Guidance for Putting Climate Resilient Development Pathways Into Practice

We make the path, and the path makes us.

1. Introduction

The use of Climate Resilient Development (CRD) pathways as a means of anticipatory planning across sectors and scales to sequence, build synergies and minimise trade-offs between climate change mitigation, adaptation and development actions is gaining traction internationally. A set of approaches are emerging and being tested to operationalise CRD pathways across a range of contexts globally. This work, commissioned by the Presidential Climate Commission (PCC), aims to stimulate discussion on how CRD pathways thinking and approaches can support coordinated action transitioning South African society in a just and inclusive manner to be net-zero and climate resilient by the 2050s, and what the practical and collaborative next steps are to be.

By centering long-term development trajectories, changing patterns and perceptions of risk, and evaluating the ways in which climate change mitigation and adaptation actions can be combined and sequenced to increase resilience and equity over time, a CRD pathways approach could be a means for adaptively coordinating the Just Transition, or multiple Just Transitions to a sustainable, cleaner, and more inclusive economy. The Just Transition Framework, published by the PCC[1], highlights the imperative to shift South Africa's emissions trajectory while preparing to better and more equitably to manage droughts, floods, and other extreme weather events, reducing unemployment, reducing stress on food systems and water resources, and building the capacity of the state to serve and empower vulnerable and marginalised groups, especially those most impacted by the climate and the shift away from fossil fuels. The Just Transition Framework notes: "Managing the transition will require strategies that both deal with the unavoidable burdens arising from the transition, as well as strategies that seize the opportunities offered by the green economy, with wide sharing of benefits" (p.3). It goes on to state: "It is important to sequence and align economic, social, and mitigation and adaptation measures, which means the country will need a just transition framework that is translated into an implementation plan and detailed employment and skills strategies… There is commitment among social partners to procedural justice, involving the most affected in the decision making process, and reconfiguring governance processes to ensure all aspects of justice in the transition are addressed (procedural, redistributive, and restorative)" (p.5). After characterising the risks facing various economic sectors, value chains and social groups across South Africa, the framework suggests numerous intervention areas for promoting the Just Transition. What is needed is a structured process for weighing up, prioritising, sequencing and coordinating the actions required to realise relevant mitigation and adaptation interventions within diverse contexts and developmental realities across South Africa.

[1] https://www.climatecommission.org.za/publications/design-addition-and-amendment-to-just-transition-framework-with-dedication-to-pcc-secretary

Operationalising a CRD pathways approach offers a means for the many, diverse public, private and civic actors implicated in bringing about a Just Transition across South African society to collectively understand the drivers and implications of the current development trajectory (at relevant spatial and temporal scales), iteratively monitor and assess climate-related risks, evaluate and negotiate intervention options that reduce and redistribute risks, and act in a coordinated way to redirect the development trajectory towards creating a more sustainable, cleaner, and inclusive economy and healthier society. Operationalising CRD pathways is by no means a singular undertaking. It provides a structure - an interconnected set of ideas and methods - within which to reflect, plan, negotiate, decide, act and evaluate at multiple spatial and temporal scales, across diverse contexts, repeatedly. It will take a huge set of changes to transition South African society from a highly unequal and risky society now, to one that is equitable and sustainable by the 2050s. The goal is to cohere the prioritisation and implementation of a set of strategies and actions over the next 30 years that fundamentally change the structure and character of South African society for the better, acting in the near-term with a long-term (multi-decadal and inter-generational) perspective to preemptively build resilience and contribute positively to ongoing changes in the larger socio-ecological systems that we all form part of.

This guide explains what CRD pathways are, why the CRD pathways approach is needed in South Africa, and what the main concepts are that underpin a CRD pathways approach. The guide is based on reviewing climate action pathways literature, convening four international expert engagements with those developing climate resilient development (CRD) pathways theory and practice, and exploring two test cases in South Africa - eThekwini metro and Saldanha Bay development zone - to contextualise the concepts and scope out what implementing a CRD pathways approach could entail and how it might add value to related ongoing processes. It is intended as a basis for discussing amongst the wider PCC network of actors the value of a CRD pathways approach in furthering South Africa's climate and development policy agenda and, most importantly, supporting the implementation and iterative enhancement of climate and development policies and plans.
The CRD pathways approach requires a more inclusive and reflexive way of screening and prioritising development options and investments based on the equity of their outcomes, the contribution they make to reducing greenhouse gas emissions, and how robust and adaptive they are to changing climate conditions (both averages and extremes). The guide provides examples from two South African contexts - eThekwini metropolitan municipality and Saldanha Bay development zone - that illustrate the application of each concept, and lays out a process for applying a CRD pathways approach in various South African contexts and systems.

2. What are Climate Resilient Development (CRD) Pathways ?

A system is an interconnected web of life. A development pathway is the evolution of a socio-ecological system, be that a dryland farming system, a river basin, a forest community, a city region, or a nation state. Any system is nested in and interconnected with other systems. Humans are one part of a system, with a responsibility of care.

In the global climate change research and policy arenas the term 'Climate Resilient Development Pathways' has been coined to refer to: *a process of implementing greenhouse gas mitigation and*

adaptation measures to support sustainable development for all (Chapter 18 of the IPCC Sixth Assessment WGII reports).

