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CHAPTER 14:
ADAPTATION AND MITIGATION: SYNERGIES AND TRADE-OFFS

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14.1. Introduction

Typically, mitigation and adaptation research has been developed separately, with the mitigation research community focused on taking a global approach to limiting cumulative greenhouse gas (GHG) emissions. The adaptation research community, however, emphasises locally-focused analysis aimed at minimising the impacts of climate change, especially within the most vulnerable communities. International climate policy has historically developed with a focus on mitigation, though in recent years increased attention has been placed on adaptation. For example, at the 21st Conference of the Parties (COP-21) to the UN Framework Convention on Climate Change, countries also committed toward adaptation responses within their Nationally Determined Contributions.

As adaptation is increasingly receiving attention in the international climate policy and financing space, there has been a growing body of literature (Launder et al., 2015; Berry et al., 2014; van Vuuren et al., 2011 and Wilbanks et al., 2007) that indicates that there are many complex interactions and interdependencies between climate change impacts, adaptation and mitigation. It is increasingly recognised that decisions that are made now could lock in development trajectories for a long time and that there is a need to understand how the mitigation of GHG emissions and climate impacts (and vice versa) interact in the development of policy.

Mitigation and adaptation strategies within southern African countries have typically been developed without explicit consideration of interactions and linkages between these strategies. Focusing on the synergies, trade-offs and conflicts between these issues provide an opportunity to bridge the gap between responding to priorities to address vulnerability to climate change impacts in developing areas and achieving global engagement in mitigation. Specifically, developmental growth could proceed in a way that will allow countries to become more resilient while maximising opportunities to synergistically reduce emissions and minimise potential trade-offs for mitigation. This chapter explores common synergies and trade-offs between mitigation and adaptation and considers the implications for climate change policy responses in southern Africa.

14.2. Linking adaptation and mitigation

Adapting to the impacts of climate change, mitigating GHG emissions and enhancing sinks are effective strategies in managing climate risk. Typically, adaptation and mitigation have been viewed in a linear manner such that emissions are first characterised to understand how climate will change, to then understanding the potential impacts of climate change and the responses that are needed, as shown in Figure 134.1 (van Vuuren et al., 2011).

