National Business Initiative

CHAPTER 05

JUST TRANSITION AND CLIMATE PATHWAYS STUDY FOR SOUTH AFRICA

DECARBONISING THE AGRICULTURE, FORESTRY AND LAND USE SECTOR IN SOUTH AFRICA

IN PARTNERSHIP WITH

BUSA BUSINESS UNITY SOUTH AFRICA

BCG BOSTON CONSULTING GROUP

ACKNOWLEDGEMENTS

RESEARCH SUPPORTED BY

UK PACT South Africa: UK PACT has partnered with South Africa to support action on Just Transition pathways and a low-carbon economic recovery. As the third largest economy in Africa, South Africa plays a critical role in economic and policy priority setting at a continental level and across the Southern Africa region. South Africa's long-standing participation in the United Nations Framework Convention on Climate Change (UNFCCC) processes creates a solid platform for an impactful and transformational UK PACT partnership. Moreover, UK PACT seeks to support climate action that will contribute to the realisation of other development imperatives in South Africa, such as job creation and poverty alleviation. Priority areas of focus for UK PACT in South Africa are aligned with key national priorities in the just energy transition, renewable energy, energy efficiency, sustainable transport, and sustainable finance. UK PACT projects can contribute to addressing industry-wide constraints, common metropolitan challenges, and bringing city, provincial and national level public and private partners together to address climate priorities.

We Mean Business: This is a global coalition of nonprofit organisations working with the world's most influential businesses to take action on climate change. The coalition brings together seven organisations: BSR, CDP, Ceres, The B Team, The Climate Group, The Prince of Wales's Corporate Leaders Group and the World Business Council for Sustainable Development. Together we catalyze business action to drive policy ambition and accelerate the transition to a zero-carbon economy. NBI has been a regional network partner to WMB since the beginning of 2015.

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

Strategic Partnerships for the Implementation of the Paris Agreement (SPIPA): Climate change is a global threat that requires a decisive and confident response from all communities, particularly from major economies that represent roughly 80 % of global greenhouse gas emissions. The 2015 Paris Agreement complemented by the 2018 Katowice climate package, provides the essential framework governing global action to deal with climate change and steering the worldwide transition towards climate-neutrality and climate-resilience. In this context, policy practitioners are keen to use various platforms to learn from one another and accelerate the dissemination of good practices.
To improve a geopolitical landscape that has become more turbulent, the EU set out in 2017 to redouble its climate diplomacy efforts and policy collaborations with major emitters outside Europe in order to promote the implementation of the Paris Agreement. This resulted in the establishment of the SPIPA programme in order to mobilise European know-how to support peer-to-peer learning. The programme builds upon and complements climate policy dialogues and cooperation with major EU economies.

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The African Climate Foundation: The ACF is the first African-led strategic climate change grant-making foundation on the continent. Building on the success of partner organisations like the European Climate Foundation and ClimateWorks Foundation, the ACF was established to provide a mechanism through which philanthropies can contribute to Africa's efforts to address climate change. As an African-led and African-based foundation, we are committed to supporting African solutions to the climate change challenges facing the continent.

PARTNERS

National Business Initiative

At the National Business Initiative (NBI), we believe in collective action and collaboration to effect change; building a South African society and economy that is inclusive, resilient, sustainable and based on trust. We are an independent, business movement of around 80 of South Africa's largest companies and institutions committed to the vision of a thriving country and society. The NBI works with our members to enhance their capacity for change, leverage the power of our collective, build trust in the role of business in society, enable action by business to transform society and create investment opportunities.

Business Unity South Africa

BUSA, formed in October 2003, is the first representative and unified organisation for business in South Africa. Through its extensive membership base, BUSA represents the private sector, being the largest federation of business organisations in terms of GDP and employment contribution. BUSA's work is largely focused around influencing policy and legislative development for an enabling environment for inclusive growth and employment.

Boston Consulting Group

BCG partners with leaders in business and society to tackle their most important challenges and capture their greatest opportunities. BCG, the pioneer in business strategy when it was founded in 1963, today works closely with clients to embrace a transformational approach aimed at benefitting all stakeholders – empowering organisations to grow, build sustainable competitive advantage, and drive positive societal impact. Their diverse global teams are passionate about unlocking potential and making change happen, and delivering integrated solutions.

TERMINOLOGIES

AFOLU	Agriculture, Forestry and Other Land Use
Base load	Permanent minimum load a power supply system is required to deliver
BAU	business-as-usual
BEV	Battery electric vehicle
BFAP	Bureau for Food and Agriculture Policy
bn	Billion
C&I	Construction & Installation
CAIA	Chemicals & Allied Industries' Association
CAPEX	Capital expenditure
CCGT	Combined Cycle Gas Turbine
CCU	Carbon Capture and Utilisation
CCUS	Carbon Capture Utilisation & Storage
CDP	A disclosure platform for companies and cities to report on their carbon emissions, water usage, forest management and climate-related financial disclosures
CGE	Computable General Equilibrium (used in socio-economic modelling)
COP26	United Nations Conference of the Parties
CO_2e	Carbon dioxide equivalent
CPI	Consumer Price Index
CSIR	Council for Scientific and Industrial Research
CTL	Coal-to-Liquid
DACCS	Direct Air Carbon Capture and Storage
DFFE	Department of Forestry, Fisheries and the Environment
DG	Distributed Generation is an approach that employs small-scale technologies to produce electricity close to the end users of power
DMRE	Department of Mineral Resources & Energy
EG	Embedded Generation is electricity generation which is connected to the distribution network rather than to the high voltage National Grid
EPRI	Electronic Power Research Institute
EU	European Union
EV	Electric vehicle
EWS	Early Warning System
FAO	Food and Agriculture Organisation of the UN
FCEV	Fuel cell electric vehicle
Feedstock	Raw material to supply or fuel a machine or industrial process
FSC	Forestry Stewardship Council
GDP	Gross Domestic Product
GHGI	Greenhouse Gas Inventory
Green hydrogen	Hydrogen produced from renewable energy sources
GJ	Gigajoule
Gt	Gigatonne (1 thousand million tonnes)
GTP	Gas-to-Power
GW	Gigawatt
IAM	Integrated Assessment Modelling
I-O	Input Output model (used in socio-economic modelling)
IDDRI	Institute for Sustainable Development and International Relations
IEA	International Energy Agency
IGUA	Industrial Gas Users Association of Southern Africa
IRENA	International Renewable Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRP	Integrated Resource Plan
kcal	kilocalories
kg	Kilogram
LCOE	Levelised cost of energy
LCOH	Levelised cost of H_2
MAT	Mean Average Temperature
Mha	Million hectares
MQA	Mining Qualifications Authority
Mt	Megatonne (1 million tonnes)
Mtpa	Megatonnes per annum
NAMC	National Agricultural Marketing Council
NDC	Nationally Determined Contribution
NDP	National Development Plan
NG	Natural Gas
NGO	Non-governmental organisation
Nedlac	National Economic Development and Labour Council
NPV	Net Present Value
n/a	Not applicable
O&M	Operation & Maintenance
OCGT	Open Cycle Gas Turbine
OE	Oxford Economics
OECD	Organisation for Economic Co-operation and Development
OPEX	Operating expenditure
P2X	Power-to-X
Peak-load	Maximum of electrical power demand
PGM	Platinum Group Metals
PM	Particular Matter
PPP	Public-Private Partnership
PSP	Pumped-storage plant
PV	Photovoltaic solar energy
QES	Quarterly Employment Survey
QLFS	Quarterly Labour Force Survey
RCP	Representative Concentration Pathways
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SA	South Africa
SAM	Social Accounting Matrix
SAREM	South African Renewable Energy Masterplan
Scope 1 emissions	All direct emissions from activities of an organisation under their control, including process emissions, fuel combustion on site, such as gas boilers, fleet vehicles and air-conditioning leaks
Scope 2 emissions	Indirect emissions from electricity and steam purchased and used by the organisation. Emissions are created during the production of the electricity and steam that is used by the organisation
SMR	Small Modular Reactors
SSA	Sub-Saharan Africa
SSP	Sector Skills Plan
Synfuels	Synthetic Fuel
TCFD	Task-Force on Climate-Related Financial Disclosures
THI	Temperature Humidity Index
TWh	Terawatt-hour
UCT	University of Cape Town
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WACC	Weighted Average Cost of Capital
WS#	Workshop(#)

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OVERVIEW OF CEO CHAMPIONS

Onboarding of additional CEOs ongoing

Joanne Yawitch
NBI CEO

Cas Coovadia
BUSA CEO

André de Ruyter
Eskom CEO

Fleetwood Grobler
Sasol CEO

Mxolisi Mgojo
Exxaro CEO

Leila Fourie
JSE Group CEO

Nolitha Fakude
Anglo American SA Chairperson

Alan Pullinger
First Rand CEO

Hloniphizwe Mtolo
Shell SA CEO

Portia Derby
Transnet CEO

Lungisa Fuzile
Standard Bank South Africa CEO

John Purchase
AgBiz CEO

Paul Hanratty
Sanlam CEO

Deidré Penfold
CAIA Exec Director

Vivien McMenamin
Mondi SA CEO

Taelo Mojapelo
BP Southern Africa CEO

Roland van Wijnen
PPC Africa CEO

Njombo Lekula
PPC MD SA Cement and Materials

Gavin Hudson
Tongaat Hulett CEO

Vikesh Ramsunder
Clicks Group CEO

Nyimpini Mabunda
GE SA CEO

Mark Dytor
AECI CEO

Alex Thiel
SAPPI CEO

Mohammed Akoojee
CEO Imperial Logistics

Yusa Hassan
Engen MD and CEO

Tshokolo TP Nchocho
IDC CEO

Stuart Mckensie
Ethos CEO

Marelise van der Westhuizen
Norton Rose Fulbright CEO

Ishmael Poolo
Central Energy Fund CEO

1.
FOREWORD

JUST TRANSITION AND CLIMATE PATHWAYS STUDY FOR SOUTH AFRICA

South Africa is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and to the Paris Agreement. As an energy and emissions intensive middle-income developing country, it recognises the need for it to contribute its fair share to the global effort to move towards net-zero carbon emissions by 2050, taking into account the principle of common but differentiated responsibilities and the need for recognition of its capabilities and national circumstances.

South Africa is highly vulnerable to the impacts of climate change and will need significant international support to transition its economy and to decarbonise. Furthermore, given the country's high rate of inequality, poverty and unemployment and the extent of dependence on a fossil fuel-based energy system and economy, this transition must take place in a way that is just, that leaves no-one behind and that sets the country onto a new, more equitable and sustainable development path; one which builds new local industries and value chains.

In response to the above imperatives, the National Business Initiative, together with Business Unity South Africa and the Boston Consulting Group has worked with corporate leaders to assess whether the pathways exist for the country's economic sectors to decarbonise by 2050, and whether this can be done in such a way as to build resilience to the impacts of climate change and to put the country onto a new, low emissions development path.

The work done by the business community has interrogated the energy, liquid fuels, mining, chemicals, AFOLU (agriculture, forestry and other land use), transport and heavy industrial sectors. The results of the modelling and analytical work have been informed by numerous industry experts, academics and scientists. The results demonstrate that these pathways do exist and that even a country with an economy that is structurally embedded in an energy-intensive production system can shift.

The results of this work to date have shown that this can be done, and that to realise these pathways, efforts must begin now. Timing is of the essence and the business community is of the view that there is no time like the present to create the regulatory and policy environment that would support transitioning the economy. **Accordingly, business can commit unequivocally to supporting South Africa's commitment to find ways to transition to a net-zero emissions economy by 2050.**

Furthermore, in November, South Africa will table its revised Nationally Determined Contribution (NDC) to the UNFCCC. Business recognises the need for greater ambition to position the country as an attractive investment destination and increase the chances of accessing green economic stimulus and funding packages. Specifically, business would support a level of ambition that would see the country committing to a range of 420–350 Mt CO_2e by 2030. This is significantly

Upington, Northern Cape. Photo: scatec.com/locations/south-africa

more ambitious than the NDC put out for public comment and would require greater levels of support with regard to means of implementation from the international community than is currently the case. It is also consistent with international assessments of South Africa's fair share contribution to the global effort, and it would also ensure that the no-regret decisions, that would put South Africa onto a net-zero 2050 emissions trajectory, would be implemented sooner.

While South Africa has leveraged a degree of climate finance from the international community, the scale and depth of the transition envisaged will require substantial investments over an extended period of time. Critically, social costs and Just Transition costs must be factored in. Significant financial, technological, and capacity support will be required to support the decarbonisation of hard to abate sectors. Early interventions in these sectors will be critical.

Business sees the support of the international community as essential for the country to achieve its climate objectives. For this reason, business believes that a more ambitious NDC, and one that would place the country firmly on a net-zero emissions by 2050 trajectory, would have to be conditional on the provision of the requisite means of support by the international community. In this light the business community will play its part to develop a portfolio of fundable adaptation and mitigation projects that would build resilience and achieve deep decarbonisation.

Despite the depth of the challenge, South African business stands ready to play its part in this historical endeavour. Business is committed to work with government and other social partners, with our employees, our stakeholders, and the international community, to embark on a deep decarbonisation path towards net-zero and to build the resilience to the impacts of climate change that will ensure that our country contributes its fair share to the global climate effort.

2. INTRODUCTION

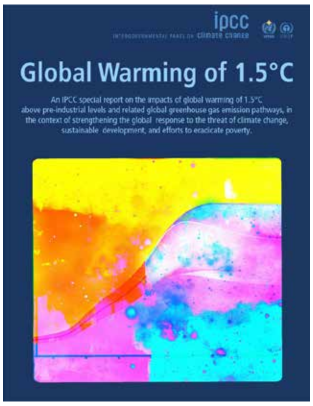
2.1 THE PURPOSE OF THIS REPORT

This report, focusing on the decarbonisation of South Africa's Agriculture, Forestry and Land Use (AFOLU) sector, is the fifth in a series being released to illustrate the findings of this project. These reports are intended to leverage further engagement with sector experts and key stakeholders, beyond the extensive stakeholder engagement that has been undertaken from August 2020 to June 2021 within the respective technical working groups of this project. We hope this will foster continued dialogue during the project as we work towards a final report that will collate the individual sector findings and provide collective insight.

2.2 THE CASE FOR CHANGE

2.2.1 CLIMATE CHANGE AND THE RACE TO GLOBAL NET-ZERO EMISSIONS BY 2050

Climate change is the defining challenge of our time. Anthropogenic climate change poses an existential threat to humanity. To avoid catastrophic climate change and irreversible 'tipping points', the Intergovernmental Panel on Climate Change (IPCC) stresses the need to stabilise global warming at 1.5 °C above pre-industrial levels. For a 66% chance of limiting warming by 2100 to 1.5 °C, this would require the world to stay within a total carbon budget estimated by the IPCC to be between 420 to 570 gigatonnes (Gt) of CO_2, to reduce net anthropogenic emission of CO_2 by ~45% of 2010 levels by 2030, and to then reach net-zero around 2050.[1]



Hence, mitigating the worst impacts of climate change requires all countries to decarbonise their economies. In the 2019 World Meteorological Organization report, 'Statement on the State of the Global Climate', the United Nations (UN) Secretary-General urged: "Time is fast running out for us to avert the worst impacts of climate disruption and protect our societies from the inevitable impacts to come."

South Africa, in order to contribute its fair share to the global decarbonisation drive, bearing in mind the principle of 'common but differentiated responsibilities and respective capabilities', should similarly set a target of reaching net-zero emissions by 2050, **and also keep it within a fair share of the global carbon budget allocated, estimated to be between 7 and 9 Gt CO_2e**.[2]

Even if global warming is limited to 1.5 °C, the world will face significantly increased risks to natural and human systems. For example, 2019 was already 1.1 °C warmer than pre-industrial temperatures, and with extreme weather events that have increased in frequency over the

1 IPCC. 2018. *Special Report on Global Warming of 1.5°C*.
2 Extrapolation of the medians of various methodologies described by Climate Action Tracker. The full range is 4–11 Gt CO_2e.

"Time is fast running out for us to avert the worst impacts of climate disruption and protect our societies from the inevitable impacts to come."

Mr António Guterres, United Nations Secretary-General

Photo: UN Climate Action Summit

past decades, the consequences are already apparent.[3] More severe and frequent floods, droughts and tropical storms, dangerous heatwaves, runaway fires, and rising sea levels are already threatening lives and livelihoods across the planet.

South Africa will be among the countries at greatest physical risk from climate change. South Africa is already a semi-arid country and a global average temperature increase of 1.5 °C above pre-industrial levels translates to an average 3 °C increase for Southern Africa, with the central interior and north-eastern periphery regions of South Africa likely to experience some of the highest increases.[4] Research shows that a regional average temperature increase of over 1.5 °C for South Africa translates to a greater variability in rainfall patterns. Models show the central and western interiors of the country trending towards warmer and dryer conditions, and the eastern coastal and escarpment regions of the country experiencing greater variability in rainfall as well as an increased risk of extreme weather events.

Rising temperatures and increased aridity and rainfall variability may have severe consequences for South Africa's agricultural systems, particularly on the country's ability to irrigate, grow and ensure the quality of fruit and grain crops; and on the health of livestock, such as sheep and cattle, which will see decreased productivity and declining health at temperature thresholds. Parasites tend to flourish in warmer conditions, threatening people as well as livestock and crops. Increasing temperatures and rainfall variability threaten South Africa's status as a megabiodiverse country. Severe climate change and temperature increases could shift biome distribution, resulting in land degradation and erosion. The most notable risk is the impact on the grassland biome, essential for the health of South Africa's water catchments, combined with the risk of prolonged drought.

3 World Meteorological Organization. 2019. 'Statement on the State of the Global Climate'.

4 Former Department of Environmental Affairs, Republic of South Africa. 2018. *South Africa's Third National Communication Under the United Nations Framework Convention on Climate Change*.

Finally, rising ambient temperatures due to climate change and the urban heat effect, threaten the health of people, particularly those living in cramped urban conditions and engaging in hard manual labour, as higher temperatures result in increased risk of heat stress and a reduction in productivity. Therefore, limiting global climate change and adapting to inevitable changes in the local climate will be critical to limit the direct, physical risks to South Africa. Like many developing countries, South Africa has the task of balancing the urgent need for a just economic transition and growth, while ensuring environmental resources are sustainably used and consumed, and responding to the local physical impacts of climate change.[5] While South Africa is highly vulnerable to the physical impacts of climate change, its economy is also vulnerable to a range of transition risks posed by the global economic trend toward a low-carbon future.

