

Increase in temperatures of 0.9°C between 1960 and 2006 have been observed with increases most rapid in December-February (mid-summer). The number of hot days and hot nights have also increased. Decreases in rainfall have been observed but these are not significant. Reductions in annual runoff and increases in evaporation losses have been found over the period 1971-2000 indicating that decreasing rainfall has practical significance in Malawi becoming more water limited.

Increased rates of warming are associated with all greenhouse gas emissions scenarios. By the end of the century temperature increases under business as usual indicate an average warming of over 5°C, with some models indicating a temperature increase of over 6°C. Even with ambitious reductions in greenhouse gases some models show temperature increases reaching and exceeding 2°C by the end of the century. While rainfall projections are uncertain the average of change across the latest models indicates decreases in rainfall, particularly by the end of the century with simulated decreases in annual rainfall of between 0 per cent and 25 per cent.

Substantial increases in drought and heat extremes are expected under business as usual emissions. All projections indicate substantial increases in the frequency of hot days and nights along with increases in the proportion of rainfall falling as heavy events. The latter will likely result in increased incidence of flooding. Increases in extreme climate events can influence poverty by affecting agricultural productivity and raising food prices that are critical to poor households

Climate change will reduce agricultural production and output in sectors linked to agriculture. Following extreme events the number of people entering poverty as a result of impacts on agriculture is likely to increase. Climate sensitive rain-fed agriculture is a major contributor to the national gross domestic and foreign exchange earnings and is likely to be adversely affected by increasing temperatures and increased occurrence of drought.

Maize is by far the dominant crop produced in Malawi, occupying more than 70 per cent of available agricultural land and is critically important to livelihoods. Recent climate variability has seen erratic productivity and future increases in temperature and water limitations are likely to see decreases in output, especially under business as usual scenarios. The impacts of climate change on food production are expected to be confounded and complex because of underlying poverty.

There is high confidence that rising temperatures, evaporation losses and changes in rainfall, together with increases in the frequency and magnitude of extremes events will impact negatively on water resources. Increases in flooding and drought are likely to increase the vulnerability of exposed communities and river-based infrastructure such as hydro-electric power and drinking water plants. Droughts are expected to impact on water levels in Lake Malawi and the Shire River that are highly vulnerable to changes in hydrology.

Direct impacts of climate change on health relate to an increased incidence of extremes which are associated with higher rates of infant mortality due to malnutrition and chronic illness associated with malaria, cholera and diarrhoea. The high incidence of HIV/AIDS increases individual and community vulnerability and decreases agricultural productivity due to frequent and prolonged illness.

In Malawi women represent the larger proportion of the poorest people and are highly dependent on local natural resources. Therefore they are more likely to be vulnerable to climate change than men because of social and cultural contexts that determine access to resources and the division of labour.

Internal migration in Malawi is primarily linked to growing land pressure due to rapid population growth with little evidence to date of migration due to increased frequency and intensity of extreme events connected to climate variability.

6: Ethiopia

In brief: Massively reliant on rain-fed and low-tech agriculture, highly vulnerable to climate change

Right Now: Growing season has already reduced by 15% in the region

Future climate change risks: Worsening difficulties with access to water, large decreases in staple cereal crops, more vulnerability to disease.

Emissions of CO_2 per capita: 0.1 metric tons – **approximately eighty times less than Ireland**

6.1 Introduction

Ethiopia is particularly vulnerable to global climate change, given its massive reliance on agriculture. Eighty-five per cent of Ethiopians live in rural areas and most rely on subsistence farming for survival. Nearly 95 per cent of the country's agricultural production is cultivated on family holdings, most of less than 1 hectare. Agriculture accounts for more than half of GDP and as much as 90 per cent of exports and employment.

Farmers and pastoralists in Ethiopia rely on two annual rainy seasons: Kiremt, the main rainy season for most of the country, from June to September, and Belg, the shorter rainy season from February to May. Rainfall is already highly variable. As most farmers have no access to irrigation, when the rains do not come, it can equal catastrophe. Nearly 40 per cent of Ethiopia's 90 million population is considered food insecure.[199] Over the period 1980-2010 ten major drought disasters were reported in Ethiopia.

The major drought of 1984 resulted in over 300,000 deaths and affected over 7.5 million people, while drought in 2003 affected over 12.6 million people.

