CLIMATE CHANGE

EFFECTIVE ACTION BASED ON ENHANCED UNDERSTANDING

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What is climate change?

'Climate change' in the sense in which it is used in the media and in everyday, non-technical conversation in the present time, means **change in the expected behaviour of the climate, based on our past experience**. More precisely, it means that the statistical properties of the climate system have changed in a significant way since the beginning of the 'modern era', which is loosely taken to mean the start of the Industrial Revolution, around 1750. Since accurate scientific records of the climate mostly only began after the middle of the 19th century, sometimes 1850 is used as the start. It makes little difference which start date we choose, because the climate changed very little between 1750 and 1850. In contrast, the climate has changed a lot since 1850, and especially after 1950.

By 'statistical properties' we mean either the *average* value of a climate feature such as temperature or rainfall, or its *variability and extremes within the year*. 'Weather' is the state of the climate system at any given moment. By its nature, the weather changes all the time – between day and night, for instance, or from one day to the next. To constitute 'climate', these short-term fluctuations are accumulated over a long period, over which we would expect them to be smoothed out. In practice, we do this averaging over a period of about three decades. This should eliminate the effects of natural cycles, such as through a day and a year, but also known longer cycles, such as the 11-year sunspot cycle. It should also take care of events that are recurring, but not strictly according to a fixed cycle, such as volcanic eruptions, or El Niño Southern Oscillation (ENSO) - related droughts. **If these long-term climate statistics are *not* stable over time, then something fundamental is changing in the Earth's climate system.**

When scientists refer to the 'climate system', they are talking about much more than just the atmosphere. In fact, the atmosphere is rather a minor player, because it has a very limited ability to store energy. The atmosphere, at a global scale, basically just behaves as the oceans and ice bodies dictate, because that is where all the energy is. It is mostly through the ocean that most energy moves between the equator, where it is hot, and the poles, where it is cold. This is the 'heat engine' that drives the weather.

The biosphere (the living part of the Earth) also participates in the climate system, because the biosphere is the biggest store of carbon, and takes up or supplies carbon-dioxide to the atmosphere. **Humans are also part of the biosphere, and we have altered the make-up of atmosphere by speeding up the emission of carbon dioxide, and other greenhouse gases** (see Box 1 for an explanation of what these are), principally by burning fossil fuels. So when we talk about measuring changes in the climate system as a whole, we are also talking about things like sea level rise, the area and volume of ice caps, and the concentration of greenhouse gases in the atmosphere, along with more familiar things like rainfall and the air temperature. 'Global warming', in other words, the rising near-surface air temperature, is part of climate change, but not the only part.

A changing climate can be due to natural processes such as changing amounts of solar radiation or volcanic eruptions. **There is very strong evidence, however, that climate change over the past century and a half is due to human-caused effects** (the technical term is 'anthropogenic') (IPCC 2014). The two main anthropogenic causes of climate change are changes in the concentration of greenhouse gases in the atmosphere (these are gases, present in relatively small amounts, that absorb solar radiation; see box), and changes in the vegetation cover of the land. If the present-day climate is changing – which it is, without any shadow of doubt -- it hardly matters to the people who have to deal with the consequences of that change whether the change was 'natural' or 'human-caused'. You still have to adapt. But when it comes to preventing climate change to reach dangerous levels in terms of unavoidable impacts and costs, it is important to know the causes. **We can do something about the climate change due to human actions.**

The climate change between 1850 and now is by far (>90%) human-caused (IPCC 2014). A part of the year-to-year variability, on the one hand, is added by natural processes, but the long-term upward or downward trends we

* Contribution by GCI to EFS on public awareness of climate change, June 2020. Recommended Citation: Scholes, B., Engelbrecht, F. & Vogel, C. 2020. 'Climate Change: Effective action based on Enhanced understanding,' *Emancipatory Futures Studies*, Climate Science Think Piece, Wits.

observe in the long-term records are *not* caused by any known natural process. On the other hand, they can be fully explained by what we know about changes in the atmospheric composition and the land cover.

What does it mean for Southern Africa to be designated a climate change 'hot spot'?

Several studies, most notably the very thorough and detailed reports of the Intergovernmental Panel on Climate Change (IPCC), have shown that **southern Africa is a climate change 'hot-spot'** (Hoegh-Guldberg et al., 2018). In other words, this is a **region more vulnerable than average to climate change**. Two considerations go into identifying a climate change 'hotspot'. The first is the *amount* of climate change it has been and will be exposed to – is it substantially more than the global average? The second is the ability of the natural and human systems in the region to cope with that amount of change. Do they have features that make them more vulnerable than other regions, or are the consequences of change in the hotspot region more serious than in other places (Scholes et al 2015).