Climate resilient development (CRD) seeks to integrate actions mitigating and adapting to climate change into the pursuit of sustainable development that promotes human and planetary health and well-being, equity and justice. CRD responds to recognizing that fossil-fuel based, high consumption oriented development pathways are generating considerable harm, inequities within and across countries as well as irreversible social and environmental tipping points. There is no singular, optimal pathway to pursue to a fixed, universally agreed goal, but multiple (often interacting sometimes conflicting) pathways emerging at various scales out of diverse and changing conditions, preferences and departure points. Many of us are currently on (and reinforcing) development pathways that are not climate resilient.

CRD pathways are sequences of decisions and actions taken within a nested socio-ecological system that progress towards equitably meeting the social, economic and material needs of present generations while rehabilitating and conserving earth's life-supporting systems (including by limiting global warming to below 2^{o}C), to avoid compromising the ability (or ideally growing the ability) of future generations to sustainably meet their needs. A CRD pathways approach helps to visualise and articulate various sequences of decisions, actions and interventions and the outcomes they lead to. It requires negotiating options and tracking progress against the actions needed to bring preferred pathways into being, and learning from processes and outcomes as conditions change, surprises emerge (like Covid-19 did), and thresholds are breached (such as the rise in sea level making some stretches of coastline no longer inhabitable). A CRD pathways approach centres around mapping pathways, but the pathways map or the pathways plan is not the primary intended outcome. Rather the processes, governance arrangements and capacities for collectively assessing, negotiating, sequencing and enacting options along pathways, weaving together multiple forms of knowledge about how systems work and our place and agency in them, is the primary intended outcome. The challenge is to layer this approach into the current workings of many actors and the systems they are part of.

CRD pathways map out and guide societal systemic transitions to radically reduce the extent of human-induced climate change and the devastating impacts that emanate from climate hazards. They involve a rapid (within the next two decades) shift away from fossil fuels, a widespread change in diets and agricultural practices, reversing trends in deforestation, a radical change in construction materials and practices, in patterns and modes of mobility, enormous efforts at rehabilitating nature, including river systems and aquifers, and so much more. CRD pathways imply deep societal changes – transformations in economic, political and cultural structures (away from those that reproduce mass consumption, inequality, poverty and marginalisation) – that raise questions of ethics and power. CRD pathways require actors - individuals and organisations - to play their part in not only assessing but changing the feasibility of development options that are not fossil-fuel based or fueling consumerism and exclusion. These include options to drastically reduce the concentration of greenhouse gases in the atmosphere (mitigation) to limit global warming, and options to drastically reduce and shift the distribution of climate-related impacts (adaptation), to achieve desirable and liveable futures and wellbeing for all. CRD pathways refocus societal development from a narrow goal of national economic growth measured as GDP towards wellbeing including physical health and safety, social connectivity, emotional support, intellectual and occupational stimulation, financial security, and spiritual resonance.

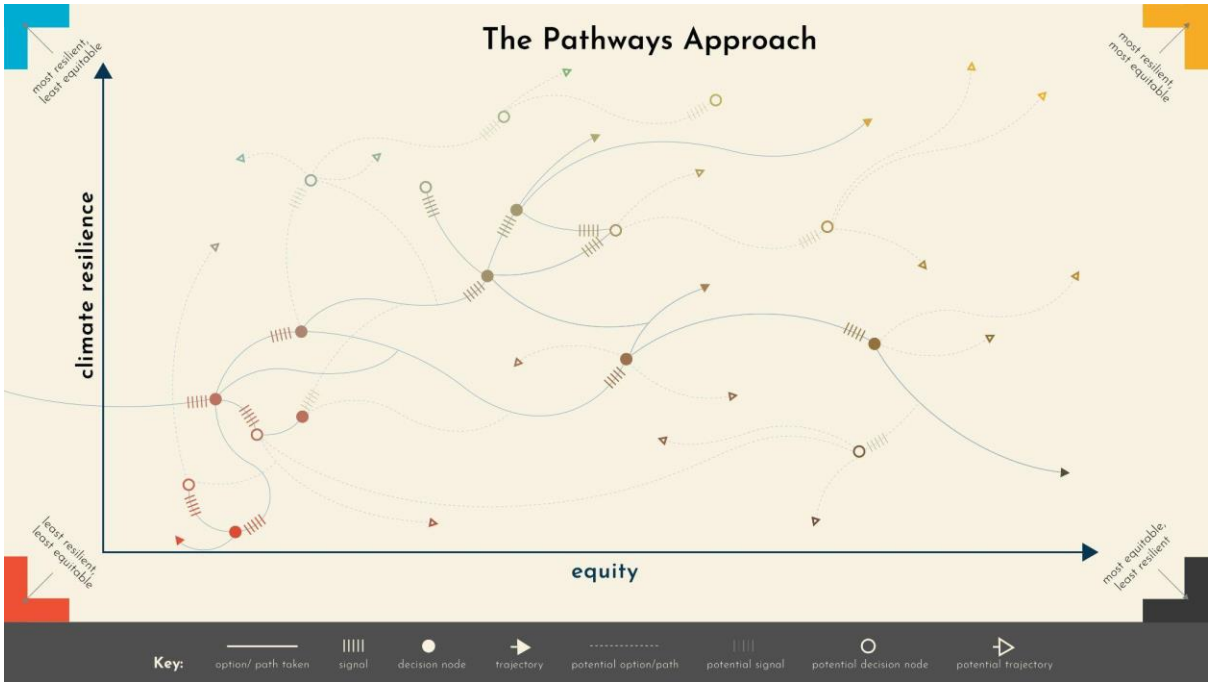

Figure 1: A visual representation of the pathways approach showing multiple intersecting pathways, made up of a sequence of interventions aimed at reducing or redistributing climate-related risks and seizing climate related opportunities, which make the system more or less resilient and more or less equitable. [Image by: Jamy Silver]

One of the key objectives of CRD pathways is to better align mitigation, adaptation and development thinking and action. Some working in the climate mitigation space do not identify themselves and their work within the concept of 'climate resilience' and are calling for a more inclusive terminology . However, climate change mitigation can be seens as an important aspect of building climate resilience, as it deals with the root causes driving human-induced climate change and associated risks.