Each successive drought makes it more difficult to recover, making the people of Ethiopia all the more vulnerable to climate change.

Already in Ethiopia, temperatures have been rising, and the length of the main growing season across eastern Africa has reduced by 15 per cent. Even if drastic reductions in emissions are achieved, future climate changes are expected to significantly reduce Ethiopia's main cereal crops. If emissions continue unabated, average temperature increases of approximately 4°C could be devastating. And yet, Ethiopia has relatively little control over which scenario plays out – since its carbon dioxide emissions, at 0.1 metric tons per capita, are already among the lowest in the world, it must rely on other countries reducing their carbon emissions to ensure its future.

6.2 Observed climate change and variability

There has been an increase in seasonal mean temperature in many areas of Ethiopia over the last 50 years.[200] For the past four decades the average annual temperature in Ethiopia has been increasing by 0.37°C per decade, with the majority of warming occurring during the second half of the 1990s.[201]

Ethiopia experiences a high degree of variability in rainfall from year to year and season to season. Changes in rainfall are non-uniform and highly sensitive to the region and period of analysis, as a number of studies show. From the majority of studies, the most prominent trend has been towards reduced rainfall amounts with the main growing season length (March-May) across much of eastern Africa declining by approximately 15 per cent since the 1980s.[202] Such changes have had multiple effects on agricultural production and water availability for irrigation, especially in the north, northeast and eastern lowlands of the country. Occurring during the main growing seasons in poor countries dependent on rain-fed agriculture, these declines are societally dangerous; impacting adversely on household livelihoods and food security and have been associated with human induced warming of the

In the Tigray district of Ethiopia, the biggest problem is something that many people in the world take for granted: water

Prolonged droughts and disappearing water sources have caused great difficulty for rural communities in Tigray, who must battle the effects of climate change on their farms.

Trócaire, in partnership with CAFOD and SCIAF, has funded a project which has brought irrigation and increased food production to over 30,000 people in the region.

Irrigation has enabled farmers in Tigray to harvest up to three times a year and boost crop production. Farmers have also been trained in new farming techniques, while newly constructed hygiene and sanitation facilities have greatly reduced health risks for the people.

Gebre Nigusse (46) from Biera village was among the farmers to benefit from the project. The lack of water was making it difficult for Gebre to harvest enough food to provide for his family. There was no irrigation and erratic rains could not be relied upon. The project has changed everything.

"I did not do much irrigation until I joined the project four years ago," he explains. "The project constructed canals and I took part in the construction. I received trainings, fruit and elephant grass seedling.

"I dug two hand wells for irrigation and bought a water pump from the vegetable money. I have planted coffee trees and will increase my fruit trees up to 120. I know I can resist drought through irrigation."

Indian Ocean.[203] In addition, recent years have seen significant socio-economic disruption due to flooding. Floods along many major rivers in 2006 resulted in the death of over 800 people and resulted in over $3 million USD losses, with more than 20,000 people being made homeless.

6.3 Projections of Future Climate Change

Warming is expected to continue in Ethiopia, for all seasons, in all regions, and even if emissions decrease. A medium high emissions scenario shows an annual warming across Ethiopia of 1.2°C by the 2020s, and warming of 2.2°C by the 2050s.[204] Regional differences in warming are modest, with warming associated with a greater frequency of heatwaves and increases in evaporation leading to moisture deficits.

The graph below shows the considerable projected warming in east Africa, with highest temperature rises expected with higher emissions. Under a business as usual scenario with no policy changes to reduce global emissions, the average warming across all models shows temperature increases of approximately 4°C by the end of the century. Some individual models show temperature increases approaching and exceeding 6°C. Under ambitious global greenhouse gas emission reductions (RCP2.6) temperatures are expected to increase by approximately 1°C by the end of the century; however, even under this ambitious scenario increases in mean annual temperature above current conditions still approach 2°C for some models.

When considering ranges of projected changes it is important to note that the average does not imply a greater likelihood of occurrence. The full range of projected changes must be accounted for when considering impacts and adaptation – the greater the temperature increases the more severe the impacts are likely to be. For Ethiopia, even the projected temperature change under the most ambitious emissions scenarios will have significant impacts for agriculture, extreme events and the livelihoods of many.