When scientist talk of an increase in the 'global mean temperature' of say 1°C (which is what we have already observed since the start of the Industrial Revolution), they refer to an increase in the near-surface air temperature, averaged in an unbiased way over several years, over both the sea and the land. Because three-quarters of the Earth's surface is covered by ocean, and the oceans warm more slowly than the land because of their huge capacity to suck up heat, it follows that *all* land areas must warm at a faster rate than the global mean -- about one-and-a-half times faster is commonly observed. **Southern Africa has warmed even faster than that, at about twice the rate of global warming; and the climate models suggest that this pattern of above-average regional warming will continue for the rest of this century** (Engelbrecht et al., 2015). The reason is the location of southern Africa near the tropics, but outside the equatorial high-rainfall zone. This is sunny South Africa, and it gets sunnier in the future!

In general, a warmer world is a wetter world, but that is unfortunately not true for southern Africa. When the world gets warmer, we get drier on average. There are several processes at work here – one is the relatively high rate of temperature increase in southern Africa. Another is the southward movement of the 'waves' of cooler air that wash over southern Africa, particularly in winter, and bring rainfall to the Cape. A third is changes in the global ocean circulation (the El Niño effect) that usually lead to a higher risk of drought periods lasting several years at a stretch. **Although southern Africa is likely to get drier in future, at the same time we are likely to experience heavier floods.** This is because although the rainfall declines overall, a larger fraction comes in the form of big storms, which exceed the capacity of the land to soak up the water. It therefore rushes off, wastefully and destructively.

Box 1: Greenhouse gases

The atmosphere of planet Earth is 78% nitrogen and 21% oxygen, and has been that way for millions of years. Both of those gases are quite transparent to solar energy, both coming in and going out. But the remaining 1% contains a whole list of 'trace gases' that are transparent to radiant energy at the wavelengths emitted by the sun ('shortwave'), but very absorptive of the energy in the wavelengths leaving the earth ('longwave'). This is because of their molecular structure. The atomic bonds in molecules of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are just the right length to interact with the outgoing radiation, absorb it, and thus warm the atmosphere. That is what makes them 'greenhouse gases'. We know the greenhouse effect is real, because without it the Earth would be a cold, lifeless place, like the moon. Or if our atmosphere had too much CO2, like Venus, it would be way too hot to support life.

We have precise measurements of their increase in concentration in the atmosphere over the past two centuries. They contribute respectively about 64, 17 and 6% of the present-day additional warming of the atmosphere due to the 'enhanced greenhouse effect'. About thirty other gases and particles collectively contribute about 13%. Water vapour (H_2O) is also a powerful greenhouse gas, and is present in the atmosphere in relatively large, but highly variable amounts. The effects of changing water vapour concentration, and clouds of water and ice droplets are taken into consideration in climate models.

The warming atmosphere reradiates the extra energy it absorbs, and eventually this outgoing radiation balances the incoming, and a new balance is reached; but right now we are still some way from that balance, which is why we are experiencing Global Warming.

The sea level is rising, slowly but inexorably, all over the world. The main reason up to now has been the warming of the oceans, which causes the water to expand. As we continue warming the world, the main cause becomes the melting of ice bodies currently on land, especially the very large ones in Greenland and Antarctica, which together could contribute many meters of sea level rise. That they are melting and will continue to do so is proven, but the big uncertainty is 'how fast?' It could take centuries, but if some unstable ice-shelves break off the continents suddenly, we could see a much more rapid rise. The coastline of South Africa is relatively steep, so we can tolerate a small and slow rise in sea level quite easily, but some African countries, including Mozambique are much more vulnerable. The big problems come when a sea level rise coincides with a storm surge (more on that under 'extreme events') and a naturally high tide. Substantial and more-rapid sea level rise, which is increasingly likely unless the world works strenuously to keep the global temperature rise as small as possible, would wreak havoc on South African coastal infrastructure as well, and would be disastrous for coastal cities all over the world.

On the 'coping capacity' side, southern Africa has several special circumstances that count against it. One is that it is one of about ten 'mega-diverse' areas in the world, that have far more than their share of other species to look after. Another is that southern Africa is made up of **developing countries, which do not yet have very sophisticated disaster management systems and infrastructures, nor money to spend on climate adaptation**. A third is that our economies are very sensitive to changes in the climate (for instance, in the agriculture and tourism sectors). Coal is one of our main exports and the mainstay of southern African energy generation, but coal is the fossil fuel most likely to be eliminated first from the global energy system.

What are the extreme weather impacts that South Africa can expect as global temperatures increase?

