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Still Feeling the Heat

How climate change continues to drive 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.

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Cover image: Shanties Dhuyuleh internally displaced people (IDPs) camp, Somalia. The accumulated effects of failed rains has forced people to migrate in search of food. Trócaire has been responding to the food crisis that has affected countries across East Africa, including Somalia, Ethiopia and Kenya. Photo: Amunga Eshuchi/Trócaire"

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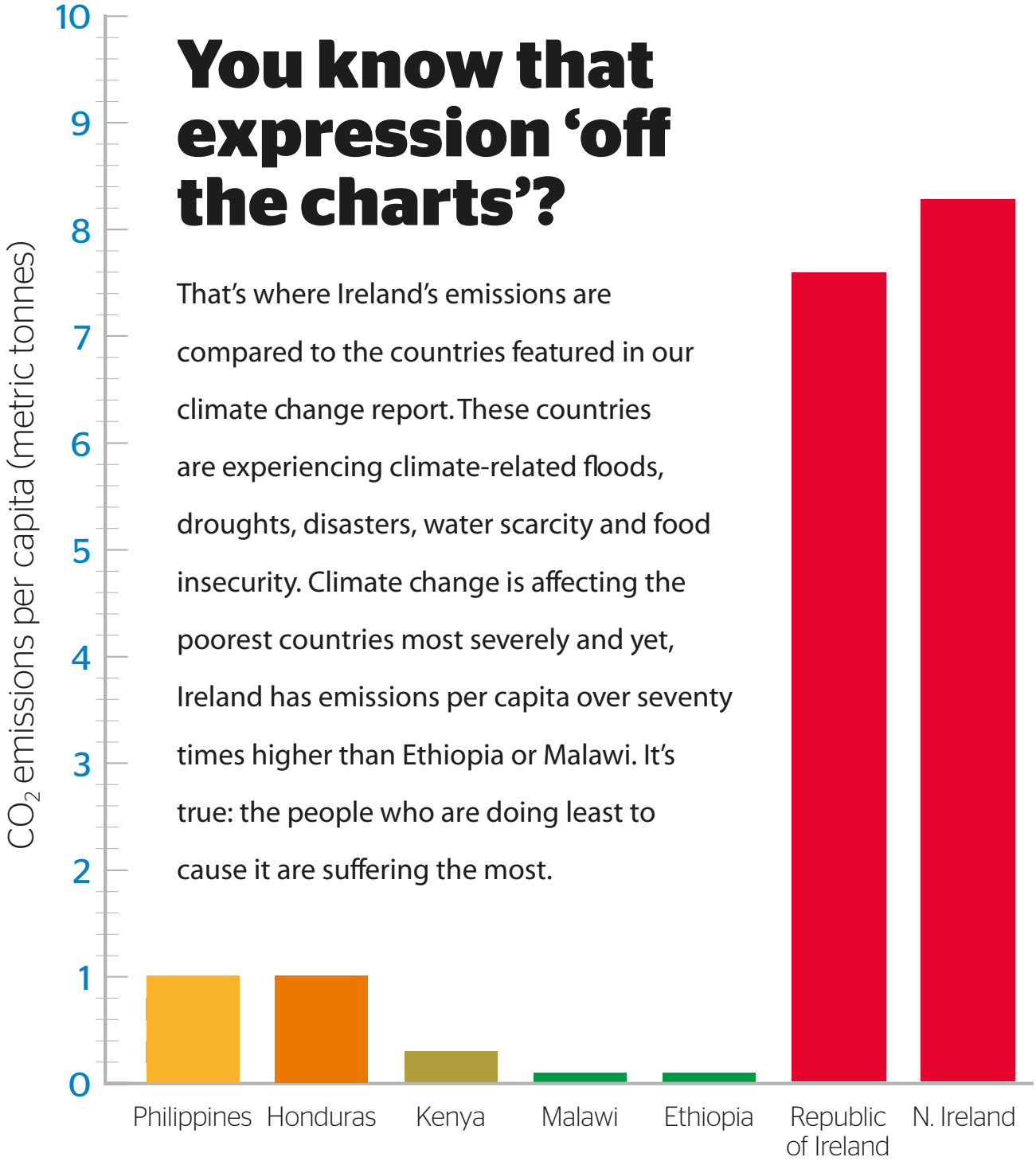
You know that expression 'off the charts'?

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 seventy times higher than Ethiopia or Malawi. It's true: the people who are doing least to cause it are suffering the most.



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Foreword

Three years on from the first edition of this report, climate change continues to be one of the greatest injustices of our time.

In those short years we have witnessed major achievements such as the global Paris Agreement and the adoption of the Climate Action and Low Carbon Development Act in Ireland. But we have also witnessed a series of devastating humanitarian crises exacerbated by climate change including serious flooding in Malawi in 2015, a major food crisis across East Africa, and – closer to home - dramatic flooding across Donegal in the summer of 2017. Throughout 2017 Trócaire has been providing humanitarian assistance including food aid, cash transfers and repair of water sources to communities in Somalia, South Sudan, Ethiopia and Kenya affected by recurrent drought.

In preparing this report we continued our collaboration with the Department of Geography in Maynooth University in order to update the review of science on climate change together with the personal experience of communities at the front-lines of climate impacts. Based on the best scientific information available the report puts forward policy proposals that need to be addressed if Ireland is to do its fair share to tackle climate change.

In 2017 experts warned that we have 'three years to safeguard the climate', and that our global emissions must peak by 2020 at the latest.

There are significant opportunities in the coming months from the Citizens Assembly and the planned National Dialogue on Climate Action in Ireland, to the global Facilitative Dialogue under the Paris Agreement, which will take stock of the collective effort towards the goals in the Paris Agreement. The majority of the actions that need to be taken are already known. What is needed now is the political will to take decisions and prioritise their implementation. As Pope Francis reminds us in Laudato Si – On Care for Our Common Home: "True statecraft is manifest when, in difficult times, we uphold high principles and think of the long-term common good".

Éamonn Meehan

Executive Director, Trócaire

Executive Summary

When Trócaire first published 'Feeling the Heat' at the end of 2014 we were anticipating the major global agreements on climate change and the Sustainable Development Goals that were due the following year.

Their adoption marked major milestones on the path to a more sustainable future for all. However, these multilateral frameworks are not a solution, but rather a call to action.

Two years on from the adoption of the landmark Paris Agreement, national emission reduction pledges remain far short of what is needed to deliver on the critical temperature limits committed to by global leaders. Recent analysis demonstrates that the window of opportunity for delivering on the 1.5°C or well below 2°C limits is rapidly closing, and that action must be urgently scaled up so that global emissions peak in the next three years.[1]

Furthermore, even with emission reductions there is a substantial need for increased action on adaptation. As the case studies in this report illustrate, climate change is already a crisis in the most vulnerable countries in the world.

Recent research indicates that the intensity of extreme rainfall across the **Philippines** has increased by about 4.3 per cent for every 1°C rise in the near-surface global mean temperature. These findings imply an additional intensification and increase in the occurrence of extreme rainfall as the global mean temperature continues to rise over the coming decades.[2] Of particular concern for **Honduras** are the possible changes in the frequency of La Niña, which are expected to double in frequency, with implications for the frequency of hurricanes.[3] For **Malawi, Ethiopia** and **Kenya** where successive droughts have led to major food crises in the last few years, projections that droughts will become more intense, frequent and severe in the future due to the impact of climate change remain one the most significant threats. Climate change is likely to make 39-59 per cent of current coffee growing areas of **Ethiopia** unsuitable for coffee production, a crop that supports 15 million farmers and accounts for a quarter of Ethiopia's export earnings.[4]

Scaled up, appropriate support and investment in communities vulnerable to climate change must be a core part of climate action. In developing adaptation plans understanding the different ways in which women and men experience vulnerability to climate change is critical, as responses that are blind to gender inequalities today may underpin future increased vulnerability for women.

Women in the Shanties Dhuyuleh internally displaced people (IDPs) camp, Somalia. The accumulated effects of failed rains has forced people to migrate in search of food. Trócaire has been responding to the food crisis that has affected countries across East Africa, including Somalia, Ethiopia and Kenya. Photo: Amunga Eshuchi/ Trócaire.

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.'

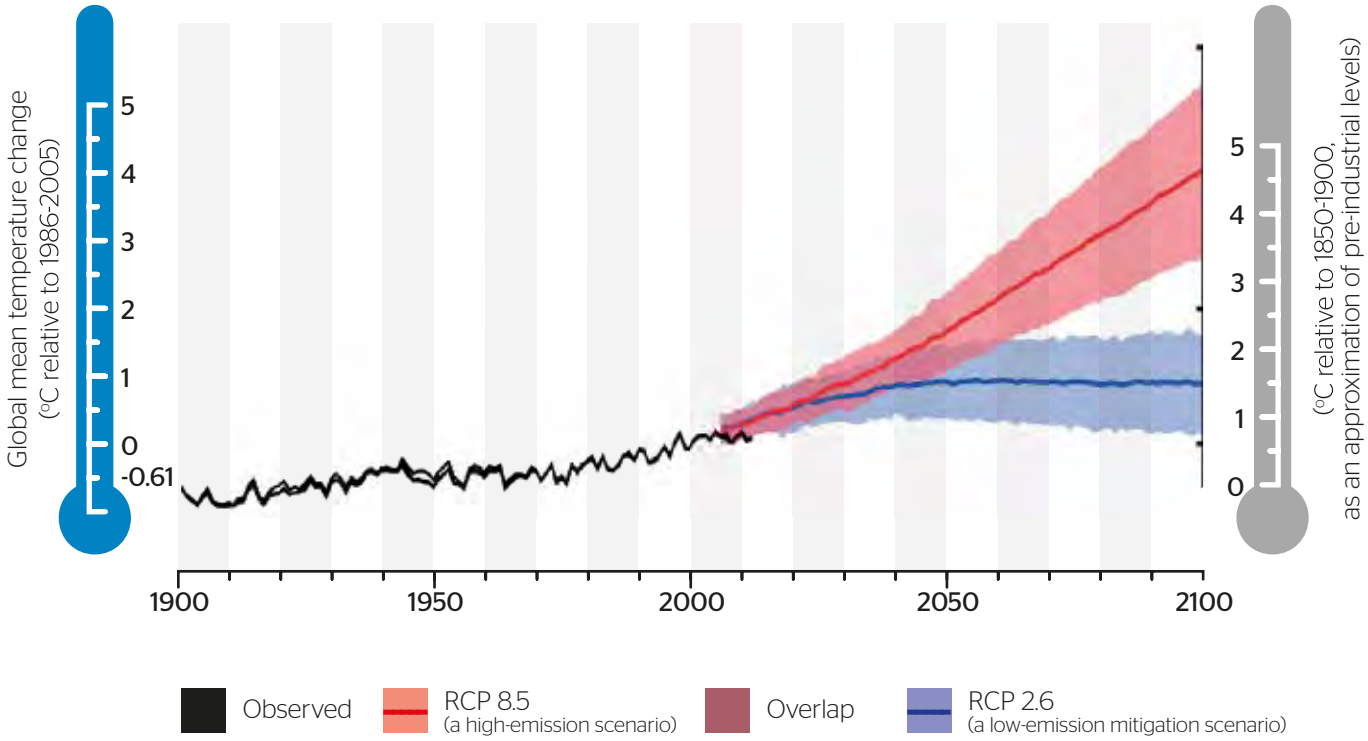
IPCC Fifth Assessment Report, Summary Report, 2013.