3. Why put CRD pathways into practice in South Africa?

Our current development model and economy – in South Africa and beyond – is not affording everyone a decent livelihood and adequate levels of health and wellbeing. Many people are woefully underpaid for the work that they do, and many are unable to find sufficient work. We continue to over-exploit our natural resources, notably water, soil, coal, oil, forests and fisheries. South Africa's means of producing electricity, along with our reliance on petrol and diesel vehicles moving people and goods long distances, are contributing significantly to the accumulation of carbon dioxide and other greenhouse gases in the atmosphere. Our regional climate patterns are diverse and highly variable, interspersed with extreme wet and dry periods, and are changing with increasingly damaging and costly consequences (not least of all revealed by recent flooding in KwaZulu Natal and persistent drought and water crisis in the Eastern Cape).

Our biggest challenge in South Africa is ongoing systemic failure to implement progressive policies and service delivery commitments. Vested interests and institutional power dynamics are at the core

of this. We need a model for putting people and climate at the heart of development. Inclusive processes of social learning and knowledge co-production must be central, shifting the paradigm in which government, business and civic leaders and managers make their choices around investments and resource allocations. It is important to avoid mitigation and adaptation strategies and plans unfolding in parallel silos (or worse competing for attention and funding). The need is for an integrated approach that aligns mitigation, adaptation and development thinking and action. But the question is how to interrelate them in ways that address synergies and trade-offs without undermining each of the agendas and creating unnavigable complexity.

With all our histories and entrenched ways of doing things, we need to breathe new life into efforts to co-design and bring into being alternative development pathways that are fairer, healthier, greener and attuned to the changes unfolding around us within and beyond South Africa. This includes chronic load-shedding and energy insecurity, increasing inflation and cost of living, growing malnutrition, poor housing conditions and homelessness. It also includes expanding formal and informal economies of waste beneficiation, European carbon taxes on imports, the emergence of a global hydrogen economy, innovations in battery cells, and much more.

A CRD pathways approach can potentially support us – a diversity of South African actors – in co-design and bring into being alternative (more inclusive, equitable and sustainable) development pathways by:

4. Understanding **what got us to where we are now**, locally, regionally and nationally.
5. Characterising **how conditions are changing** and likely to change into the future.
6. Identifying and **co-designing development options** and differentiating those that are **climate-compatible and foster resilience**, from those that are not.
7. **Sequencing options** in light of feasibility and range of conditions for which each option (in combination with preceding options) keeps the risk profile of the system (and the actors operating in the system) within an acceptable range.
8. **Negotiating roles** and the **allocation of costs and benefits** in realising preferred options.
9. **Coordinating** efforts, **tracking** collection action, **assessing** outcomes, and facilitating shared learning **to adjust** the trajectory **or switch** between pathways.

The CRD pathways approach offers a more inclusive and reflexive way of screening and prioritising development options and investments based on the equity of their outcomes, the contribution they make to reducing greenhouse gas emissions, and how robust and adaptive they are to changing climate conditions (both averages and extremes). It emphasises monitoring and acting on emerging signals that may trigger a change in development options, such as introducing a new crop, switching to an alternative energy source, investing in a water reclamation plant, or initiating a managed retreat from a flood zone.

CRD pathways show conceptual and operational promise, having been developed and applied in varied contexts, including the UK, Netherlands and Australia. There is still work to be done in adapting and applying these ideas in South African contexts, especially those with traumatic development histories that have given rise to high levels of inequality, unemployment, social discord, environmental degradation, ailing infrastructure and institutional mistrust.

The impact of adopting a CRD pathways approach is not only achieved through co-producing a set of climate change adaptive and mitigative development pathways based on collectively prioritising and sequencing options and interventions in various contexts and scales across South Africa. More importantly, impact is achieved over the longer-term by developing and exercising a practice of

deliberative and adaptive planning and implementation that is alive to uncertainties, contingencies, feedbacks and emerging conditions. The practice involves fostering safe, deliberative spaces in which aspirations, values, fears, risk perceptions, power dynamics and vested interests can be surfaced, explored, challenged and negotiated. It also involves nurturing new or altered relationships between residents, practitioners, business operators, researchers and policymakers. This is no easy task in current South Africa, where dysfunction, mistrust, marginalisation, fragmentation, frustration, violence and ongoing exploitation of people and nature is rife. But that is even more reason to keep trying.