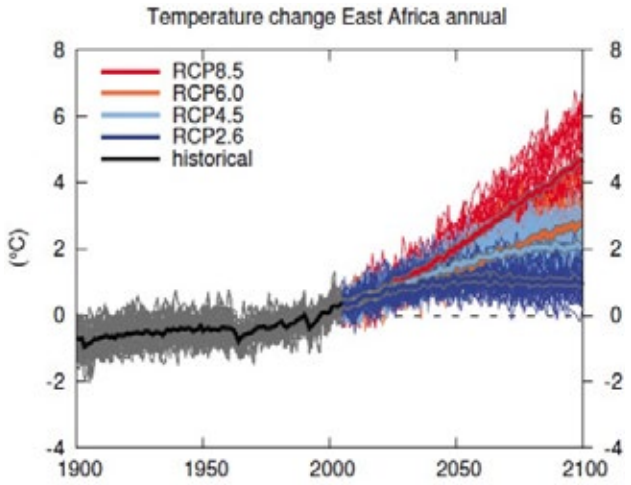


Figure 1 Projected changes in annual temperature relative to 1986-2005 under different greenhouse gas emissions pathways for East Africa. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin lines denote a single model projection; thick lines showthe mean simulation for multiple climate models. (Source; IPCC, 2014)

Global warming will furthermore enhance the likelihood of anomalously intense, short rains across east Africa.[205] The main climate hazards in Ethiopia are associated with rainfall variability including amount, timing, intensity and associated floods and droughts. Increased precipitation trends are projected from early this century.[206] The link between observed declines in growing season rainfall and human induced warming in the Indian Ocean is likely to intensify over the coming decades as warming continues.[207]

Future projections of rainfall are more complex to disentangle. Research indicates a future positive shift in rainfall for most models with increases in both average rainfall and intensity simulated for most of east Africa, including Ethiopia.[208] Increases in rainfall extremes are likely to translate into rising flood risks for the region.[209] In addition, rising temperatures and the higher risk of excessive rainfall have implications for the health sector by shifting and extending the areas affected by diseases such as malaria or Rift Valley fever - a viral disease spread to livestock and humans via mosquitoes.[210] In highland regions, warming is leading to an expansion of crop pests into previously cold-limited areas.

The most significant coffee pest, the coffee berry borer, had never been reported in plantations above 1,500m until 10 years ago, and thus Arabica coffee, a valuable crop which grows at high altitudes was largely unaffected. Increasing temperatures now mean that attacks of the insect are reported at higher altitudes.

In the coffee producing Ethiopian highlands, warming trends may result in increased presence of the coffee berry borer with implications for livelihoods based on coffee production.[211] Small-scale coffee producers are likely to be hardest hit because they rely more heavily on natural resources for survival and have little capital to invest in costly adaptation strategies and/or pest and disease management.[212]

6.4 Food Production and Climate Change

Food production is expected to be consistently and negatively impacted in Africa in the coming decades due to higher average temperatures, greater extremes, longer periods of dangerously hot weather, and high temperatures at important and vulnerable times in the life cycle of plants.[213] The IPCC Fifth Assessment Report projects fluctuations and variability in precipitation and temperature over the coming century. In Ethiopia the variability of precipitation and temperature is critical to 84 per cent of rural Ethiopians dependent on rain-fed agricultural livelihoods[214] with changes likely to affect productivity of certain crops, timing of agricultural practices and losses imposed by pests and diseases, all of which impact on food security. Stories such as Gebre's provide just one example of where these impacts are being felt, and how they are being tackled with support from Trócaire.

The impacts of climate change on food production are expected to be widespread and complex to manage as food production systems differ widely according to socio-economic conditions and ethnicity in Ethiopia.[215] Climate variability and change will impact farmers and pastoralists differently.

For farmers, the decline of main growing season rainfall will continue to provide difficulties in

decision making - particularly deciding on planting dates and increasing the risk of crop failure. Similarly, critical decisions around the timing of land preparation and planting for long-cycle crops such as maize, sorghum and millet will become more problematic due to changes in variability. Changes in rainfall can impact adversely on flowering and development of perennial crops, in particular coffee.[216] Such changes in climatic inputs highlight the challenges for food and livelihood security in Ethiopia. One study shows the sheer scale of the challenge for cereal production.[217] The study showed decreasing trends for the four main cereal crops (teff, maize, sorghum and barley) currently critical to food security. Barley was predicted to have the greatest reductions, with net losses in land area ranging from 28 to 62 per cent. Sorghum had the least change, ranging from a possible net loss of 21 per cent to a possible net gain of 14 per cent. In addition the study shows dramatic geographic shifts in land suitability for cereal production over the coming century.[218]