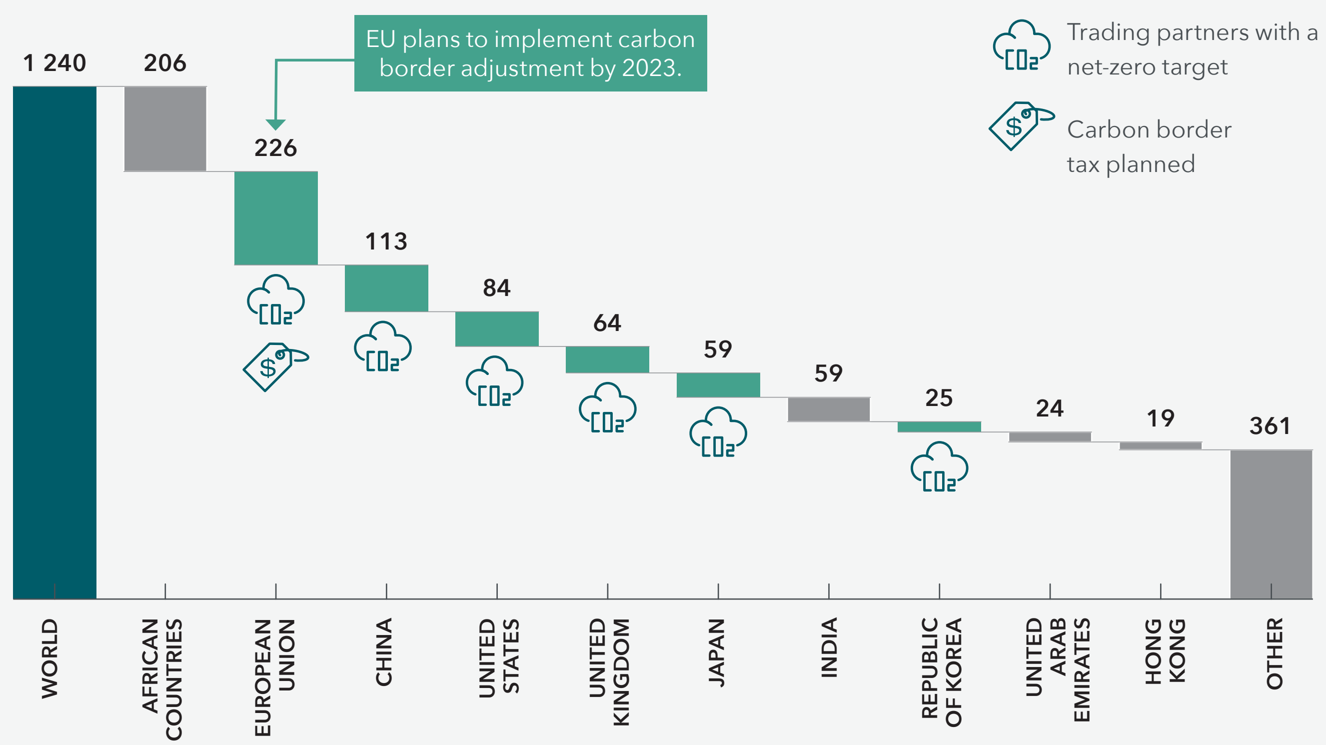
South Africa is also facing a significant trade risk. South Africa ranks in the top 20 most carbon-intensive global economies on an emissions per Gross Domestic Product (GDP) basis, and in the top five amongst countries with GDP in excess of US$100 billion (bn) per annum. The South African economy will face mounting trade pressure, as trade partners implement their low-carbon commitments.

South Africa has predominantly coal-based power generation, the coal-to-liquid (CTL) process in the liquid fuels sector, and a coal-reliant industrial sector. In the mining sector, three of the four most significant minerals in South Africa's commodity footprint are at risk, given the global efforts to curb emissions: thermal coal, Platinum Group Metals (PGMs) with mainly palladium and iron ore. The fourth mineral is gold.

The bulk of South Africa's exports comprise carbon-intensive commodities from the mining, manufacturing, and agricultural sectors which will become less competitive in markets in a future decarbonised world. These sectors also provide the majority of employment of unskilled labour at a regional level.

The carbon-intensity of the South African economy, key sectors, and export commodities must be seen against the backdrop of the country's key trading partners committing to ambitious decarbonisation goals. By early 2021, countries representing more than 65% of global carbon dioxide emissions and more than 70% of the world's economy have made ambitious commitments to carbon-neutrality. Seven of South Africa's key export markets have all set net-zero targets, including the European Union (EU),

Figure 1: Volumes of South Africa's exports to leading partners in 2018 (ZAR billion)



Source: World Integrated Trade Solution. 2018. 'Press research'.

5 Former Department of Environmental Affairs, Republic of South Africa. 2016. *South Africa's Second Annual Climate Change Report*.

China, the United States, the United Kingdom, Japan, and South Korea.[6]

At the UN Climate Change Conference of the Parties (COP26) in November 2021, all countries are expected to set out more ambitious goals, including setting concrete mid-term reduction targets. The COP26 Presidency's stated priorities include 'seizing the massive opportunities of cheaper renewables and storage', 'accelerating the move to zero-carbon road transport', and 'the need to unleash the finance which will make all of this possible and power the shift to a zero-carbon economy'.

Over and above this, select geographies like the EU are also considering carbon border taxes which could impact future trade. It is therefore essential to consider how South Africa's competitiveness in global markets, and therefore the viability of its industries, will be affected should key trading partners start taking steps to protect their net-zero commitments and enable their net-zero carbon growth trajectories. South Africa will need to address the risks and seize the opportunities presented by climate change.

South Africa will also have the chance to tap into new opportunities. Goldman Sachs estimate that around 35% of the decarbonisation of global anthropogenic greenhouse gas emissions is reliant on access to clean power generation, and that lower-carbon hydrogen and clean fuels will be required for hard-to-decarbonise sectors.[7] South Africa has key strategic advantages which can be leveraged to tap into such emerging opportunities.

South Africa has a number of significant assets including plenty of sun and wind. Renewables-dominated energy systems and local manufacturing are key. South Africa's coal assets are aged, and decommissioning coal plants can be done within the carbon budget and with minimal stranded asset risk. South Africa's motor vehicle manufacturing expertise could be transitioned to electric vehicle production. The country's stable and well-regulated financial services sector, among the most competitive in the world, would make a strong base for green finance for the continent. The combination of wind and solar enables the right kind of conditions for green hydrogen, setting the stage for South Africa to be a net exporter. The role of PGMs in hydrogen and fuel cell technology and the increased demand for certain mined commodities, like copper for use in green technology, could bolster the minerals sector. South Africa's experience with the Fischer–Tropsch process positions it to be one of the world leaders in carbon-neutral fuels and other innovations are thus waiting to be unlocked.

The imperative is clear: South Africa must decarbonise its economy in the next three decades and transform it into a low-carbon, climate-resilient, and innovative economy. This transition also needs to take place in a manner that is just and simultaneously addresses inequality, poverty and unemployment to ensure that no-one is left behind and that our future economy is also socially-resilient and inclusive.

6 United Nations News. 2020. *The race to zero emissions, and why the world depends on it.*

7 Goldman Sachs. 2020. *Carbonomics: Innovation, Deflation and Affordable De-carbonisation.*

2.2.2 THE NEED FOR A JUST TRANSITION

With a Gini coefficient of 0.63, South Africa is one of the most unequal societies in the world today.[8] A recent study shows that the top 10% of South Africa's population owns 86% of aggregate wealth and the top 0.1% close to one-third. Since the onset of the COVID-19 pandemic, levels of poverty have further increased and have likely shifted beyond 55% of the population living in poverty. In July 2020, a record 30.8% of the population was unemployed.[9] Exacerbating this are levels of youth unemployment that are amongst the highest in the world.[10]

As South Africa grapples with the economic recession accompanying the pandemic, and copes with the need to rebuild the capacity of the State and its institutions following a decade of state capture, it must start rebuilding and transforming its economy to make it resilient and relevant in a decarbonised world. However, while a transition towards a net-zero economy will create new economic opportunities for South Africa, it is also a transition away from coal, which without careful planning and new investments, will put many jobs and value chains at risk in the short-term, and exacerbate current socio-economic challenges.

Today, the coal mining sector provides almost 0.4 million jobs in the broader economy, with ~80 k direct jobs and ~200 to 300 k indirect and induced jobs in the broader coal value chain and economy. The impact is even broader when it is taken into account that, on average, each mine worker supports 5–10 dependents. This implies a total of ~2 to 4 million livelihoods.[11] The low-carbon transition must do more than simply address what is directly at risk from decarbonisation. The transition must also address the broader economic concern of stalled GDP growth of ~1% for the last five years, rising unemployment with ~3% increase over the last five years,[12] deteriorating debt to GDP ratio, with growth of ~6% for the last 10 years, and the consistently negative balance of trade.[13]

These challenges are more severe given further deterioration during the COVID-19 pandemic. It is therefore critical that South Africa's transition is designed and pursued in a way that is just; meaning that it reduces inequality, maintains and strengthens social cohesion, eradicates poverty, ensures participation in a new economy for all, and creates a socio-economic and environmental context which builds resilience against the physical impacts of climate change.

This transition requires action, coordination, and collaboration at all levels. Within sectors, action will need to be taken on closures or the repurposing of single assets. Job losses must also be addressed with initiatives like early retirement and reskilling programmes, with the latter having the potential for integration with topics like skills inventories and shared infrastructure planning and development. A national, coordinated effort to enable the Just Transition will also be crucial to address the education system and conduct national workforce planning. In order to implement its Just Transition, South Africa will need to leverage global support in the form of preferential green funding, capacity-building, technology-sharing, skills development, and trade cooperation.

To move towards this net-zero vision for the economy by 2050, South Africa must mitigate rather than exacerbate existing socio-economic challenges and seize emerging economic opportunities to support its socio-economic development agenda. How to ensure a Just Transition towards net-zero and advancing South Africa's socio-economic context, is therefore the key guiding principle of this study.

2.3 OBJECTIVE AND APPROACH

Key objectives of this study. Achieving net-zero emissions in South Africa by 2050, whilst ensuring a Just Transition, is a complex and unique challenge. Extensive studies examining how a Just Transition towards a lower-carbon economy can be achieved in South Africa have already been conducted or are currently underway. There are many different views on what defines a Just Transition in South Africa, which decarbonisation ambitions South Africa is able to pursue and commit to, and how a transition towards a lower-carbon economy can be achieved.

8 The World Bank. 2021. 'South Africa Overview'.

9 Stats SA. 2017. *Poverty Trends in South Africa. An examination of absolute poverty between 2006 and 2015.*

10 Chatterjee, A., et al. 2020. *Estimating the Distribution of Household Wealth in South Africa.*

11 Minerals Council of South Africa. 2020. 'Facts and Figures'.

12 Department of Statistics, Republic of South Africa. 2021.

13 South African Reserve Bank. 2021.

This study is not advocating for a particular position. It is not setting ambitions around levels and timelines for South Africa's emission reduction. Nor is this study prescribing sector- or company-specific emission reduction targets.

The study does aim to develop the necessary technical and socio-economic pathways research and analysis to support decision-making and bolster a coordinated and coherent effort among national and international stakeholders. This research is anchored around three key questions:

- What is the cost of inaction for South Africa should it fail to respond to critical global economic drivers stemming from global climate action?
- What would it take, from a technical perspective, to transition each of South Africa's economic sectors to net-zero emissions by 2050?
- What are the social and economic implications for South Africa in reaching net-zero emissions by 2050?

Approach of this study. To understand how a transition of the South African economy towards net-zero emissions can be achieved, this study assesses each sector and intersectoral interdependencies in detail (with this report detailing the initial findings of the AFOLU sector analysis). Our analysis of the South African economy is structured along understanding what the decarbonisation pathways could be for key heavy emitting sectors, namely: electricity, petrochemicals and chemicals, mining, metals and minerals, manufacturing, transport and AFOLU (Figure 2). Given this is a multi-year project, a preliminary report will be released as each sector is completed. Towards the end of the study, each sector analysis will be further refined on the basis of understanding interlinkages better. For example, insights gained from the transport sector analysis around the impact of electric vehicles on electricity demand will be leveraged for further refinement of the electricity sector analysis.

The first phase of the study focuses on today's key drivers of South Africa's emissions: electricity and the petrochemicals and chemicals sectors which make up more than 60% of the country's total emissions. Given the socio-economic implications of decarbonising South Africa's energy landscape, particularly impacting coal mining regions and the mining workforce, the mining sector was assessed as part of the project's first phase. The second phase of the study focuses on the transport and AFOLU sectors. Eventually, the study will provide a comprehensive view of the South African economy, its potential future net-zero economy and the pathways that can lead to this future economy as informed by various key stakeholders (see Figure 2).

The study is a collaborative effort, aiming to create a 'unified voice of South African business' on the country's needs, opportunities, and challenges in achieving a net-zero economy, involving multiple stakeholders from all sectors. The governance arrangement that has overseen this work is key to enabling this collaborative, multi-stakeholder approach: across multiple levels, key stakeholders are involved in the content development.

The sector assessments are conducted within technical committees which include South African and international experts and stakeholders from private and public sectors, as well as civil society and academia. An advisory board consisting of high-profile representatives from various sectors including industry, government, labour, civil society, and academia; and a steering committee consisting of selected private and public sector representatives provided continuous direction on content development. In addition, a group of 27 Chief Executive Officers (CEOs) from across the private sector endorsed and guided the study development (see Figure 3).

This report is the fifth in a series being released to illustrate the findings of this study. Other reports focused on the decarbonisation of the electricity, petrochemicals and chemicals, mining and transport sectors. These reports are intended as consultation material to leverage further engagement with sector experts and key stakeholders, beyond the extensive stakeholder engagement that was already undertaken from August 2020 to June 2021 within the respective technical working groups of this project.

We hope this will foster continued dialogue during the project as we work towards a final report that will collate the individual sector findings and provide collective insight.

Figure 2: Approach of this study

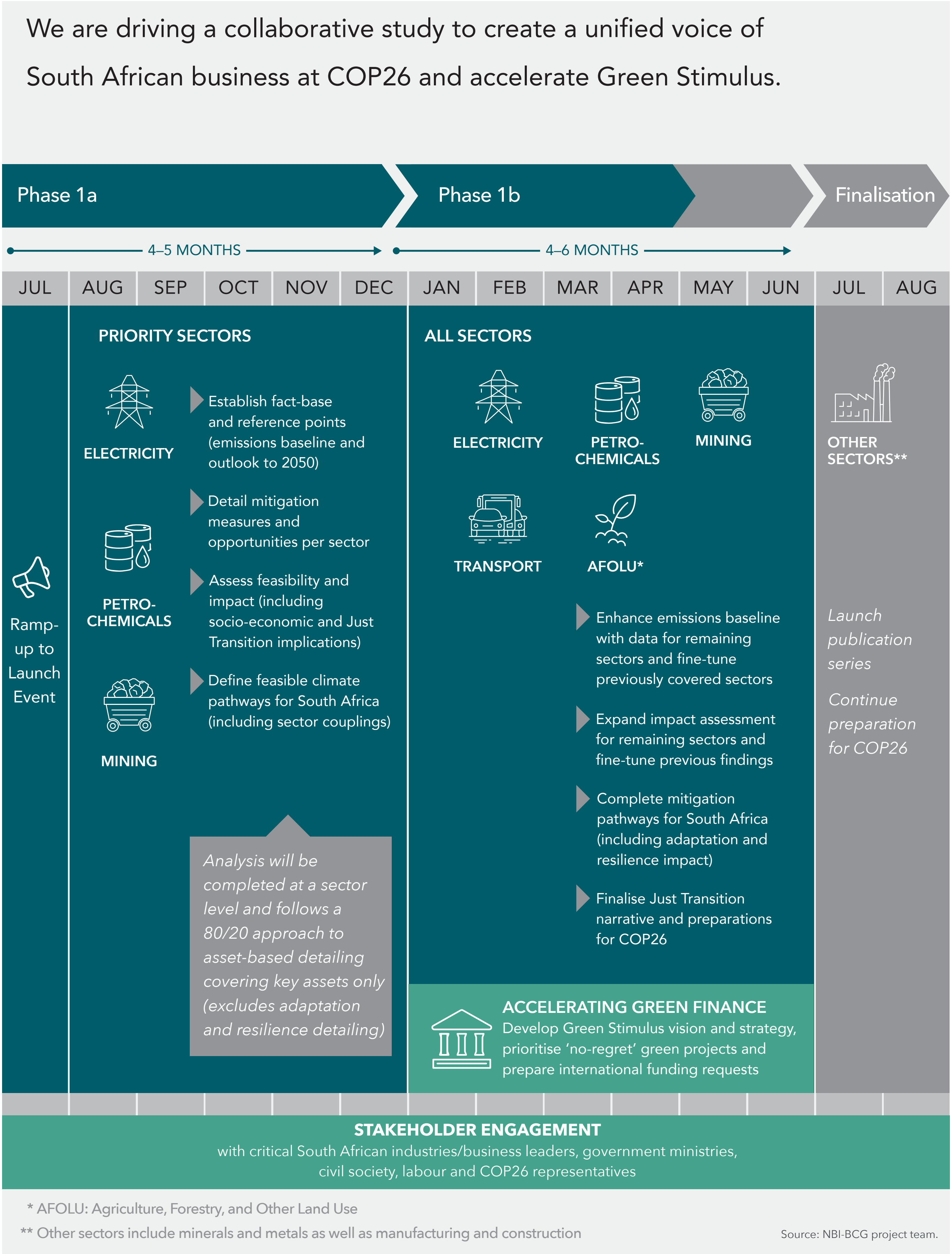


Figure 3: Governance set-up of the study

To ensure representative, balanced and fact-based content, a comprehensive governance structure is in place.