As an interviewee in one of the two South African contexts where we worked to ground the CRD pathways said: *"You're never going to get a framework that dictates what everyone is going to do… but something more structured to say: okay, if we're going down this route, we must think about these things, and know that these are the trade-offs that we're going to make, and this is how we might mitigate some of the risks. That would be awesome to have… it won't be perfect, but it will help a lot… Whatever conversations help people to think across the spectrum of ideas [and competing priorities] would be very valuable".*

4. What are the key CRD pathways concepts?

Development pathway(s)

A development pathway is a sequence of decisions and actions (or inactions) stretching from the past into the future undertaken to meet a developmental need, goal or aspiration. Important to note that there is not one pathway but often various pathways may interact and by doing so contradict or reinforce each other. A pathway may be more or less climate resilient based on the extent to which the sequence integrates actions that reduce greenhouse gas concentrations and reduce physical climate and transition risks in an inclusive and equitable manner.

For example, a major development pathway in the case of eThekwini relates to long-term investment in transport and logistics-related infrastructure to support trade and manufacturing, particularly related to the seaside port and the airport. The growth of the manufacturing and trade sectors in eThekwini stems from this pathway, which was set in motion in the mid 1800s and continues with ongoing investment/upgrading of sea and airport infrastructure, as well as proposed growth and development nodes that link to the main sectors in the city-region. This pathway has also been strengthened by national decisions related to Special Economic Zones and Strategic Integrated Projects, which aim to support infrastructure investment for the economic growth of South Africa. Over time, investment in infrastructure has also supported decentralisation of economic activities and associated living areas (e.g. outside of the urban core and into the East of the city). Major development and growth projects such as the Durban Aerotropolis/Dube TradePort (see section on decision nodes below) in the north of eThekwini and the Automotive Supplier Park in the South are expected to fuel economic growth and create more jobs.

Probing this pathway for its climate resilience, it became apparent that climate-related impacts such as floods and landslides pose major risks to trade and manufacturing businesses, as well as associated infrastructure. This is particularly the case for businesses and infrastructure that are located in floodplains and areas that are susceptible to geohazards as a result of the erodibility of

soil, active soil, the high water table, seepage etc. For example, 1 152 businesses were damaged during the April 2022 floods because they are located within eThekwini's floodplains[2].

Trade and manufacturing sectors are currently carbon-intensive and therefore dominate Durban's greenhouse gas emissions. This hampers the ambitions of Durban's Climate Adaptation Plan (2019) to reduce Durban's total greenhouse gas emissions by 80% by 2050 (using 2015 as the baseline) through three major pathways, namely: i) increasing energy supplied from renewables; ii) improved public transport; and iii) increased energy efficiency of industrial equipment (CAP, 2019). However, several major catalytic projects associated with trade and manufacturing sectors can also potentially connect to transition projects such as the "hydrogen valley" (see decision nodes section below).

Another development pathway that gained traction in eThekwini over the past decade has been shaped by environmental concerns and efforts to protect and rehabilitate local ecosystems. This pathway can be traced back to ideas for the Durban Metropolitan Open Space System (D'MOSS) in the 1970s. As a result of decisions that have supported this pathway over time, eThekwini has grown a globally-recognised portfolio of climate change related interventions including Community Ecosystem-based Adaptation (CEBA). CEBA is promoted as an effective and important option for interventions that reduce climate risks and create employment. Anecdotal evidence suggests that some waterway management interventions were effective at reducing losses in some areas during April 2022 floods. The importance of functioning ecosystems for reducing climate-related risks such as floods and for supporting infrastructure maintenance by reducing runoff and siltation in culverts is increasingly being acknowledged not only among promoters of CEBA but also some water engineers and operators in the Durban port.

In the context of Saldanha Bay, a major development pathway has been investment in large-scale infrastructure to support industrial activity associated with port-related activities. The availability of piped water from the Berg River in the 1970s further supported this development pathway, enabling industrialisation in the area. Saldanha's industrial pathway was and still is today largely centred around the export of iron ore from mines in the Northern Cape. Saldanha, developed at a time of cheap energy input costs and including energy intensive industries such as steel producing and steel processing plants, a mineral sands smelter and others, is now constrained by a steep increase in energy input costs, and insecurity of supply. Whilst being tied into this energy intensive pathway, there is recognition amongst the major actors that there is an urgent need to reduce their greenhouse gas emissions. This conundrum has presented an opportunity to explore using the high renewable energy potential in the area coupled with the availability of land to develop alternative fuels, such as green hydrogen (see 'synergies' section below).

Decision nodes

Decision nodes are the points along a pathway where a choice of development options is considered, and decision taken, to implement a new or alternative action, intervention or technology in an attempt to harness an opportunity and/or move a climate-related risk (either a risk from a physical climate hazard or a transition risk associated with abandoning fossil fuels) to a socially and technically acceptable level or pattern. This refers not only to an aggregate level of risk but also to the distribution of that risk from an equity perspective.

For example, a key decision node in eThekwini's development pathway of investment in transport and logistics-related infrastructure to support trade and manufacturing was the inclusion of the

[2] https://www.freightnews.co.za/article/kzn-floods-economic-impact-update

Durban-Free State-Gauteng logistics and industrial corridor as one of the Strategic Integrated Projects (SIPs) which was established as part of the National Infrastructure Plan in 2012. This plays into the proposal for Durban to be a "hydrogen hub" in the Hydrogen Valley report (2021). The Department of Science and Innovation is working with Anglo-American, Bambili Energy and ENGIE to identify opportunities to transform the Bushveld complex and larger region around Johannesburg, Mogalakwena and Durban into what they are proposing as a "Hydrogen Valley".