Projected changes in climate

The graph below shows the projected changes in global temperature published by the Intergovernmental Panel on Climate Change (IPCC).[5] The red line shows what would happen to global temperature if we continue with 'business as usual' – no reduction in emissions. The blue line 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, as committed to in the Paris Agreement. 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 this study, 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.[6] 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.[7] 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.

This updated analysis of the scientific literature continues to point to major implications for food security, access to water, health, migration, gender and economic impacts across all five of the countries studied.



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.[8] By curbing greenhouse gas (GHG) 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.[9]

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.[10] 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.[11] 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.[12] 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, climate change will also affect those with least power within all societies most profoundly. This includes women, who remain culturally disempowered and under-represented in many countries and 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.[13] Access to water has important gender dimensions, with young girls in particular being more vulnerable to water availability and competition.[14] 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 up to 80 per cent 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.[15]

However, when women are involved as equal participants in climate-related strategies and coping mechanisms, those strategies are more likely to succeed. For example, 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.[16]

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. 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.[17] 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.[18] In the Philippines, the cost of adaptation for agriculture and coastal zones is expected to be about $5 billion/year by 2020 on average.[19] In Kenya, net economic costs of climate 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.[20] 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.[21]

Conclusion and recommendations

The core message of our report remains the same – the projections of the impacts of climate change on the five countries featured in this report are unacceptable. We can and we must take the necessary urgent action to reduce emissions to avoid the worst impacts of climate change. The question is whether we will act quickly enough and whether we will act justly. The report recommends:

1 We must act with the urgency the crisis requires, by ensuring ambitious and fair mitigation and adaptation planning in line with the science.

The majority of the actions that need to be taken are already known, including in Ireland, North and South. What is needed now is the political will to take decisions and prioritise their implementation. In many cases, what would be required is not new exchequer resources, but elimination of incoherent policies, the recalibration of incentives and re-allocation of existing resources. A radical turn-around from where we are currently is needed, including an increase in national climate action ambition, the elimination of incoherent policies and investments, and a robust plan of action to meet current commitments and get on a path to a zero-emissions society as soon as possible.

Globally, the Facilitative Dialogue under the Paris Agreement is the opportunity to align countries' intended emissions reductions (known as Nationally Determined Contributions, NDCs) with achieving the temperature limits set out in the Paris Agreement. If we are to have any chance of achieving the targets set in Paris countries must ensure that the Facilitative Dialogue results in the implementation of current NDCs being speeded up and their emission reductions and sectoral targets surpassed. It should also result in a new round of NDCs that are in line with what is needed to keep temperatures below 1.5°C or well below 2°C. It should also consider the adequacy of and progress toward meeting adaptation commitments, and deliver increased ambition and public finance for adaptation implementation.

The EU must show real global leadership by increasing its collective 2030 emission reduction pledge in advance of the Facilitative Dialogue to at least 55 per cent by 2030, and by ensuring the integrity of the EU's Climate and Energy targets by rejecting proposed loopholes in the rules governing implementation. Ireland should support these measures.

The Irish Government must also increase the level of national ambition and the speed of implementation of domestic action on climate change, so that we contribute our fair share to increased collective action to deliver the temperature limits set out in the Paris Agreement. Each National Mitigation Plan under the Climate Action and Low Carbon Development Act should set out clearly how, and by how much, we will reduce emissions over the time-frame of that plan. Each plan should be informed by public consultation, and should be debated and voted on by the Dáil.

For the Northern Ireland Assembly to be effective in tackling climate change, it should urgently introduce a Northern Ireland Climate Change Act. The Act should include targets that are fully aligned with the Paris Agreement and latest scientific evidence.

The Irish Government and NI Assembly should ensure all climate policy is equity-proofed to maximise potential benefits and minimise potential negative impacts on vulnerable domestic groups. A *Just Transition Fund* should be established to support workers who will be affected by changes to economic sectors.[22] Development of domestic policy to tackle climate change must also examine, understand and prevent unintended negative impacts on poor communities in poor countries.[23]

To meet its obligations to support adaptation, the Irish Government should establish mechanisms to ensure regular contributions to the UN Green Climate Fund in line with our fair share of the

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

commitment by developed countries in the Paris Agreement to support climate action in developing countries.

The Irish Government should also publish a multiannual plan with year-on-year percentage increases in the Overseas Development Assistance (ODA) budget to support the fulfilment of the Agenda 2030 Sustainable Development Goals (SDGs). As the longstanding 2015 deadline to reach the UN target of 0.7 per cent of GNI to ODA has already passed, at a minimum the Irish Government should demonstrate its commitment to now meet this historical commitment by 2025 at the latest and outline a clear pathway to achieve this.

2 We must act with urgency to transform the way we produce and consume, in particular by taking immediate measures to decrease Ireland's dependence on fossil fuels and address our rising emissions from agriculture.

Globally, burning fossil fuels in industry, the residential, commercial and public sectors, and in transport and energy supply accounts for over 60 per cent of GHG 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 order to reduce emissions to stay within the temperature limits set out in the Paris Agreement, 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 are required.[24] Analysis by financial experts in the city of London has shown that the vast majority, around 80 per cent, of remaining fossil fuel reserves owned by fossil fuel companies cannot be burned if the upper temperature limit of 'well below 2°C' set out in the Paris Agreement is to be achieved.[25]

Over the past 50 years, GHG emissions resulting from 'Agriculture, Forestry and Other Land Use' (AFOLU) have nearly doubled.[26] Conversely agriculture, forestry and land use can also serve to mitigate climate change by removing GHGs from the atmosphere. A business as usual approach means agriculture will account for an ever increasing proportion of global emissions in the period to 2050. Agriculture is the largest contributing sector to Ireland's GHG emissions and this is projected to increase by up to 7 percent in the period 2014-2020. By 2020 agriculture is projected to account for as much as 47 per cent of Ireland's emissions. The projected growth in emissions in the period to 2025 will be driven by increases in the dairy cowherd and an attendant increase in nitrogen fertiliser use.[27] A 2016 report on *A Climate Smart Pathway for Irish Agricultural Development* observed 'a growing contradiction between Ireland's climate and agriculture policy objectives'.[28] The report emphasised that 'supply side efficiency gains will not yield anything close to the levels of mitigation required from agriculture' and concluded that 'demand side responses, in particular reducing food waste and dietary changes' will also be required.

The Irish Government should expedite the passage of the Fossil Fuel Divestment Bill currently going through the Dáil to ensure the divestment by the Ireland Strategic Investment Fund of its assets in fossil fuel companies. Within a 'just transition' approach, the Irish Government should phase out fossil fuel subsidies, ban future exploration for fossil fuels in Ireland, decrease domestic dependency on fossil fuels and increase investment in, and use of, renewable energy alternatives. In Northern Ireland, energy policy objectives and plans should specify 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. Mitigation plans for agriculture must go beyond efficiencies in production and supply and include actions across the entire food system including 'demand side' actions on food waste and diet.

3 We must promote resilience and global food security by providing sufficient support to sustainable approaches to agriculture in developing countries.

As the main livelihood of many of the world's poorest people, agriculture is a vital sector to increase resilience to climate change. Achieving sustainable agriculture requires incentivising agricultural development approaches that simultaneously increase smallholder farmers' resilience to adverse impacts of climate change, enhance subsistence farming productivity while also mitigating GHG emissions. Agro-ecological systems that build resilience including biodiversity, healthy soils, water management and the optimisation of yield increases, are a practical approach to addressing these multidimensional objectives. There is a growing body of evidence to show how scaling up agro-ecological approaches is an effective means to ensuring food, nutrition and livelihood security as well as addressing the climate challenge. However, transitioning towards such approaches will not happen without adequate support to and promotion of such approaches, and an enabling policy and institutional environment that incentivises practices to strengthen the resilience of individual farmers, households and communities.

Globally, the Committee on World Food Security (CFS) is well placed to advocate for agricultural policies that are coherent with the Global Sustainable Goals adopted in Agenda 2030 and the Paris Agreement - building on its existing decisions, particularly those on investing in smallholder agriculture to strengthen agro-ecological food systems. Mainstreaming the type of inclusivity associated with the CFS by democratising agricultural and food governance at all levels is key. A particular focus must be placed on increasing the active participation of women and men smallholder farmers – who supply 70 percent of the world's food - in decisions that affect them and that shape agricultural and food systems.

Intellectual property rights must also ensure rather than compromise farmers' rights to save, use, exchange and sell their own seeds, while trade and investment rules should confirm the right of national governments to take measures necessary for ensuring national food security and protecting small farmers from cheap industrial food imports that distort domestic markets.

Providing resources for the reorienting of public agricultural research, extension services and education in order to identify the best transition paths towards diversified farming systems for both subsistence and industrial agriculture is essential. Scaling up research into agro-ecological systems and providing financial supports to farmers making the transition should be prioritised in adaptation funding decisions.

Tenure security in the form of secure access to natural resources including land, water and forests is critical to strengthening farmers and rural communities' food, nutrition and livelihood security as well as their resilience to climate change. Yet, trends favour the privatisation of communal natural resources and the concentration of resource management. Laws that recognise, respect and protect the diverse tenurial systems from which small scale farmers and rural communities derive their resource rights should be promoted. This can be advanced through the domestication of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT).[29]

1. Introduction and Overview

"The human environment and the natural environment are deteriorating together, and this deterioration of the planet weighs upon the most vulnerable of its people. The impact of climate change affects, first and foremost, those who live in poverty in every corner of the globe."

Joint Statement of Pope Francis and Patriarch Bartholomew, 1st September 2017[30]

In 2014 Trócaire launched 'Feeling the Heat: How climate change is driving extreme weather in the developing world', a scientific review of current and projected climate impacts in five countries where we work: the Philippines, Honduras, Kenya, Malawi and Ethiopia. This updated report brings together the latest research both globally and in the five programme countries, to take stock of current and projected climate change impacts and to assess the political response. Recent findings compound the existing evidence, that climate change is already a crisis, that it is hitting the most vulnerable women and men who have done least to cause it hardest, and that it is presenting a significant threat to the goal of poverty eradication.

1.1 Key Developments since the last report

...there have been some major milestones

The 2030 Agenda for Sustainable Development agreed in September 2015 adopted 17 Goals across social, economic and environmental development objectives to be pursued by all countries at all stages of development.[31] Negotiations within the UN on this landmark Agenda were skilfully co-chaired by Ireland.

In December 2015, the much anticipated Paris Conference on Climate Change resulted in a breakthrough international treaty. 196 governments agreed to act collectively to hold the increase in global average temperatures to 'well below 2°C', and to pursue a lower limit of 1.5°C. The Paris Agreement commits to act based on science and equity, to respect human rights, and to promote gender equality. It also reaffirms the commitment by rich countries to provide $100billion annually by 2020 to poorer countries to support them to respond to climate change.[32] [33] Critically, the Paris Agreement includes a provision known as the 'ratchet mechanism' that requires all countries to submit new emission reduction pledges (known as Nationally Determined Contributions, NDCs) at regular intervals. This mechanism was included as it was widely understood that NDCs pledged ahead of the Paris conference fell far short of what is required to deliver on the temperature limits set out in the agreement.