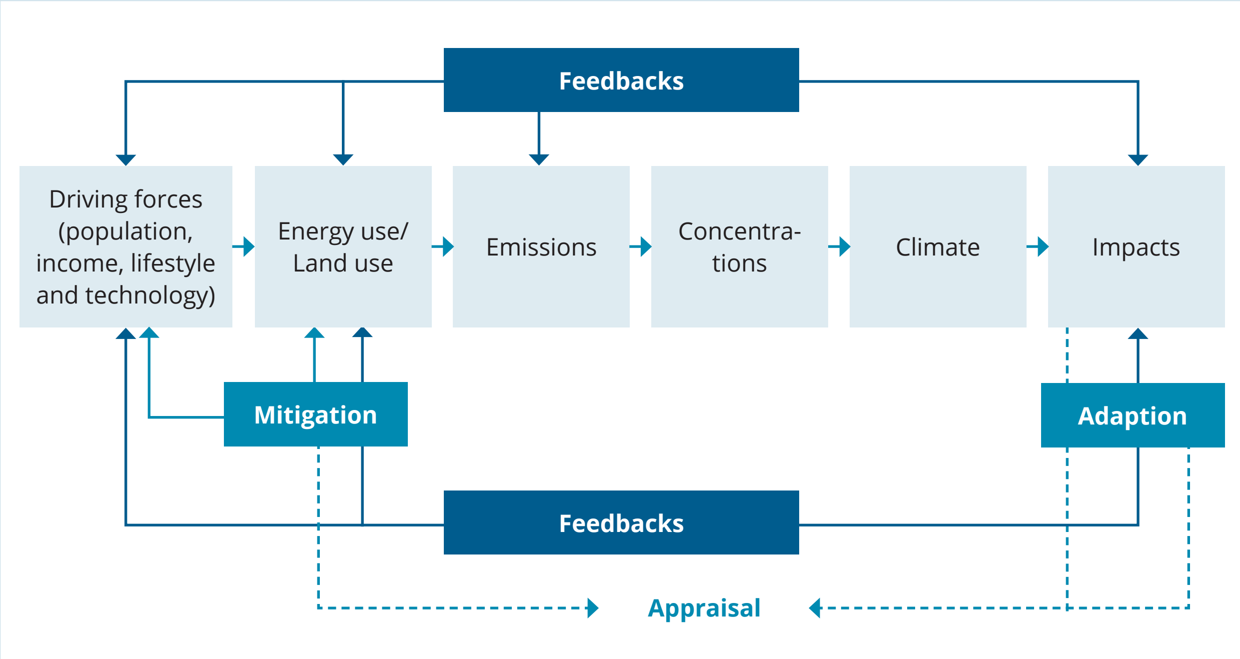


Figure 14.1: Linkages and potential feedbacks between climate change mitigation and adaptation using the driving force-pressure-state-impact-response framework (van Vuuren, 2011).

There are various links and potential feedbacks that exist between adaptation and mitigation (Figure 14.1). As such, responses may not always complement each other, and in some instances, may be counterproductive. At a global level, the potential impacts of mitigation for adaptation, and vice versa, are perhaps easier to conceptualise. Intuitively, more mitigation will equate to less adaptation, however, the type and location of mitigation measure could have trade-offs for adaptation (Calvin et al., 2012). Likewise, climate impacts on key socio-economic sectors may increase the costs of mitigation (Calvin et al., 2012). Most often win-win solutions (or measures that have synergies) for simultaneously addressing both adaptation and mitigation are found at a local level (Laukkonenen et al., 2009; Walsh et al., 2011; and Vigué and Hallegate, 2012), notably through options such as climate-smart agriculture interventions (Lipper et al., 2014) and through measures for mitigating the urban heat island (UHI) effect (Laukkonenen et al., 2009; Dulal, 2017).

Cities are potential hotspots of vulnerability to the impacts of climate change owing to their high concentration of people and assets (Walsh et al., 2010). Climate is variable locally and regionally and this means that the magnitude of climate impacts also varies from city to city. Vulnerability of individuals and communities to climate change impacts is determined by various factors linked to the location and the level of development of each community. In addition, urban climate policies are implemented in conjunction with economic and social policies, which results in interactions between policy goals. As such, socio-economic change can be just as crucial in determining the magnitudes of impacts as climate change (Hall et al., 2005).

The interrelationship between adaptation and mitigation at a local level is complex and there are different implications for each response for spatial planning (see Beisbroek et al., 2009). There is also a tendency for certain sectors to have an adaptation or mitigation focus: sectors vulnerable to climate change usually prioritise adaptation, whereas mitigation is predominantly considered within the energy, transport and industry sectors (Huq & Grubb, 2007).

The Agriculture, Forestry and Other Land Use (AFOLU) sector and infrastructure planning are considered integral components of an urban environment. These sectors are known sources and sinks of GHGs and are important to consider from the perspective of developing low-carbon cities. Due to the dual role these key sectors could play in the areas of mitigation and adaptation, there are likely to be synergies and trade-offs from different policies that are implemented. The AFOLU sector (Box 134.1) highlights potential for synergies that have been exploited by SADC within the REDD+ initiatives. Further to this, the interrelationships between climate change response strategies and land use and land cover changes are complex and diverse. When planned and managed properly, urban agriculture can contribute to climate change mitigation efforts by lowering the ecological footprint associated with food production, and contribute to adaptation efforts by increasing vegetation cover and reducing surface water run-off, while at the same time conserving biodiversity (UN-Habitat, 2014). Urban vegetation can also contribute to the reduction of the UHI effect, and microclimate amelioration (Chang et al., 2007), in conjunction with urban forestry (e.g. the formation of urban parks and tree planting along streets), which promotes adaptation to heat stress due to warming while also leading to carbon sequestration in trees and soil. A multi-species, multi-purpose approach would help reduce the vulnerability of trees to climate change (Ravindranath, 2007).

Agroforestry, one of the most conspicuous land-use systems across landscapes and agroecological zones in Africa, provides another good example of a mitigation-adaptation synergy in the AFOLU sector. Trees planted provide assets and income from carbon and provide wood energy, improved soil fertility, while ecosystem services and tree products can provide livelihood benefits to communities, especially during drought years. Most of these benefits have direct value for local adaptation while also contributing to global efforts to control atmospheric GHG concentrations (Mbow et al., 2014).