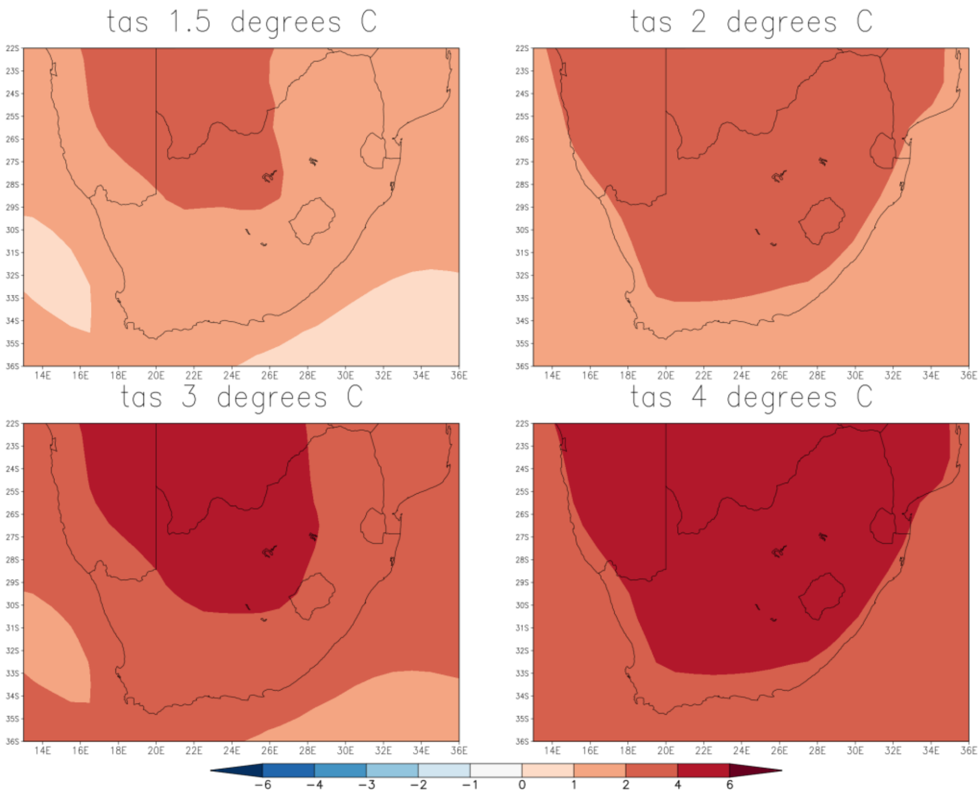

***Figure 1:** Projected increases in temperature (°C) over southern Africa under different levels of global warming, as derived from the 'ensemble average' of 14 GCMs contributing to Assessment Report Six of the IPCC. The use of an 'ensemble'- in other words, a set of different models running under the same assumptions - is more reliable than trying to pick just one 'best model'.*

Temperatures over southern Africa have risen drastically over the last six decades, at about twice the rate of global warming (Engelbrecht et al., 2015). This relatively high regional sensitivity to the enhanced greenhouse effect is large due to the region's location in the Southern Hemisphere subtropics, a part of the world already affected by changing weather patterns in a changing climate (see the previous section for details).

Global climate models (GCMs) project that under ongoing global warming, the southern African region will continue to warm at a rate higher than the global average (Figure 1). In fact, even under strong climate change mitigation as required under the Paris Agreement on Climate Change, where the increase in the global average surface temperature is restricted to 1.5-2 °C above pre-industrial temperatures, regional temperature increases of 3-4 °C are likely over the southern African interior (Figure 1). **Should the world fail to implement the Paris Agreement, and global warming reaches 3 °C or higher, regional warming over the southern African region may be expected to be around 6 °C** (Figure 1).

The relatively large increases in annual average temperature over southern Africa are projected to occur in association with increases in extreme warm temperature events, and a reduction in extreme cold events (which are not common in South Africa, anyway). Increases in the number of high fire-danger days, heat-wave days and very hot days have been detected across the region in recent decades. Such events will occur even more frequently should global warming increase to levels between 1.5 and 2 °C. **Under 3 °C of global warming, the increase in heat-wave duration and frequency is projected to be so severe that it may contribute to the collapse of both the maize crop and cattle industry in large parts of southern Africa** (Hoegh-Guldberg et al., 2018).