In the Saldanha area an early decision node, responding to the heavy and potentially environmentally compromising industrial development of Saldanha Bay, saw the enactment of protected area status to the interconnected system of Langebaan Lagoon in the 1970's. By the end of the 1980's this had expanded to become the Marine Protected Area, West Coast National Park and Ramsar site in existence today. Subsequent decision nodes along this conservation pathway have been informed by detailed mapping of critical biodiversity areas (CBAs), and ecological support areas (ESAs) in CapeNature's Western Cape Biodiversity Spatial Plan (WCBSP, 2017). Climate corridors have been identified that combine areas of intact ecosystems with areas indicating climate resilience to form ecological corridors to facilitate the movement of species in response to climate and other environmental changes.

Thresholds

Thresholds are realised when biophysical, social, political, or economic conditions change to an extent that existing measures (actions, interventions or technologies) no longer produce an acceptable or tenable risk profile. A threshold is some level of a social, biophysical or economic variable being monitored as a signal (see next concept) that one should avoid crossing because it represents an unacceptable risk profile/distribution that is collectively agreed. When discussing and determining thresholds (as well as related signals and triggers) it is important to recognise and work with the different impacts and coping capacities of various actors and stakeholder groups in a system. Different values and expectations need to be considered through a participatory engagement process that helps to determine key signals and planned triggers for new, additional or alternative measures. Sole reliance on outsider expert framings of risk is inadequate as it ignores or discounts the importance of local values and knowledge, various risk perceptions and experiences, and the often conflicting preferences in terms of cost and benefit distributions of either action or inaction.

Water availability in the arid West Coast region of South Africa in which Saldanha Bay is located, presents a biophysical threshold. This was clearly highlighted in the recent drought that saw a number of water intensive companies in the area install desalination plants in order to continue doing business. Given that climate projections indicate a drying trend in this region, combined with ongoing water constraints as growing urban areas compete for shared and limited resources, the availability of freshwater will continue to be a very real threshold on development pathways into the future.

In eThekwini, the combination of increasing alien vegetation, poor solid waste management and transformation of landscapes (hardening of surfaces and upstream transformation) has resulted in a situation where ecosystems are below sustainability thresholds according to the most recent Strategic Environmental Assessment (SEA). This needs to be considered in the adaptation pathways that focus on ecosystem-based approaches. The declining state of ecosystems across the landscape (including upstream) has also contributed to increasing damage to infrastructure during flood events

and the need for more adaptation/disaster risk measures towards a CRD pathway (e.g. a combination of built and ecological infrastructure, as well as social networks).

Signals

Signals are detected and evaluated by monitoring social and biophysical variables to proactively identify the impending arrival of a threshold and thereby prompt or trigger the decision processes required to select and implement the next option. The time between the signal being identified and triggering the implementation of a new option is the decision time. This is followed by the implementation time required to get the new measure operational. A burning question within the CRD pathways approach is whether signals can be detected with sufficient lead time to enable decision-making and implementation to occur before the worst of the impacts start to be realised. The aim of the CRD pathways approach is to establish triggers in advance and proactively plan for the options that will need to be taken if or when signals suggest that an associated threshold is approaching, i.e. unplanned trigger. However, in reality it is sometimes the experience of a climate-related disaster (like a flood or a water crisis) that triggers a reactive response to implement a new option, i.e. an unplanned trigger.

Examples of signals of relevance for eThekwini's development pathway(s) are described below.

- Monitoring of blockages in water bodies to show that the majority are caused by alien vegetation (~70%), which provided impetus for the municipal-led Sihlanzimvelo programme in 2011. Sihlanzimvelo involves employment (and upskilling) of community co-operatives to manage waterways (i.e. by removing waste and alien vegetation) to support the maintenance of roads and stormwater infrastructure.
- The 2019 major flood event triggered the establishment of the Forecast Early Warning System (FEWS) for protecting lives, strategic assets and resources. FEWS contributes to the mix of approaches to build climate resilience in eThekwini.
- Declining availability of water following the April 2022 floods has led to the decision to ration water for residents of eThekwini between 2022 and 2023. The Durban Heights Water Treatment Plant, which supplies at least 50 reservoirs, was damaged and therefore not able to source sufficient water from the Nagle Dam.

Synergies

Synergies occur when measures or interventions (either along the same pathway or between pathways) enhance each other's opportunities for success in reducing climate-related risks or seizing climate-related development opportunities.

For example, in the Saldanha Bay development zone test case, the mothballed Saldanha Steel plant owned by ArcelorMittal has a globally unusual configuration of furnaces that would allow conversion to a Direct Reduced Iron steel plant supplied by gas or green hydrogen. As the steel plant is located right next to the port, should the Saldanha Bay Industrial Development Zone Licencing Company (SBIDZ-LC) be reconfigured for green hydrogen or powerfuels (P2X) production, this would present an opportunity for synergy between industrial development (i.e. steel), socio-economic development (i.e. through job creation) and mitigation objectives (i.e. reduced greenhouse gas emissions for ArcelorMittal).

In eThekwini, studies have shown the benefits of river management and rehabilitation interventions for supporting infrastructure maintenance by reducing runoff and siltation in culverts. There is,

however, an increasing realisation that multiple interventions need to be implemented simultaneously to enable climate resilience and deal with residual risk (especially in relation to extreme events as well as water security), including built infrastructure, ecological infrastructure, social infrastructure and Disaster Risk Management, as has been demonstrated multiple times over the past few years.