For pastoralists, climate change is likely to lead to increased conflicts over pasture and water for livestock.[219] For pastoral communities in Ethiopia, droughts and high temperatures threaten cattle life, feed and water. Some pastoralists may shift from livestock to crop cultivation, from nomadism to sedentary livestock keeping, from pastoralism to agro-pastoralism.[220]

6.5 Access to water

The impact of climate change on African fresh water resources is likely to be significant by the end of the 21st century.[221] It is expected that increasing temperatures will affect the water balance and thus water availability through changes in transpiration, vegetation structure and distribution. Increasing temperatures in arid and semi-arid areas will decrease water availability for human consumption and for agriculture. Climate change will undermine the technical performance of large reservoirs with knock-on effects for agriculture and electricity production.[222]

In Ethiopia projected water supplies are affected by increases in temperature and local variability of precipitation.[223] In the Gibe catchment in the south west of Ethiopia, average annual streamflow (an important indicator of water availability) is predicted to decrease up to 2050.[224] In addition, research on the Geba river suggests annual reductions in river flows by up to 50 per cent by the end of the century under a high emissions scenario, with significant decreases also expected under lower emissions scenarios. Reduced river flows in the Ganane and Nile Basins in Ethiopia are expected towards the end of 21st century because of increasing temperatures and associated evaporation losses.[225]

It is also expected that climate change will reduce raw water quality and even pose risks to treated drinking water because of anticipated increases in extremes.[226] Increased intense rainfall will bring increased floods and soil erosion, which introduces sediments and pollutants in fresh water bodies.[227] Soil erosion is already a serious problem in Ethiopia. Every year, 1.5 billion metric tons of topsoil erodes from the highlands into streams and rivers, thus increasing sediments, pollutants and reducing stream flows.[228]

Climate change is only one of the many pressures that will determine access to water in future decades. Forty-eight per cent of the population in Ethiopia is without access to safe water and relies on water sources such as unprotected springs, ponds, streams and rivers many of which are located far from households and are contaminated.[229] Drought seriously impacts pastoral regions, which cover 50 to 61 per cent of the surface area of Ethiopia.[230] In these semi-arid and arid regions droughts and temperature rise cause traditional water sources for people and livestock to rapidly disappear. Water access also has important gender dimensions throughout much of Africa, including Ethiopia. Women and girls are mainly involved in water collection in Ethiopia, but young girls are particularly vulnerable to associated health and physical risks.[231]

6.6 Gender

Existing gender inequality is heightened by climate-related hazards.[232] Men and women are differently affected by climate change and climate variability related disasters intertwined with socioeconomic, institutional, cultural and political drivers.[233] Women play a vital role in food security. In Ethiopia, as in most African countries, more women than men are engaged in the production, distribution and utilization of food. Agriculture is therefore central to women's livelihoods, with climate change impacts on agricultural production making women especially vulnerable. Evidence shows that during extreme weather conditions, women experience more social disruption given a greater reliance on agricultural employment in rural

areas as compared to men employed in service sectors across the country.[234]

Koye Kora with one of her cows in Guji, Ethiopia. During periods of drought many lose livestock and struggle to cope.

6.7 Migration

Historically, drought has been a major driver of population movements in Ethiopia. An increased frequency and intensity of extreme events is expected under climate change and may lead to further migration as changes exceed the coping capacity of individuals.

One study exploring mobility dynamics in two rural areas of the northern highlands gives us an insight into climate-driven migration in Ethiopia.[235] Within the region, livelihoods revolve around small scale, rain-fed subsistence agriculture. Over the past 20-25 years, the region has experienced worsening rainfall conditions (less rainfall totals, shorter seasons, and more intense and variable rainfall), increased exposure to severe frosts at high altitudes and losses of topsoil and soil fertility.[236]

The impact of such extreme weather events has led to production shortfalls with many households seeing their stores of wealth reduced and cattle stocks depleted due to lack of available grazing or through sale to purchase cereals and other necessities.[237]