Southern Africa is likely to also become generally drier under future climate change (Engelbrecht et al., 2015; Hoegh-Guldberg et al., 2018). This is a robust assessment of the Intergovernmental on Climate Change (IPCC), dating back to its Fourth Assessment Report in 2007. Substantial decreases in annual rainfall can already be detected over South Africa's winter rainfall region, where the likelihood for extreme multi-year droughts to occur are already three times higher than under natural climate variability. This is largely due to the systematic poleward displacement of cold fronts in a warmer word. Rainfall decreases over southern Africa's summer rainfall region can so far be most clearly detected over the north-eastern interior, but are projected to become more widespread under 1.5 °C of global warming (Figure 2). Under 2 °C of warming the projected decreases in rainfall become substantial, whilst under higher levels of warming rainfall decreases and more frequently occurring multi-year droughts (Figure 2, Box 2) are expected to directly threaten the sustainability of dryland agriculture in large parts of southern Africa (Hoegh-Guldberg et al., 2018).

Southern Africa is a generally warm and dry region, even without climate change. **Many organisms and environmental processes lie close to their tolerance limits for heat and drought. Therefore, becoming drastically warmer and drier poses grave risks to the environment and society.** This is a key reason why the region has been identified as a climate change hotspot by the IPCC (Hoegh-Guldberg et al., 2018; see also the previous section). Some of these changes are difficult to adapt to because of their fundamental nature (see the next section).

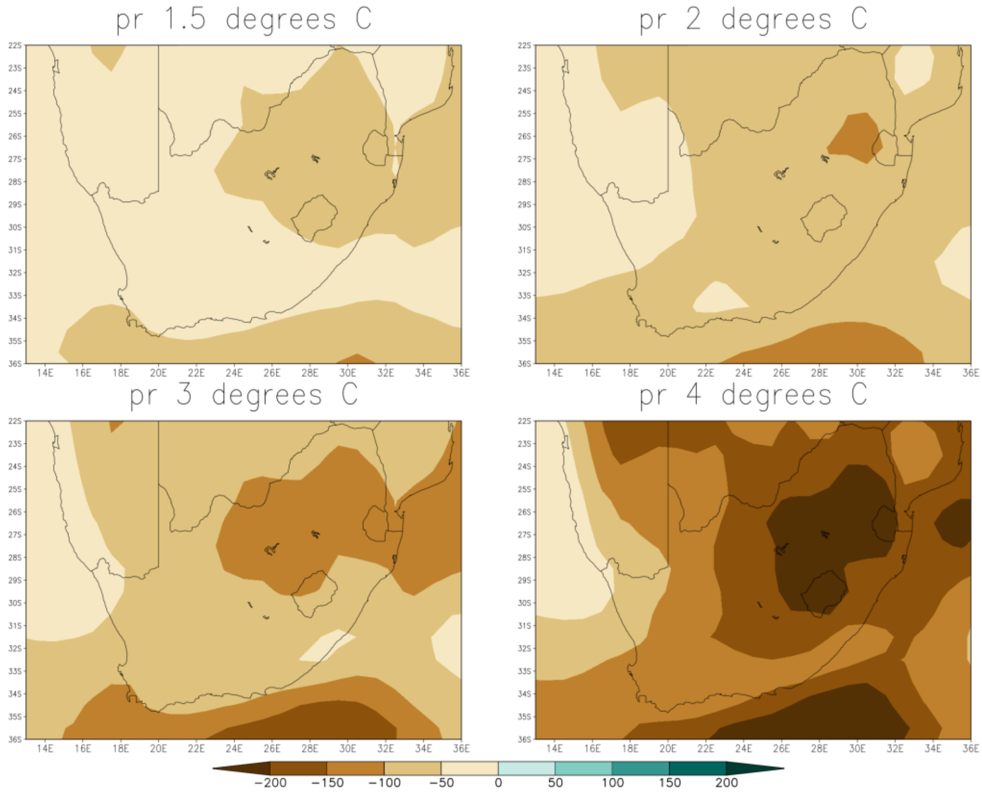

Figure 2: Projected changes in rainfall (mm) over southern Africa under different levels of global warming, as derived from the ensemble average of 14 GCMs contributing to Assessment Report Six of the IPCC. Note that the tan and brown colours, which represent drier futures than at present dominate over the whole region, and the drying becomes more pronounced with greater global warming.

It may finally be noted that despite these large-scale trends towards a generally drier climate,