A strong and focused investment in renewables in eThekwini (e.g. through the establishment of the small-scale embedded generation system) and hydrogen production/consumption (e.g. the Durban hydrogen hub) has the potential to create synergies across the adaptation, mitigation, social and economic development pathways. There is also strong potential for mitigation and infrastructure development ambitions to converge through ideas of the hydrogen valley, which follows part of the Strategic Integrated Project (SIP2) corridor.

Trade-offs

Trade-offs between measures or interventions undermine or dampen each other's opportunities for success and risk reducing or redistribution potential.

Climate resilient development needs to be seriously considered as a guiding principle for infrastructure development options, otherwise these are likely to be exposed to climate hazards that result in ongoing risk of loss of life and livelihoods. The 1 152 businesses that are located within eThekwini's floodplain were severely impacted by the April 2022 floods. Enforcing strict rules associated with building within flood lines will mean relocating these businesses and informal settlements outside of these flood lines, the latter of which is likely to have social implications. If the flood lines are updated to consider a different return period, more trade-offs of this nature will need to be made.

While Community Ecosystem-based Adaptation has been considered a "no regrets" strategy in eThekwini, a stronger emphasis on this pathway might mean trading off with other options for developing infrastructure along the coast, or on flat parcels of land that currently support groundwater recharge. For example, a strong focus on supporting or protecting ecosystems might mean moving infrastructure away from and rehabilitating dunes (for coastal protection).

In Saldanha there is an ongoing tension between industrial development and protecting sensitive, and in some places critically endangered, ecosystems. Trade-offs around similar tensions, which occur nation-wide, have resulted in the use of biodiversity offsets whereby developers invest in retaining or recreating an area of 'equal' biodiversity status as the one they wish to destroy through the proposed development. In Saldanha, the Western Cape Biodiversity Spatial Plan: Saldanha Bay (2017) and the 'Risk and Resilience Assessment of Natural Capital in the Greater Saldanha Bay Municipality: A Navigational Tool for Strategic-Level Decision-Making' are used in environmental authorization applications to identify critical biodiversity areas (CBAs) and ecological support areas (ESAs).

Maladaptive zone

A development pathway is in the maladaptive zone if the implementation of chosen measures or interventions increases the risk profile and/or heightens the inequality of how risk is distributed.

One could argue that eThekwini is already in a maladaptive space because so many of the most vulnerable communities are repeatedly exposed to (and impacted by) hazards such as floods.

Prioritising investments in infrastructure, ecosystems or other options without shifting the distribution of resources and power will contribute to persistent inequality, which will likely have far reaching consequences. For example, these decisions could continue to move development pathways beyond social thresholds, resulting in repeated social unrest.

Similarly one could argue that some decisions taken on the Saldanha industrial development pathway have led into a maladaptive zone characterised by increased transition risk. This is exemplified through a cluster of decisions that included the promulgation of the Saldanha Bay Industrial Development Zone (SBIDZ) in 2013, and the development of Operation Phakisa: Oceans Economy in 2014, both of which invested in positioning Saldanha Bay to 1) service the offshore oil and gas industry, and 2) develop port-based infrastructure to support gas as a transition fuel to a low-carbon economy. These developments were tied into a pathway that envisaged fossil fuels as a primary fuel stock or at least as a transition fuel into the medium- to long- term. However subsequent signals such as the war in Ukraine resulting in escalated gas prices, and the shift in public sentiment following the release of the IPCC 6th Assessment Report (2022) urging a substantial and rapid reduction in all fossil fuel use, have led to a recognition amongst key actors of the transition risk associated with these decisions. These include stranded assets if investment in capital-intensive onshore gas-to-power facilities is realised, a potential reduced market for offshore oil and gas servicing, reduced markets and financial penalties (carbon tax) on carbon intensive manufacturing processes, and lost opportunity to position Saldanha and South Africa in an emerging energy sector such as powerfuels. Taking cognisance of these signals the pathway course is being altered with new decision nodes presenting and being navigated according to priorities in line with this changing context. For example, phrases in the public domain have changed from 'servicing the offshore oil and gas, and maritime sectors' to 'servicing the energy and maritime engineering sectors', the SBIDZ Licencing Company has hosted two webinars on exploring the potential for positioning Saldanha Bay as a green hydrogen hub championing green shipping, and ArcelorMittal is considering using green hydrogen as a fuel source for its Saldanha plant.