CEO champions	Advisory boards	Steering committee
CEOs	Industry, government and civil society representatives	Company representatives

Core project team

NBI, BCG, IDDRI

Technical committees and expert meetings

Energy sector	Chemicals and petrochemicals sector	Mining sector
Transport sector	AFOLU sector	Other sectors

Socio-economic modelling for a Just Transition

Four key objectives of governance structure

- Enable multi-stakeholder inputs through an inclusive consultation process
- Create a platform for collaboration and alignment on key assumptions and methodology
- Ensure that the final output is fact-based and balanced in its recommendations
- Provide a fact-based business perspective into national consultations and planning processes hosted by government

3.
KEY FINDINGS OF THE AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU) SECTOR ANALYSIS

Nine key findings of the AFOLU sector analysis

1. *The South African AFOLU sector is at significant climate risk – ensuring food security and sustainable and healthy diets for all South Africans, and maintaining the sector's socio-economic contribution requires the development of a climate-resilient AFOLU sector.*

2. *Global climate change could impact South Africa significantly: In low and moderate mitigation scenarios, South Africa's average inland temperature could rise 2–4 °C by 2050[14], ~2 times the average global temperature increase, and average rainfall could decrease >60 mm/annum in most western and northern regions of the country.*

3. *Export earnings, farmworker and timber plantation worker livelihoods, and food availability are at risk, particularly in the Western and Northern Cape, which are expected to face the worst water stress, but also account for ~95% of South Africa's deciduous fruit exports, ~25% of national agricultural earnings, and ~35% of national agricultural employment.*

4. *On a farm and timber plantation-level, adaptation measures, such as climate-breed matching, and fire and pest prevention systems can build resilience, production efficiency, and reduce emissions per unit produced. On a system-level, improved water-use monitoring and transmission infrastructure, data-backed agricultural and forestry water allocation, and accessible climate event monitoring will be critical to ensure climate resilience.*

5. *To enable effective adaptation, it will be critical to build more capacity among farmers and growers, and to improve and expand agricultural and forestry extension services – this would require a doubling of AFOLU-related research and development (R&D) spending in line with the National Development Plan (NDP) targets, roll-out of demand-side incentives, such as market access in exchange for resilient practices and deployment of blended finance mechanisms.*

14 Relative to pre-industrial temperatures (1850–1900).

6 *The AFOLU sector accounts for ~10% of national emissions – driven by livestock (75%), fertiliser use (18%) and fuel combustion (7%) – and adaptation measures taken in the sector could drive some emission reduction. However, significant emissions remain, and to fully decarbonise the sector, dedicated mitigation levers need to be deployed.*

a. *In light of a growing population, food demand could grow by ~50% by 2050, causing the AFOLU emissions baseline to grow by ~40% if current, nutritionally-inadequate diets are maintained, or shrink by ~37% if sustainable (low red meat), diverse and nutritionally-balanced diets are adopted.*

b. *Regardless of diet progression, ensuring farming and forestry best practice reduces emissions and builds resilience. Best practice livestock health, feed, manure, and breeding management can eliminate ~19% of annual emissions, while sustainable land and fertiliser management, and integration of renewable energy to meet energy demand can eliminate 17% and 19% of annual emissions, respectively.*

c. *However, with farming and forestry best practices implemented, by 2050, emissions can only be reduced by ~40% versus the 2017 baseline with current diets, and by ~70% with sustainable, healthy diets, leaving 16–39 Mt CO_2e/a in residual emissions that would need to be addressed using new and more disruptive levers, such as hydroponics, and in the more distant future lab-grown meat.*

7 *Meeting a sustainable, healthy diet for all South Africans could require >170% increases in soybean and vegetable production, and ~20% increase in deciduous fruit production by 2050, even if production for export and livestock is diverted to local food demand. This would require land use prioritisation for hardier, nutritionally-dense foods and import strategies for starchy staple commodities that are expected to be in shrinking demand.*

8 *A Just Transition needs to unlock sustainable and healthy diets for all South Africans. However, sustainable, nutritional diets currently cost ~4 times more than the average, nutritionally-inadequate, local diet, and ~1.5 times more than the cheapest nutritional, carbon-intense diet in South Africa. Measures to build a climate-resilient food supply could further increase production costs – therefore it will be critical to ensure affordability of future food supply.*

9 *To ensure a Just Transition, small-scale producers must be supported to increase productivity and gain both agricultural and business skills. This requires improved extension services and climate monitoring, access to finance and off-take incentives for sustainable practices. It may also require tenure reform; farmworkers require new work opportunities, and agri-dependent communities need to be identified and plans made to diversify economic opportunities.*

3.1 SCOPE AND APPROACH OF THE AFOLU SECTOR ANALYSIS

The AFOLU sector in South Africa is a key socio-economic contributor and critical for ensuring local food security, employment, vibrant rural communities and forex earnings. This analysis aims to provide an understanding of how driving a Just Transition towards a decarbonised, climate-resilient South African AFOLU sector will be vital to ensuring the availability of healthy and sustainable food supply, maintaining and increasing export earnings, and enabling decarbonisation in other sectors, which require for example, biomass as a sustainable carbon feedstock. The findings of this analysis are intended to serve as inputs for aligning broad, diverse stakeholder views and for strategic decision-making in and around the AFOLU sector.

The focus of this analysis is the primary production stage of the AFOLU sector. This includes planting, cultivation, harvesting and preliminary processing of AFOLU products. Production of fertiliser is considered as part of the petrochemicals sector analysis, and downstream processing, packaging, distribution and sale of processed AFOLU products may be studied in future, as part of the manufacturing, and commercial and residential sector analyses. These analyses will place greater emphasis on the decarbonisation of food and forestry product manufacturing, energy supply to the industry and the reduction of food waste.

The AFOLU sector analysis is intended to:

- Quantify the 'book-end scenarios' of demand change for South African AFOLU products to 2050
- Provide sufficient resolution on the potential impact of climate change on important production regions and AFOLU commodities, to inform strategic decision-making, and identify areas in which further research is required to achieve the required resolution
- Identify key mitigation levers and quantify the extent to which the sector can be decarbonised using techno-economically feasible levers
- Identify and, where data is available, quantify the food security, socio-economic, and environmental risks and opportunities of potential decarbonisation pathways and key technology, policy, and finance actions required to enable the development of a climate-resilient AFOLU sector.

The AFOLU sector analysis is not intended to:

- Provide commodity-specific projections of national production change due to climate impact
- Provide projections of sequestration potential for different biomes
- Set any production or land conversion targets
- Make a call on which commodities to prioritise
- Decide on the assignment of natural carbon sinks to residual emissions of specific sectors.

In this context, the AFOLU sector analysis was designed to answer five key questions:

1. How will demand for South Africa's agricultural and bio-based products change, given changing local demographics, product demand, diets and global decarbonisation trends?
2. What are the risks to the AFOLU sector posed by local climate change impacts?
3. What are climate-resilient pathways for the AFOLU supply base, based on key mitigation and adaptation levers?
4. What are the food security, socio-economic, and environmental resilience implications of a pathway towards a climate-resilient, decarbonised AFOLU sector?
5. What are the key challenges, enablers and sector interdependencies that need to be considered to pursue the considered actions and pathway?

To answer these key questions a six-step approach was applied:

1. **Establish AFOLU sector context**: The socio-economic challenges and contributions of South Africa's AFOLU sector on a regional level were assessed and the emissions baseline of the sector analysed.
2. **Develop demand outlook**: Two 'book-end'[15] 2050 demand scenarios for local and global food and forestry product demand were developed. In the case of food, the demand scenarios accounted for the same population growth and poverty reduction rates. However, scenarios are differentiated by the type of diet assumed to 2050. Further details on the demand scenario development are found in Section 3.2.2.
3. **Assess of local climate impact and identify commodities and regions at risk**: An assessment of the latest climate modelling literature on projected rainfall, temperature, and extreme weather event changes

15 'Book-end' scenarios are developed to represent the upper and lower boundaries of what could possibly occur, with the actual outcomes lying somewhere in between the 'book-end' scenarios.

by 2050 in South Africa, on a regional basis was undertaken. This view was used to determine regions at highest risk of physical climate impact from an environmental, earnings and employment perspective. This was supported by a view of likely changes in regional climatic zones, shifts in arable land availability and potential areas of increasing land use competition due to climate impact.

4. **Define decarbonisation and adaptation pathways for the AFOLU sector**: Key farm and timber plantation-level and sector-level adaptation and decarbonisation levers for the AFOLU sector were identified through a literature review and expert interviews. The combined emissions reduction potential of these levers was modelled to 2050 for each demand scenario and residual emissions calculated (the latest 2017 National Greenhouse Gas Inventory[16] was used as a baseline). A view of the techno-economic feasibility and cost of farm and timber plantation-level levers was developed and 'last-mile', disruptive levers identified to address residual emissions in the sector. Further details on the emissions modelling approach are found in Section 3.2.5.
5. **Assess the potential impact of considered pathways**: Potential impacts of the adaptation and decarbonisation pathway on food security, socio-economic development, and environmental sustainability were assessed. This included impacts on food basket prices and food availability, the risk faced by agricultural communities, farmworkers, timber plantation workers, rural small-holders, and the opportunities and challenges of using the AFOLU sector as a vehicle for cross-sector decarbonisation.
6. **Identify key enablers and no-regret actions to ensure a Just Transition**: Technology, finance, and policy actions were identified which are required in the short- medium-, and long-term to enable farm and timber plantation-level decarbonisation, build resilience against potential climate impacts, and achieve the objectives of food security, socio-economic development, and environmental sustainability and resilience in the sector.

3.2 TOWARDS A CLIMATE-RESILIENT AFOLU SECTOR IN SOUTH AFRICA

3.2.1 SOUTH AFRICA'S AFOLU SECTOR TODAY

Socio-economic contribution

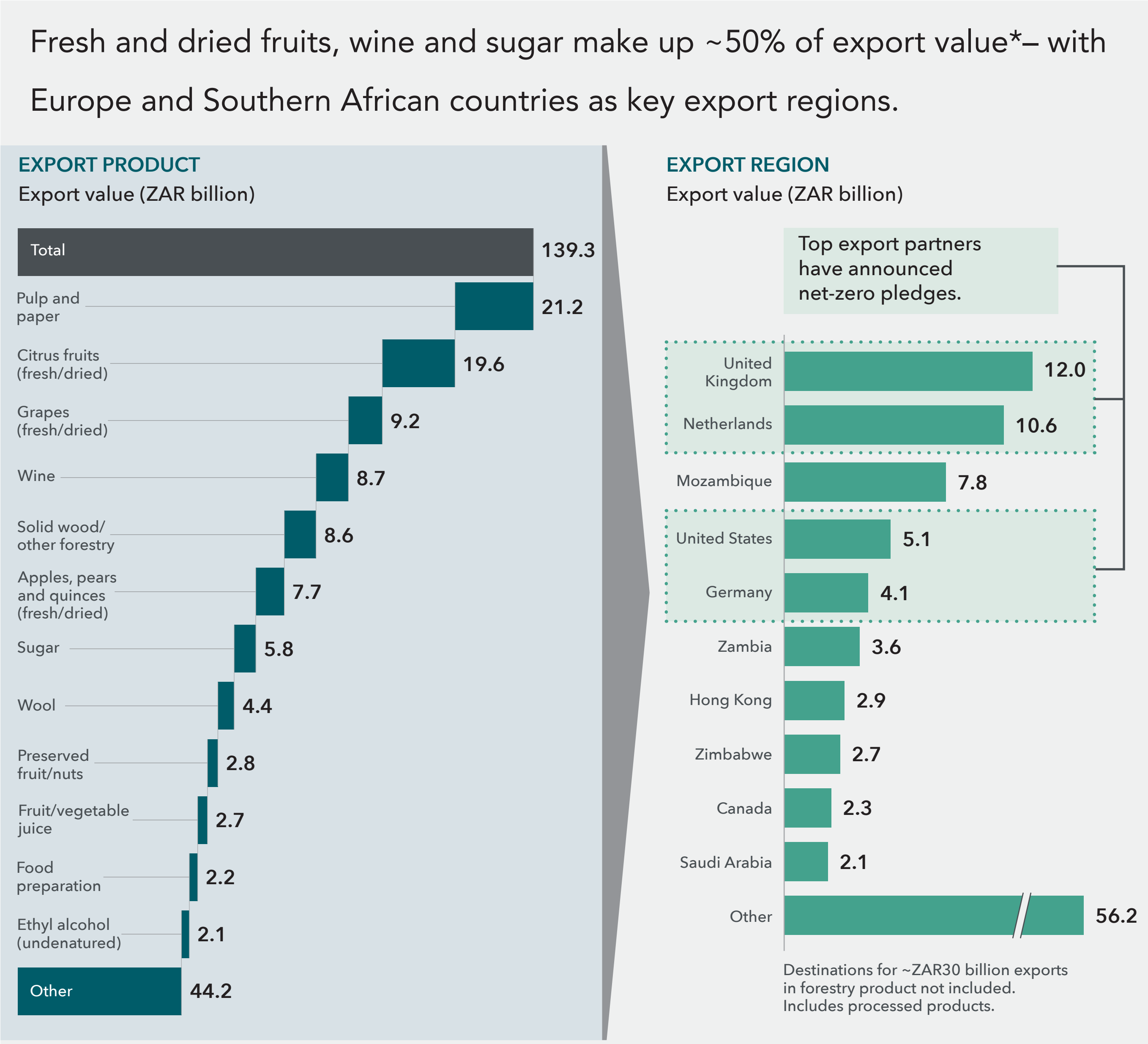
The AFOLU sector is a significant socio-economic contributor to South Africa, providing ~890 000 direct jobs (~5.4% of national employment) and ~2.7% of national GDP. The sector has also been a key source of economic growth in recent times, growing ~13% in 2020, at a time when most sectors were contracting.

Agriculture provides one of South Africa's largest pools of export revenue. In 2018, the sector produced a ~ZAR46 billion (bn) positive trade balance, driven by ~ZAR38 bn in citrus, deciduous fruit and wine exports and ~ZAR21 bn in pulp and paper exports (Figure 4).[17] Locally, livestock is the highest earning AFOLU sub-sector, contributing ~ZAR142 bn, or ~45% of national AFOLU earnings. Horticulture is the largest employment contributor, making up ~36% of agricultural employment in South Africa.[18] The forestry value chain also makes a significant contribution to employment in South Africa, contributing ~60 000 direct and ~30 000 indirect jobs at the primary production step, and a further ~50 000 direct and ~20 000 indirect jobs in the downstream pulp and paper, saw milling and specialist timber industries.[19]

South Africa's agricultural production is geographically distributed, with livestock production concentrated in the southern and eastern regions of the country and field crop production concentrated in the central and northern interior of the country. Horticultural products, such as deciduous fruit (e.g., grapes, apples and pears) are largely produced in the Western Cape, a province that accounts for ~25% of national agricultural employment and ~20% of national agricultural revenues (Figure 5).[20] Primary forestry production is concentrated in KwaZulu-Natal and Mpumalanga, which account for ~92% of the national eucalyptus planting area and ~75% of the national pine planting area, and over 80% of direct and indirect forestry jobs.[21]

16 Department of Forestry, Fisheries, and the Environment (DFFE). 2021. *National GHG Inventory Report, 2017.*
17 Statistics South Africa. 2021.
18 Department of Agriculture, Land Reform and Rural Development (DALRRD). 2021. *Abstract of Agricultural Statistics, 2020.*
19 Forestry South Africa. 2018.
20 Statistics South Africa. 2021.
21 Forestry South Africa. 2019. South African Forestry and Forestry Products Industry, 2018.

Figure 4: South African AFOLU export profile



Notes: * Note that export value here includes beneficiated products, such as wine and alcohol, but not FMCG products.
** Includes agriculture products like mohair, nuts and corn.
*** Includes processed products.

Source: Stats SA. 2021.

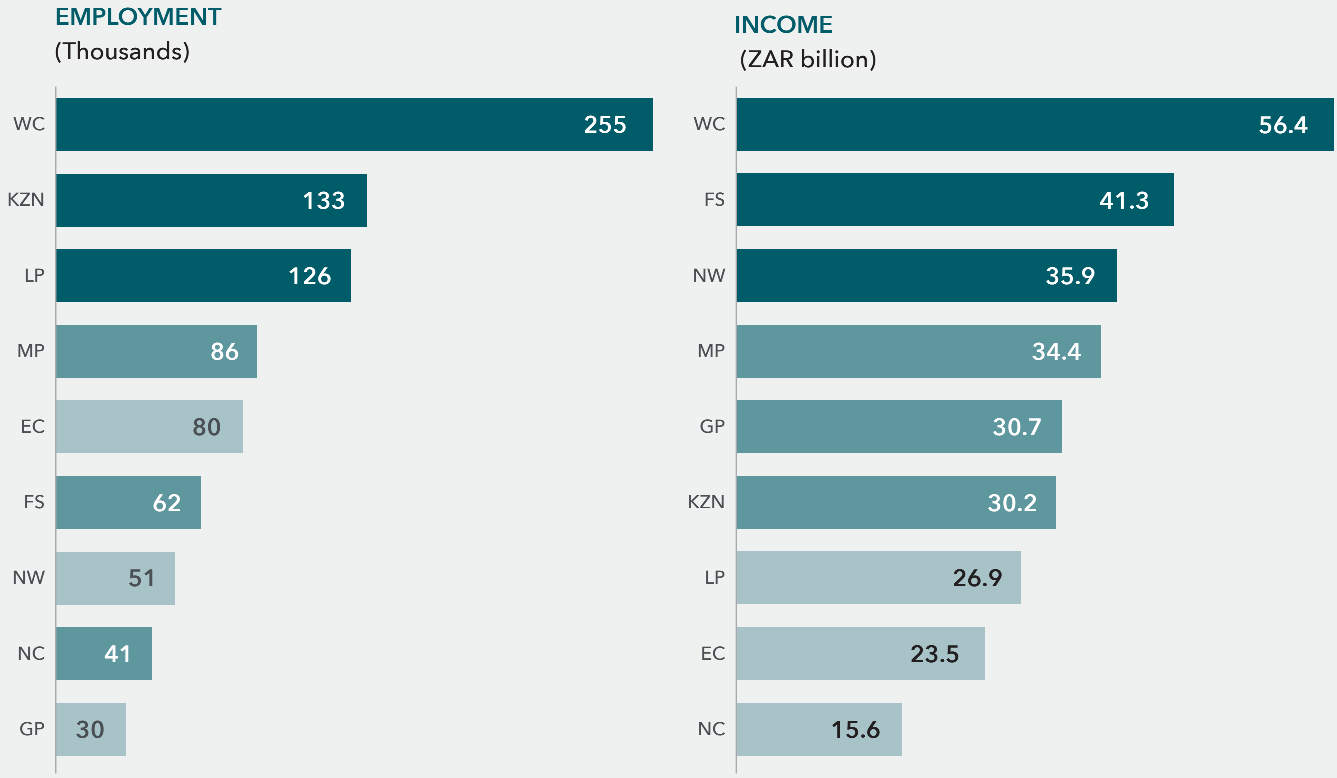
The 'dualism' of South Africa's AFOLU sector

Most agricultural production and earnings in South Africa is generated by a relatively small group of ~2 600 commercial farming units. The legacy of South Africa's 'homeland' regions, and the resulting lack of economic opportunities in many rural districts, has entrenched poverty in many of the historic labour-sending regions. This has resulted in the emergence of a dual agriculture system in the country.[22] On the one hand, South Africa's commercial AFOLU sector is generally well capitalised, employs sophisticated methods, and has access to local and international markets. On the other hand, rural farmers in historic labour-sending regions often contend with lower quality, communally-owned land, dysfunctional extension systems, and low access to capital and markets. Over two thirds of national agricultural income and over half of national agricultural employment in South Africa is generated by just 7% of farms. These farms utilise sophisticated technologies and farming methods and each generate annual revenues in excess of ZAR22.5 million.

22 Trade and Industrial Policy Strategies (TIPS). 2019. *Sector Jobs Resilience Plan: Agriculture Value Chain.*

Figure 5: Geographical spread of agriculture employment and income

>50% of farming employment (~500 k) concentrated in Western Cape, KwaZulu-Natal and Limpopo in 2020.