Box 2: Recent multi-year droughts in southern Africa

Recent multi-year droughts in southern Africa have demonstrated how vulnerable the region is, should such events occur more frequently as a consequence of anthropogenic climate change. The 2015-2017 Cape Town drought was associated with three consecutive years of below-normal rainfall in South Africa's winter rainfall region, which led to severe water restrictions in the City of Cape Town and brought the city to the brink of running out of water (the "day zero" drought). The period 2015-2017 was also exceptionally warm, and the Knysna and Garden Route fires of June 2017 occurred after the warmest autumn in the region in recorded history. Climate statistics and modelling have since been shown that the risk of such "day zero" drought to occur in South Africa's winter rainfall region have already increased by a factor of three as a consequence of climate change. The trends of increasing rainfall, increasing temperatures and increasing number of high fire-danger days in South Africa's winter rainfall region can be directly attributed to climate change – in particular the poleward displacement of cold fronts in a warming climate. Multi-year droughts have also occurred on the summer rainfall regions of southern Africa in recent years. Three consecutive years of below normal summer rains were recorded during the summers of 2013/14 through to 2015/16, culminating in the devastating El Niño drought of 2015/16. This latter summer was the driest in recorded history over the Free State and Northwest Provinces of South Africa, and the drought also impacted severely in the KwaZulu-Natal, Mpumalanga and Limpopo Provinces, as well as in Kruger Park. Botswana lost 20% of its cattle in 2015, and a further 2016 in 2016. In South Africa, the maize crop yields were substantially lower in 2016 compared to previous years, and at the peak of the drought the level of the Vaal Dam fell to below 25%. The 2015/16 El Niño was the strongest ever recorded by humans and co-occurred with the two warmest years (2015 and 2016) recorded by humans (at the time – 2019 now holds the record of the 2nd warmest year on record, after 2016). Climate change projections are indicative that multi-year droughts over the summer rainfall region of summer Africa may occur more frequently under 1.5 °C of global warming, with further increases under higher levels of global warming (Hoegh-Guldberg et al., 2018). This is partially related to the more frequent occurrence of strong El Niño events in a warmer climate.

it is plausible that extreme rainfall events will occur more frequently across the region. Over Mozambique and southwards into the north-eastern parts of South Africa, the risk that intense tropical cyclones will reach the land is higher than in the past under even 1.5 °C of global warming, and substantially higher under higher levels of global warming. **Intense thunderstorms causing hail, flash floods and damaging winds are also expected to occur more frequently across eastern southern Africa**, in response to enhanced surface warming. The increased likelihood of weather systems that deliver heavy rainfall over relatively short periods of time has implications for flooding, soil erosion and the design of roads, bridges and dams.

When a large storm occurs over the ocean, it pulls water from far and wide under it, and the high winds whip up the waves. This is known as 'storm surge', and can amount to a local sea level rise of many meters. When added to the steadily-rising base sea level, and especially if the storm coincides with a high tide when it makes landfall, the result is 'wave run-on' to the land that can cause flooding far inland of the normal coastline. This has already been experienced in southern Africa, especially on the subtropical east coast, and **the likelihood of such severe floods increases in the future due to the cumulative effects of sea level rise and increasing storm intensity** (Figure 3).

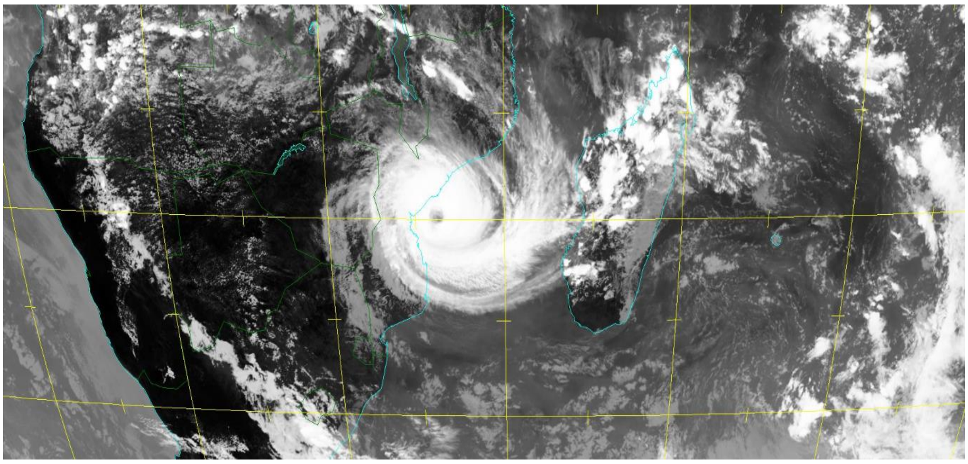

Figure 3: *A satellite image of Tropical Cyclone Idai making landfall at Beira in Mozambique around midnight on 14 March 2019. More than 1000 people in Malawi, Zimbabwe and Mozambique lost their lives in the flooding and destruction caused by this weather system, making it the worst flood disaster in the recorded history of southern Africa, and the 2nd worst on record in the Southern Hemisphere. Hundreds of people died in Beira due to a storm surge that was several meters high. (Source: Meteosat Second Generation)*

The implications of climate change for South Africa

The IPCC, in its Special Report on Global Warming of 1.5°C, assessed that **the largest reductions in economic growth under continued Global Warming are likely to occur in low- and middle-income countries and regions in the tropics and Southern Hemisphere subtropics, including southern Africa** (Hoegh-Guldberg et al., 2018). A comprehensive estimate of the future costs of climate change is not available for South Africa. However, the country has in recent years experienced a number of high-impact climate events, particularly extreme droughts, and floods. These events, of the early 1990s drought in the region, give us glimpses of what we may experience going into the future in terms of costs to the economy (Box 3).