Such circumstances have resulted in high levels of migration to urban areas, particularly among the young. In addition, access to credit is generally available only to those with land who can offer holdings as collateral. The pursuit of education in developing alternative livelihoods also forces movement to urban areas.[238]

Shrinking land holdings also play an important part in shaping livelihoods in Ethiopia. The system of land ownership means that households cannot acquire land other than through centrally organised re-distributions. Coupled with rural population growth, this system of redistribution tends to fracture landholdings so that individual household plots are very small. Reducing land holdings compromises livelihood security by reducing available harvests and limiting the size of herds that households can maintain. Such land tenure arrangements decreases the coping and adaptive capacity of communities to extreme climatic events. This is particularly the case for women where land ownership is traditionally held by men.[239]

6.8 Health

Limited scientific information is available on the impact upon health from current and future climate change in Ethiopia. Rising temperatures and increases in rainfall intensity may shift or extend the areas affected by vector borne diseases. Increased occurrence of floods and heatwaves will also have implications for health, as will impacts on food production.

As noted above, climate change may impact on water quality and availability, with significant impacts on an already vulnerable population. Deaths from diarrheal diseases in Ethiopia are already significantly higher than in other East African countries.[240]

6.9 Economic impacts

The economic cost of climate change to Ethiopia is high given the importance of the agricultural sector to livelihoods, production and employment. In addition, in poor countries large costs can be incurred due to small shifts in climate due to low levels of adaptive capacity, technology and resources. Ethiopian agriculture accounts for nearly 42 per cent of the nation's output, employs 85 per cent of the population and contributes more than 90 per cent to national exports and serves as the main input to the industrial sector. The main export commodity is coffee accounting for 35.7 per cent of total exports. Failure in agriculture therefore has widespread impacts throughout the economy, as has been experienced by recent climate extremes.

Agricultural output is closely linked to fluctuations in rainfall in Ethiopia with micro-level analysis suggesting that climate variability has already created costs through the drying of lakes,

decreased water volumes leading to serious electrical power interruptions, increased drought length and frequency and flood events. One study estimates that Ethiopia lost a cumulative level of over 13 per cent of its agricultural output between 1991 and 2008, leading to increased poverty, while

over the coming years the country could lose in the order of $2 billion USD due to rainfall variability.[241]

By 2050, climate change could reduce Ethiopian GDP by 8-10 per cent and increase variability in agricultural production by a factor of two.[242] Adapting to climate change in the areas of agriculture, energy provision and road infrastructure may cost an annual average of $0.8-2.8 billion USD.[243] Climate change impacts are likely to be felt most by the rural poor and particularly women. The poor in urban areas are also likely to be negatively impacted due to increasing food prices. Climate change will make the prospect of economic development harder for Ethiopia in at least two ways: first, by reducing agricultural production and output in sectors linked to agriculture, which is likely to reduce Ethiopia's GDP by about 10 per cent from its benchmark level; and second, by raising the degree of income inequality which is likely to further decrease economic growth and fuel poverty.[244] In addition, extreme climatic events have historically been shown to be costly to individuals, reducing consumption or forcing the sale or destruction of assets; thereby re-enforcing poverty.[245]

6.10 Looking to the future

It is clear that, if the worst possible effects of climate change are to be averted, global emissions must be reduced right now. However, even in the most optimistic of scenarios, large losses in the production of key cereal crops are forecast, posing very significant risks to food security in Ethiopia.

The majority of smallholder farmers do not have the resources to facilitate adaptation of their cropping and livestock systems to climate variability, casting into serious doubt the ability in future decades to feed more than 90 million people in Ethiopia.

These risks are exacerbated by our increasing need for food worldwide – the FAO estimates that 60 per cent more food will be needed worldwide by 2050.[246]In Ethiopia, multinational corporations are leasing large tracts of land for biofuels or agricultural exports, which will *'result in a type of farming that will have much less powerful poverty-reducing impacts than if access to land and water were improved for the local farming communities',* according to Olivier de Schutter, the UN Special Rapporteur on the right to food. Having produced the majority of the emissions which are contributing to Ethiopia's food insecurity through climate change, we in the developed world are further undermining the potential of smallholders to provide for themselves.