2015 also saw the enactment of climate legislation in Ireland. The intention behind the law, which Trócaire had campaigned for, is to strengthen policy development, implementation, and political accountability for climate action in Ireland.

In June of the same year, Pope Francis launched his seminal Papal Encyclical, Laudato Si: on care for our common home. A Papal Encyclical represents the highest-level moral teaching of a Pope. Laudato Si is extraordinary because it is the first such document to elucidate comprehensively on the climate crisis and the social crisis with which it is inextricably interwoven. In it he speaks 'to every person living on this planet' and appeals for a new dialogue about how we are shaping the future of our planet. In this report, Trócaire urgently reiterates this appeal.

...the case for action has further strengthened

The years 2014, 2015 and 2016 broke records for the highest recorded global temperatures.[34] At the same time humanitarian needs during the period 2015-2017 have been significant. The 2015-2016 El Niño was devastating, affecting over 60 million people across the world. Experts predict

that Climate change will increase the frequency and intensity of extreme weather events and may increase the frequency and intensity of ENSO[35] (see box). Research also indicates that La Niña in particular may double in frequency due to climate change.[36]

The El Niño-Southern Oscillation (ENSO) is a change in global weather conditions caused by the warming of part of the Pacific Ocean and it has three states: El Niño (warming), La Niña (cooling) and Neutral. This results in a cycle of floods and droughts, with significant impacts, particularly on food and agricultural systems in many regions across the world.

In Eastern and Southern Africa alone the UN estimated in 2016 that some 50.2 million people were affected by drought.[37] As a result of continued poor rains, in July 2017 8.5 million people in Ethiopia remained in need of food aid.[38] The Kenyan Government declared the drought a national disaster early in 2017, and the UN estimates that 5.6 million people in Kenya are currently in need of humanitarian assistance.[39]

In January 2015 Malawi experienced its worst flood in decades. More than 63,000 hectares were submerged by floodwaters and around 250,000 people were displaced from their homes. In 2016, while Malawi experienced the driest growing season in 35 years, heavy rains continued in the northern region, exacerbating ongoing flooding.[40]

In Central America, by the end of June 2016, the impact of one of the worst El Niño events ever recorded was compounding damage from two consecutive years of drought in the region with over 3.5 million people in need of humanitarian assistance.[41]

In the Philippines, in 2016, the City Disaster Risk Reduction and Management Council of Kidapawan City passed a resolution to declare an official State of Calamity. More than 11,000 families or about 25 per cent of the city's total population were affected by a dry period as a result of El Niño impacting in particular the livelihoods of tenant and marginal farmers, labourers, and indigent workers.[42]

Closer to home, climate-related extreme events are taking their toll. Climate change accounted for approximately 85,000 additional deaths in Europe over the period 1980-2013.[43] In Ireland, the floods of 2015/16 coming on the heels of the storms of winter 2013/14 have exposed Ireland's vulnerability to extreme events.[44] The Environmental Protection Agency has stated that Ireland will experience more frequent and intense weather events as a result of climate change, such as more extreme storms and rainfall, and increased drought and water shortages.[45] Even if global average temperature increase is limited to 2°C, research suggests that within the European context Ireland will be a hotspot for flooding and drought.[46]

.....evidence shows that the window of opportunity for achieving Paris goals is closing

Recent analysis demonstrates that the window of opportunity for delivering on the the 1.5°C or well below 2°C limits is rapidly closing, and that action must be urgently scaled up so that global emissions peak in the next three years. The inclusion of the lower temperature limit of 1.5°C in the Paris Agreement is an acknowledgment of the severity of impacts of a rise of 2°C, in particular in some regions - including disappearance of entire island nations. A 2°C increase in average global temperatures will not limit warming everywhere to 2°C. Recent studies indicate that those in most vulnerable parts of the world are likely to experience increases in temperature beyond the global average.[47] Even at a rise of 1.5°C above pre-industrial average surface temperatures, many additional millions of people, particularly in tropical areas, may be at increased exposure to potentially deadly temperature extremes with impacts on sensitive ecosystems upon which millions depend.[48] While some recent studies suggest the 1.5°C limit may no longer be possible, aiming for this goal, and for as low a limit as possible is critical.[49]

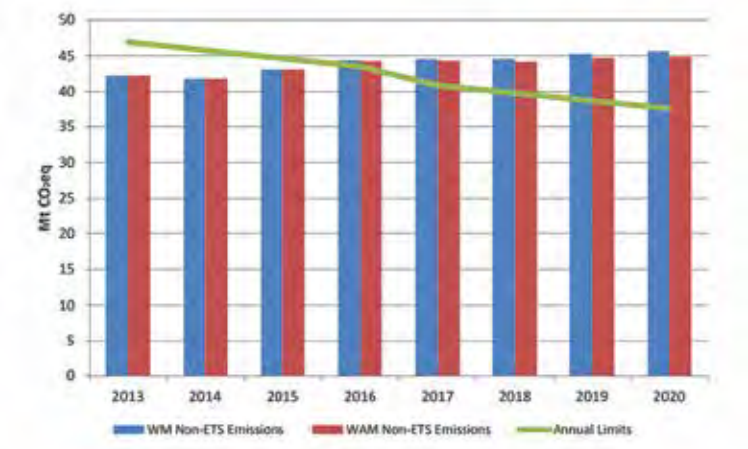
....and that the costs of inaction are rising

In 2016, the UN Environment Programme estimated that the cost of adapting to climate change in developing countries could rise to between $280 and $500 billion per year by 2050, a figure four to five times greater than previous estimates.[50] A dedicated goal on adaptation was included in the Paris Agreement, as well as a commitment to balance climate finance between adaptation and mitigation.[51] Total bilateral and multilateral funding for climate change adaptation in developing countries has risen since 2010, reaching $22.5 billion in 2014, however the UN is warning that there will be a significant funding gap by 2050 unless new and additional finance for adaptation is made available. Already current adaptation finance is not enough to meet actual needs. The Government of Haiti received a $20 million insurance pay out following Hurricane Matthew in 2016. However, the estimated cost of damage to infrastructure alone was $2.25 billion – more than eight times the amount of adaptation funding available to the entire Caribbean region via existing climate funds.[52]

.....but there remains a worrying lack of urgency in response

The call in the Paris Agreement for an increase in climate action before 2020 has not translated into reality. The EU had been a longstanding advocate for the Paris Agreement and commendably, responded firmly to the decision by US President Trump in 2017 to seek US withdrawal from the Paris Agreement by stating that it would take up a global leadership role. However, its emission reduction target of 40 per cent by 2030 is not in line with the Paris temperature limits and the EU has rejected repeated calls to increase its collective target. Also of concern are ongoing negotiations over the rules for the accounting of Member State emissions reductions, which look set to include a number of loopholes that risk significantly undermining the integrity of the EU's already inadequate 2030 target.[53]

The Republic of Ireland has ratified the Paris Agreement and enacted a Climate Action and Low Carbon Development Act, but as yet has failed to increase ambition in acting on its commitments. It is one of only five EU Member States set to miss its EU 2020 climate targets, and the only one whose emissions are predicted to continue to rise out to 2030.[54] While it has been suggested that Ireland's targets were unrealistic, expert commentators have noted that our emission reduction commitments could have been met if, like other EU countries, the State had taken action in a timely manner.[55] The Environmental Protection Agency has warned that current policies and plans remain inadequate to fulfil our international obligations and that our performance is getting worse, not better.[56] However, the first 5-year action plan under the Climate Act, called the National Mitigation Plan (NMP) fails to commit the State to substantive new policy change or to provide a clear analysis of how emissions will be progressively reduced in line with national, EU and UN targets.



Planning to Fail:

EPA figures show that emissions have risen since 2014 and are projected to rise even with the implementation of 'existing measures' (current policies) and 'with additional measures' (expected further implementation of policies). Ireland is projected to exceed its 2020 targets by 11.5-13.7 million tons of $C0_2$.

Source: EPA 2017

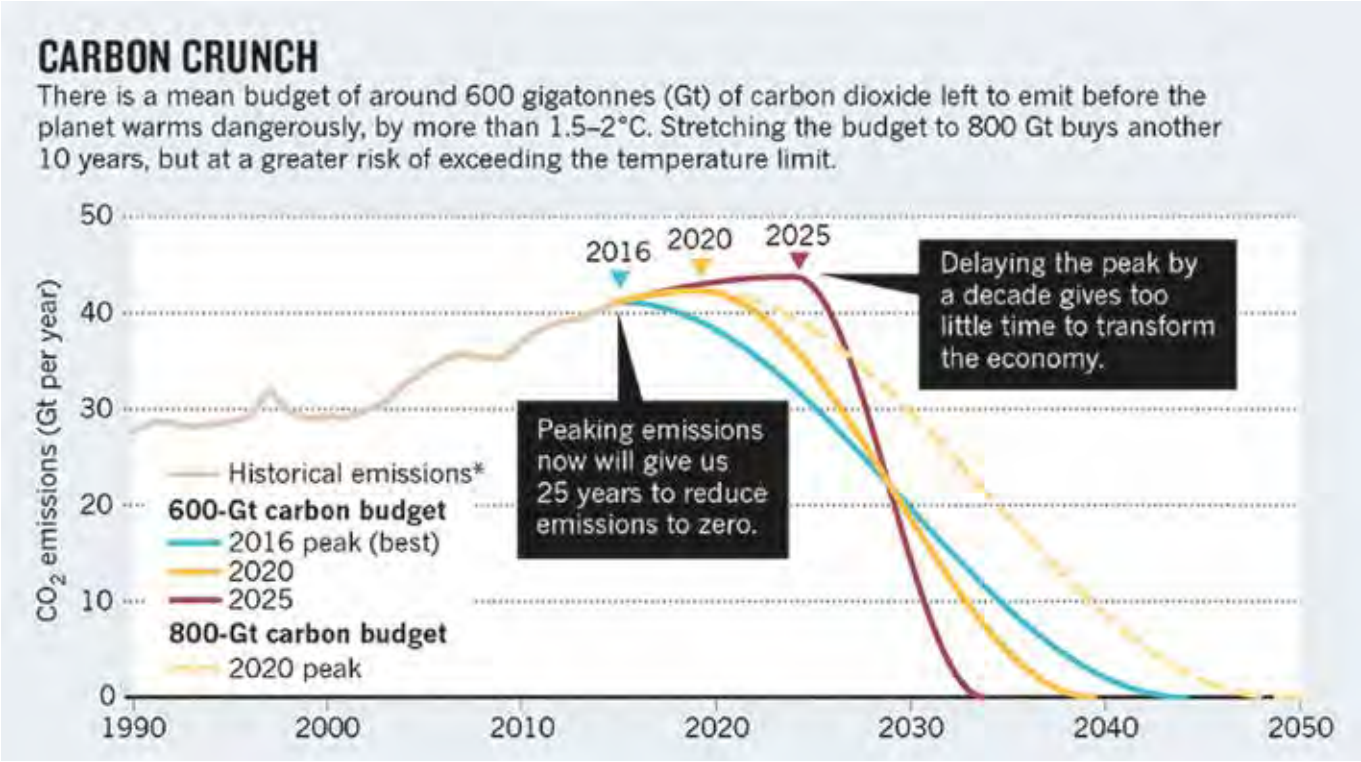
> The Environmental Protection Agency has warned that current policies and plans remain inadequate to fulfil our international obligations and that our performance is getting worse, not better.