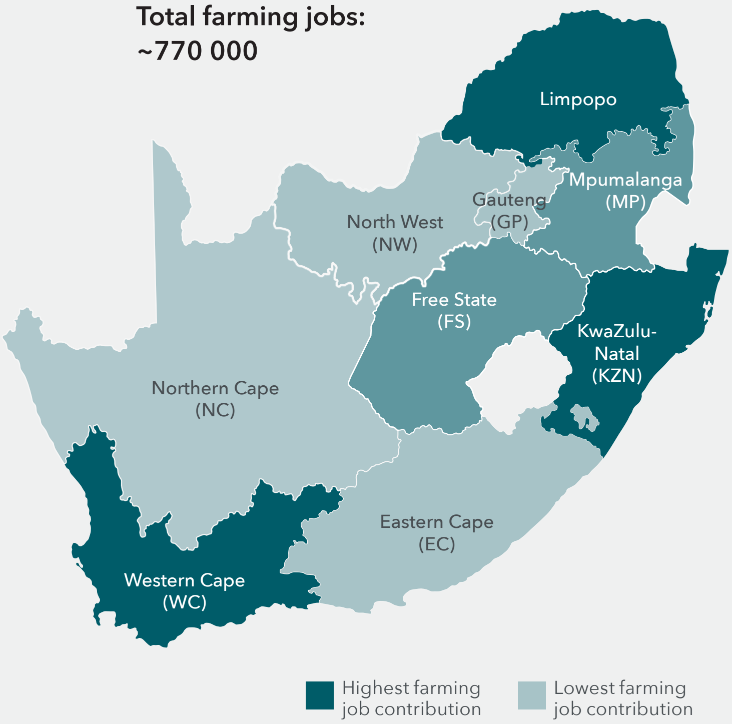


INCOME SHARE

	Field crops*	Horticulture	Animals
WC	~16%	~46%	~38%
FS	~44%	~5%	~51%
NW	~21%	~7%	~72%
MP	~33%	~15%	~52%
GP	~12%	~11%	~77%
KZN	~32%	~9%	~59%
LP	~17%	~61%	~23%
EC	~7%	~29%	~64%
NC	~30%	~31%	~39%

RANK

Total farming jobs: ~770 000



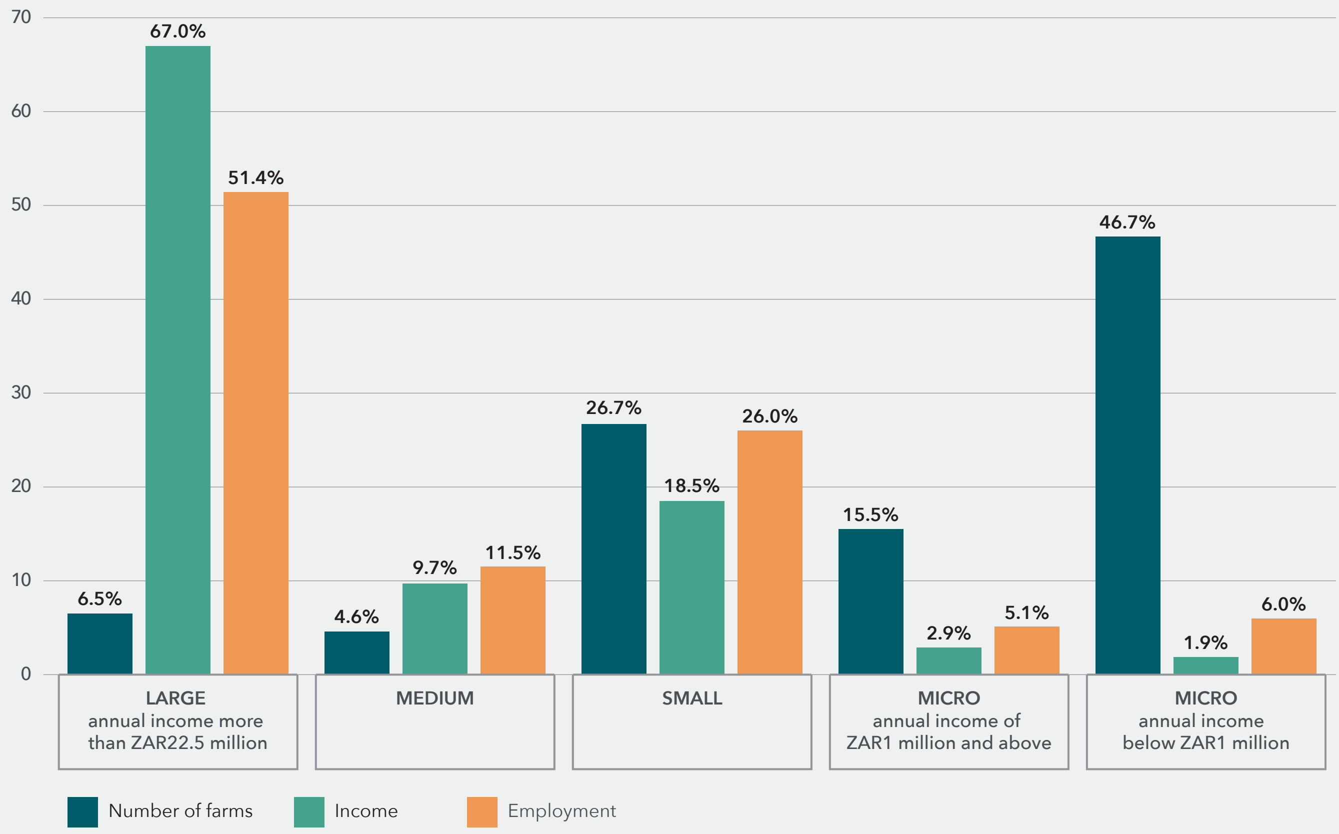
Note: * Includes 'Other'.

Source: Statistics South Africa, 2021.

Figure 6: Farming income and employment split between different size farming operations

Less than 7% of farms account for ~70% and ~50% of total income and total employment, respectively.

Number of farms, income and employment in the commercial agriculture industry by farm size, as a percentage of total, 2017.



Note: In 2017, 2 610 large farms (those with annual income of more than ZAR1 mn) constituted 6.5% of the total number of farms in the commercial agriculture industry, and accounted for 67,0% of total income and 51.4% of total employment. This was in contrast to the 18 710 micro farms (annual income below R1 M) which made up almost half of the total number of farms, but which accounted for just 1,9% of total income and 6,0% of total employment. Taken together, there were 15 810 large, medium and small farms in 2017, with combined shares of 37,8% of the number of farms, 95.2% of income, and 88,9% of employment. Measured by farms size, small farming units were the second largest in terms of number of farms, income and employment in 2017.

Source: Stats SA, *Census of Commercial Agriculture: 2017.*

Conversely, the lowest earning 50% of farming operations in South Africa (comprising 18 000 farming units) contribute just ~2% of national agricultural income and 6% of national agricultural employment (Figure 6). [23 24]

In forestry, over 90% of production comes from 10 corporate producers, one large state-owned producer and ~1 100 medium-sized commercial growers. Roughly 25 000 small-scale growers operate in South Africa but combined only account for ~3.5% of total production value. In general, these small-scale growers lack, for example, hybrid development skills and forestry business development experience, have limited access to extension services, climate monitoring and fair markets, and operate in an uncertain land tenure context.

Not only must the South African AFOLU sector contend with the inequalities of the 'dual agriculture system', but the welfare of farmworkers is a major concern. The median monthly income for farmworkers in South Africa is ZAR2 500–ZAR2 800, relative to median monthly incomes of ZAR5 700–ZAR10 000 for comparable positions in

23 Statistics South Africa. 2020. *Census of Commercial Agriculture: 2017.*

24 Forestry South Africa. 2019. *South African Forestry and Forestry Products Industry, 2018.*

other sectors, in non-agricultural regions of the country. Farm labour is also highly seasonal (particularly in the labour-intense horticulture sub-sector), with only ~50% of farmworkers securing permanent jobs. Furthermore, farmworkers have little in the form of a safety net. Over a third of farmworkers in South Africa only completed primary level education, only ~15% have retirement funds, and only 0.7% of unemployed farmworkers receive support from the Unemployment Insurance Fund (UIF) compared to 1.7% of other jobless workers.[25 26]

In forestry, over 85% of employees on large timber plantations and 35% of employees on medium-scale plantations work for contractors or on fixed-term contracts, with contract terms generally only lasting one to four years. Only 9% of large-scale timber plantation workers are unionised, earn living wages and receive employment benefits, while the majority of the remaining 91% of large-scale plantation workers are paid the sectoral minimum wage and work on fixed-term contracts without employment benefits. While the average CEO-to-worker wage ratio is ~390 in South Africa's mining sector, two of the largest forestry companies in South Africa produced ratios of ~923 and ~1 325 as of 2011. Furthermore, the living conditions of workers on medium-scale timber plantations may be lower, given that most medium-scale growers are not Forestry Stewardship Council (FSC) certified and there is a risk of legal non-compliance of their contractors. Largely as a result of a widespread shift towards contracting rather than employing timber plantation workers, benefits such as on-plantation housing, meals, electricity and water have diminished, and more workers are excluded from company providence funds and medical aids. Lastly, 'piecework', an outlawed practice of deducting contractor pay if daily tasks are not completed is expected to still exist in some operations.[27]

Food security contribution and the current state of South African diets

Average daily caloric consumption per capita in South Africa reached ~3 100 kilocalories (kcal) in 2021, on par with developed nations, such as South Korea and the Netherlands.[28] However, ~15% and ~5% of South African households reported inadequate or severe inadequate access to food, respectively, with the North West and Northern Cape reporting the lowest food adequacy rates in the country. Approximately 13% of households with children under 5 years experienced hunger in 2017, and ~25% of South African households live below the food poverty line (ZAR441/person/month), meaning they are unlikely to afford the required daily energy intake, let alone a nutritionally-balanced diet.[29] Equally concerning is that ~28% of adult South Africans are classified as obese – only ~8% lower than the United States (~36% obesity rate) – and a further ~25% are classified as overweight. This gives South Africa the 30th highest obesity rate globally.[30]

On average, South African households only spend ~ZAR1 100 per month on food and non-alcoholic beverages. The lowest-income 10% of households allocate ~42% of food expenditure to breads, cereals and sugar, whereas the highest-income 10% of households only allocate 23% to these food types.[31] These food types are not nutritionally complete, but are energy-dense, resulting in a low cost per unit energy and making them a popular choice for lower-income South Africans. In combination with a range of other behavioural factors, this means that, on average, South Africans consume less than 50% of the global average consumption of fruits, vegetables, legumes and nuts and 3–4 times less than optimal consumption of each (Figure 7).[32] Ensuring adequate, healthy diets for all South Africans will need to be ensured as part of a Just Transition.

Emissions contribution

According to the latest version of the Department of Forestry, Fisheries and the Environment's (DFFE) 2017 *Greenhouse Gas Inventory for South Africa*, the AFOLU sector contributes ~52 Mt CO_2e of direct emissions annually, or ~10% of South Africa's annual gross total emissions (if sinks and land conversion emissions are excluded). This makes AFOLU the fourth highest emitting sector in South Africa (Figure 8).[33]

However, the sector, particularly forestry, will be critical in enabling decarbonisation across sectors, via for example the provision of sustainable construction materials and biomass for industrial use (see 'Deep-dive: Biomass in South Africa').

25 Trade and Industrial Policy Strategies (TIPS). 2019. *National Employment Vulnerability Assessment: Analysis of potential climate-change related impacts and vulnerable groups.*

26 Trade and Industrial Policy Strategies (TIPS). 2020. *Sector Jobs Resilience Plan: Agriculture Value Chain.*

27 DFFE (formerly DAFF). 2012. *Investigation of Working Conditions of Forestry Workers in South Africa.*

28 Economist Intelligence Unit. 2019. *Global Food Security Index.*

29 Statistics South Africa. 2017. *Towards measuring the extent of food security in South Africa.*

30 World Health Organization (WHO). 2020. *Global Health Observatory data repository.*

31 Statistics South Africa. 2015. *Living Conditions Survey: 2014/15.*

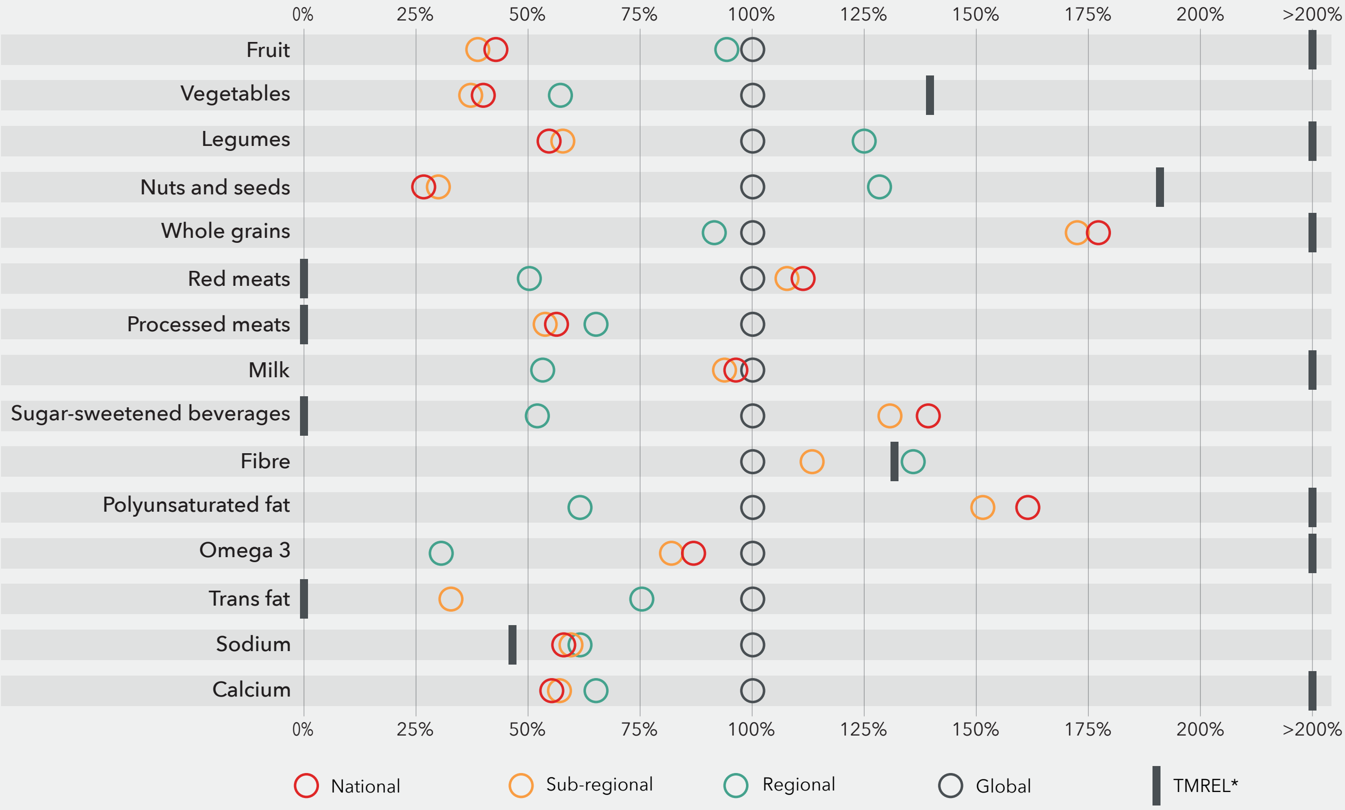
32 Global Nutrition Report. 2020. *Country Nutrition Profiles.*

33 Department of Forestry, Fisheries, and the Environment (DFFE). 2021. *National GHG Inventory Report.*

Figure 7: South African food consumption trends versus global and regional benchmarks

South African households consume, on average, less than 50% of the global average consumption of fruits, vegetables and nuts.

Dietary intakes of key foods and nutrients in adults aged 25 years and over



Note: * Theoretical minimum risk of exposure level (TMREL) represents the optimal dietary intake that minimises risk from all causes of deaths combined.

Source: Global Nutrition Report, 2020.

Furthermore, the AFOLU sector also provides natural carbon sinks, which will be critical in addressing potentially remaining residual emissions across sectors. The natural carbon sink refers to the capacity of South Africa's land and vegetation to store carbon, preventing CO_2 from entering the atmosphere. (See Section 3.2.8 for further details on the role of AFOLU, particularly forestry, in enabling cross-sector decarbonisation in South Africa).