In conjunction with synergies, it is necessary to consider trade-offs that may occur between adaptation and mitigation activities that do not always complement each other, and may in some instances be counterproductive. Afforestation and reforestation contribute to enhanced carbon sequestration potential while increasing soil water retention, preventing erosion and landslides. There may be competition between land uses where some monocultures planted could have a negative impact on water availability or reduce biodiversity (Bustamante et al., 2014). Similarly, mangroves contribute to storing carbon in addition to protecting coastal areas. However, there may be trade-offs between carbon and the local ecosystem services prioritised by an adaptation project where, for example, spatial priorities for the conservation of hydrological ecosystem services and carbon may be different (Locatelli, 2011).

Infrastructure and planning in cities encompass issues of energy, transport, building, industries and water where the interactions across sectors have the potential for many synergies and trade-offs. Spatial configurations of urban areas and land-use plans have significant implications for both adaptation to climate change (Hurlimann and March, 2012) and reduction of GHG emissions (Lindley et al., 2007). For example, ensuring the survival of mangroves as a barrier against storm surges (adaptation-related responses) involves land-use and land-management decisions, while GHG emission and energy use (mitigation-related responses) are dependent on urban form (Walsh et al., 2013). The case study shown later in this chapter, highlights the co-benefits of using an integrated approach toward adaptation and mitigation responses in the AFOLU and infrastructure planning sectors to alleviate the impact of the UHI. Other examples of the synergies and trade-offs of measures that are typically taken within each of these sectors are shown in Tables 14.1 and 14.2.

Box 14.1: Synergies and trade-offs in the Agriculture, Forestry and Other Land Use (AFOLU) sector

The sector is considered multifunctional, diverse and unique since it is the only sector with sources and sinks of GHGs. The mitigation potential of the AFOLU sector is extremely important in meeting emission reduction targets. The sector offers a variety of cost-competitive mitigation options and most approaches indicate a decline in emissions largely due to decreasing deforestation rates (Bustamante et al., 2014). While references to adaptation or the development of adaptive capacity are rarely included in these mitigation activities, adaptation practices could be included synergistically in most mitigation projects and contribute to the sustainability of the project outcomes.

Carbon emission reduction through REDD+ can contribute significantly to land-based mitigation in two ways: firstly, reducing land-based GHG emissions and secondly, sequestering carbon dioxide through reforestation and agroforestry. Forest mitigation projects such as REDD+ and CDM, for example, have the potential to facilitate the adaptation of forests to climate change by reducing anthropogenic pressures on forests, enhancing connectivity between forest areas and the conservation of biodiversity hotspots, and increasing the value and resilience of forests (Locatelli, 2011). A priority for SADC in their REDD+ programmes was not just to reduce emissions, but for REDD+ to be used as a mechanism for enhancing national development and thus creating the capacity to curb emissions from land-use change and forestry.

Table 14.1: Examples of climate change synergies and trade-offs in the AFOLU sector

Sector	Measure	Synergies		Trade-offs	
		Mitigation	Adaptation	Mitigation	Adaptation
Forestry	Afforestation/ reforestation	Enhanced carbon sequestration potential; Increase C storage (on newly planted land)	Increased habitat diversity and habitat availability; restore water quality	Subsequent thinning and management can reduce C storage	Competition between land uses; some monocultures may have a negative impact on water availability
	Controlled burning of grasslands	Increases soil carbon stock; carbon sequestration	Control invasive plant species, reduce fuel loading to reduce catastrophic wildfire risk; manage land for endangered species (ensure ongoing recruitment of important plant species); reduces risk of runaway fires (through use of firebreaks); ensures catchments are functioning effectively	Increases black carbon emissions	
Land-based agriculture	Cropland management and grazing and land management	Increases soil carbon stock; carbon sequestration	Appropriate management practices can support regulation of the hydrological cycle and protection of watersheds; soil conservation; improvement of soil quality and fertility		Competition between land uses; Impacts on N&P cycle; potential water depletion due to irrigation; some monocultures may have a negative impact on water availability
	Conservation agriculture	Possible increase in soil C storage, reduce energy inputs	Improve crop water efficiency; increase soil water storage; reduce N leaching	Increase GHG emissions depending on measure and implementation	Possible weed and pest control problems
Other land uses	Wetland/ coastal habitat creation	Enhanced carbon sequestration	Increased habitat; species richness and carrying capacity; long- term improvement in water quality; decreased flood risk	Increase in CH_4 and N_20 emissions	Loss of agricultural land; short-term impact on water quality may be negative