Northern Ireland is the lowest performing region on emission reductions within the UK. The UK's 2008 Climate Change Act introduced a legally binding target to reduce overall emissions to at least 80 per cent below 1990 levels by 2050, with an interim target of a 35 per cent reduction by 2020. By 2015, the UK has reduced emissions by 38 per cent, with England and Scotland performing highest. The Scottish Parliament adopted a climate law in 2009 and set an ambitious 2020 target for emission reductions of 42 percent below 1990 levels, which it met six years early and it is now targeting a 66 per cent reduction by 2032. Northern Ireland reduced emissions by a total of almost 18 per cent since 1990, but between 2014 and 2016 there was in fact an increase in emissions in Northern Ireland of 0.6 per cent.[57] The Act does not legally require Northern Ireland to cut emissions against the targets, as they only apply to overall UK emissions. It is in Northern Ireland's strategic interest to significantly increase action now however, both to do our part in avoiding the systemic risks that unchecked climate change will bring, and to ensure we are not left behind in the ongoing transition to a low carbon global society and economy.

Progress in delivering climate finance for adaptation is difficult to track. This is because many donor countries are not in fact providing new and additional funds but are re-labelling existing Overseas Development Assistance flows as climate finance – despite the very clear need for additional financial support to developing countries as a result of climate change. The Irish Government has commendably focused its climate finance to date on adaptation, aligning its support for climate action with its pro-poor focused overseas development programme. However, Ireland's climate finance contributions have been largely re-labelled ODA flows which had already been committed to, rather than new and additional finance to meet the growing needs.

1.2 Looking forward

Safeguarding the poor and the planet requires an urgent increase in action, ambition, and adaptation in the next three years. If emissions continue to rise beyond 2020, a managed delivery of the temperature limits set out in the Paris Agreement will become virtually impossible.[58] An emissions reduction pathway that can comply with the Paris targets requires emissions to peak by 2020 to allow a gradual twenty five year, managed decarbonisation process, as illustrated in the diagram below.[59]



Sources: Stefan Rahmstorf/Global Carbon Project; http://go.nature.com/2RCPCRU

Every policy and investment decision taken in these next few years, will either serve to bring us onto a Paris-compliant, managed transition pathway, or they leave us all, in particular the poorest communities, exposed to both climate and transition chaos. Priority areas for action to reduce emissions and increase resilience to the impacts of climate change are outlined in our recommendations in this report.

Some positive signs of transition emerging include figures suggesting that global CO_2 emissions from fossil fuels have remained flat for the past three years, while the global economy has grown by at least 3.1 per cent per year. Previously this has happened only in times of economic downturn, suggesting that emissions may be de-coupling from growth.[60] Renewables are making up an increasing share of electricity supply. The International Energy Agency (IEA) predicts that renewable sources could deliver 26–27 per cent of the world's electricity needs by 2020, and this is considered a conservative estimate. Many analysts highlight that changes are happening quicker than expected: a forecast by the IEA back in 2000 estimated that the world would have 6 Gigawatts (GW) of solar capacity by 2020. In reality, at the end of 2015, the world had 226 GW of deployed solar capacity. In many European countries, including Ireland, solar and wind already make up over 20 per cent of electricity supply thanks to demand management, better regulations, wider grids and renewable forecasting.[61]

"...a forecast by the IEA back in 2000 estimated that the world would have 6 Gigawatts (GW) of solar capacity by 2020. In reality, at the end of 2015, the world had 226 GW of deployed solar capacity.

The decarbonisation agenda is already profitable and creating jobs. The International Renewable Energy Agency and the IEA published a report this year showing that efforts to stop climate change could boost the global economy by $19 trillion, while the IEA has also said that implementing the Paris agreement could unlock $13.5 trillion or more before 2050.[62] In Ireland, PWC published a report stating that the pursuit of climate action in Ireland can also be expected to deliver a wide range of additional benefits, including greater energy security and the creation of new job opportunities and direct health benefits.[63]

1.3 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. This updated report draws on more than 170 publications of 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.
- Evidence 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.

1.4 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, CO_2 emissions stay at current levels until 2020, and then decline and become negative by 2100. This is the low emissions 'best case scenario', which is the only scenario that adheres to the temperature goals set out in the Paris Agreement.

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.

2. The Philippines

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

Right now: the Philippines is one of the most vulnerable countries to climate change and there are limited coping tools available to low income households, in particular those headed by women. The intensity of extreme rainfall across the country has increased by about 4.3 per cent for every 1°C rise in the near-surface global mean temperature.[64]

Future climate change risks: additional intensification and increase in the occurrence of extreme rainfall as the global mean temperature continues to rise over the coming decades.[65] Eroded coastlines and coral reefs; increased risk of tropical storms.

Emissions of CO_2 per capita: 1 metric tons **– over seven times less than Ireland.**

2.1 Introduction

The Philippines is classified as one of the least developed countries in the world, ranked at 116 out of 187 countries on the 2016 Human Development Index. Over half of the population of the Philippines live in poverty.[66] It is also one of the most vulnerable countries in the world to the potential impacts of climate change and already faces a pervasive threat from intense tropical cyclones, rainfall variability, sea level rise and increasing temperatures, flooding and landslides. 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.[67]

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 per cent of the country's land area is economically at risk from multiple hazards such as floods, typhoon, and earthquakes. This means some 81.3 per cent of the country's population or around 76.6 million Filipinos are prone to economic impacts brought by natural disasters."[68]

Indeed, in recent years the country has seen an increase in both frequency and intensity of extreme weather events.[69] In 2011, a study highlighted the early recognition of the increased potential for disasters as a matter of urgent concern.[70] 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.[71] 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[72] and destruction of coral reef ecosystems, on which many Filipinos are dependent for coastal protection, subsistence fisheries and tourism.[73]

Future projections of climate change 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.[74]

Climate change therefore presents a systemic challenge to the country's efforts to address poverty and realise sustainable development.[75]

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*'.[76] The Commission's message is representative of a high level of 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

Households in the Philippines 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.[77]

Data shows that there is an increase in observed mean temperatures in the Philippines of 0.64°C from 1951-2010.[78] 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.[79] The country is experiencing an increased number of hot days and a decreasing number of cold nights.[80]

The El Niño effect causes year to year variations in rainfall and large variability in extreme precipitation in the Philippines.[81] Increasing trends in the number of "no rain" days have been observed over western Philippines.[82] 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.[83]

According to long-term, quality assured regional data, the amount of extreme precipitation appears to be on the rise. The number of consecutive dry days is increasing for those locations that are already dry, and the number of consecutive wet days is increasing for the already wet areas.[84] 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.[85] A recent study attempted to attribute observed changes in extreme rainfall across the Philippines and found that changes in extreme rainfall are linked to near-surface global mean temperature increases and ENSO. The study found that the intensity of extreme rainfall across the country has increased by about 4.3 percent for every 1°C rise in the near-surface global mean temperature. These findings imply an additional intensification and increase in the occurrence of extreme rainfall as the global mean temperature continues to rise over the coming decades.[86]

2.3 Projections of future climate –changes in averages and extremes

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.

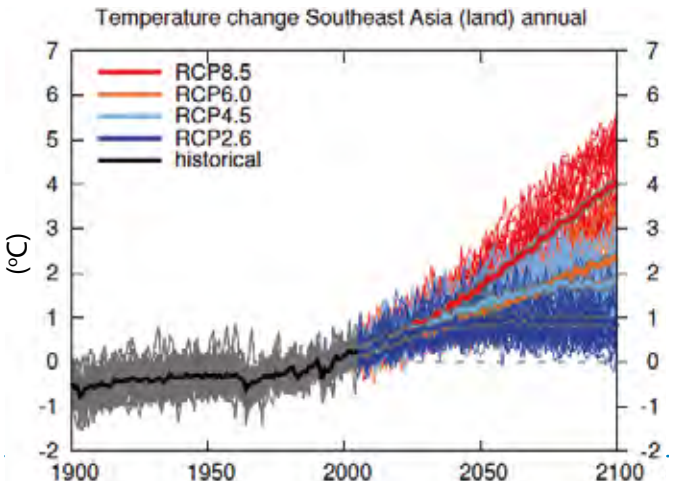


Figure 1. Projected changes in annual temperature relative to 1986-2005 (left) under different greenhouse gas emissions pathways for south-east Asia. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin lines denote a single model projection; thick lines show the mean simulation for multiple climate models.[87]

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,[88] 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).[89] 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.[90]

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

> "Sea levels are forecast to rise and some low-lying islands may be completely submerged.

sector is most vulnerable to drought and changes in the southwest monsoon rainfall.[91] About thirteen million hectares of agricultural area produce a wide 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.[92]

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.[93] Resources on the coast will likely be severely impacted by global warming, particularly coral reefs which underpin fisheries in the country. Flood risk is also likely to increase.[94] Sea levels are forecast to rise and some low-lying islands may be completely submerged.[95]

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.[96] Coastal flooding, coastal erosion, saltwater intrusion and drought may exacerbate food insecurity and habitat degradation in coastal regions, for example in Manila Bay.[97] 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.[98]

As noted above, increasing temperatures are expected to negatively impact on coral reefs, an important resource in small tropical islands and a source of wellbeing 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.[99] 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.[100] 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.

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.[101] 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. In terms of flooding, an increase in flood events is likely for the middle and southern parts of the country during the wet season. In the north, projections are for an increase in peak flow return periods for both wet and dry seasons.[102] These findings suggest a general increase in threat of flooding and enhanced soil erosion throughout the country.[103]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.[104]

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.[105] 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.[106] 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 wellbeing in the Philippines.[107] The country often experiences climate-related disasters, and both men and women have developed adaptation strategies that make them resilient to extreme weather events.[108] Available evidence shows that men and women adapt to flooding according to their traditional roles but women have extra roles and burdens in addition to farming roles and managing daily household welfare.[109] 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.[110] 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.[111]

> "Understanding the role of gender in determining vulnerability to climate change is critical in developing adaptation strategies as gendered distinctions today may propagate to underpin future gendered vulnerabilities.

In the Philippines women lack resources and power and usually take up roles that make them less mobile.[112] Recent research highlights the limited coping tools available to low income households, particularly those headed by women, in responding to climate change impacts on food[113]. 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.[114] 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.[115] Women in the countryside have lower incomes and are more likely to be economically dependent which compromises their adaptive capacity.[116]

In an urban setting recent work has also highlighted that extreme weather events have significant gender dimensions that can further exacerbate challenges for women of fulfilling both domestic and income earning responsibilities.[117] Gendered dimensions of vulnerability to climate change are also evident in indigenous communities with studies

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.