3.2.2 AFOLU PRODUCT DEMAND SCENARIOS

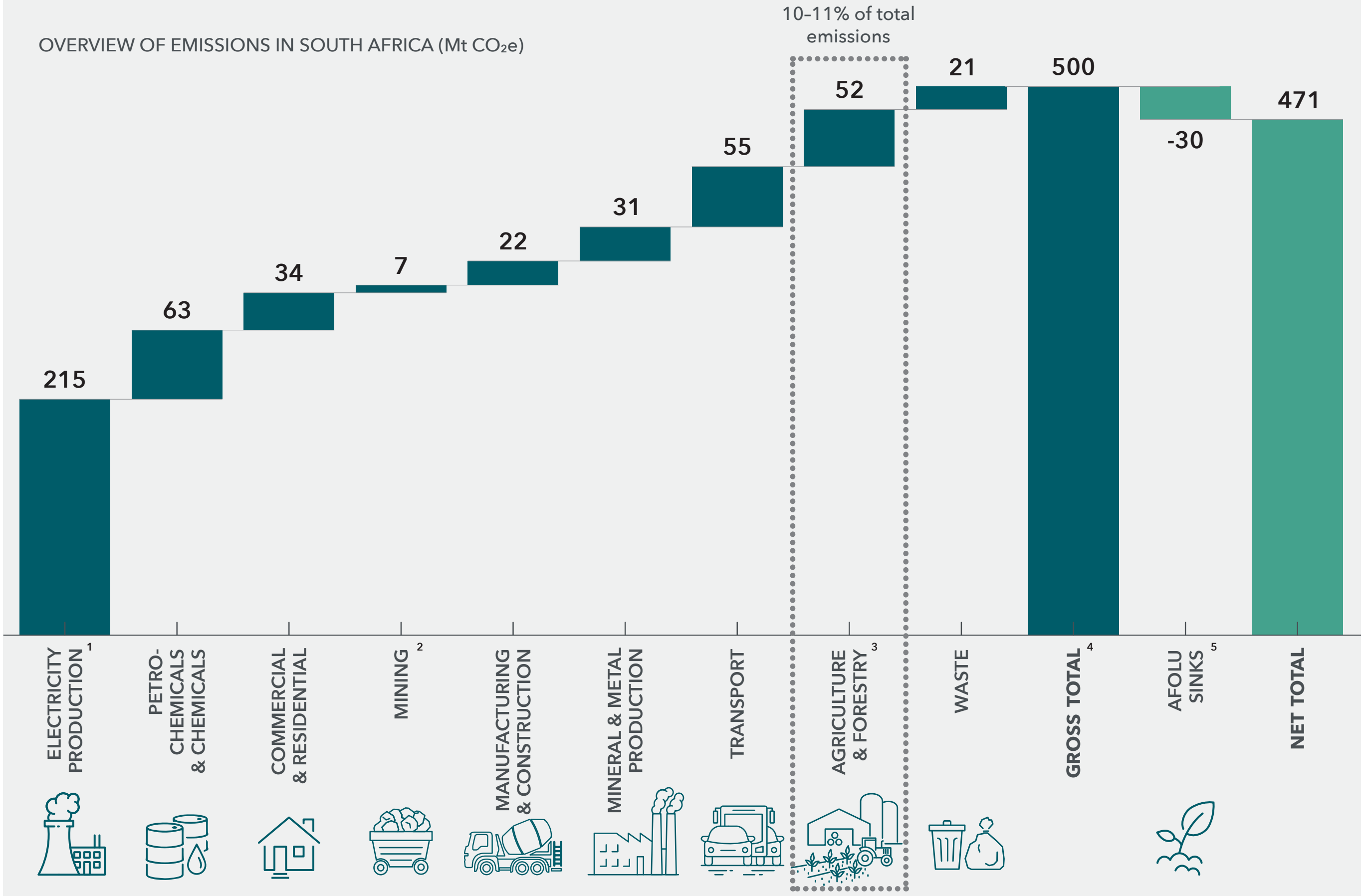
> ***The South African AFOLU sector is at significant climate risk – ensuring food security and sustainable and healthy diets for all South Africans, and maintaining the sector's socio-economic contribution requires the development of a climate-resilient AFOLU sector.***

The Food and Agriculture Organization (FAO) projects that global food demand could increase by ~70% by 2050, driven by a 110% population increase in Sub-Saharan Africa and an 11% increase in global per capita consumption (base year 2007).[34] South Africa's population is projected to grow ~28% by 2050, while daily consumption per capita is expected to stagnate.[35]

34 Food and Agriculture Organization of the United Nations (FAO). 2012. *World Agriculture Towards 2030/2050: The 2012 Revision.*
35 United Nations (UN). 2015. *World Population Prospects: 2015 Revision.*

Figure 8: 2017 emissions baseline for South Africa

Direct emissions from the AFOLU sector are responsible for ~10% of South Africa's total gross emissions (as per latest Department of Forestry, Fisheries and the Environment estimate).



1. The National Greenhouse Gas Inventory (GHGI) emission figures based on Electricity and Heat Production, of which electricity production contributes >97% of emissions.

2. GHGI does not explicitly state estimate for mining emissions, so this has been estimated. Assumed Scope 1 emissions share of top 12 companies is same as their market share (80%) and uses this to gross up to 100%.

3. Agriculture (~47 Mt, labelled as 'AFOLU excluding FOLU' in GHGI) and energy emissions in Agriculture/Forestry/Fishing (~4 Mt).

4. Gross total excludes categories 1A5 as it is not linked to any sectors and 1B1 to avoid the double counting of fugitive emissions from coal, gold, and PGMs mining which are included in the mining sector emissions approximation.

5. AFOLU sinks: FOLU (labelled as 'Land' in GHGI) + Other ('harvested wood products').

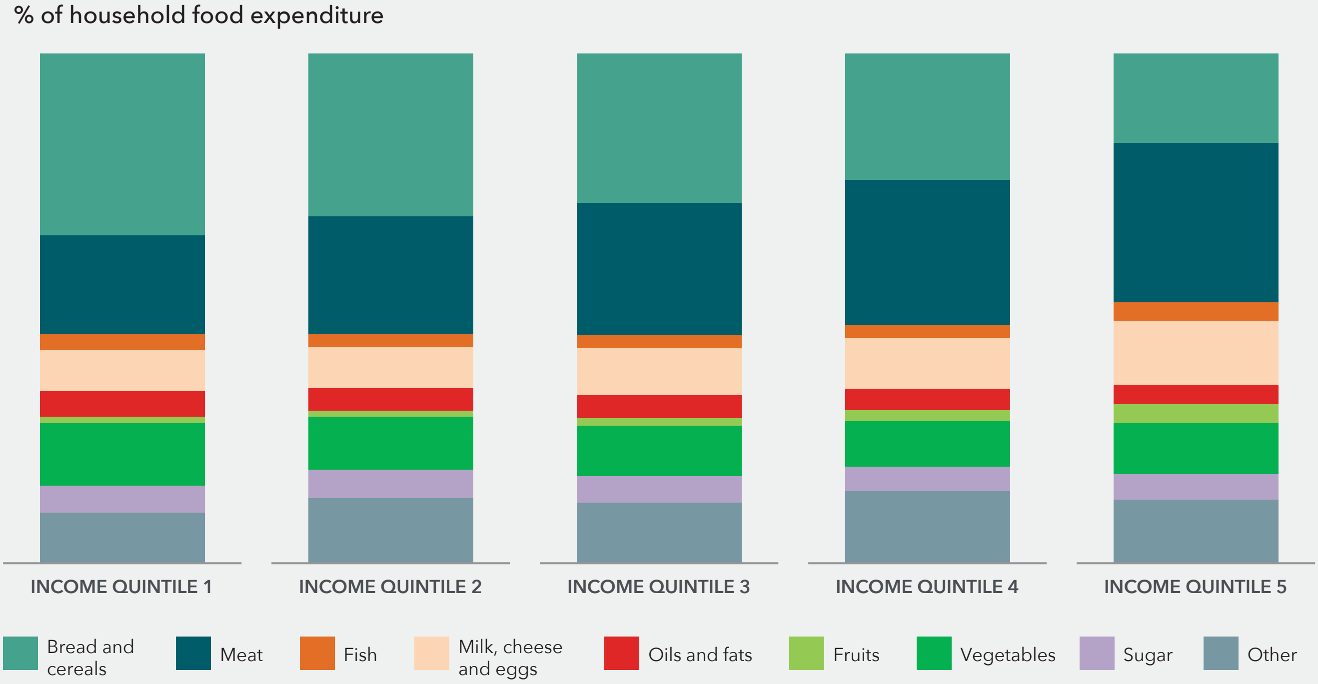
Sources: GHGI, 2017; IEA, 2015; WEO, 2019; CDP, 2015; GHGI, 2015; CAT; NBI-BCG analysis.

[36] As income levels rise, food expenditure is expected to shift from low-cost starchy staples towards higher-cost meats and fruits. In South Africa, 36% of household food expenditure in the lowest income households is allocated to breads and cereal versus 18% for the highest income households, while percent food expenditure on meat is 19% for the lowest income households and 31% for the highest income households. This difference in spending habits may be used as a proxy to predict how food demand may evolve as households attain more disposable income (Figure 9).[37] Understanding how local and global demand for AFOLU products may evolve will be critical to effective planning of the sector, particularly to inform long-term land use decisions. In this analysis, two 'book-end' scenarios were developed to project local and global food and forestry product demand.

36 Food and Agriculture Organization of the United Nations (FAO). 2021. *Food Balance Sheets*.
37 Statistics South Africa. 2015. *Living Conditions Survey: 2014/15*.

Figure 9: Household food expenditure split by income quintile

Food expenditure could shift towards red meat, fruit and vegetables, and shrinks as a proportion of total expenditure as incomes rise.



Source: Stats SA, *Living Conditions Survey 2014/15*.

Developing 'book-end' diets to project South Africa's food demand to 2050

Business-as-usual diet: This scenario intends to provide a view of how diets would likely evolve in South Africa to 2050, if no major policy or advocacy actions were taken to shift food consumption patterns. South African household expenditure data from Stats SA was used as a baseline for this diet, to root it in today's actual average South African diet. This diet is characterised by comparatively high red meat and cereals consumption and is not intended to achieve the goal of a 'healthy' or 'low-emissions' diet, only reflect current patterns. Food commodity demand is projected to 2050, with marginal increases in average calorie consumption and optimistic increases in the size of South Africa's middle class assumed, therefore increasing per capita consumption of higher-cost foods, such as red meat. Therefore, this diet provides an 'upper-bound' of the consumption of high-emissions foods such as red meat.

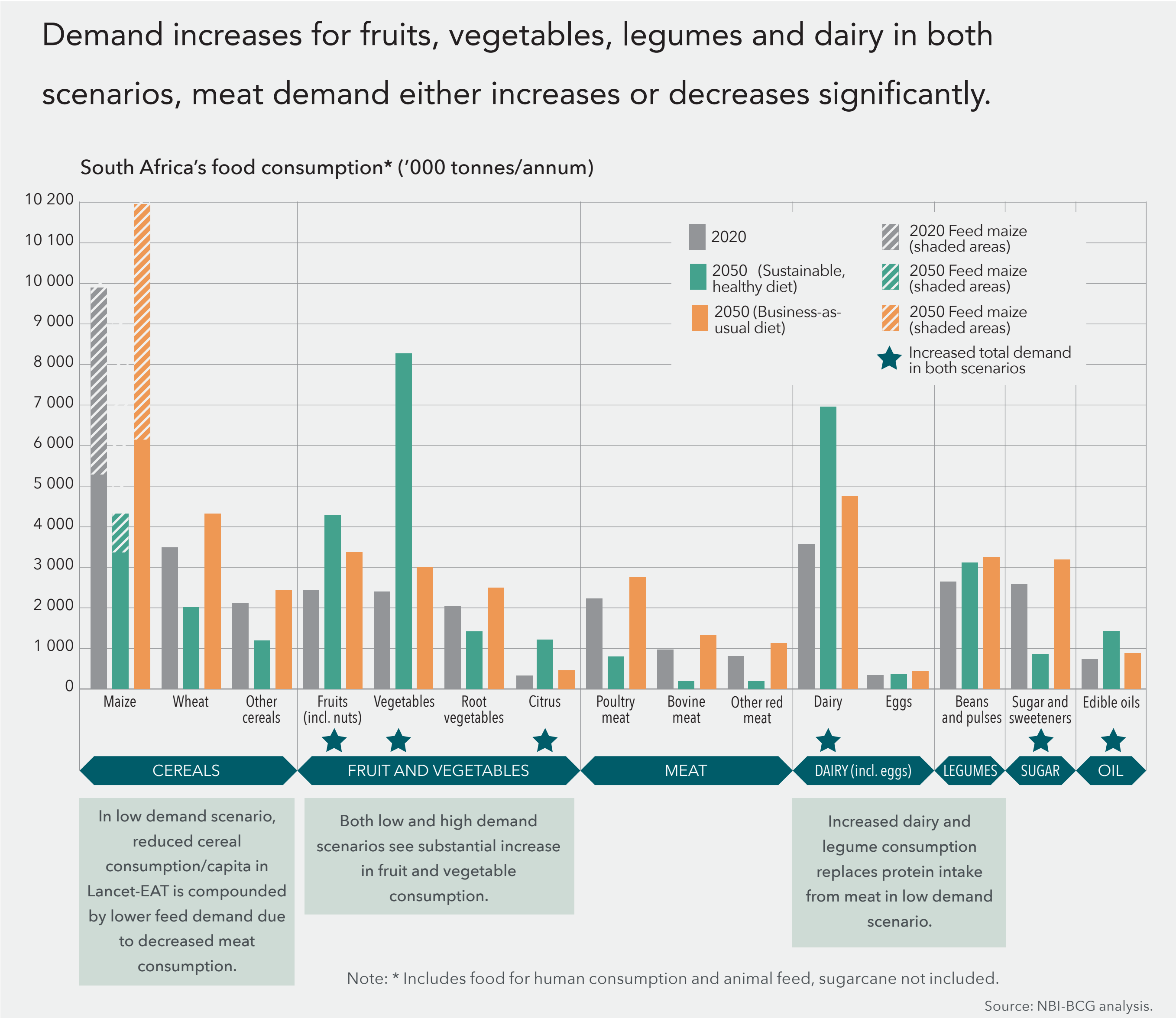
Sustainable, healthy diet: This scenario intends to provide an aspirational view of how diets may evolve in South Africa to 2050, if decisive policy and advocacy actions (including potential subsidisation of healthier foods) are taken to promote the consumption of healthier foods that produce lower emissions in production. The Lancet-EAT diet was selected as a baseline for this diet, given that this diet was optimised from a carbon emission footprint and nutritional content perspective. Furthermore, the key recommendations of the diet, namely reduced (but not fully eliminated) red meat consumption and increased fruit, vegetable and legume consumption are supported by the FAO and United Nations (UN) views of what represents 'climate compatible diets'. However, this study does not endorse the Lancet-EAT diet as the ideal diet, but leverages it to provide a 'book-end' scenario view of a potential net-zero compatible, healthy diet. Projecting South Africa's diet along a gradual shift to the Lancet-EAT diet by 2050 sees significant decreases in red meat consumption and significant increases in fruit, vegetable and legume consumption. Therefore, this diet provides a healthy 'lower-bound' of the consumption of high-emissions foods, such as red meat (without requiring a widespread move to zero-meat diets).

Food demand scenarios

Global and local food demand was projected to 2050 in line with a *business-as-usual diet* and *sustainable, healthy diet* scenarios. In all scenarios, population growth and poverty reduction rates were considered. For both the local and global scenarios, UN population projections were leveraged.[38] In the local scenarios, NDP poverty reduction targets were taken into account, while in the global scenarios FAO consumption increase projections were leveraged.[39] In the *business-as-usual diet* scenario, local and global diets are assumed to remain roughly the same to 2050, whereas in the *sustainable, healthy diet* scenario, diets are assumed to shift towards a lower red meat, nutritionally-complete diet by 2050. This diet is roughly aligned with the Lancet-EAT[40] diet, but considered additional sources.

Given population increases and the growing middle class, total food demand in South Africa increases by 25–30% by 2050 in all scenarios. In a *business-as-usual diet* scenario, increased demand is observed for all commodities. The strongest local demand increases in this scenario are in red meat (38%), dairy products (33%), and fruits and citrus (37%), outstripping population growth, due to growing incomes. Cereals demand (including for animal feed) only

Figure 10: Local food consumption projections to 2050

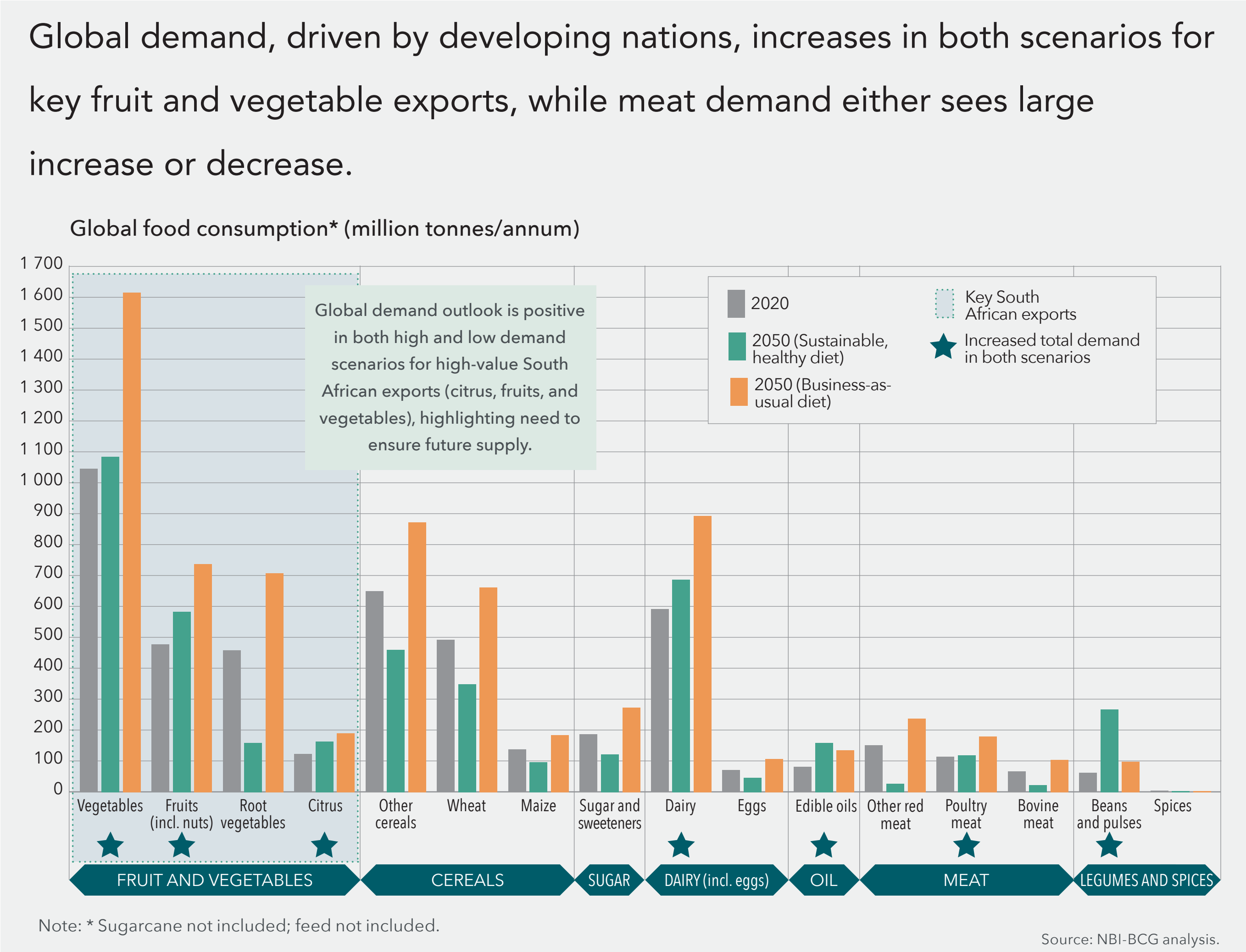


38 United Nations. 2015. *World Population Prospects: 2015 Revision.*

39 World Bank, Statistics South Africa. 2018. *Overcoming Poverty and Inequality in South Africa.*

40 The Lancet-EAT diet (developed by the EAT-Lancet Commission) is designed to generate minimal production emissions while meeting all nutritional requirements of a healthy diet. The diet calls for reduced red meat and cereals consumption and increased legumes, fruit and vegetable consumption.

Figure 11: Global demand for key South African agricultural export commodities likely to grow across scenarios



Note: * Sugarcane not included; feed not included.

Source: NBI-BCG analysis.

grows 17% by 2050, due to decreasing consumption per capita with increasing incomes. In a *sustainable, healthy diet* scenario, demand increases are observed by 2050, in fruits and citrus (99%), non-root vegetables (245%), and dairy and egg products (94%), alongside significant decreases in red meat (-78%), sugar (-67%), and cereals (-51%) demand, in line with the per capita consumption requirements of the 'book-end' *sustainable, healthy diet* (Figure 10). Regardless of scenario, fruits, vegetables, legumes, dairy products and edible oils, see increased demand in South Africa by 2050.