The costs of flood impacts (Table 1) can be easier to estimate because they are often shorter in duration (a few days) and have a clear impact area, as opposed to droughts that can be creeping over a number of years and affect an entire region in various ways.

Box 3: Estimating climate related costs in South Africa

The chain of impacts resulting from extreme climate events are messy and complex, often defying simple additive 'counting'. For example, although agriculture accounts for a relatively small contribution to overall GDP in South Africa, the impacts of unfavourable climate are felt by a large number of people, via agricultural employment, as well as by rising food prices and hunger. The 1992 drought (Benson and Clay, 1994: 32), for example, 'was expected to have a net negative effect of at least R1,200m on the current account of the balance of payments. Other studies simulated that a 14% decline in agricultural sector value added would result in a 1.8 % decline in GDP, representing around US$500 million (Benson and Clay, 1994:32Pretorius and Smal, 1992). In terms of employment, the drought was estimated to have resulted in the loss of 49 000 agricultural jobs and 20 000 formal sector jobs in non-agricultural sectors (Benson and Clay, 1994:32). As the job losses escalate they cascade beyond those directly dependent on agricultural employment, eventually impacting around 250 million people (Mniki, 2009). Counting the full costs is similarly difficult for other climate-linked phenomena, such as severe heat spells, fires and floods. Even the partial accounting that we are able to do demonstrates that the costs of climate change are very high. Since impact costs are felt year after year, while the costs of climate change mitigation are mostly experienced early in the process, impact costs rapidly mount up and exceed mitigation costs unless you assume that future costs are much less important than present costs (an ethical issue in economics, known as the 'discount rate').

Table 1: Examples of flooding impacts and costs (Note that these events occurred at rather different scales: a whole province, part of a province, or portion of a coastline)

Year of flood	Impacts	Estimated Costs and losses
1987 flooding KZN	14 bridges washed away; 68 000 people homeless, 388 lives lost.	Not available
Cut off low flooding November 2007, Western Cape	Estimates of damages over 22 municipalities impacting 298 425 households.	Direct damage cost – R 793,523,179; Direct damage cost per household over the 22 municipalities – R 2,659.04
2008 storm surge western, southern coasts of South Africa	Damage to coastal property and infrastructure	Estimated at R1 billion

Sources: Grobler, 2003; Disaster Mitigation for Sustainable Livelihoods Programme, 2010; Smith, 2013: Davis-Reddy and Vincent, 2017.

Floods come in various forms and can range from impacts at the provincial scale as induced by weather systems such as tropical cyclones and cut-off lows, to smaller scale flash-floods caused by intense thunderstorms. In the western Cape for the period 2003-2008, national departments and parastatals sustained ‘direct damage costs exceeding R221 million in 8 severe weather events’ (RADAR, 2010:99). The Provincial Road Department reported damage costs of more than R600 million over the same period. 636 farms recorded damages in ‘excess of R765 million from November 2007-November 2008.’

The impacts of climate change and climate variability are complex in both their causes and their consequences (IPCC, 2014; Satgar, 2018; Ziervogel et al., 2019). This makes it hard to say that a particular impact is clearly and solely due to a particular cause (see Box 4), but it is increasingly possible to assign probabilities that climate change contributed to the observed damages. **The impacts, costs and losses are not the result of only a climate hazard (e.g. a flood and excessive heat) but are also linked to a range of ‘threat multipliers’ and ‘drivers of vulnerability’ including development, service delivery and access to water and food**.