The story of Gebre Nigusse above illustrates how, with the help of Trócaire and other agencies, Ethiopian farmers can begin to adapt to the uncertainties of climate change. CAFOD, SCIAF and Trócaire work together in Ethiopia to build the capacity of marginalised men and women and reduce their vulnerability to shocks and stressors, including climate change. Poor households are supported to become more resilient by promoting more diversified and increased incomes, enabling sustainable access to water and natural resources, increasing productivity in agriculture and livestock, and reducing the risks associated with disasters. Trócaire's humanitarian programme works to ensure an effective response when disasters strike. Risk reduction is integrated into the programme for example through strengthening early warning and rapid assessment systems linked to contingency planning and finance.

Qersi Godana, 12, at a water point in the Borana zone of Southern Ethiopia. Water is so limited she spends 3 hours queueing to get water from this pump.

6.11 Summary of Findings

Increases in seasonal mean temperatures have been observed across Ethiopia over past 50 years, and the length of the growing season has reduced by ~15% in the region.

Increased rates of warming are associated with all greenhouse gas emissions scenarios. Under a business as usual scenario median temperature increases of approximately 4°C are projected. With ambitious reductions in emissions warming may be contained within the 2°C threshold associated with dangerous climate change.

Increased rainfall intensity is likely to result in greater likelihood of flood events. Greater extreme hot events are also expected. The impact of climate change on drought is unclear and depends on the balance between increased rainfall and increased evaporation losses.

Climate change will reduce agricultural production and output in sectors linked to agriculture and is likely to reduce GDP by ~10 %. At an individual level climate change is likely to raise income inequality, reduce household wealth and fuel poverty.

Food production is expected to be consistently and negatively impacted and compound challenges of food security. Changes in rainfall will make critical decisions at household level such as dates for preparing and planting more difficult. Large decreases in the productivity of major cereals have been projected. Coupled with small and decreasing farm sizes adaptation to future impacts will be challenging.

Benefits of potentially increased rainfall will be compromised by increased floods and soil erosion, which are associated with increased sediments and pollutants in fresh water bodies. A number of studies of the response of major rivers suggest decreasing river flows towards the end of the century due to increasing temperatures and associated evaporation losses.

Rising temperatures and increases in rainfall intensity may shift or extend the areas affected by vector borne diseases. Increased occurrence of floods and heatwaves will also have implications for health, as will impacts on food production.

Women are more reliant on agriculture than men and are therefore likely to be more adversely affected by climate change. In addition water access also has important gender dimensions with young girls in particular being more vulnerable to changes in water availability and competition.

Historically drought has been a major driver of population movements in Ethiopia. Research is also highlighting that issues with land tenure, coupled with increases in climatic extremes are acting as important drivers of rural-urban migration in the northern highland of Ethiopia under present conditions. Increases in the frequency of extreme events is likely to reducing coping capacities and increase rates of migration with social and cultural impacts in both sending and receiving areas.

7: Conclusions and Recommendations

People march in New York as part of the largest ever worldwide movement calling for action on climate change, September 2014.

The key conclusion from our report is that climate change is having profound impacts on poor people, with the most vulnerable most badly affected, and unfortunately there is worse to come. The global shift in policy required to contend with these effects is large-scale and challenging – but not impossible. Tackling both the causes and the consequences of climate change in an equitable way requires a set of integrated actions that prioritise the rights of the most vulnerable women and men at all levels.

1 We must set a fair, legally binding framework on climate change that keeps global temperature rises as far below 2°C as possible and ensures that the most vulnerable women and men can adapt to the impacts of climate change.

While the threat of climate change may seem overwhelming, the Fifth Assessment Report of the IPCC concluded that limiting warming to below 2°C is both technically and economically feasible. Limiting temperature rises to no more than 2°C above pre-industrial times has been adopted by the international community as the threshold necessary to avoid the most dangerous impacts of climate change. For many developing countries 2°C is too high a limit to avoid dangerous impacts and for this reason have called for a target of 1.5°C instead.

An international agreement is essential to ensure co-ordinated and collective action. The Climate Summit in Copenhagen in 2009 aimed to do just that but is now a byword for failure. However, the Climate Summit in Durban in 2011 established a renewed commitment by the international community to develop a new global agreement by the end of 2015, at COP 21 in Paris. This deal will see each party commit a 'nationally determined contribution'. It is vital that taken collectively these contributions ensure emission reductions that keep global temperatures as far below 2°C as possible. To do so means action needs to start now, and global emissions must peak no later than 2015.