Globally, similar trends are observed, with overall food demand increasing 55–60% by 2050 across scenarios. Of particular importance for South Africa is global demand for fruits, citrus and vegetables, which together contribute ~45% of South Africa's AFOLU export revenue. Global demand for fruit and citrus is projected to grow 54% in a *business-as-usual diet* scenario and 26% in a *sustainable, healthy diet* scenario, given that average global per capita fruit consumption rates are already in line with sustainable diet recommendations. Similarly, global demand for non-root vegetables is projected to increase by 52% by 2050 in a *business-as-usual diet* scenario, but only by ~5% in a *sustainable, healthy diet* scenario These trends indicate that demand for South African agricultural exports is likely to remain, if lower emission production can be secured. Most notably, in a *sustainable, healthy diet* scenario, a 320% increase in demand for legumes and pulses could emerge (Figure 11).

Forestry product demand scenarios

Global and local forestry product demand were projected to 2050 in line with *high demand* and *low demand* scenarios. In the *low demand* scenarios, local and global pulp demand and global timber demand were all scaled in line with global growth rates[41] to 2030, after which growth

41 Boston Consulting Group. 2020. *Forestry Product Future Market Trends.*

rates are assumed to halve. Local timber demand was scaled in line with historic timber demand growth trends in South Africa.[42] In the *high demand* scenario, local and global pulp demand and global timber demand were all scaled in line with growth rates developed by Boston Consulting Group (BCG) to 2050. Local timber demand was scaled to meet Australian per capita structural timber demand (which served as a benchmark due to similar climatic and geographic conditions), implying a significant demand creation effort.[43]

Global and local demand for pulpwood will be driven by e-commerce paper packaging demand and dissolving pulp demand for cellulosic fibres to produce textile fabrics. Pulpwood demand is projected to increase by 80–113% in South Africa and globally, by 2050, presenting further export opportunity for South Africa's developed pulpwood sector. Similarly, strong growth is likely to be seen for timber, as structural timber emerges as a lower emissions building material. Locally, sawlog and veneer log demand is projected to grow 60% in a *low demand* scenario (in line with historic trends) and over 400% in a *high demand* scenario (in which South African structural timber demand per capita reaches current Australian levels). Globally, sawlog and veneer log demand is projected to grow 90–135%, in line with the global shift towards timber as a construction material. This could present an opportunity for South Africa to partake in the growing global timber market, however, local demand creation initiatives will be needed to scale South African timber operations to achieve global competitiveness.

3.2.3 THE CLIMATE RISK OF SOUTH AFRICA'S AFOLU SECTOR

> ***Global climate change could impact South Africa significantly: In low and moderate mitigation scenarios, South Africa's average inland temperature could rise 2–4 °C by 2050,[44] ~2 times the average global temperature increase, and average rainfall could decrease >60 mm/annum in most western and northern regions of the country.***

South Africa will be among the countries at greatest risk from climate change. South Africa is already a semi-arid country and will experience temperature increases 2 times the global average temperature increase in most regions, with the central interior and north-eastern periphery regions of South Africa likely to experience the highest temperature increases. Additionally, increasing atmospheric CO_2 concentrations will drive greater variability in rainfall patterns in South Africa, with the most recent modelling showing reduced rainfall and increased risk of extreme weather events throughout South Africa by 2050, while others indicate rainfall increases in KwaZulu-Natal before 2040, but decreases thereafter.[45 46]

Underlying climate scenarios that were considered for the impact analysis

The impact of climate change in South Africa was assessed for two climate scenarios (Representative Concentration Pathways – RCPs), upon which most currently existing climate change research in South Africa, and to a large extend also globally, has been based.

- RCP 4.5: A global moderate mitigation scenario aligned with a 1.7–3.2 °C global mean surface temperature increase (relative to pre-industrial levels) by 2100 (~1.3 °C increase by 2050).
- RCP 8.5: A global low mitigation scenario aligned with a 3.2–5.4 °C global mean surface temperature increase (relative to pre-industrial levels) by 2100 (~2 °C increase by 2050).[47]

These scenarios follow relatively similar trajectories to 2050, after which the RCP 8.5 scenario sees significantly higher temperature increases and associated impacts to 2100.

Projected key trends across the considered scenarios

Changes in temperature:[48] (Figure 12)

- Mean temperature increases are *virtually certain* throughout South Africa by 2050, meaning there is a greater than 99% likelihood of occurrence.
- The highest temperature increases (~2 times global mean surface temperature increase) is expected to occur in the central and western interior of the country.
- Increasing frequency of very hot, heat wave, and high fire danger days is *virtually certain* throughout the

42 Forestry South Africa. 2018. *Roundwood Statistics: 1992–2018*.

43 Food and Agriculture Organization of the United Nations (FAO). 2014. *Yearbook of Forest Products: 2008–12*.

44 Relative to pre-industrial temperatures (1850-1900).

45 Council for Scientific and Industrial Research. 2018. *Green Book: Adapting South African settlements to climate change*.

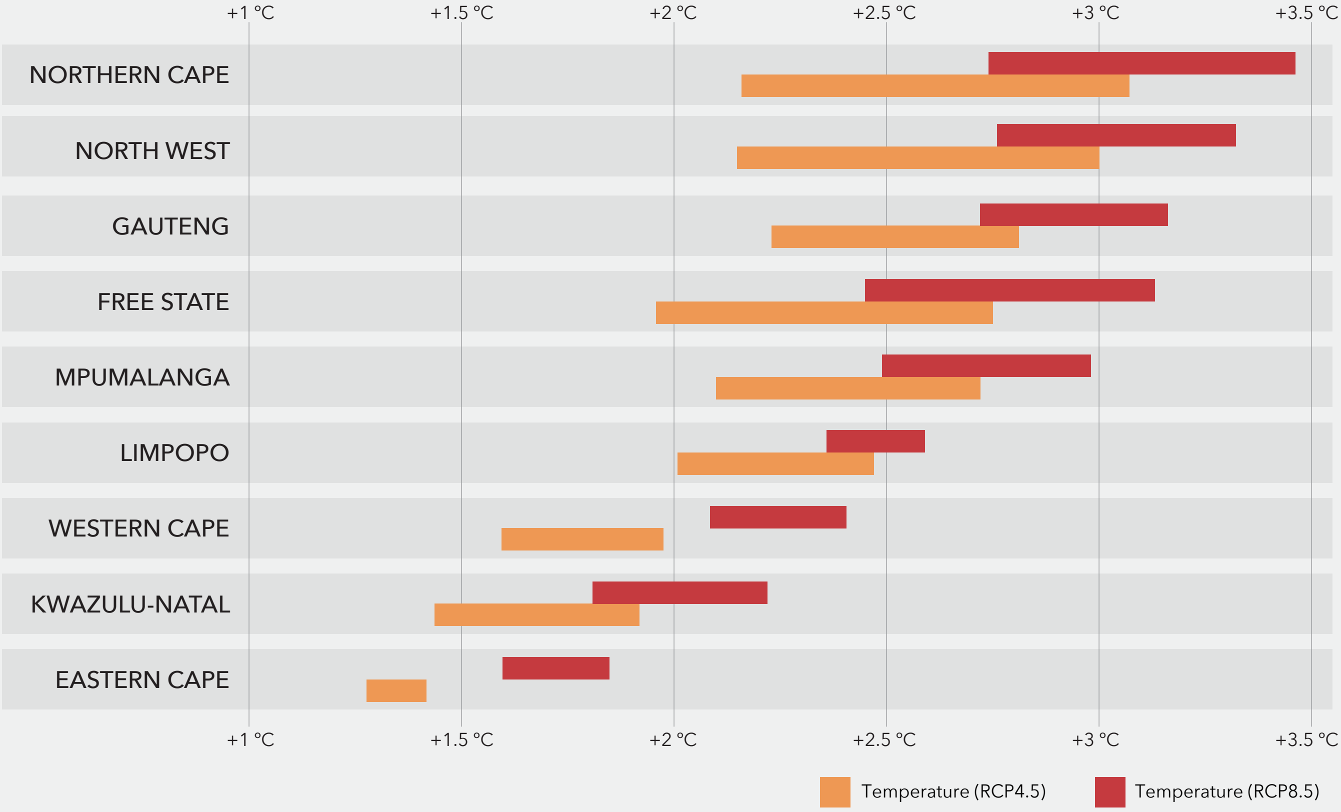
46 Water Research Commission. 2021.

47 Intergovernmental Panel on Climate Change (IPCC). 2014. *Assessment Report 5*.

48 Former Department of Environmental Affairs (DEA). 2017. *South Africa's Third National Communication under the United Nations Framework Convention on Climate Change*.

Figure 12: Provincial projected temperature increase ranges by 2050

Northern Cape and North West likely to experience highest temperature increases, with temperature increases decreasing towards the coast.



Notes: Ranges relative to 1961–1990 baseline. Range between 10th and 90th percentile values for 6 down-scaled global climate models shown.
Values shown are for municipalities with the highest agricultural revenue in each province.

Source: CSIR, *Green Book*; Stats SA, *Census of Commercial Agriculture 2017*; NBI-BCG analysis.

country, with greatest increases in the central and western interior of South Africa.

- Greater diurnal temperature range is *likely* throughout the country by 2050, meaning there is a greater than 66% likelihood of occurrence.

Changes in rainfall patterns:[49]

- There is still a degree of uncertainty around the impact on absolute rainfall levels, however, shifts in rainfall patterns are virtually certain. Mean annual rainfall is *likely* to decline across the highest water-risk regions of South Africa by 2050 by more than 60 mm (~10% of current annual rainfall).
- The greatest mean rainfall decline by 2050 is *likely* to occur in the northern and south-western interior regions of the country (Northern Cape, Western Cape, and North West), while regions along the escarpment in KwaZulu-Natal may experience increased annual rainfall in the short-term but a drying trend in the longer-term (towards 2100).
- Later onset and shorter duration of rainy seasons is *likely* across the country.
- Increased frequency of heavy rainfall and drought events is *likely* across most of South Africa.

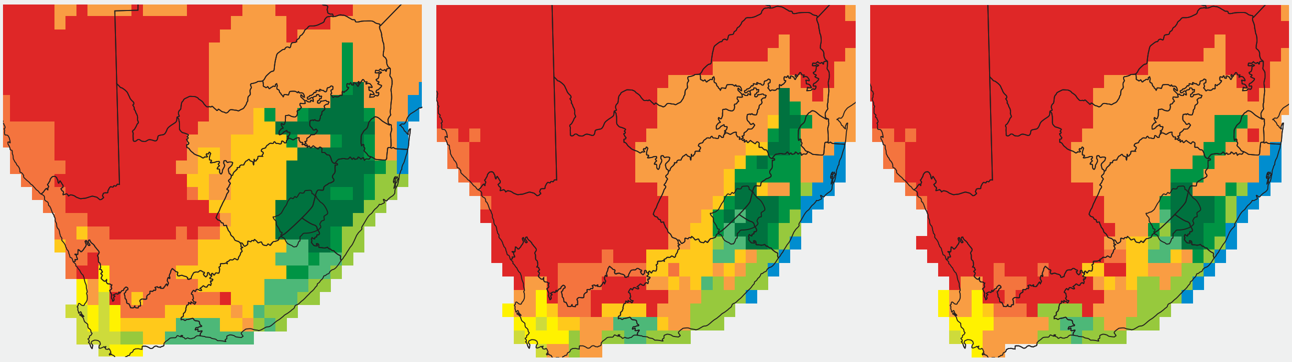
Figure 13 highlights the potential impact of climate change on climate zones in South Africa. By 2050, the hot desert region (currently restricted to the northern regions of the Northern Cape, North West and Limpopo) is projected to grow ~25% in an RCP 4.5 scenario and ~48% in an RCP 8.5 scenario, extending into agricultural regions of the Western Cape, Free State, and deep into Limpopo. This would result in hot desert zones occupying 45–60%

49 University of the Witwatersrand, Global Change Institute (GCI). 2021. *CMIP6 Ensemble Modelling.*

Figure 13: Potential climatic change across climate zones in South Africa

Significant increase in hot desert zone and shift from warm to hot temperature zones expected across both scenarios.

Koppen Geiger climate zones in South Africa (1961–1990)	RCP4.5 (eq.*) (2040–2060; 2 °C MIROC3.2-medres model)	2050 RCP8.5 (eq.**) (2040–2060; 3 °C MIROC3.2-medres model)



Koppen Geiger climate zones in South Africa (1961–1990)	RCP4.5 (eq.*) (2040–2060; 2 °C MIROC3.2-medres model)	2050 RCP8.5 (eq.**) (2040–2060; 3 °C MIROC3.2-medres model)
Cold and hot desert in the west	**~25% increase** in size of hot desert	**~48% increase***** in size of hot desert
Cold steppe in the centre and south-west	**~18% increase** in size of hot, arid steppe	**~34% increase***** in size of hot, arid steppe
Warm temperature regions in the east and south-east	Warm temperate partially **replaced** by hot temperate	Warm temperate replaced by hot temperate except in Lesotho. **~124% increase** in size of tropical savannah (east coast) – relative to base period

Temperature zones:

Arid Desert Hot	Arid Steppe Cold	Temperate Dry and hot summer	Temperate Dry winter Hot summer	Temperate No dry season Hot summer	Tropical Savannah
Arid Desert Cold	Arid Steppe Hot	Temperate Dry winter Warm summer	Temperate Dry winter Warm summer	Temperate No dry season Warm summer	

Notes: * 2 °C mean global surface temperature increase.
** 3 °C mean global surface temperature increase.
*** Relative to base period.

Source: Theoretical and Applied Climatology,2015; Agricultural Research Council and DAFF; NBI-BCG analysis.

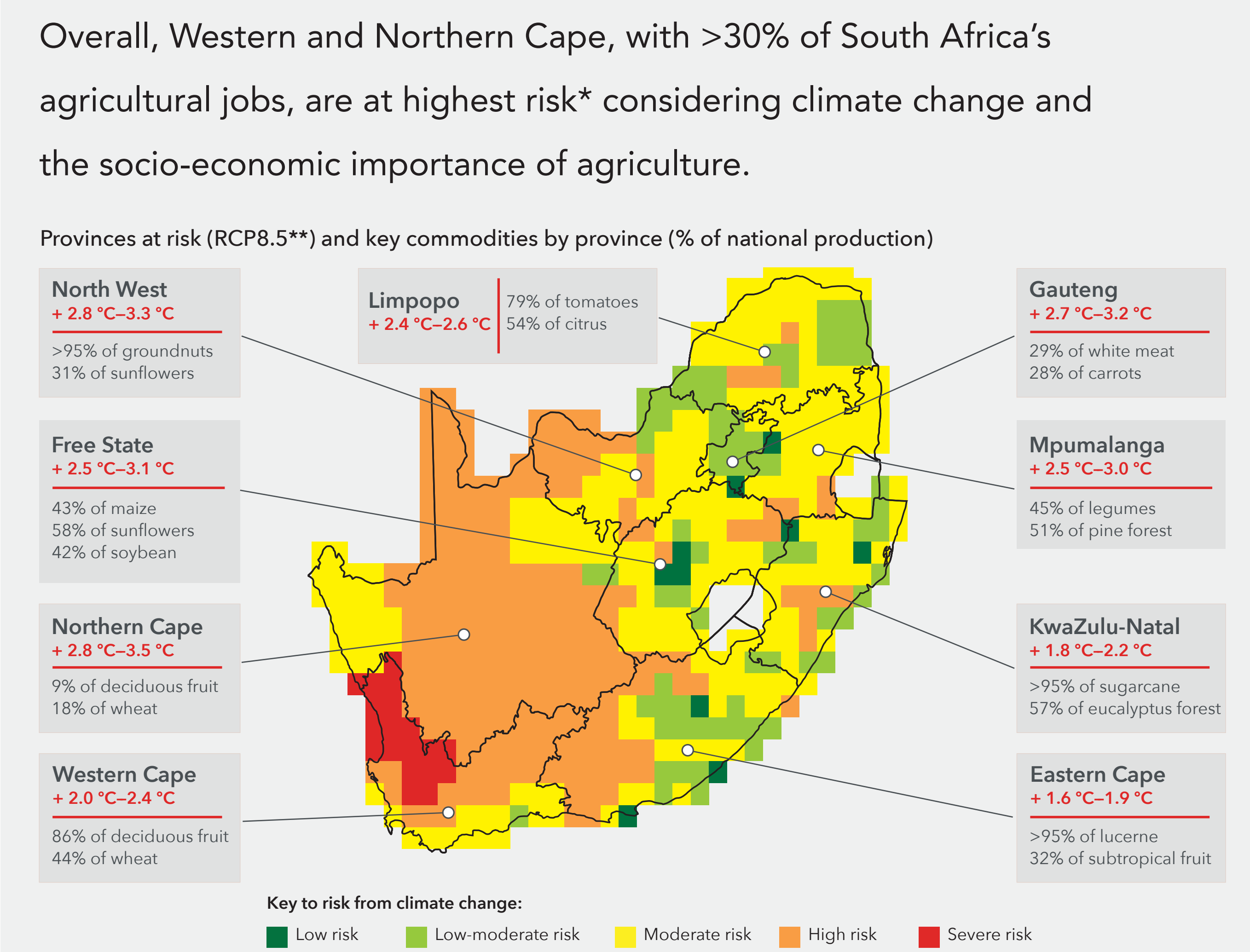
of total land area in South Africa in an RCP 8.5 scenario by 2050.

South Africa's most pristine grasslands, located within the warm temperature regions along the eastern escarpment, are to be almost entirely replaced with hot temperate and hot arid regions by 2050, with only parts of Lesotho retaining warm temperate zones. The Western Cape's unique fynbos regime is also likely to come under increasing pressure, with the intrusion of the hot steppe climate zone.[50]

Export earnings, farmworker and timber plantation worker livelihoods, and food availability are at risk, particularly in the Western and Northern Cape, which are expected to face the worst water stress, but also account for ~95% of South Africa's deciduous fruit exports, ~25% of national agricultural earnings, and ~35% of national agricultural employment.

50 Engelbrecht, C., Engelbrecht, F. 2015. *Shifts in Koppen-Geiger Climate Zones over Southern Africa in relation to key global temperature goals.*

Figure 14: High risk regions, such as the Western Cape and provinces in the northern interior are also key for production of staple crops, such as maize and wheat, and export earning, high labour-intensity crops, such as deciduous fruit



Notes: * 'Risk' defined based on relationship between projected climate change impacts on municipalities and the relative economic importance of agriculture to those municipalities.
** Relative to 1961–1990 baseline.

Source: CSIR, *Green Book*; Stats SA, *Census of Commercial Agriculture 2017*; LTAS Phase I; Department of Environmental Affairs, *3rd National Communication*; NBI-BCG analysis.