Table 14.2: Examples of climate change synergies and trade-offs in the infrastructure planning sector

Sector	Measure	Synergies		Trade-offs	
		Mitigation	Adaptation	Mitigation	Adaptation
Energy	Energy-efficient stoves	Reduced emissions due to more efficient burning, improved carbon sequestration due to avoided deforestation	Reduced vulnerability to landslides, droughts and extreme events due to ecosystem management. More resilient livelihoods due to health benefits, time and cost saving sin households	-	-
	Improve thermal and electrical efficiency of buildings	Reduce GHG emissions related to the generation of electricity from coal	Retrofitting inefficient bulidngs can enhance the existing building stock through densification in the land-use and the use of green infrastructure.	-	-
Transport	Reduce energy consumption from road transportation	Reduce air pollution and GHG emissions	Reduced vulnerability to air pollution	-	-
Building/ Infrastructure	In designing new buildings use green roofs	Carbon sequestration	Stormwater. infiltration and flow reduction	-	-
	Storm surge barriers	-	Protection urban areas from flooding	-	Potential to damage natural coastal defences and increase rates of erosion
Water	Urban densification	Reduce GHG through reduced distance for travel	-	Increase GHG and air pollution due to congestion	Possible increased run-off

14.2. Responses to linking mitigation and adaptation

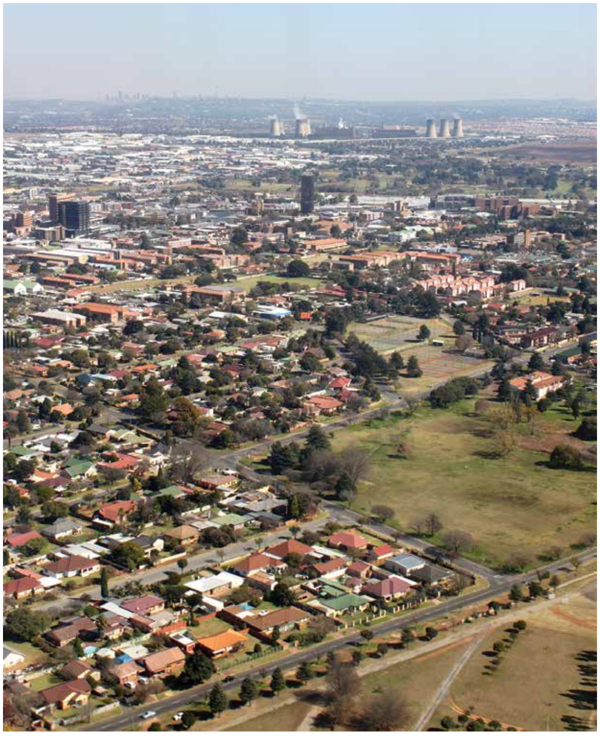
The prospect of balancing mitigation and adaptation endeavours is attractive, especially within a developing country context with competing priorities. Synergies among mitigation and adaptation actions should be enabled to support sustainable development (Suckall et al, 2015) and the creation of more efficient, responsive and comprehensive climate policies. Without integrative decision-making, climate change mitigation and adaptation interventions could result in energy-intensive adaptation or mitigation that contributes to maladaptation; either of which can lock a city into a development trajectory (function and form) that has unintended trade-offs. The development or intensification of UHI effects (refer to case study on the UHI below) impacts on air and water quality, as well as increased risks to natural disasters such as floods due to reduced permeability, being key examples of concern.

Cities in developing countries are expected to be most impacted by climate change, however, these areas still have significant potential for further growth and development, and thus present opportunities for the planning of energy provision, infrastructure, roads and waste management in a manner that will facilitate a reduction of GHG emissions, while simultaneously building the resilience of communities to the potential impacts of climate change and vice versa. Given the developmental trajectory of many southern African countries, opportunities for sustainable development pathways can be charted by enhancing our understanding of how these sectors are likely to be impacted by climate change in conjunction with processes of long-term change, e.g. economy, changes in demography.