Trócaire responded with a first phase emergency response including food assistance and emergency shelter kits in the 6-months after the disaster. This was followed by two-year recovery phase providing shelter (rebuilding homes) and support to re-build livelihoods (providing seeds and tools, fishing, livestock and poultry).

showing that issues like religion and gender are related to capacity to adapt to climate change.[118] Understanding the role of gender in determining vulnerability to climate change is critical in developing adaptation strategies as gendered distinctions today may propagate to underpin future gendered vulnerabilities. [119]

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.[120] 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.[121] 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.[122] In the Philippines human health is profoundly affected by weather and climate. Climate

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

change threatens to increase mortality rates from extreme weather events, cardiovascular and respiratory diseases, infectious diseases and malnutrition. Extreme events also induce health issues through undermining water and food supplies, infrastructure, health systems and social protection systems.[123] 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.[124]

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.[125]

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.[126] 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.'[127]

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 provided support for a two-phase emergency response – providing emergency shelter, food assistance and psychosocial assistance in the first six months following the disaster, and then providing long-term shelter through house-building and support for livelihoods over the next two years.

> "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.

The purpose of the rehabilitation response was to leave the Philippines with stronger and more disaster-resilient communities by building safe and disaster resilient homes, schools, sanitary facilities and livelihoods. The Trócaire programme concluded in 2017. It ensured that 958 families affected by typhoon Haiyan have safer homes to live in, with connecting water, hygiene and sanitation facilities, which can better withstand typhoons in the future; seven communities affected by typhoon Haiyan have safe and strong school structures to go to school in and to evacuate to in times of emergencies; 46 communities are better prepared for typhoons and are better organised to withstand and recover from future typhoons; and 759 households have improved and diversified livelihood options within the vicinity of their living area.

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 responded by distributing food, shelter, hygiene kits and cooking utensils.

2.11 Summary of Findings

Observed Changes in Climate	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. Changes in rainfall extremes have been attributed to increases in global average temperature, caused by human activities.
Projected Changes in Climate	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.
Likelihood of Extreme Events	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.
Economic Impacts	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.
Food Production	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.
Access to Water	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.
Health	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.
Gender	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	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 frequency and intensity of flooding. Increased water scarcity and contamination, reduced staple food production yields.

Annual emissions of CO_2 per capita: 1 metric ton **– over seven 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, with more than 66 percent of the population living in poverty in 2016, according to official data. In rural areas, approximately one out of 5 Hondurans live in extreme poverty, or on less than US$1.90 per day.[128] 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 1996 to 2015.[129] Over these 20 years, at least 61 extreme weather events occurred in Honduras, leading to annual economic losses of over 2.1 per cent of GDP.[130] 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.[131]

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.[132] Extremely warm temperatures occur more frequently while extremely cold temperature events have decreased.[133] There have not been significant increases in the total amount of rainfall, but rainfall is intensifying, with more wet and very wet days.[134] 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 Nino. 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.[135]

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.

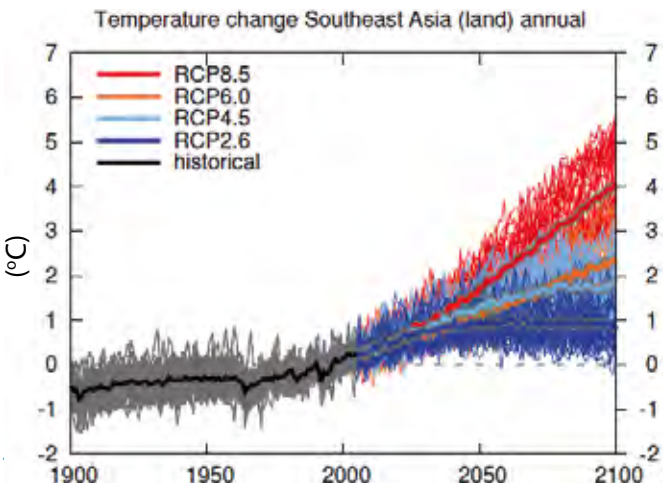


Figure 1 Projected changes in annual temperature relative to 1986-2005 (left) and annual precipitation (right) under different greenhouse gas emissions pathways for Central America. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin 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 rainfalls during the rainy season are projected, with negative impacts for the regions high value ecosystems.[136]

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.[137] Such changes in dryness will have implications for crop production on which the economy of Honduras is heavily dependent. Under business as usual emissions (RCP 8.5) the number of consecutive dry days is projected to increase with such long dry spells expected to greatly impact vegetation growth by limiting water availability.[138]

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.[139]

With climate change, an increasing frequency and intensity of extreme weather events, together with greater climatic variability will increase the social, economic and environmental risks posed by disasters in Honduras. Many of the strongest hurricanes recorded, which impacted Honduras, occurred during La Niña conditions (e.g. Mitch). Research shows that La Niña events are likely to double in frequency with climate change, with potentially concurrent increases in the occurrence of hurricanes.[140]This raises significant concerns given that 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. Climate change is predicted to increase the frequency of high-intensity storms in selected ocean basins depending on the climate model.[141]

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.[142] An increase of 13 per cent in the volume of heavy rainfall is associated with high emissions for the 2050s which would result in increasing common flood flows by about 60 per cent. With more

Maize that was planted in "primera", in May 2016 has been lost because of the June drought. Pespire municipality, southern Honduras, where 85% of the rural population rely on agriculture.

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.[143]

3.4 Food production and climate change

Climate change will have serious repercussions for agriculture, ecosystems, and farmer livelihoods in Central America. Smallholder farmers are particularly vulnerable due to their reliance on agriculture and ecosystem services for their livelihoods.[144] Production of many of the most important crops are expected to decrease significantly in a warmer climate, while many farmers have a low capacity to respond to climate change impacts and depend heavily on sensitive ecosystems for on farm and off farm income[25]. Scientific understanding of impacts on agriculture are supported by a strong perception among smallholder farmers in the region that climate change and variability are already reducing crop productivity, causing crop losses, and affecting water availability.[145]

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.[146] 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.[147]

> "All parts of the country are expected to experience yield losses in excess of at least 10% by 2020

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^{0}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.[148] Losses from maize production in Honduras could amount to 120,000 tonnes annually, valued at $40 million USD by 2025.[149]

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.[150] 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.[151]

Coffee is a critically important cash crop throughout the region of Central America. Studies of the region suggest that both yield and the area suitable for coffee cultivation will reduce as the climate changes.[152] Coffee is sensitive to climate change given its small thermal range. Therefore the extent of temperature increases is most likely to determine the severity of negative changes in coffee production.[153]

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.[154] 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 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.[155] Increased drought frequency is also expected across the region, with likely serious ramifications for livelihoods.[156]

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.[157]

3.6 Gender

Research suggests that, given the opportunity, women are more likely to receive and act on early warnings.[158] 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.[159] Six months before the disaster, a community emergency preparedness 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.[160] Women in La Masica reported a lower incidence of depression following the disaster, most likely because of their active role.[161]

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.[162]

"I will only rest when we have saved the community"

Santos Francisco "Chico" Diaz looks worried at the engine of his boat. The worst weather of the year is about to come, and Chico will probably have to evacuate his neighbours to a safer place when the sea waves reach the houses. He needs 15.000 lempiras (€600) to revamp the engine, but he only earns 3000 (€120) per month. Life is tough is the Cuyamel and Motagua sandbars, on the Caribbean coast of Honduras, two communities besieged by climate change. Every time a storm comes, the sea and the nearby river flood the houses, and Chico has to take his neighbours to a safe place on his boat.

"Nobody worried about us until CASM and Trócaire arrived here, they were truly pioneers; I don't even think that the Government knows that we are here, besides, Omoa is a poor area with many needs so the local government can't provide for everybody" he says. With support, Chico went from a good neighbour to a community leader and coordinator of the local emergency committee. "Thanks to all the training and all the support from CASM and Trócaire the situation has changed radically in our communities". Trócaire supported digging canals to improve the evacuation route, "these two or three kilometres of canals make a real difference in a tough moment" Chico supervises all the risk management work and their maintenance. "Rules exist for a reason," he says seriously "we need to follow them to save lives and also to keep our credibility as community leaders".

Chico is at all time available for the job "I don't care if it is 2 am, first I bring people to my stilt house where I can shelter up to 15 families for a night or two, if the situation doesn't improve, we evacuate", he explains. "I left school when I was 9 years old, but I have more skills than a diplomat" Chico says laughing. He is always in close contact with the municipal emergency committee, with whose members he coordinates where to leave the people while they organise shelters and provide food.

"Our final goal is to resettle the communities in a higher place, and we already know where but we need the money to buy the plot" Chico asserts "local politicians don't give a damn about us, so we need to look for it ourselves, if we could buy the plot of land, as soon as tomorrow we would be building houses" he claims "I would love to live in a good safe house, and I wish Trócaire would be present the day we have our new houses, I have dreamt about it". Until then, he has no plan to give up "I will only rest when we have saved the community" he says. "Well" Chico stops for a second, "even in that case I will still be a community leader, and I will try to keep the order, and the youth on the right path, we are in a difficult country".

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.[163] 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.[164] 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.[165] 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.[166] 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.[167]

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.[168] 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 promoting 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. Trócaire also works to help local farming communities build sustainable food production systems. These are designed with climate change in mind, and aim to reduce the risk and potential impact of disasters.

Furthermore Trócaire's work on Disaster Risk Management includes a strong component on advocacy towards governmental policies on climate change in order to reduce the vulnerability of communities to the effects of climate change. The Honduran Alliance on Climate Change, a network of 30 civil society organisations supported by Trócaire has been engaging with the government to ensure that the National Adaptation Plan as well as policies and laws related to climate change include the human rights and climate justice perspectives. The Alliance has also carried out advocacy to defend the relocation demand of a fishing community in Northern Honduras whom Trócaire has been supporting to prepare themselves against the occurrence of hurricanes, floods and rising sea levels that can be at least in part attributed to climate change.

3.11 Summary of Findings

Observed Changes in Climate	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
Projected Changes in Climate	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.
Likelihood of Extreme 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. Of concern are possible changes in the frequency of La Niña events with implications for Hurricane frequency.
Economic Impacts	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.
Food Production	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.
Access to Water	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.
Health	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 direct and indirect impacts on health. Research has also shown linkages between climate variability and outbreaks of Dengue fever in Honduras.
Gender	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.
Migration	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.

Annual emissions of CO_2 per capita: 0.3 metric tons – **almost twenty-five times less than Ireland.**

4.1 Introduction

Kenya's socio-economic development is already highly susceptible to climate variability and climate-related extreme events.[169] 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.[170] 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.[171] 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.[172] Kenya's National Climate Change Response Strategy highlights that observed temperature trends between 1960-2006 show general warming over land locations exceptfor 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.[173]

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.[174] 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

The carcass of a dead camel in Nayuu in northern Kenya. Pastoralist people are seeing their animals perish because of a lack of water and grazing due to prolonged drought. One local told Trócaire that when camels start dying you know the situation is critical. Photo: David O'Hare.

decade. Drought conditions between 2008-2011 badly affected pastoralist communities in the north east of Kenya, where some 70 per cent of livestock died.[175] Quality assured rainfall stations across Kenya find a significant decrease in rainfall over Kenya.[176]

Research has indicated that there has been an increase in seasonal mean temperature in many areas of Kenya over the last 50 years.[177] 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.[178] 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.[179] Recent research has highlighted that maize yields in Kenya have seen increased variability and attribute a substantial portion of change in yield variability to climate change in a statistically significant manner.[180]

4.3 Projections of future climate-changes in averages and extremes

With continued emissions of greenhouse gases, global climate models show warming projected for all seasons in all regions of Kenya, except for coastal regions.[181] 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.[182] 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.