The lack of data and analysis around the climate risk for South Africa's AFOLU sector

Almost all geospatial studies of the impact of climate change on South African crop production have focused on single commodities, within a specific region. More studies that employ a uniform approach to project national production impacts across a broad range of commodities will be required in future. One of the few studies that provided a national, multi-commodity view of possible yield change was conducted as part of the Southern Africa – Towards Inclusive Economic Development (SA-TIED) project and employed an empirical modelling approach. In this study, national maize production was indicated to potentially experience yield changes ranging from a 30% decrease, to a 20% increase by 2050 (with a median value of a 3.5% decrease).[51] Such broad ranges make it difficult to ensure clear messaging to the AFOLU sector and government. However, select studies on a regional level do nonetheless provide a view on the production trends and challenges that key commodities are likely to face in South Africa as a result of the climate changes described in Section 3.2.3.

51 Cullis et al. 2015. *Southern Africa – Towards Inclusive Economic Development.*

Regions and commodities at highest risk of climate change impact

Drought events, fire hazards and pests are already challenging the AFOLU sector in South Africa and are likely to increase in frequency and intensity by 2050, driven by temperature increases and rainfall decreases. Agricultural production in cooler regions of northern Europe and southern South America may benefit from climate shifts, as areas previously too cold to produce fruits become climatically suitable, due to increased temperatures and better suited rainfall patterns. Conversely, regions, such as the Western Cape that are currently climatically suitable for high-quality deciduous fruit production, will be at risk of losing climatic suitability and thus the ability to produce export-worthy products if temperatures increase further.

Climate risk for field crops and horticulture production in South Africa

Production of most agricultural commodities is likely to decrease in South Africa by 2050, if significant adaptation does not take place, due to a combination of declining arable land area and decreasing yields. Figure 14 highlights key region-commodity interdependencies and the degree of climate and socio-economic risk that each region is expected to face. Key agricultural regions of the Western Cape, where water stress is already acute, are expected to see average rainfall decreases of more than 80 mm per annum by 2050 in a RCP 8.5 scenario. This puts ~95% of national deciduous fruit production (a key export earner) at risk, as irrigation reservoirs face decreasing replenishment, and ~44% of national wheat production at high risk with decreasing winter rainfall. Rainfall could decrease by over 80 mm per annum in large parts of Gauteng, North West, Limpopo and Free State provinces, and could be compounded by average temperature increases in excess of 3 °C in both RCP 8.5 and RCP 4.5 scenarios. This could increase evapotranspiration (potentially reducing the availability of water for crops in the soil) and could intensify heat stress.

Increasing temperatures are also linked to increases in pest life cycles, potentially rendering pests an even greater risk for livestock, crops and horticulture. These impacts could put ~45% of national maize production at risk in the Free State alone, and ~54% of national citrus and ~80% of national tomato production at risk in Limpopo alone. Although certain crops, such as soybeans, sunflowers and potatoes may see yield increases in the near- to mid-term due to increased atmospheric CO_2 , these gains may be reversed by 2050, as potential heat stress increases and potential rainfall and irrigation availability decreases persist. [52] [53] [54]

52 University of the Witwatersrand, Global Change Institute (GCI). 2021. *CMIP6 Ensemble Modelling.*

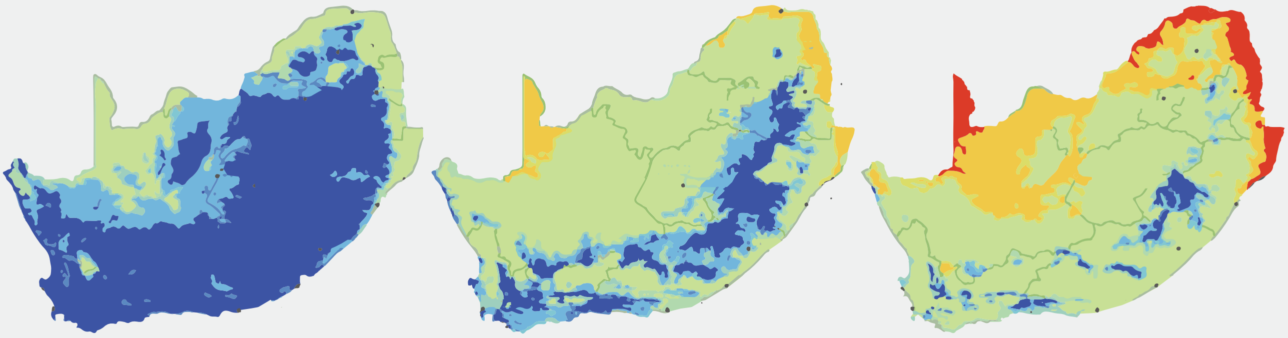
53 Statistics South Africa. 2020. *Census of Commercial Agriculture: 2017.*

54 Schulze. et al. 2017. *Handbook on adaptation to climate change for farmers, officials and others in the agricultural sector of South Africa.*

Figure 15: Projected changes to livestock suitability of South African land

Livestock vulnerability dependent on Temperature Humidity Index (THI), with significant adaptation required by 2050 and thresholds exceeded by 2100.

2020: baseline challenges	2050: adaptation required	2070: regions become unsuitable



2020: baseline challenges

- Decreased milk production in northern South African periphery.
- Dairy cows and sheep at higher temperature risk than beef cows and goats.
- >70% of agricultural income in North West and Gauteng dependent on livestock.

2050: adaptation required

- Livestock feed consumption decreases 3% for each 1 °C above 30 °C in northern interior.
- THI exceeds 72 in most parts of interior.
- Grazing capacity of rangelands may decrease >30%.
- Northern periphery becomes unsuitable for livestock.

2070: regions become unsuitable

- Feed consumption drops with ~6° C temperature increases in northern interior.
- Only small parts of escarpment optimal for dairy cattle and sheep.

Temperature Humidity Index value:
- <70 (Optimal)
- 70–72 (Performance reduces)
- 72–78 (Decreased milk production)
- 78–80 (Feed consumption drops)
- >80 (Unsuitable for livestock)

Source: CSIR, *Green Book*; LTAS Phase I; Department of Environmental Affairs, *3rd National Communication*.

Climate risk for livestock farming in South Africa

Livestock production could also be at increasingly high risk. Climate impacts could reduce livestock production-efficiency, placing additional strain on rural producers with limited access to the knowledge, capability and funding required to adapt to severe climate change. Potential temperature increases in the northern interior of the country could result in increased Temperature Humidity Index (THI) values (Figure 15).

By 2050, studies conducted by the Council for Scientific and Industrial Research (CSIR) indicate that most currently optimal livestock-rearing regions in South Africa (with THI values below 70) could be replaced by THI values between 72 and 78, leading to reduced milk production in dairy cows. In the northern periphery regions of South Africa, THI values may exceed 78 by 2050 in an RCP 8.5 scenario, leading to reduced feed consumption and higher mortality rates.[55]

Additionally, increasing temperatures could very likely result in increased pest and disease risk (especially tick and tick-borne diseases) and increasing competition for feed production (e.g., maize and soybean) could put pressure on intensive systems. However, extensive systems will also be challenged, as some studies project up to 30% decreases in rangeland grazing capacity by 2050 in an RCP 8.5 scenario. [56]

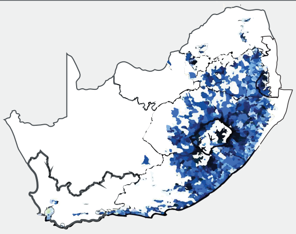
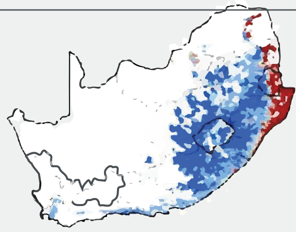
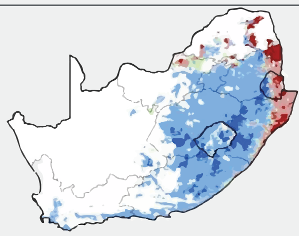
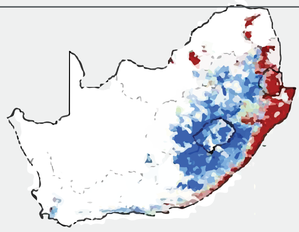
Climate risk for South African forestry

Most forestry production in South Africa is dominated by 10 corporate growers. These players have the capacity and knowledge to develop more resilient breeds and operations. The forestry sector could also benefit from

55 Council for Scientific and Industrial Research. 2018. *Green Book: Adapting South African settlements to climate change.*
56 Former Department of Environmental Affairs. 2013. *Long Term Adaptation Scenarios Flagship Research Programme: Phase 1.*

Figure 16: Projected changes to forestry yield by 2050

Yield decreases in current growing areas may be balanced by yield increases in inland regions, but uncertainty exists given constrictive water licensing.

	Key province/s	Key risks	2050 geographic yield change (t/ha/yr)	Yield sensitivity
Pinus patula	KwaZulu-Natal, Mpumalanga	Up to +3 °C (Mpumalanga) *Sphaeropsis sapinea* (very vulnerable after hail)		■ Moderate yield reduction in presently suitable areas ■ High yield increase in presently unsuitable areas
Pinus taeda	KwaZulu-Natal, Mpumalanga	Up to +3 °C (Mpumalanga) *Sphaeropsis sapinea*		■ High yield reduction in presently suitable areas ■ Moderate yield increase in presently unsuitable areas
Pinus elliottii	KwaZulu-Natal, Mpumalanga	Up to +3 °C (Mpumalanga) *Sphaeropsis sapinea* (less vulnerable than *patula*)		■ Low yield reduction in presently suitable areas ■ Low yield increase in presently unsuitable inland areas
Eucalyptus grandis	KwaZulu-Natal, Eastern Cape, Mpumalanga	Up to +2.3 °C (KZN) gall wasp, leptacybe invasion		■ High yield reduction in presently suitable areas ■ High yield increase in presently unsuitable inland areas

Yield change (t/ha/yr):

>1 t decrease | 0-1 t decrease | 0-1 t increase | 1-2 t increase | 2-3 t increase | 3-4 t increase | >4 t increase

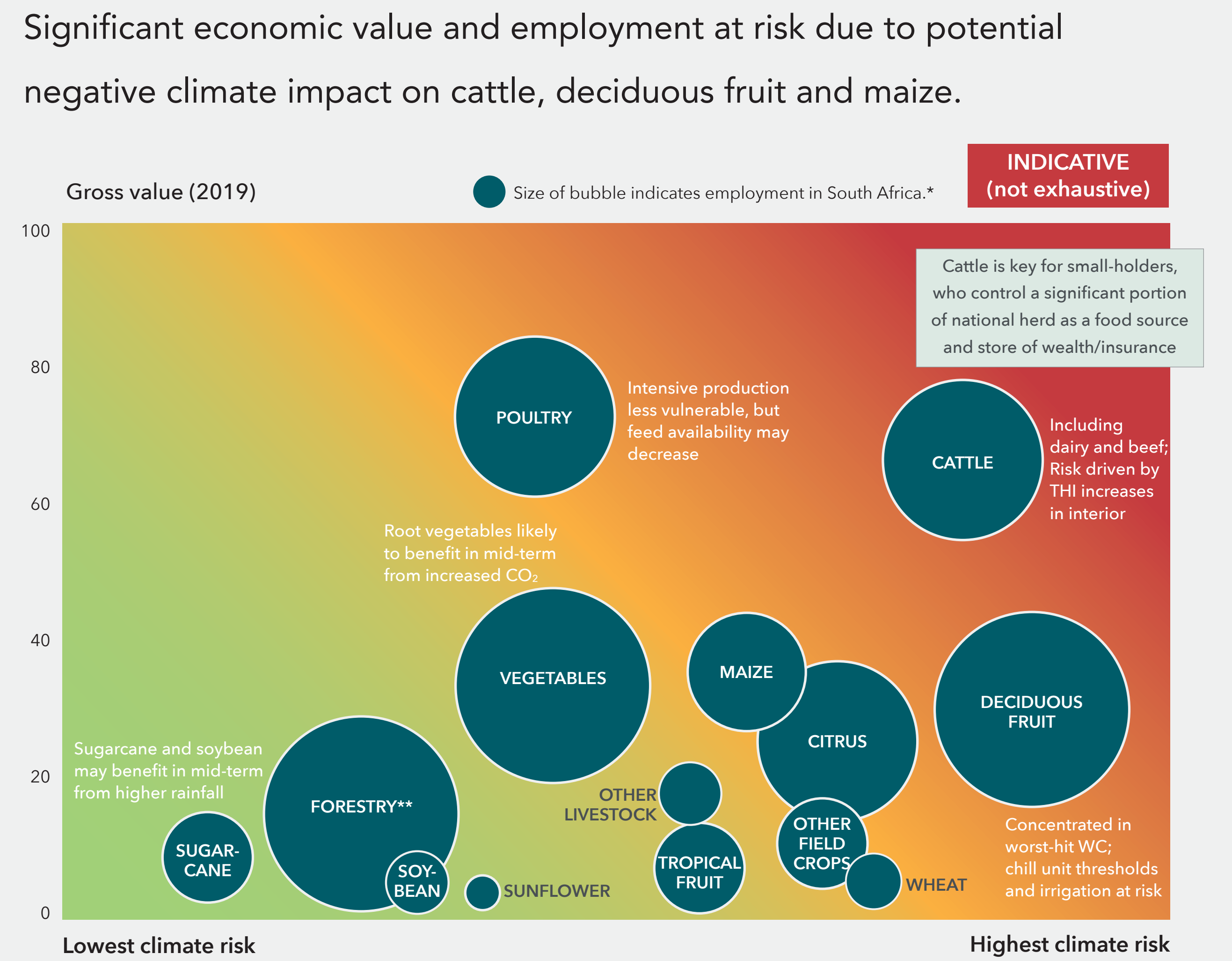
Source: SCSIR; Schulze et al., *Handbook on adaptation to climate change*; NBI-BCG analysis.

potentially lower temperature increases in KwaZulu-Natal, southern Mpumalanga and Eastern Cape than most interior regions of the country. In some modelling, optimal growing areas may expand inland before 2050, despite potentially reduced yields in current growing regions of KwaZulu-Natal, located closer to the coast (Figure 16).

The primary concern for forestry is the increasing risk of wildfires and pest invasion that would likely be brought upon by temperature increases and increasing heat wave risk (Figure 17). *Leptacybe invasa* or 'Eucalyptus gall wasp' risk is likely to increase with mean average temperatures (MAT) greater than 20 °C, extending from the KwaZulu-Natal coast to the midlands forestry regions of KwaZulu-Natal and forestry-dense regions of Mpumalanga, by 2050. Furthermore, fires have already damaged over 600 kha of forested area in South Africa since 1980. This could worsen as an increasing percentage of forested areas in inland KwaZulu-Natal and Mpumalanga are projected to fall under the 'very likely' fire danger rating, with increasing temperatures and decreasing rainfall. Restrictive national water licensing processes may also prevent planting area expansion.[57]

57 Schulze et al. 2017. *Handbook on adaptation to climate change for farmers, officials and others in the agricultural sector of South Africa.*

Figure 17: Climate risk faced by key commodities



Notes: Gross income and employment statistics only account for primary products (i.e., products that are consumed directly or sold for further processing).
* Excludes employment in mixed agriculture (~186 k jobs).
** Does not include jobs down the value chain, only primary stage.

Source: Stats SA, *Census of Commercial Agriculture*: 2017; Stats SA, *Abstract of Agricultural Statistics*, 2020; Forestry SA.

Although this analysis is constrained to a 2050 view of climate impact, it should be highlighted that trends towards reduced rainfall, increased temperatures and more frequent extreme weather events are projected to worsen beyond 2050 in both RCP 4.5 and RCP 8.5 scenarios, hence also resulting in higher climate risk to the AFOLU sector in the second half of the century.

3.2.4 THE NEED FOR A JUST TRANSITION IN THE AFOLU SECTOR

The impacts of climate change on agricultural production are already being felt by the South African AFOLU sector, and the vulnerability to extreme weather events of small-scale producers, farmworkers and timber plantation workers, and the sector at-large has already been displayed (see Case Study 1). This highlights the need for a coordinated, systematic, national effort to tackle the increasing climate challenge, with a focus on identifying and building resilience to climate impacts in the most at-risk municipalities and communities. Figure 18 highlights the commodities at highest climate risk in South Africa and the economic and employment contribution of each commodity. It should be inferred that almost all AFOLU commodities will be at some risk of reduced production volume and quality by 2050 if action towards more climate-resilient production is not taken. At particularly high risk are cattle, deciduous fruit and staple rainfed crops, such as maize and wheat. Cattle represent an important, culturally significant store of wealth and source of food security in rural communities across South Africa. However, this poses a risk, given the low adaptive capacity of a

CASE STUDY 1: THE IMPACT OF DROUGHT ON SOUTH AFRICA (2015/16)

A series of severe droughts in South Africa occurred during the summer seasons of 2014/2015 and 2015/2016, worsened by a very strong 2015/2016 El Niño.[59] Rainfall in South Africa in 2015 was the lowest on record and was ~34% lower than the 100-year average of 608 mm per annum.[60] The frequency of extreme drought events such as this is virtually certain to increase by 2050 in South Africa due to climate change.

Food availability and inflation impact:[61]

- The impacts on field crop production were immediate, given that ~83% of maize and ~53% of wheat in South Africa is rainfed. Between 2014 and 2016, annual maize and wheat production in South Africa decreased by ~50% and ~23%, respectively.
- Livestock production was impacted by shrinking suitable grazing area and lower availability of feed. Between 2015 and 2018, drought led to a 7% decrease in the size of the national herd. These effects were felt disproportionately by small-holders, with one study finding ~2 out of 5 cattle farmers in historic labour-sending regions were heavily affected by a single year of drought, versus 1 in 30 for commercial farmers.[62]
- The Consumer Price Index (CPI) for food increased 12.3% between 2015 and 2016, compared to 5.6% for all items, while producer prices rose 19% for agriculture and 40% for cereal crops specifically, over the same period.

Trade, earnings, and employment impact:[63]

- In 2016, maize exports were ~60% lower than the 10-year average, and maize imports shot up to 3.8 million tonnes (~50% of local production), resulting in an estimated ZAR4.7 bn and ZAR15 bn impact on the balance of payments, respectively.
- Overall, the value of agricultural production in South Africa dropped 11% between 2015 and 2016.
- The Western Cape alone saw a net loss of 40 000 jobs because of the drought (~5% of national agriculture employment).

Financial impact on farmers:[64]

- Between 2011 and 2018, agricultural debt as a percent of assets rose from ~25% to ~33%, a trend that has been exacerbated by drought. AgriSA estimated that the fiscal outlay required for drought interventions in the 2016/17 season (mainly subsidisation of feed purchasing and grants for at-risk small-holders) was ~ZAR16.6 bn in a worst case 6-month scenario.