Comprehensive responses that link and integrate climate change adaptation and mitigation activities to support the sustainable development of vulnerable communities within urban environments are essential to ensure that development goals are met in a sustainable and cost-effective way. A broad interdisciplinary approach is needed to develop a better understanding of cross-cutting issues and interactions between the different sectors and stakeholders within the city, and beyond the urban limits to address climate change effectively in an urban environment (Viguié et al., 2012; Illman et al., 2013).

The complexity of integrated approaches may hamper decision-making. For this reason, methods and tools to facilitate and inform integrated assessment are needed to help design integrated responses (Walsh et al., 2011). Internationally, numerous initiatives have begun to build the capacity to work on integrated assessments of mitigation and adaptation (see for example Masson et al., 2014) and simulating the effects of different mitigation and adaptation options (Hoyman and Goetzke, 2016). While many integrated assessment models (IAMs) have been proposed, few are fully developed and tested, with the result being that there is little quantified information on synergies and trade-offs. From a southern African perspective, we lack access to comprehensive and suitable integrated assessment models or tools that can be used for further investigation into understanding the opportunities for synergies and trade-offs for different climate change responses. However, policy-makers can still create enabling conditions for synergies, through the design and implementation of climate change strategies that address both mitigation and adaptation.

This is key to facilitating institutional arrangements such that there can be an implementing body with a mandate to ensure that these issues are considered for synergies, to source financing, and undertake programmes and projects that are likely to yield substantial benefits for mitigation and adaptation (Duguma et al., 2014).



Case study A: Mitigating the urban heat island in African cities

By Sasha Naidoo and Tirusha Thambiran

Africa has the highest rate of population growth among major areas, growing at a pace of 2.55% annually in 2010-2015, with the population projected to increase by 1.3 billion people between 2015 and 2050 (United Nations, 2015). While Africa remains mostly rural, with 40% of the continent's population living in urban areas, this figure is projected to increase to 56% by 2050 (United Nations, 2014). African governments have been advised to take early action to position themselves for predominantly urban populations (UN-Habitat, 2010). Johannesburg (South Africa), Dar es Salaam (Tanzania), and Luanda (Angola) are expected to emerge as megacities by 2030 and each of their populations is projected to surpass the 10 million mark (United Nations, 2014). The increasing urbanisation rate is adding pressure on cities to provide services, housing and infrastructure to an increasing population.

Urbanised cities generally have replaced natural land surfaces with materials that retain heat, as well as experience waste heat from buildings, motor vehicles and industries. Altering the local environment can result in local environmental stresses. Rapid urbanisation coupled with climate change could, among other issues, increase the local urban heat island (UHI) effect. The UHI, a phenomenon where a temperature difference between the built-up environment and the surrounding (natural) environment exists, is of increasing concern given that more people are moving to cities each year. This contributes to the intensity of the UHI increasing and the number of people affected by it. The extent of the temperature differences varies in time and space due to the influence of meteorological, locational and urban characteristics. The UHI effect is of increasing concern in Africa given that more people are moving to cities each year and are thus likely to be affected by it. It is critical to understand the interactions that take place among the urbanisation process, current local environmental change, and accelerating climate change, and how they influence each other (Revi et al., 2014). It is also expected that the UHI will be compounded by the temperature increases projected for Africa.

Limited studies have previously been undertaken to characterise the UHI in African cities, e.g. in Ibadan, Nigeria (Adebayo, 1987) and Johannesburg, South Africa (Goldreich, 1992). More recently, studies have been undertaken in South Africa, e.g. Johannesburg (Hardy & Nel, 2015); eThekwini (Durban, KwaZulu-Natal) (Odindi et al., 2015a; Odindi et al., 2015b); Buffalo City and Nelson Mandela Bay (Eastern Cape) (Odindi et al., 2015b); Dar es Salaam, Tanzania (Lindley et al., 2015; Kibassa, 2014); and Cairo, Egypt (Rehan, 2014; Abutaleb et al., 2015). While these studies provide evidence of urban temperatures being higher in urban than rural areas, there are still gaps in understanding how these temperatures will change in the future under climate change, with greater urbanisation. As such, cities should not just plan to manage heat as an extreme event, but rather also respond to urban energy/heat challenges through addressing the built environment and adopting systematic approaches to cooling cities.