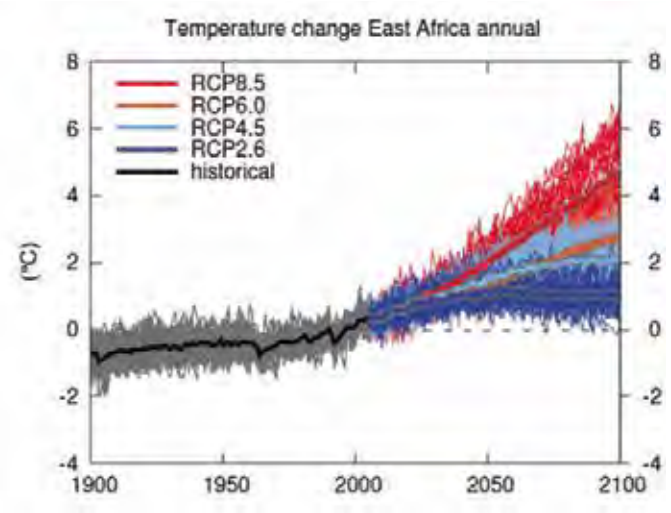


Figure 1 Projected changes in annual temperature relative to 1986-2005 (left) and annual precipitation (right) under different greenhouse gas emissions pathways for East Africa. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin lines 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-20th Century.[183] 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.[184] 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.[185] Under all

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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.

greenhouse gas emissions scenarios se 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.[186]

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.[187] In recent years droughts have become frequent, reducing production of maize, the staple food crop, sugarcane and coffee, worsening Kenya's food security.[188]

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.[189] 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

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In Kenya climate change is having far reaching negative effects on the already precarious food security situation for both crop cultivators and pastoralists.

climatic conditions.[190] 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.[191] 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.[192] Ticks and tick-borne diseases will specifically exacerbate the growing food insecurity among the pastoral community in Kenya.[193]

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 extremes events are expected to impact negatively on water resources in eastern Africa.[194] In Kenya water supplies are projected to be affected by increases in temperature and local variability of precipitation.[195] Most water for domestic use and other uses is derived from rivers whose recharge depends on rainfall.[196] 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.[197]

Kenya's per capita water availability is very low and likely to decrease with climate change in combination with population growth and environmental degradation.[198] 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.[199] Meanwhile, water demand is predicted to rise by 2020.[200]

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.[201] These losses are likely to be exacerbated by climate variability and change over the coming decades and, consequently, increase pressure on water resources.[202]

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.[203] 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.[204]

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.[205] If a woman survives and her husband does not, she has poorer customary rights to the land, water and livestock.

4.7 Migration

Rural-urban migration in Kenya is accelerated during periods of drought such as in 2008-2011.[206] During these drought conditions many pastoralists migrated to peri-urban areas increasing significantly their vulnerability and dependency on food aid.[207]

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.[208]

Increasing drought frequency is also associated with intensifying violent conflicts between pastoral groups, exacerbating the complexities and challenges experienced by local communities.[209] Oil exploration has also been found to increase local community vulnerability to climate change, especially in northwest Kenya, where tensions surrounding water resources, employment and development pose risks for violent conflict between local communities and oil companies.[210] Reduced access to critical natural resources such as pasture land and water can spark conflict, contributing 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.[211] 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.[212] 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.[213] 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.[214]

Research also argues that climate change is expected to increase stunting among children in the country.[215] 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.[216] 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.[217]

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.[218] 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 a year (for 2012).[219] The cost of adaptation by 2030 will increase: an upper estimate likely to be in the range of $1 to 2 billion a year.[220]

“...an initial estimate of immediate needs for addressing current climate as well as preparing for future climate change for Kenya is $500 million a year (for 2012). The cost of adaptation by 2030 will increase: an upper estimate likely to be in the range of $1 to 2 billion a year.

Taking back control in drought ravaged Kenya

Joseph Ireri (38) counts himself very lucky. He is a farmer who owns 1.5 acres of land in Ishiara, Kenya. This land was however not producing enough to support his family until he became a beneficiary of an irrigation scheme by Trócaire in the area. The yield from the land given irrigation now sustains his family.

Ishiara has always been prone to drought and so residents know when to expect it and have been able to plan for when it strikes. In recent years though weather patterns have become totally unpredictable. Rains come early and wash away seeds or come too late to nourish the crops. The effects of climate change have been adverse especially on crops that rely on the rains to grow.

"No matter what I did, I couldn't grow enough food to feed my family," says Joseph. "I had no choice other than to leave my home and look for casual work so I could support them better." Joseph did what thousands of men and women have had to do in this area. He moved to a city in the hope of finding work. In Joseph's case this was Mombasa which is 600km away from Ishiara. Where easy and regular travel back home was concerned, this could just as well have been the other side of the world.

Joseph could very well have still been in Mombasa, separated from his family, if it wasn't for the irrigation scheme funded by Trócaire through the support of Irish Aid. The parish of Ishiara, one of Trócaire's partners, began the installation of an irrigation scheme in the area in 2011. This simple scheme saw the laying of pipes which take water from the river and feed it by gravity to local farms. Today 30km of piping translates to 700 households being served by the scheme. Joseph's household is one of these.

"The water supplied by the irrigation scheme has made all the difference to my family. Without it I would still be away in Mombasa. It has restored predictability which is very key to farming," Joseph says. "Before I would only have grown maize and would have been very lucky to get one or two harvests a year at most. Now I am growing maize, tomatoes, kale, spinach, onions and melons. I can get up to four harvests a year. "I not only have enough to feed my family but also to sell in the nearby Ishiara market."

This success has transformed the fortunes of Joseph's family. His children, two boys aged eight and two and a half, are eating a much more balanced diet which has improved their health. There is also a lot less stress on Joseph and his wife as they don't have to worry about where their next meal will come from. The family has a steady income now because they can sell their surplus consistently and this has meant school fees can be paid for Joseph's older son. Even more, Joseph has been able to buy chickens with his profits and these are a valuable source of eggs and protein for the family.

The scheme is locally managed by a very strong community water management committee. There is total community buy-in and it is evident that bottom-up solutions work best. The proof of the success of this project is the fact that people like Joseph have returned to farm their land and the local market is now full of local produce instead of produce grown many miles away.

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, 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. 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

Observed Changes in Climate	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.
Projected Changes in Climate	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.
Likelihood of 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-20th 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.
Economic Impacts	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 a year.
Food Production	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. Increased variability in maize yields in recent years have been attributed to climate change.
Access to Water	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.
Health	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 increase and areas above 2,000m, with temperatures currently too low to support malaria transmission are affected
Gender	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.
Migration	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. Major flooding in 2015 displaced 230,000 people across 15 out of 28 districts in the country.

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

Annual emissions of CO_2 per capita: 0.1 metric tons – **nearly seventy-four 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.[221] 90 per cent of the population are dependent on rain-fed agriculture, 60 per cent of whom are food insecure on a year-round-basis.[222] 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.[223]

Climate extremes and weather events severely erode the resilience and adaptive capacity of individuals and communities via declining yields and food security. The cumulative effects of several years of multiple weather related disasters have had a substantial impact on Malawi. Climate change has ensured the nature and pattern of these weather-related hazards have become more frequent, intense and unpredictable. Malawi's weather related crises, coupled with a weak economic profile have combined to create a vicious cycle of food insecurity and malnutrition, with devastating consequences on basic services and, consequentially, on long term development. In 2016-17, a State of National Disaster was declared as Malawi experienced record high humanitarian needs with over 6.7 million people in need of food aid and supported through the Food Insecurity Response Plan (FIRP).[224] In the last few decades Malawi has experienced droughts during the 1978/79, 1981/82, 1991/92, 1993/94, 2001/02, 2014/15 and 2015/16 crop growing seasons. It also experienced devastating floods in 2012/13 and 2014/15 rainy seasons where many lost their lives and livelihoods. 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, economic 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 particularly female headed households.

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.[225] The increase in temperature has been most rapid in December-February (mid-summer) and slowest during September-November (early summer).[226] Observations in Malawi are consistent with Sub-Saharan Africa and global trends.[227] 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.[228]

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.[229] 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[230] 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.[231] By the end of the century temperature increases under business as usual indicate an average warming of over 5°C across all models for southern Africa –with some models indicating a temperature increase of over 6°C. Such changes would be very difficult to adapt to. Under a best case scenario a mean temperature increase of just over 1°C is projected, with some models showing increases in excess of 2°C.

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.[232]

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.[233]

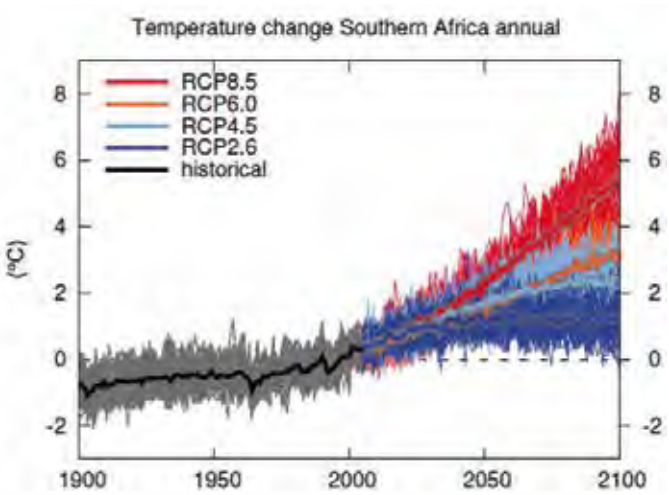

Figure 1 Projected changes in annual temperature relative to 1986-2005 under different greenhouse gas emissions pathways for southern Africa. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin lines denote a single model projection;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

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.[234] 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).[235] 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.[236]

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.[237] The most up to date study suggests that measures to increase soil fertility and moisture should be developed to build resilience into Malawi's agriculture sector.[238] Assessment of climate change impacts for Lilongwe district, the main cereal producing region, indicates that while maize farming might benefit in the short-term future, faster crop growth could worsen Malawi's soil fertility problems. In the medium to long term increasing temperature will likely drive lower maize yields. [239]

> "...yields in sub-Saharan Africa are projected to decrease by as much as 50% over the century while crop net revenues could fall by as much as 90% by 2100.

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.[240] 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.[241]

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.[242] 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.[243]

"What shall we eat?"

It's already past lunch hour in Katunga Village, GVH Chejero – Traditional Authority Kachindamoto in Dedza District, yet Andrew's family don't know what to eat. The question "what shall we eat" is everybody's concern despite being only a few months after harvest.

Aisha and Andrew Malizeni survive on a daily 'ganyu' (casual labour) if they are to feed their three children. "It is a very worrisome situation here in Katunga because everyone depends on casual labour in well-to-do people's homes and fields".

Andrew explains, the village like other surrounding villages, receives very little rainfall, not enough to support crop growth, moreover the rains are very unreliable it terms of onset and cessation. "We only managed to harvest 300kgs of maize which was only enough for five months of the year" says Aisha.