Box 4: Climate change attribution

“Climate change attribution” refers to the scientific analysis process used to determine to what extent recent changes (i.e. changes observed over the last few decades) in climate were caused by human actions, particularly in the form of the enhanced greenhouse effect. That is, climate change attribution strives to distinguish trends in climate caused by human activities from natural variability (e.g. long-term cycles) and trends induced by natural processes. This includes the attribution of trends in extreme weather events to the underlying cause (or more frequently, causes), as well as the analysis of whether individual extreme events that have occurred, have been made more likely to occur by anthropogenic forcing. The IPCC has in its recent Special Report on Global Warming of 1.5 °C concluded that it is virtually certain that the systematic Global Warming observed in recent decades can be directly attributed to anthropogenic forcing. The strong regional trend of increasing temperature and associated substantial increases in heat-wave days and high fire-danger days in southern Africa have similarly been attributed to anthropogenic forcing (Hoegh-Guldberg et al., 2018), as a regional consequence of Global Warming. The most discernible trends in rainfall that can be detected over southern Africa are the rainfall decreases that have occurred in recent decades over those parts of the region that receive winter rainfall, namely the south-western Cape and the Cape south coast. These decreases can likely be attributed to the systematic poleward displacement of cold fronts that have been detected in the Southern Hemisphere over the same period as a consequence of anthropogenic forcing. Few studies have to date been performed to explore whether individual extreme weather events that have occurred in southern Africa can be attributed to anthropogenic forcing. One important recent attribution study concluded that occurrence of the Cape Town drought of 2015-17 has been made at least three times more likely because of systematic anthropogenically induced climate change. Moreover, attribution studies have determined that tropical cyclones are causing 10-20% more rainfall than in the past as a consequence of being able hold more moisture in an anthropogenically warmer world, and that intense tropical cyclones have started to occur more frequently over the last several decades. These studies strongly suggest that tropical cyclone Idai has been made more intense and destructive by Global Warming, although a formal attribution study remains to be undertaken for this event.

Responding to climate change

How do we respond to change in the global climate that has expression locally? Responses include both *mitigation* and *adaptation*. **The IPCC (2014) describes mitigation as "a human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs)", while adaptation is the adjustment process to actual or expected climate and its effects**. "In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities" (IPCC, 2014: 118, 125). These two categories are not completely independent. Often there are interactions between mitigation and adaptation, which can be beneficial (co-benefits) or harmful (unintended consequences).

The time frames with which we prepare and intervene are also critical considerations. Do we just manage to get by, and brace ourselves for the next flood and drought, or do we prepare for the next decades where droughts and floods, amongst other climate challenges, may become a 'new normal? As a result of different perspectives, **adaptation is sometimes seen as *incremental*** (shorter-term changes to respond to climate risks) **or *transformative*** (a change in the fundamental attributes of natural and human systems, IPCC, 2014:128).

The way you 'frame' the issue therefore matters, both in terms of how we measure 'loss' and what we mean by costs. For whom, and how, do we derive such costs? Our approach can also significantly shape what we do in practice and how we begin to reduce risks (Leach *et al.,* 2010) See table 2.

Adaptation and the adaptation pathways chosen for the future are also not politically neutral (Giddens, 2009). Allied to the pathways or transitions that we may choose (for example the *Just Transition* widely under discussion in South Africa) are the calls for *technocratic adaptation* options (such as the construction of sea walls against sea level rise, desalinisation plants to relieve water storages, biotechnology to adapt crops to higher temperatures, etc.) and also *personal transformations* (Figure 4). All these adaptations are related to and informed by individual and collective assumptions, beliefs, values and world views (O' Brien and Sygna, 2013; Leichenko and O'Brien, 2019; see also IPCC, 2014, page 96).

The adaptations we choose are therefore influenced to some degree by world views, personal beliefs and value systems. A range of questions need to be addressed if we are to successfully adapt to climate change (Table 2).

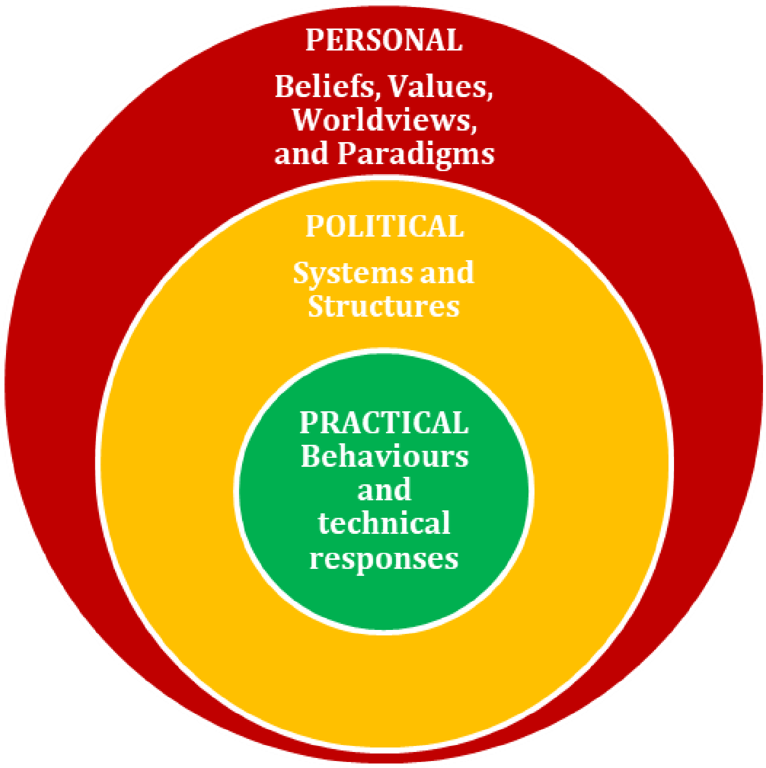

Figure 4: *Transformations: practical, political and personal suggested to effectively deal with climate change and other challenges (Source: Adapted from O'Brien and Sygna, 2013; adapted by S. Smit 2020*