Ensuring equity is at the heart of the agreement requires those who bear most responsibility lead the efforts for emission reductions, as well as

providing sufficient financial support for adaptation and mitigation actions in developing countries, that is new and additional to official development assistance. Developed countries committed to ensuring $100 billion USD per year by 2020 and this commitment should be respected. Developed countries must include within their intended 'nationally determined contributions' information on their planned climate finance provisions. The European Union represents Ireland and the UK in the international negotiations. The 2030 EU Climate and Energy Package commits to *at least* a 40 per cent reduction in emissions, which although far below the levels called for by civil society organisations, still provides an opportunity for increasing ambition in the coming years. The EU should also commit €24.3 billion annually towards its fair share of the $100 billion USD by 2020 commitment.

Climate change is a global problem and requires international coordination. However, history illustrates that international targets alone have been insufficient for Ireland to make significant progress towards doing its fair share of emission reductions. The Republic of Ireland is significantly off-track for meeting the 2020 target for emission reductions set by the EU. Legislation on climate action is necessary to put in place the legal framework for integrated planning across government departments as well as ensuring adequate monitoring and accountability to keep progress on track. To be effective, legislation in the Republic of Ireland should incorporate all of the recommendations of the report on the Outline Heads of the Climate Action and Low Carbon Development Bill produced by the Oireachtas Joint Committee on the Environment, Culture and the Gaeltacht produced in November 2013.[247]

For the Northern Ireland Assembly to be effective in tackling climate change, they should urgently seek to introduce a Northern Ireland Climate Change Act, with a legally binding regional target to reduce emissions from 1990 levels by 80 per cent by 2050.

2 We must switch to more sustainable ways of producing and consuming, in particular energy and agriculture.

An emissions framework as above provides the overall limits within which countries can operate. Actually delivering upon the changes necessary to meet these targets requires a transition in the way we produce and consume, in particular in the areas of agriculture and energy.

Globally the agriculture, forestry and other land use sector accounts for about a quarter (approximately 10–12 gigatonnes) of net anthropogenic greenhouse gas emissions, mainly from deforestation, agricultural emissions from soil and nutrient management and livestock.[248] In Ireland agriculture accounts for almost one third of emissions.[249] According to the IPCC Fifth Assessment Report, in agriculture, the most cost-effective supply-side mitigation options are cropland management, grazing land management, and restoration of organic soils. Demand-side measures, such as changes in diet and reductions of losses and waste in the food supply chain, also have the potential to reduce GHG emissions from food production.[250]

Globally burning fossil fuels (coal, natural gas and oil) in industry, the residential, commercial and public sectors, and in transport and energy supply accounts for over 60 per cent of greenhouse gas emissions. Direct carbon dioxide emissions from the energy supply sector alone are projected to almost double or even triple by 2050 compared to 2010. In the last decade, the main contributors to emission growth were a growing energy demand and an increase of the share of coal in the global fuel mix.[251]

In order to reduce emissions to stay below 2°C large-scale global changes in the energy supply sector will be necessary. According to the IPCC reductions of 90 per cent or more below 2010 levels between 2040 and 2070, and to below zero thereafter.[252]

As highlighted by Mary Robinson, the unpalatable truth is that 'we have to move away from fossil fuels and we have to keep the majority of known fossil fuel reserves in the ground'.[253]In order to contain temperature rises below 2°C, more than two-thirds of current commercially viable fossil fuels will need to remain in the ground. Despite a three year old political commitment to phasing out fossil fuel subsidies, many of the world's richest countries continue to pour money into them. The negative effects are profound. Fossil fuel subsidies are creating perverse incentives - where investment in carbon-intensive energy is favoured. This presents a major obstacle to green investment, and seriously undermines attempts to put a price on carbon.

The Sustainable Development Goals provide a

unique opportunity for global commitments to more sustainable production and consumption, including in ensuring renewable energy for all, reducing agricultural emissions, and ensuring more sustainable production and consumption practices.

The EU 2030 Climate and Energy Package commits to *at least* 27 per cent energy savings and *at least* 27 per cent renewable energy production, both of which should be revised upwards.

In the Republic of Ireland, the national and sectoral roadmaps proposed in the draft Climate Action and Low Carbon Development Bill should specify the policies and measures that will be implemented in the coming years to ensure the Republic of Ireland meets its emission reduction targets. In line with the provisions of the Bill, Ministers with responsibility for each sector should be accountable to the Dáil for ensuring that these roadmaps deliver the necessary emission reductions.