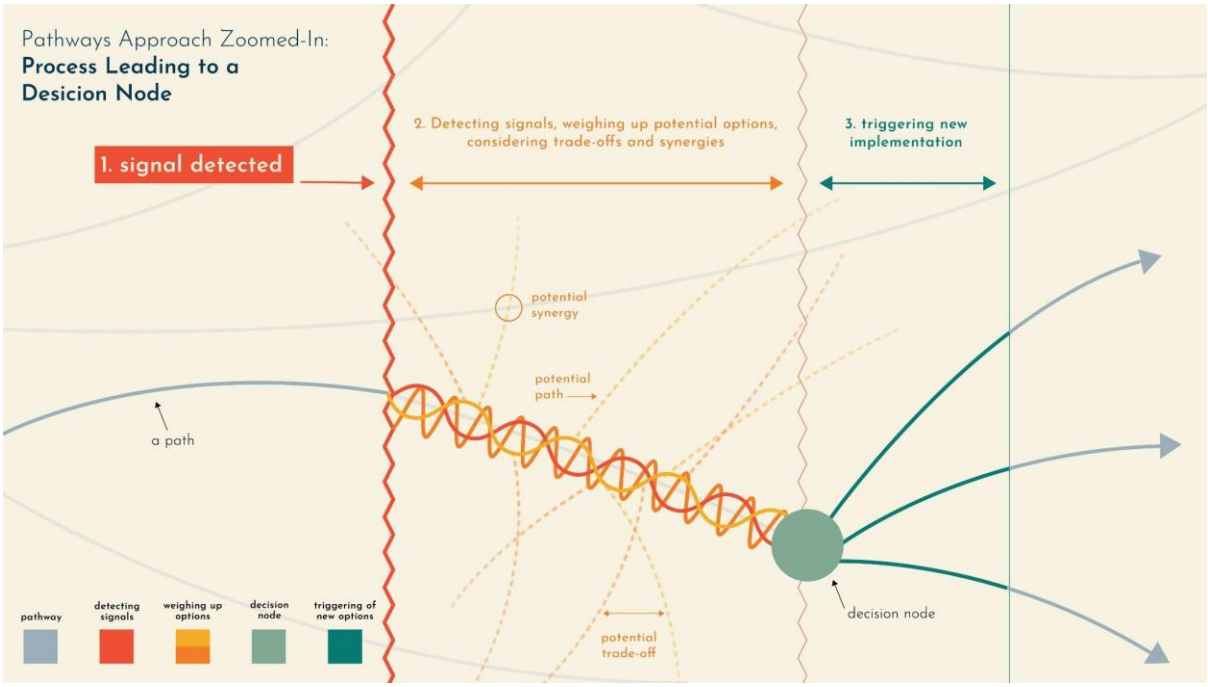

Figure 2: An illustration of how detecting signals of an approaching threshold may lead to weighing up new or additional options, assessing how options synergise or present trade-offs with other options, and deciding on a new course of action. [Image by: Jamy Silver]

5. What is the process for putting these ideas into practice?

For practical purposes this process may need to be packaged into a set of separate (yet interconnected) projects with suitable funding arrangements and different combinations of actors and knowledge bases. But coordination between such projects is essential to ensure a systems perspective, iteration and learning. The process for putting CRD pathways ideas into action is presented below.

Bound the system being considered, recognising larger and smaller nested systems. Is the focus a municipality, a city region, a catchment, an agricultural district or sub-sector, a coastal and marine area, a national sector? This choice needs to be informed by institutional arrangements and ongoing decision processes that the CRD pathways approach will feed into. Testing is needed, beyond the scoping already undertaken, to determine if the CRD pathways approach can be applied within each of these systems, and if so, whether resulting pathways can be meaningfully and usefully connected up or nested to identify synergies and trade-offs.

Characterise more and less desirable pathway destinations by co-developing a set of scenarios that bring together qualitative and qualitative evidence from mental and computational modelling exercises that explore the potential evolution of the system. The aim is not a singular, agreed set of goals, but a shared understanding of possible direction of travel, i.e. the system's development trajectory, based on interacting internal and external forces or drivers of change. Actors are asked to envision and articulate alusible CRD futures, as well as futures that are not climate resilient. This forms the basis for establishing a set of criteria against which options and alternative pathways can be assessed.

Map development pathways, first in smaller, more homogenous groups (e.g. industrial and commercial actors separate from civic and community-based actors, or actors working in the agricultural sector separate from those operating in the manufacturing sector), then together in more diverse groups. This is likely to require a series of engagements, the gathering and integration of disparate sources of evidence, and undertaking additional analyses to build new knowledge on contentious or poorly understood issues.

- **Looking back** 10, 20 and 30 years, identify **historical developments options** that have shaped the system.
- **Looking forward** 10, 20 and 30 years, suggest **prospective development options** that would reshape the system to adapt to changing climate risks, reduce greenhouse gas emissions, and increase equity.
- Rate each option for **carbon intensity** as high, medium, low, or negative (i.e. reduces greenhouse gas concentrations in the atmosphere).
- Rate each option by **sensitivity** to climate variables as high, medium, low or adaptive (i.e. builds resilience) under a range of possible climate scenarios.
- Rate by impact on **equity** between affected groups, as increases equity, decreases equity, or unclear (i.e. don't know or depends on how it is implemented / taken up).
- **Cluster** those that relate to or are contingent on each other (i.e. they will become a pathway distinct from the other options) – there may be some options that fit within more than one pathway, these become pathway connecting nodes.

Negotiate preferences, surface and acknowledge vested interests, empower marginalised groups, build shared understanding of inter-dependencies between actors, and unpack synergies and trade-offs between options to understand who stands to gain what, at whose or what cost.

Assign responsibilities for implementation, monitoring and evaluation and ensure these are carried through into relevant plans, programmes, projects and budgets.

Monitor changes and approaching thresholds that signal the need for new/additional measures.

Convene learning exchanges as part of a coordination platform, expanding and deepening existing such platforms where possible.

Revisit and revise pathways maps periodically based on new information and learning to ensure that the process stays alive as a means of anticipatory adaptive systems planning.