Andrew and Aisha farm a ¾ acre of land growing maize and pigeon peas. They have no irrigation system and rely entirely on the rain to water the crops. Their one annual harvest only feeds them for five months, leaving a hungry period of seven long months. "Between September and March we have no food," says Aisha. "We work on other people's land as labourers during this time. We get paid maize, sometimes a tin, sometimes money to pay for other household needs like medicine and relish".

This was not always the case, Andrew believes all this is due to climate change because previously rains were very reliable and there were surplus crops every year from the same piece of land which his mother could sell. "If it were not for good harvests those years, my parents could not have been able to support my education in terms of school uniform as well as contribution to the school's development. I don't know if we'll be able to support our children's education considering the impact of climate change we are feeling right now," says Andrew.

Katunga village has a community borehole that has greatly reduced the distance women and girls have to travel in search of safe potable water for domestic uses. "Previously we were relying on unprotected rivers and wells which are some few kilometres from our house. The only worry we have now is that during hot months the level of water in the well goes down as a result less water comes from the borehole which makes waiting time to be long," says Aisha. "This situation forces some women and girls to opt for the unsafe water sources. I believe this is the reason why during the months of September, October and November cases of diarrhoea and abdominal pains are very common in this village" says Andrew.

Trócaire together with our partner organisation CADECOM Dedza started working in T/A Kachindamoto in 2017 to support households, such as the Malizeni's, with the knowledge, skills and resources to adapt sustainable agriculture practices that promote food security, resilience to climate change and women's empowerment.

Women carrying water in TA Kachindamoto, Dedza, Malawi.

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,[244] which are dependent on rainfall recharge and are highly impacted by projected droughts and floods.[245] 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.[246] In addition to droughts, soil erosion due to surface run-off is a serious environmental problem causing sedimentation.[247] 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.

Hydropower accounts for almost 100 percent of electricity production in Malawi. Recent research shows the vulnerability of energy to water shortage whereby the severe 1992 drought caused a drop in GDP of approximately 7–9 percent, with knock on effects on increases in household poverty.[248] Such inter-related and cascading impacts highlight the importance of interactions between water, energy and food in Malawi.[249] Currently Malawi is losing about MKW8.8 billion (approx. €16.5 million) due to water connected economic losses[250] and these losses are likely to be exacerbated by climate variability and change over the coming decades.

"Recent research shows the vulnerability of energy to water shortage whereby the severe 1992 drought caused a drop in GDP of approximately 7-9%, with knock on effects on increases in household poverty.

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.[251] In Malawi projected water supplies are affected by increases in temperature and local variability of precipitation.[252] 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.[253] 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.[254]

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.[255] 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.[256] 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.[257]

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.[258] 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.[259]

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.[260] 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^{0}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 opportunities 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

Observed Changes in Climate	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.
Projected Changes in Climate	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.
Likelihood of Extreme Events	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
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.
Food Production	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.
Access to Water	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.
Health	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.
Gender	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.
Migration	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 per cent in the region. Cyclical droughts that used to happen about once a decade have now affected the country in 2011, 2012, 2015, 2016, and 2017.

Future climate change risks: Worsening difficulties with access to water, increased occurrence of drought, large decreases in staple cereal crops, and increased vulnerability to disease.

Annual emissions of CO_2 per capita: 0.1 metric tons – **nearly seventy-four times less than Ireland.**

6.1 Introduction

Ethiopia is particularly vulnerable to global climate change, given its significant reliance on agriculture. Eighty 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 less than 1 hectare. Agriculture accounts for 37 per cent of GDP and as much as 90 per cent of exports and employment.[261]

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 100 million population is considered food insecure.[262] 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. Consecutive but separate droughts in 2015/16 and 2017 each affected over 15 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. Climate change is also likely to make 39-59 per cent of current coffee growing areas of Ethiopia unsuitable to coffee production, a crop that supports 15 million farmers and accounts for a quarter of Ethiopia's export earnings.[263] 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.

“ Climate change is also likely to make 39-59 per cent of current coffee growing areas of Ethiopia unsuitable to coffee production, a crop that supports 15 million farmers and accounts for a quarter of Ethiopia's export earnings.

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.[264] 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.[265]

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. Research has found significant trends in total wet-day precipitation and heavy precipitation days over the period 1970-2009 for the Central Rift Valley area.[266] The valley floor showed increasing annual rainfall while the escarpments and the highlands showed decreasing annual rainfall over the last 40 years. During Belg (March – May) season increases in the maximum number of consecutive dry days were found for all parts of studied areas.[267] 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.[268] 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.[269] While droughts are common natural phenomenon in Ethiopia, severe droughts happened only once every 10 years in the north and north east Ethiopia, but are now becoming more frequent and covering areas that never experienced drought before, including the southern parts of the country.[270] According to the IPCC droughts will become more intense, frequent and severe in the future due to the impact of climate change.[271]

Recent research has also found that both increased rainfall intensity and land use change are contributing to increases in flash flood occurrence.[272] 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.[273]

6.3 Projections of future climate change

Warming is expected to continue in Ethiopia, for all seasons, in all regions, 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.[274] 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 on the following page shows the considerable projected warming in east Africa, with higher 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.

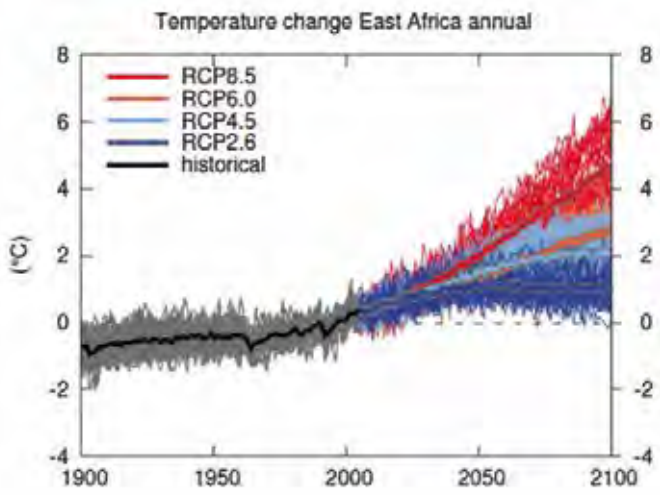

Figure 1 Projected changes in annual temperature relative to 1986-2005 under different greenhouse gas emissions pathways for East Africa. Red is business as usual emissions (RCP8.5), dark blue represents ambitious reductions in global emissions (RCP2.6) Thin lines denote a single model projection; thick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

Global warming will furthermore enhance the likelihood of anomalously intense, short rains across east Africa.[275] 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.[276] 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.[277]

Future projections of rainfall are more complex to disentangle. Research indicates a future shift in rainfall for most models with increases in both average rainfall and intensity simulated for most of east Africa, including Ethiopia.[278] Increases in rainfall extremes are likely to translate into rising flood risks for the region.[279]

Kiremt-season precipitation represents a primary water source for Ethiopia's rain-fed agriculture, which is critical to the country's economy and to the livelihoods of the majority of Ethiopians.[280] Latest studies suggest that increases in Kiremt season rainfall are likely under intermediate emissions scenarios, in the central Highlights and the Northern Great Rift Valley, while decreases are likely across the south of the country.[281]

In addition, rising temperatures and the higher risk of excessive rainfall have implications for

Irrigation schemes providing new lease of life

Amlesu Yibeyn, is a 30 year old mother of four who lives in the town of Adwa in Northern Ethiopia. Her family was dependent on rain fed agriculture for six months every year. She has 0.5 hectares [5,000 metres square] cultivable land, out of which half is irrigable land. Her annual harvest was not more than 6 quintals (600kgs), which was not enough to meet the food needs of the family. She was also unable to cover the school costs for her children.

In 2015, the watershed committee selected her to be a beneficiary of a Trócaire project. She received vegetable seeds and training on vegetable production and cooperative management. After the training, she planted tomato seeds on 2,500 square metres plot of land and got water to irrigate her field from a river diversion that had been constructed. She was rewarded for her efforts and was able to harvest 90 quintals (9,000kg) of tomatoes.

She described her success: "I am better off now as there is no more hunger in my family. I send my children to school, I own a dairy cow, and a motor pump. The future will be bright because I know what to do now and am confident of doing the right thing. In addition, I will maximize my income by renting land from others."

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.[282] In highland regions, warming is leading to an expansion of crop pests into previously cold-limited areas. For example, 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.[283] 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.[284]

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, and longer periods of dangerously hot weather, and high temperatures at important and vulnerable times in the life cycle of plants.[285] 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[286] 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.

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.[287] Climate variability and change will impact farmers and pastoralists differently.

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

For farmers, the decline of main growing season rainfall will continue to provide difficulties indecision 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.[288] As highlighted above, climate change is likely to make 39-59 per cent of current coffee growing areas of Ethiopia unsuitable to coffee production, a crop that supports 15 million farmers and accounts for a quarter of Ethiopia's export earnings.[289] 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.[290] Their 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.[291]

For pastoralists, climate change is likely to lead to increased conflicts over pasture and water for livestock.[292] 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.[293] Many people in Ethiopia are coming to the conclusion that many of the pastoralists in some of the Southern and Eastern areas of Ethiopia are most likely now 'former' pastoralists due to the scale and impact of the drought on livestock in 2017. It is too soon to tell for certain, but the impact of hundreds of thousands of cattle dead means that any restocking efforts will pale in comparison to the numbers lost and many people will be left with no alternative but to transition away from pastoralism.[294]

"It is too soon to tell for certain, but the impact of hundreds of thousands of cattle dead means that any restocking efforts will pale in comparison to the numbers lost and many people will be left with no alternative but to transition away from pastoralism.

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.[295] 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.[296]

In Ethiopia projected water supplies are affected by increases in temperature and local variability of precipitation.[297] 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.[298] 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.[299]

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.[300] Increased intense rainfall will bring increased floods and soil erosion, which introduces sediments and pollutants in fresh water bodies.[301] 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.[302]

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.[303] Drought seriously impacts pastoral regions, which cover 50 to 61 per cent of the surface area of Ethiopia.[304] 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.[305]

6.6 Gender

Existing gender inequality is heightened by climate-related hazards.[306] Men and women are differently affected by climate change and climate variability related disasters, intertwined with socioeconomic, institutional, cultural and political drivers.[307] 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.[308]

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.[309] 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.[310]

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.[311] Such circumstances have resulted in high levels of migration to urban areas, particularly among the young who cannot obtain land by private purchase. 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.[312]

> "...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.

Shrinking land holdings also play an important part in shaping livelihoods in Ethiopia. The government's decision to maintain ownership of all the country's land in transitioning from the feudal system of Selasie's regime 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.[313]

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 in Ethiopia than in other East African countries.[314]

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.[315]

By 2050, climate change could reduce Ethiopian GDP by 8-10 per cent and increase variability in agricultural production by a factor of two.[316] 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.[317] 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

> "...over the coming years the country could lose in the order of $2 billion USD due to rainfall variability.

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.[318] 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.[319]

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.[320] 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, the developed world are further undermining the potential of smallholders to provide for themselves.