In Northern Ireland, energy and agricultural plans should specify policies and measures to make the transition towards low carbon development. A Climate Change Act in Northern Ireland is essential to ensure this transition takes place with full accountability measures for departmental reporting. The upcoming transfer of planning powers to local authorities also offers an opportunity to embed climate change action into planning policy.

Furthermore, all sectoral policies that are designed to meet mitigation targets must be designed with adequate social and environmental safeguards, with particular attention to the human rights of vulnerable people.

3 We must support and promote sustainable agricultural approaches and secure access to natural resources to ensure that the most vulnerable people can adapt to the impacts of climate change.

As the case studies demonstrate, agriculture, which the majority of people living in poverty depend upon for their livelihood, is particularly vulnerable to the impacts of climate change. The agricultural sector in developing countries witnessed a dramatic decline in investment, with the percentage of aid going to this sector dropping from 18 per cent in 1979 to a record low of just 2.6 per cent in 2006.[254] While investment in small scale farmers has risen up the political agenda since the food price crisis in 2008, many farmers cannot afford farming inputs or do not have secure access to land or water to enable investment in better agricultural practices, such as agroforestry or watershed management.

However, the stories in this report also demonstrate the resilience of small scale farmers, and how with relatively small levels of investment in even simple technologies such as irrigation systems (e.g. see Kenya, page 20 and Ethiopia, page 30) they can flourish.

The estimated 500 million small farmers in developing countries already support 2 billion people, almost a third of humanity.[255] Small holder farmers are very efficient in terms of production per hectare and have a huge potential for growth. Providing adequate support to small holder farmers would enhance their resilience to climate change, and contribute to world food security and poverty reduction. In order to reach this potential,there needs to be sufficient investment, including from the $100 billion climate finance commitment, in resilient and sustainable small scale food production, especially by women producers. Such investment should be accompanied by an appropriate policy framework that supports rather than undermines sustainable agricultural approaches, such as open-pollinated seed varieties, diversified cropping and low-input techniques.

Ensuring secure access to natural resources, in particular land and water, are pre-requisites for small scale farmers to secure resilient livelihoods that protect them from the impacts of climate change and contribute to food security (e.g. see Honduras, page 13). However, for many of the world's poorest people trends such as climate change and a new scramble for resources driven by agricultural investment and 'green grab' further threaten people's already insecure access. In developing countries, customary rights to land and natural resources need to be strengthened. Globally, the Voluntary Guidelines for the Responsible Governance of Land, Fisheries and Forests[256], and the Committee on Food Security principles on Responsible Agricultural Investment[257], should be rapidly implemented.

Conclusion

While the case studies in our report present some of the worst possible outcomes of continuing with 'business as usual' emissions, they should act not as a reason to despair, but as a spur to action. The scenarios presented by climate change models clearly demonstrate that we still have a choice – by acting now, we can curb the worst effects of climate change. And more and more, ordinary citizens are understanding the importance of action.

The Climate Change Summit in New York in September 2014 witnessed a renewed impetus around climate change. Not so much in the General Assembly Hall – although the attendance of so many heads of states was encouraging – but out in the streets. The march through the streets of New York and the hundreds of others throughout the world, marked a watershed in the climate movement which has lain dormant and despondent since Copenhagen in 2009.

In the five years since Copenhagen, the conversation and the means of communicating on climate change has shifted. People themselves are making the linkages between addressing climate change and related challenges such as divestment in fossil fuels. Ordinary citizens - not just NGO supporters or environmental campaigners - have come to the conclusion that climate change is an issue which is going to affect them and their children. It is no longer only about polar bears and ice caps but the people of the Philippines, Honduras, Kenya, Ethiopia, Malawi – communities in these and many other countries around the world who are faced with the devastating consequences of a problem they did little to cause.

As momentum builds towards the 21st UN Climate Change Conference at the end of 2015, we must continue to speak up, individually and collectively, so that we can guarantee a brighter, more sustainable future for all people and for future generations.

Students from St Dominic's in Ballyfermot, Bronagh O'Reilly, Niamh Menton, Danielle McGouran, Chloe Ennis, Lorna Bird meet Derek Keating TD (FG) and ask for a strong climate law.

Endnotes

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