6. What climate information is needed by whom to realise and navigate CRD pathways?

A comprehensive suite of climate information services and strong integration of physical climate science expertise, together with mitigation, climate impacts and adaptation expertise, is needed in CRD pathways processes. These relate to identifying current thresholds, characterising current and historical climate hazards, predicting and monitoring for future thresholds, and anticipating potential future climate hazards that emerge from changes in the climate system. This places particular demands on South Africa's climate science and information system, many of which are not currently adequately met, despite numerous ongoing efforts at monitoring, data integration and complex systems modelling to produce a range of scenarios and future projections. These efforts and resulting product and services are described in output 2, which concludes with a set of recommendations on expanding observations and monitoring systems, building the sustainability of climate information and service providers, an implementation plan for the National Framework for Climate Services that encourages innovation, partnerships and a diversity of high quality climate services, and broad-based capacity building to work across the science-policy-practice interfaces. Full details can be found in the accompanying report entitled 'Putting Climate Resilient Development Pathways Into Practice: Climate Information and Services'.

7. What capacities are required to realise and navigate CRD pathways?

A review of literature on resilience, mitigation, adaptation and pathways revealed a number of capacities that enable a CRD pathways approach, which were consolidated into nine broad capacity clusters. These include: 1) awareness of decisions and actions that may be impacted by or impact on climate change; 2) leadership; 3) working across levels, sectors, disciplines, organisations and teams; 4) fostering a learning culture; 5) costing and resourcing development and risk management interventions; 6) designing, acting and maintaining risk management interventions; 7) technical expertise in assessing climate-related risks and opportunities; 8) promoting justice and equity; and 9)

managing uncertainties. Three ways of assessing capacities are presented, namely via desktop review and targeted interviews, via a participatory process, and using a structured software tool.

The climate-related capacity development landscape in South Africa was also reviewed to understand where investments have been made, and whether these investments have (or can) support the development of capacities for CRD pathways planning. This review showed that past and ongoing capacity development activities have focused on empowering the youth and cultivating leadership skills, increasing the accessibility of climate information, improving collaboration (but with limited focus on working together across disciplines and levels), and, to a limited extent, mainstreaming justice and equity concerns. There was minimal evidence of training activities that strengthened learning cultures, leveraged technical expertise to manage climate risks, improved the capacities to design, act on and maintain interventions (including how to deal with trade-offs and find synergies), and improved stakeholders' ability to manage uncertainty. Full details can be found in the accompanying report entitled 'Putting Climate Resilient Development Pathways Into Practice: Capacity Assessment Framework'.

8. What next for progressing CRD pathways work in South Africa?

To ensure that CRD pathways become a valuable decision-support tool within South Africa it is important to take the insights and foundation established through the scoping phase of this project forward and invest in multi-stakeholder testing and development of the approach. Briefly summarised below are a set of high-level proposals that have the potential to advance CRD pathways practice in South Africa, with a particular focus on enhancing equity. These are by no means exhaustive of what could happen next, but are intended to spark interest and fuel dialogue regarding CRD-related priorities and investment options.

Advancing CRD pathways in eThekwini

This proposal calls for a structured, equity focused CRD Pathways process including actors from multiple sectors and lived realities in eThekwini. The process seeks to further interrogate the development options associated with major growth and development infrastructure, Community Ecosystem-based Adaptation and human settlements, with a focus on potential thresholds, signals, synergies and trade-offs associated with these pathways into the future. An important aim of the work is to assess the potential economic costs of implementing vs. not implementing various development options, and to understand the blend of options that will transition eThekwini onto a CRD Pathway.

Advancing CRD pathways in Greater Saldanha Region Industrial Complex

This proposal calls for the application of the CRDPs to the Greater Saldanha Regional Industrial Complex (GSRIC), an area centred around Saldanha Bay, but extending into the surrounding region in terms of connected industrial activity. For example, the Saldanha-Northern Cape Corridor which includes the mining, transport, beneficiation, and export of iron ore and other minerals. The region presents numerous energy related opportunities and challenges which provide key entry points to exploring future pathways which include addressing water constraints and unemployment challenges. The proposed process seeks to convene a group of key actors from the region representing a range of interests that weave together greenhouse gas reduction requirements, water-sensitive industrial design options that do not reduce the resilience of the sensitive ecosystem within which a large part of the GSRIC is located, and promote equitable development that includes skills development and employment in line with the just transition.

Capacity strengthening for CRD pathways

Three types of activities are proposed for developing capacities to support a CRD pathways approach in South Africa based on the review of capacities for implementing CRD pathways and the capacities assessment framework: 1) CRD pathways capacity training for local actors using simulation and gameplay; 2) Developing a CRD Pathways capacities course; and 3) Tailoring and applying the Climate Capacity Diagnosis & Development (CaDD) tool with a network of organisations to assess current CRD Pathways capacities and prioritise actions for capacity strengthening.

Extending CRD pathways applications through the work of WWF-SA

A proposal to support knowledge co-production, capacity development and inclusive planning through action research in three ‘proofing grounds’ that offer a variety of governance, scale and economic contexts across South Africa, namely: i) the agricultural sub-sector; ii) a rural district and water catchment area; and iii) a rapidly urbanising town.

Further details of each of these proposals, including key partners and indicative costs, can be found in the accompanying report entitled ‘Putting Climate Resilient Development Pathways Into Practice: High-level proposals for taking the CRD pathways approach forward’.

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