Open spaces, buildings, and road transport are key areas in which interventions can be implemented in support of reducing the occurrence of the UHI. Key interventions include expanding green spaces in cities, increasing the albedo of the urban environment, reducing energy consumption and waste heat from buildings and road transport, as well as increasing ventilation (refer to Figure 14.2). A 'one-solution-fits-all' approach cannot be adopted across cities in Africa since UHI mitigation measures vary in scale and each key area has different drivers and associated challenges. As such, optimal strategies for managing and responding to the UHI should be done on a city-by-city basis.

Case study A: Mitigating the urban heat island in African cities (continued)

Planning for a cool city

Adaption	Planning actions	Benefits
Urban greening	• Green roofs • Green infrastructure	• UHI thermal comfort • Reduce strom water run-off • Increased resilience to climate change induced temperature increases • Energy conservation • Reduced air pollution
Increased solar reflectance	• Cool buildings and pavements • Reflective materials	
Energy efficiency	• Reduce waste heat from buildings and waste transport	
Increased ventilation	• Open spaces • Green corridors	

Figure 14.2: Planning for a cool city (Rehan, 2014)

Exploring options such as creating 'green infrastructure systems' can support efforts by municipalities in South Africa to bring service delivery and resource sustainability closer together (CSU,l 2014). The City of Cape Town and eThekwini Municipality have started developing green agendas to promote green infrastructure at a city scale. These plans, which are rooted in preserving biodiversity, aim to create a shift in the way green assets are planned and managed. These green agendas also have a particular focus on service-specific plans to assist with adapting to or mitigating climate change (Bobbins and Culwick, 2014). In the City of Johannesburg in South Africa, improving its capacity to manage the threat of the UHI is addressed as part of the City of Johannesburg's 2040 strategy in terms of building climate change resilience and environmental protection, along with managing the threats of urban flooding, investing in more green infrastructure, making the built environment more energy efficient, and making the transport sector greener (CSU, 2014). The city has also developed practical guidance on ways of designing buildings that minimise energy requirements and has implemented the Rea Vaya Bus Rapid Transit to help curb congestion on the roads.

UHI thus presents an opportunity for cities to make targeted interventions toward increasing green spaces, increasing building resilience and reducing road transport emissions. Cities with potential for significant new development, should consider mandating that integrative assessments are completed for mitigation and adaptation. Implementing such interventions to reduce the occurrence of the UHI now, will provide benefits to society now and into the future under a changing climate.

Case study B: Technologies for low-carbon and climate-resilient development CTCN: Mozambique

By Julia Mambo

Feasibility study on the use of waste that is refuse-derived fuel (RDF) for cement factories mitigation

Mozambique generates an estimated 2.5 million tons of municipal solid waste per year, 60% of which is organic waste. Most solid waste ends up in open bins and uncontrolled dumpsites, with no or very little waste treatment. The cement industry in Mozambique, which has been developing rapidly in recent years, requires substantial amounts of energy for cement processing, which is done at very high temperatures. This consumes ten times more energy than the average needed for other manufacturing.

The Department of Science and Technology requested technical assistance from the Climate Technology Centre Network to provide support for the assessment of the technical and financial feasibility of generating energy using waste materials that are generally reusable (refuse-derived fuel - RDF) from municipal solid waste in cement factories in Mozambique. RDF, which is also referred to as solid recovered fuel or specified recovered fuel, is a fuel produced from shredding and dehydrating solid waste using waste-converter technology, usually from combustible municipal waste, for example plastics and biodegradable waste (Velis et al., 2010).

Technical assistance was requested to:

- develop the technical specifications needed to turn waste into RDF;
- provide recommendations to cement factories on how to adapt their infrastructure to receive RDF;
- propose a monitoring and evaluation system to estimate impact in terms of greenhouse gases; and
- analyse potential funding opportunities which might support financing of technology needs.

Outcomes of the technical assistance:

- Cement kilns are able to use energy generated by the waste material.
- The result was a decrease in the consumption of non-renewable resources.
- Subsequent lowering of greenhouse gas emissions.
- Longer useful life of waste disposal sites.
- Boost of the recycling/waste management sector.

Country partners

Association of Municipalities (ANAMM); Carbon Africa; Investment Promotion Centre (CPI) – Mozambique; Centro de Gestao de Conhecimento; Global Cement; Fund of the Environment (FUNAB); Ministry of Earth, Environment and Rural Development (MITADER); Mozambican Association of Recycling (AMOR); and Reduce, Reuse, Recycle (3R).