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 and communities 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 has integrated its humanitarian programme with its longer term development works to ensure better planning, risk reduction, disaster preparedness, an effective response when disasters strike, and planned transitions from disaster recovery to long term rehabilitation and development, all for greater community and household resilience. 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

Observed Changes in Climate	Increases in seasonal mean temperatures have been observed across Ethiopia over past 50 years, and the length of the growing season has reduced by approximately 15 per cent in the region.
Projected Changes in Climate	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. An increase in rainfall for the central Highlands and Northern Great Rift Valley are expected during the Kiremt season, while decreases are expected over the southern part of the country.
Likelihood of Extreme Events	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.
Economic Impacts	Climate change will reduce agricultural production and output in sectors linked to agriculture and is likely to reduce GDP by approximately 10 per cent. At an individual level climate change is likely to raise income inequality, reduce household wealth and fuel poverty.
Food Production	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.
Access to Water	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.
Health	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.
Gender	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.
Migration	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 increases rates of migration with social and cultural impacts in both sending and receiving areas.

Conclusions and Recommendations

'Hope would have us recognise that there is always a way out, that we can always redirect our steps, that we can always do something to solve our problems (...) We must regain the conviction that we need one another, that we have a shared responsibility for others and the world.'

Pope Francis, '*Laudato Si: on care for our common home*', Papal Encyclical 2015

The key conclusion from our report is that climate change is already having profound impacts on the poorest women and men in the world. Developing countries have produced relatively few of the greenhouse gases that are driving global climate change, yet they are already feeling the consequences of changing weather patterns most acutely.

Current impacts are already too much for the communities that Trócaire works with. They are the women and men on the front lines of a climate crisis to which they have not contributed. While there have been significant developments in global policy, in the adoption of the Paris Agreement and the SDGs, and in the enactment of climate legislation in Ireland, government commitments to action remain far short of what is needed to deliver on the targets they have set.

Meanwhile the exposure and vulnerability of large proportions of the poorest people in the world has changed little. Without a significant and urgent scaling up of both mitigation and adaptation, we will knowingly condemn them to increased, unnecessary suffering. The global shift in policy required to contend with these effects is large-scale and challenging – but it is possible and there are significant potential benefits to both society and economy in doing so.

There are significant opportunities now to build a new development path globally, and in Ireland. The Citizens Assembly, and the planned National Dialogue on Climate Action in are welcome initiatives to provide spaces for dialogue and the development of proposals for the kind of society we want to live in in a climate-changed world. Globally, as part of the Paris Agreement, countries will embark on a Facilitative Dialogue, intended to take stock of the collective effort towards the Paris goals, and inform the development of the next round of NDCs, which are due by 2020.

The Facilitative Dialogue represents perhaps the last opportunity for the international community to enhance global aggregate ambition so as not to foreclose the possibility of achieving the 1.5°C goal.

The majority of the actions that need to be taken are already known, including in Ireland. What is needed now is the political will to take decisions and prioritise their implementation. In many cases, what would be required is not new exchequer resources, but elimination of incoherent policies, the recalibration of incentives and re-allocation of existing resources.[321]

When responses are designed without a focus on how actions impact on the most vulnerable women and men, they not only run a greater risk of failure to put us on a truly sustainable pathway, they also risk exacerbating existing vulnerabilities. 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.[322] 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.

In Ireland, vulnerable rural and urban communities, those living in energy poverty, and workers whose jobs must inevitably be phased out as we decarbonise, are some of the groups that must be placed at centre of concern in domestic policy development as we decarbonise.

The implications of unchecked climate change are such that we do not have a choice on whether to act. The critical question is whether we will act quickly enough, and whether we will act justly.

Recommendations

1 We must act with the urgency the crisis requires, by ensuring ambitious and fair mitigation and adaptation planning in line with the science.

The majority of the actions that need to be taken are already known, including Ireland, North and South. What is needed now is the political will to take decisions and prioritise their implementation. In many cases, what would be required is not new exchequer resources, but elimination of incoherent policies, the recalibration of incentives and re-allocation of existing resources. A radical turn-around from where we are currently is needed, including an increase in national climate action ambition, the elimination of incoherent policies and investments, and a robust plan of action to meet current commitments and get on a path to a zero-emissions society as soon as possible.

Globally, the Facilitative Dialogue under the Paris Agreement is the opportunity to align countries' intended emissions reductions (known as Nationally Determined Contributions, NDCs) with achieving the temperature limits set out in the Paris Agreement. If we are to have any chance of achieving the targets set in Paris countries must ensure that the Facilitative Dialogue results in the implementation of current NDCs being speeded up and their emission reductions and sectoral targets surpassed. It should also result in a new round of NDCs that are in line with what is needed to keep temperatures below 1.5°C or 2°C. It should also consider the adequacy of and progress toward meeting adaptation commitments, and deliver increased ambition and public finance for adaptation implementation.

The EU must show real global leadership by increasing its collective 2030 emission reduction pledge in advance of the Facilitative Dialogue to at least 55 per cent by 2030, and by ensuring the integrity of the EU's Climate and Energy targets by rejecting proposed loopholes in the rules governing implementation. Ireland should support these measures.

The Republic of Ireland must also increase the level of ambition and the speed of implementation of action on climate change, so that we contribute our fair share of increased collective action to deliver the temperature limits set out in the Paris Agreement. Each National Mitigation Plan under the Climate Action and Low Carbon Development Act should set out clearly how, and by how much, Ireland will reduce emissions over the time-frame of that plan. Each plan should be informed by public consultation, and should be debated and voted on by the Dáil.

For the Northern Ireland Assembly to be effective in tackling climate change, it should urgently introduce a Northern Ireland Climate Change Act. The Act should include targets that are fully aligned with the Paris Agreement and latest scientific evidence.

Ireland should ensure all climate policy is equity-proofed to maximise potential benefits and minimise potential negative impacts on vulnerable domestic groups. A *Just Transition Fund* should be established to support workers who will be affected by changes to economic sectors. [323] Development of domestic policy to tackle climate change must also examine, understand and prevent unintended negative impacts on poor communities in poor countries.[324]

To meet its obligations to support adaptation, the Irish Government should establish mechanisms to ensure regular contributions to the UN Green Climate Fund in line with our fair share of the commitment by developed countries in the Paris Agreement to support climate action in developing countries. The Irish Government should also publish a multiannual plan with year-on-year percentage increases in the Overseas Development Assistance (ODA) budget to

support the fulfilment of the Agenda 2030 Sustainable Development Goals (SDGs). As the longstanding 2015 deadline to reach the UN target of 0.7 per cent of GNI to ODA has already passed, at a minimum the government should demonstrate its commitment to now meet this historical commitment by 2025 at the latest and outline a clear pathway to achieve this.

2 We must act with urgency to transform the way we produce and consume, in particular by taking immediate measures to decrease Ireland's dependence on fossil fuels and address our rising emissions from agriculture.

Globally, burning fossil fuels in industry, the residential, commercial and public sectors, and in transport and energy supply accounts for over 60 per cent of GHG 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.[325] 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 are required.[326] Analysis by financial experts in the city of London has shown that the vast majority, around 80 per cent of remaining fossil fuel reserves owned by fossil fuel companies cannot be burned if the upper temperature limit of 'well below 2°C' set out in the Paris Agreement is to be achieved.[327]

Over the past 50 years, GHG emissions resulting from 'Agriculture, Forestry and Other Land Use' (AFOLU) have nearly doubled.[328] Conversely agriculture, forestry and land use can also serve to mitigate climate change by removing GHGs from the atmosphere. A business as usual approach means agriculture will account for an ever increasing proportion of global emissions

The Turkana region of northern Kenya has experienced successive drought made worse by the effects of climate change.Survival has become a challenge for the people of Turkana. Photo: David O' Hare, Trócaire.

in the period to 2050. Agriculture is the largest contributing sector to Ireland's GHG emissions and this is projected to increase by up to 7 per cent in the period 2014-2020. By 2020 agriculture is projected to account for as much as 47 per cent of the country's emissions. The projected growth in emissions in the period to 2025 will be driven by increases in the dairy cowherd and an attendant increase in nitrogen fertiliser use.[329] A 2016 report on *A Climate Smart Pathway for Irish Agricultural Development* observed 'a growing contradiction between Ireland's climate and agriculture policy objectives'.[330] The report emphasised that 'supply side efficiency gains will not yield anything close to the levels of mitigation required from agriculture' and concluded that 'demand side responses, in particular reducing food waste and dietary changes' will also be required.

The Irish Government should expedite the passage of the Fossil Fuel Divestment Bill currently going through the Dáil to ensure the divestment by the Ireland Strategic Investment Fund of its assets in fossil fuel companies. Within a 'just transition' approach, the Irish Government should phase out fossil fuel subsidies, ban future exploration for fossil fuels in Ireland, decrease domestic dependency on fossil fuels and increase investment in, and use of, renewable energy alternatives. In Northern Ireland, energy policy objectives and plans should specify 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. Mitigation plans for agriculture must go beyond efficiencies in production and supply and include actions across the entire food system including 'demand side' actions on food waste and diet.

3 We must promote resilience and food security by providing sufficient support to sustainable approaches to agriculture in developing countries.

As the main livelihood of many of the world's poorest people, agriculture is a vital sector to increase resilience to climate change. Achieving sustainable agriculture requires incentivising agricultural development approaches that simultaneously increase smallholder farmers' resilience to adverse impacts of climate change, enhance subsistence farming productivity while also mitigating GHG emissions. Agro-ecological systems that build resilience including biodiversity, healthy soils, water management and the optimisation of yield increases, are a practical approach to addressing these multidimensional objectives. There is a growing body of evidence to show that scaling up agro-ecological approaches is an effective means to ensuring food, nutrition and livelihood security as well as addressing the climate challenge. However, transitioning towards such approaches will not happen without adequate support to and promotion of such approaches and an enabling policy and institutional environment that incentivises practices to strengthen the resilience of individual farmers, households and communities.

Globally, the Committee on World Food Security (CFS) is well placed to advocate for agricultural policies that are coherent with the Sustainble Development Goals adopted in Agenda 2030 and the Paris Agreement - building on its existing decisions, particularly those on investing in smallholder agriculture to strengthen agro-ecological food systems. Mainstreaming the type of inclusivity associated with the CFS by democratising agricultural and food governance at all levels is key. A particular focus must be placed on increasing the active participation of women and men smallholder farmers – who supply 70 per cent of the world's food - in decisions that affect them and shape agricultural and food systems.

Intellectual property rights must also ensure rather than compromise farmers' rights to save, use, exchange and sell their own seeds, while trade and investment rules should confirm the right of national governments to take measures necessary for ensuring national food security and protecting small farmers from cheap industrial food imports that distort domestic markets.

Providing resources for the reorienting of public agricultural research, extension services and education in order to identify the best transition paths towards diversified farming systems for both subsistence and industrial agriculture is essential. Scaling up research into agro-ecological systems and providing financial supports to farmers making the transition should be prioritised in adaptation funding decisions.

Tenure security in the form of secure access to natural resources including land, water and forests is critical to strengthening farmers and rural communities' food, nutrition and livelihood security as well as their resilience and adaptation to climate change. Yet, trends favour the privatisation of communal natural resources and the concentration of resource management. Laws that recognise, respect and protect the diverse tenurial systems from which small scale farmers and rural communities derive their resource rights should be promoted. This can be advanced through the domestication of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT).[331]

Endnotes

Chapter 1: Introduction and Overview

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Chapter 7 : Conclusion and Recommendations

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