Further examples of actions taken to adapt to climate change, in the context of South Africa, include those in water management (water conservation through reduction of wastage, construction of storage capacity in dams and aquifers, recycling and purification, and reducing the demand for water by developing more efficient processes or by altering the price of water); improved agricultural practices (for instance agricultural systems that store carbon in the soil, use rainfall and irrigation more effectively, and include crops that are more resilient to drought); better access and entitlement to basic resources for life, such as food, energy and water; better disaster risk reduction (for example effective early warning systems, leading to proactive hazard and disaster response, and better tracking and capturing of disaster loss information in order to avoid future disasters.) In all these cases, however, trade-offs and contestation in assessment of issues and decision-making approaches adopted (e.g. whose voices count and 'who is at the table') and what becomes priority interventions are challenges that can and usually do arise.

Table 2: Examples of types of adaptive and systems change

Types of change	Incremental	Reform	Transformation
Core questions	How can we do more of the same? Are we doing things right?	What rules shall we create? What structures and processes do we need?	How do I make sense of this? What is the purpose? How do we know what is best?
Purpose	To improve performance	To understand and change the system and its parts	To innovate and create previously unimagined possibilities
Power and relationships	Confirms existing rules. Preserves the established power structures and relationships among actors in the system.	Opens rules to revision. Suspends established power relationships.	Opens issues to creation of new ways of thinking about and enacting power. Promotes transformation of relationships with whole-system awareness and identity. Promotes examining deep structures that sustain the system.
Archetypical actions	Copying, duplicating, mimicking	Changing policy, adjusting, adapting	Visioning, experimenting, inventing
Logic	Negotiation logic	Mediation logic	Envisioning logic

Source: Adapted from Waddell, 2011 and Waddock et al, 2015

The role of the 'view' and the 'eyes' (Andreottie and de Souze, 2007) we use to frame our adaptation and transformation are evident in how various people are responding to climate risks. For some in the business community (e.g. UN Global Compact and UN Environment Programme, 2012) adaptation may be more of a technocratic approach, including sustainable supply chain management, health and safety and community engagement projects. Those in government may focus on adaptation efforts that reduce climate risks in the form of policy, institutional and governance arrangements. Non-Governmental and civil society organisations often take a very practical 'hands on' approach, working to effect fair, just and sustainable change.

For some, however, a '*transformation*' is also urgently called for in the personal, practical and political spheres of our lives (Figure 4). Here the focus is on changing the design of practices that are *fundamentally making us vulnerable to climate risks in the first place.* Examples are **transformations that lead to enhanced access to jobs and employment, greater equity in the economic system and a re-imagining and implementation of a just and fair economy**.

Many views (e.g. pluralistic views) need to be considered when trying to co-plan and co-build robust lives in the case of climate change and climate variability (Andreottie and de Souza, 2007):

> "Perhaps we need to promote a new conceptualization of wealth in the world – as productive, social relationships – and educate ourselves and our children accordingly" (Andreottie and de Souza, 2007, preface).

In an article "*What climate collapse asks of us"*, from The Emergence Network, the author Akomolafe (2020) cites Butler (referring to the United States of America):

> "The greatest challenge the Anthropocene poses isn't how the Department of Defence should plan for resource wars, whether we should put up sea walls to protect Manhattan, or when we should abandon Miami. It won't be addressed by buying a Prius, turning off the air conditioning or signing a treaty. The greatest challenge we face is a philosophical one: understanding that this civilization is already dead. The sooner we confront our situation and realize that there is nothing we can do to save ourselves, *the sooner we can get down to the difficult task of adapting, with mortal humility, to our new reality*" (emphasis added).

What are some of the crucial lessons we have learned from the COVID-19 pandemic that can be used for reducing risks to ongoing climate change? The pandemic is showing us that a ***collective and just approach*** **is needed that is mindful of local, regional and global vulnerabilities**. Moreover, the pandemic is urgently demonstrating that a proactive rather than a reactive response is required. The big questions that remain are "**are we up to the challenge**" and "**what may it take to bring about effective sustainable change?"**

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