As a result of the severity of this series of droughts, the National Agricultural Marketing Council (NAMC) recommended the establishment of:

1. A National Drought Management Commission to provide the government with a means of assessing drought conditions
2. A Disaster Fund and Public-Private Partnerships (PPPs) to establish forums for subsidised interest rates and extensions to the capital repayment periods for farmers
3. Multi-peril agricultural insurance to support existing insurance options to which government can contribute in the form of insurance subsidies
4. An Early Warning System (EWS) for extreme climatic events.

large proportion of the cattle ownership base of historic labour-sending regions.[58] Deciduous fruit production is at risk given its geographic concentration in the Western Cape, where existing water scarcity will be compounded by the highest rainfall reductions in the country, putting pressure on irrigation supplies, and temperature increases that are likely to affect the quality and thus exportability of produce, if not produced in higher altitude, cooler regions. Deciduous fruit not only accounts for a significant portion of agricultural export revenues but is also a key source of employment. Rainfed crops, which are key for food security, will also be at high risk, given their dependence on rainfall and their positioning in the central and northern interior of the country, which will see some of the worst rainfall decreases and temperature increases by 2050.

58 Meissner et al. 2013. *Sustainability of the South African Livestock Sector towards 2050 Part 2: Challenges, changes and required implementations.*

59 El Niño is a climate pattern that describes the unusual warming of surface waters in the eastern tropical Pacific Ocean, and which is known to affect weather patterns in South Africa.

60 South African Weather Service (SAWS).

61 AgriSA. 2019. *Impact of the drought on the agricultural sector.*

62 Quine et al. 2009.

63 National Development Agency (NDA). 2016. *Impact of drought on crop production and the food value chain.*

64 AgriSA. 2016. *AgriSA's status report on the current drought crises.*

The Just Transition risk is not limited to export earnings and livestock production in historic labour-sending regions. Approximately 150 000 emerging farmers and over 1.7 million household producers (or 'gardening households') operate within the historic labour-sending regions of South Africa. Less than 10% of household producers subsist on their produce and over 95% of maize and 99% of wheat cultivated in South Africa is produced by ~50 000 agro-industrial, commercial operations.[65] This suggests that the risk of securing the national supply of staple foods will fall on the relatively well-resourced commercial sector, rather than small-scale subsistence producers. However, household production still provides an important supplementary source of income and food to rural households and there are significant socio-economic barriers to effective adaptation in these settings. For example, over 80% of gardening households in South Africa rely on social grants for a portion of their income, the median income of gardening households is 26% lower than that of non-gardening households in the same area, and over 50% of gardening households do not own the land on which they produce.

Numerous agriculture-dependent communities across the country are also at high risk. Roughly 10% of South Africans reside in towns where agriculture contributes more than 10% of total income. In these agricultural communities, an average of 30% of employees are farmworkers and GDP per capita is 33% lower than in non-agricultural towns located in the same region. The vulnerability of farming communities is higher in historic labour-sending regions, where the employment rate is 2 times lower than in agricultural towns outside historic labour-sending regions. As a result, the impacts of climate change will be felt most acutely by municipalities, particularly in the Western Cape and Northern Cape, where highly agriculture-dependent local economies are met with harsh climate change impact. [66] [67]


Photo: Shutterstock.com

65 Statistics South Africa. 2020. *Census of Commercial Agriculture: 2017.*

66 Trade and Industrial Policy Strategies (TIPS). 2019. *National Employment Vulnerability Assessment: Analysis of potential climate-change related impacts and vulnerable groups.*

67 Trade and Industrial Policy Strategies (TIPS). 2020. *Sector Jobs Resilience Plan: Agriculture Value Chain.*

3.2.5 ADAPTING THE AFOLU SECTOR TO THE IMPACTS OF CLIMATE CHANGE

On a farm and timber plantation-level adaptation measures, such as climate-breed matching and fire and pest prevention systems can build resilience and production efficiency, and reduce emissions per unit produced. On a system-level, improved water-use monitoring and transmission infrastructure, data-backed agricultural and forestry water allocation, and accessible climate event monitoring will be critical to ensure climate resilience.

Given the significant climate risk the sector faces, this analysis does not just assess decarbonisation options for the AFOLU sector, but also aims to understand what measures need to be taken to build climate resilience. Figure 19 highlights the key adaptation measures that will be required in livestock, field crop, horticulture and forestry production to build resilience against climate change in South Africa. The core focus of these levers is to, on the one hand adapt to shifting local climates and environmental conditions, and – on the other hand – to improve the efficiency of agricultural and forestry systems, thereby reducing the amount of input (for example, feed, water, energy, or land) required per unit of output. This therefore also reduces the emissions produced per unit of product. Furthermore, as highlighted before, likely changes in temperature and rainfall patterns will result in the encroachment of the bush habitat into South Africa's most productive grassland regions – placing additional strain on, in particular, livestock and field crop production. This will require a coordinated bush clearing effort from both farmers and provincial land care programmes to minimise impact, but may also present an additional, economically-sustainable employment opportunity if cleared biomass is collectivised to be used as industrial feedstock.

Adapting agriculture (horticulture and field crop production) in South Africa

Water management: Horticulture and field crops (particularly irrigated field crops) share similar adaptation needs. Of particular concern for both will be the increasing constraints around water availability, requiring better, data-backed management and allocation of agricultural water supplies and improved irrigation system-efficiency (for example, using drip irrigation, irrigating at night, and applying mulch and plastic liners to retain soil moisture).

South Africa is a water-scarce country and agriculture consumes ~63% of the national groundwater supply (of which ~98% is already allocated each year). Given that South Africa has few exploitable aquifers and water is already overexploited in most regions of the country, there is little room for increased consumption – requiring farmers to increase yields per litre consumed. While clearing of alien plant species is estimated to be able to reduce total water use by up to 9%, the largest potential sources of water savings are in better management of water reserves and flows – with ~37% of potable water lost to leaks each year in South Africa.[68]

Cultivar development and selection: Furthermore, potential increases in temperatures and the likely higher risk of drought will require both sub-sectors to pursue the development and planting of more resilient cultivars that match local changes in temperature and rainfall patterns. The introduction of increasingly better suited cultivars has been crucial in driving significant yield gains in South Africa over the last 20 years, including a ~90% increase in maize yield per ha and a 43% increase in apple yield per ha, and will be increasingly important as climate impact worsens.[69] For example, grape varieties, such as Chenin Blanc, Pinotage and Colombard, show greater heat resistance, while switching to more heat resistance products, such as olives, pomegranates and millet may be increasingly required. Particularly for field crops, it will also be increasingly important to incorporate livestock to diversify and increase soil quality and promote the use of poorer soils to produce oats and fodder.

Pest management: Likely temperature increases and therefore likely increases in pest breeding cycles requires the implementation of shade and pest netting in conjunction with organic pesticides, particularly in horticulture, to preserve produce quality for export and reduce pest risk.

Driving adaptation will be particularly difficult for small-scale farmers. Commercial farmers in South Africa, who account for >95% of food production, closely resemble the well-capitalised, agro-industrial operations that dominate the United States (US) and European agricultural markets. Conversely, South Africa's small-scale and emerging farmers generally operate on small plots, and have limited access to markets, capital and knowledge of best practice irrigation and fertilisation. In this regard, small-scale farmers in South Africa share many of the same challenges to adaptation as emerging farmers in the rest of Sub-Saharan Africa.

68 Water Research Commission; Department of Water and Sanitation.
69 FAO. 2020.

A systems approach is required to develop competitive small-holder operations that can make a more meaningful contribution to national food security and build adaptative capability. Supply-side approaches to uplifting small-holder agriculture provide an immediate poverty alleviation and short-term political benefit. However, to create long-term, sustainable and adaptive food supply in rural areas, a combination of funding, capacity development (to ensure small-holder farmers have the knowledge and skills to implement and manage adaptation levers) and demand-side incentives must be pursued (further details are provided in Section 3.3.1).

Demand-side incentives include, for example, food retailers or corporate producers offering preferential market access or prices to small-scale farmers or foresters who implement the levers required to build climate-resilience (as shown in Case Studies 2, 3 and 4).

Grocery retailers such as Woolworths are driving a local push to build more resilient and sustainable food production systems by providing demand-side incentives, such as off-takes for sustainable operations and by enforcing regular evaluation of sustainability performance of suppliers (see Case Study 2).

CASE STUDY 2: WOOLWORTHS FARMING FOR THE FUTURE PROGRAMME

Woolworths is a South African retailer holding a ~4% grocery retail market share and a ~20% fresh fruit and vegetables market share. In 2009, the company established its Farming for the Future programme to address the challenges of water quality and scarcity, ecosystem and soil degradation, food security, climate change, and rising input costs amongst the retailer's 14 largest local, primary farming suppliers.

Programme governance:
The project is part of the company's broader Good Business Journey – a comprehensive plan for making a difference in sustainable farming and fishing, energy, water, waste, transformation and social development. This plan is monitored by the company's Sustainability Committee, which meets quarterly to oversee progress in the Good Business Journey programme. Sustainability is a strategic focus area for the business and is integrated into the strategic planning cycle, with each business unit being measured against Good Business Journey objectives twice per annum. A manager directs and oversees the programme, however, buyers and technologists communicate directly with suppliers.

Programme actions and objectives:
As a new supplier is added to the programme, Woolworths and the World Wildlife Fund South Africa perform a baseline audit and provide extension support to drive implementation of adaptation practices. Audits are conducted annually and track supplier performance in the following areas:

1. **Soil management**, for example, soil nutrient and carbon content status, erosion management, fertilisation practices, and substrate and run-off management.
2. **Water and biodiversity management**, for example, irrigation water use efficiency and water health, invasive species clearing, endangered species protection, and fire management.
3. **Pest and waste management**, for example, integrated pest and disease management, weed management, and farm and agri-industrial waste management.
4. **Cooling and energy management**, for example, energy use tracking, including in refrigeration, and continuous improvement programmes.

Initially, the suppliers are required to achieve a 50% mark to pass the audit, but this requirement increases with each successive audit, to ensure continuous improvement.

Key outcomes:
All of Woolworth's locally grown, fresh produce is now cultivated using Farming for the Future practices and the company is currently onboarding its horticulture and livestock suppliers.

- Within the first three years of programme participation, the following gains in environmental performance were measured amongst Woolworths' 15 largest fruit and vegetable suppliers (accounting for 37% of supply):
  - 20% reduction in synthetic fertiliser use, 3% increase in soil carbon storage, and ~50% decrease in the use of pesticides and herbicides
  - 16% drop in water usage, 18% drop in fossil fuel use, and 32% increase in recycling.
- Improved soil quality has reduced input costs for farmers without compromising yield, employment opportunities have been created through, for example, a switch from herbicides to manual weed management practices, and Woolworths is now able to market sustainable produce at lower prices and has improved the resilience of its primary suppliers to face the increasing threat of climate change.

While these adaptation levers are applicable across the spectrum from subsistence to large commercial farmers, certain sub-sectors will require greater support for widespread adaptation.

Adapting livestock farming in South Africa

Improved herd management: Preserving and increasing calving rates requires improved nutrition, appropriate stocking rates, carefully managed herd ratios and breeding, and culling selection and timing. The continued development and selection of the most well-suited breeds to each region will be crucial to effective adaptation.

Improved health management: Reducing mortality rates will largely depend on animal health and therefore improved parasite control procedures, complete vaccination and access to better quality feed. Maintaining the livestock vegetation base to ensure feed access will require management of bush encroachment, alignment between stocking rates and grazing capacity, reduced soil erosion and planting of drought-tolerant species (for example, Atriplex).

Livestock switches and intensification: In regions where THI values increase beyond thresholds, switches to more adapted or indigenous breeds or to hardier species, such as goats, may be required, while sustainable intensification offers greater control over the production process (The trade-offs associated with livestock intensification in South Africa are discussed in the 'Deep-dive: The potential role of livestock production intensification in decarbonising AFOLU').

Adapting forestry in South Africa

Lastly, forestry will require a focus on the development of hybrid breeds and clonal selection, focusing on increased water-efficiency, drought and fire-tolerance and disease-resistance. Species, such as *Pinus patula, Pinus taeda* and *Eucalyptus grandis* will be at greatest risk in the long-term, while more resilient species, such as *Pinus ellioti* and *Acacia mearnsii* will likely fair better, as will hybrids such as *Eucalyptus grandis x urophylla*.

Adapting to increased pest risk: Proper species-site matching, planting stock from a broad genetic base, diversifying species in timber plantation programmes, and increased deployment of biological, chemical and

CASE STUDY 3: SAPPI KHULISA PROJECT

As in agriculture, a combination of demand-side incentives and capacity development will be critical to enable small-scale forestry producers to build resilience. Some corporate forestry companies in South Africa are using their resources to support this effort and, in doing so, bolster the resilience of their own operations.

Context:
SAPPI is a South African pulp and paper company with global operations, and is the world's largest producer of dissolving pulp. In 1983 the company started the SAPPI Khulisa tree-growing scheme with the objective of supporting subsistence farmers with 1–20 ha of land to become profitable players in the forestry value chain. In doing so, the company aims to enhance its own fibre supply, create sustainable sources of employment and develop entrepreneurship in rural communities.

Strategy:
The Khulisa Project is the focus of the company's enterprise development strategy and has been scaled using a structured approach:

1. Small-scale growers are provided with resilient seedlings that match local climates, an interest free loan to cover input costs, and a dedicated team of foresters who provide extension support to ensure best-practices are applied.
2. SAPPI secures a market for growers to sell timber into, at market-related prices.
3. Growers receive advances for the work conducted over the 8–10 year growing cycle.

In addition, SAPPI encourages the formation of 'growing clusters' between the range of stakeholders to maximise opportunities in the value chain, and has established training centres and resources that cover topics from cultivation to business development.

Outcomes:
The project now covers over 3 600 growers (~10–15% of the estimated small grower population in South Africa), working over 32 000 ha of land and creating 1 100 indirect jobs and 103 Small, Medium and Micro Enterprises to support the SAPPI Khulisa value chain. Since 1995, ZAR2.7 bn worth of timber has been delivered by Khulisa growers, with ZAR232 mn worth being delivered to SAPPI in 2020 alone. SAPPI have also been recognised as a leader in supplier development.

Figure 18: Key farm-level adaptation levers

Climate action in AFOLU requires integrated mitigation and adaptation to grow the sector's resilience.

ADAPTATION

Field crops / **Horticulture**

1. Improve **irrigation systems** and **water management**
2. Develop and plant **temperature-, drought- and pest-resilient cultivars**
3. Implement **pest netting and organic pesticides**

Forestry

4. Deploy climate and **pest-resilient hybrids and diversify tree species**
5. Implement **fire and pest management practices** (e.g., fire breaks, trimming and active forest health monitoring)

Livestock

6. **Sustainable intensification**
7. **Improved herd management**: selective breeding and culling, genetic selection of lower emissions specimens, switching to hardier breeds/animals
8. **Improved health management**: deploy parasite control, vaccinations, improved feed
9. Explore and deploy **alternative protein sources or new production methods** (e.g., lab-grown meat, fish protein, etc.)

All sectors

10. Assess land changes and shift to **more suitable areas where possible**
11. Develop and deploy **extreme weather event management systems**

Source: NBI-BCG analysis.

mechanical controls, such as salvage or removal of infested trees, will all be crucial to increase pest-resilience.

Adapting to increased fire risk: Controlled burning to create buffer strips, reactive fire-fighting at high risk locations, and more intensively managed forest landscapes, will be required to deal with likely increases in high fire danger days in forestry areas. Greater investment will also be required in forest monitoring to ensure that any fires are detected at an early stage and that the equipment and water required to extinguish them before they spread, is speedily available.

Overall, improved monitoring and management of extreme weather events, and assessment of changes to land suitability will be required. However, a restrictive water licensing process may limit the forestry sector's ability to make required land shifts. This issue requires proactive engagements between the forestry sector and government in relation to long-term planning related to water availability and licencing.

> ***To enable effective adaptation, it will be critical to build more capacity among farmers and growers, and to improve and expand agricultural and forestry extension services – this would require a doubling of AFOLU-related research and development (R&D) spending in line with the National Development Plan (NDP) targets, roll-out of demand-side incentives, such as market access in exchange for resilient practices and deployment of blended finance mechanisms.***

3.2.6 DECARBONISING THE AFOLU SECTOR

The required adaptation measures will not just build resilience towards a changing local climate, but also drive emission reduction. However, to fully decarbonise the AFOLU sector, which is the fourth largest contributor of emissions to South Africa's national emissions (after power, petrochemicals and chemicals, and transport) further mitigation action needs to be pursued.

Roughly 73% of direct (Scope 1) AFOLU sector emissions in South Africa are a result of livestock cultivation. Almost half of direct AFOLU emissions (46%) come from enteric fermentation, the release of methane (CH_4) from ruminant animals, primarily cattle, during digestion. Methane is also released during the decomposition of livestock manure, contributing a further ~4% of Scope 1 AFOLU emissions. Another 23% of Scope 1 AFOLU emissions come from the conversion of animal urine deposits on pasture into nitrous oxide (N_2O). The remaining 27% of Scope 1 AFOLU emissions in South Africa come from synthetic and organic fertiliser application (14%), the combustion of fossil fuels in farm and timber plantation equipment and burning of biomass (9%), nitrous oxide release from crop residue and the mineralisation of nitrogen fertiliser (4%).[70] Over 80% of fertiliser emissions and over 95% of crop residue emissions are estimated to originate from field crops as opposed to horticulture and forestry.[71]

Unlike other sectors, AFOLU contributes a carbon sink component to the emissions baseline. For example, grassland and land converted to grassland contributes a carbon sink of 15.6 Mt CO_2e, whereas 'other land' and land converted to 'other land' contributes positive emissions of 13.5 Mt CO_2e (Figure 19). This is primarily due to grassland being converted to 'other land', whereby the carbon storage potential of the 'other land' type is lower than that of grassland. The progression of South Africa's natural carbon sink will in part depend on natural resource protection, restoration and prudent land management. In South Africa in particular, responsible land management in the beef cattle production sector will be key to ensuring healthy soils with active microbial life, accelerated grass growth to ensure sufficient grass cover and good land management (including appropriate stocking rates).[72] When direct emissions and land change and land use emissions are considered in combination, the AFOLU sector's emissions contribution decreases to ~18 Mt CO_2e per annum (~4% of the national baseline). However, in this study, no conclusion is drawn around whether carbon sinks should be assigned to the AFOLU sector.

The AFOLU sector accounts for ~10% of national emissions – driven by livestock (75%), fertiliser use (18%) and fuel combustion (7%) – and adaptation measures taken in the sector could drive some emission reduction. However, significant emissions remain and to fully decarbonise the sector, dedicated mitigation levers need to be deployed.

a. ***In light of a growing population, food demand could grow by ~50% by 2050, causing the AFOLU emissions baseline to grow by ~40% if current, nutritionally-inadequate diets are maintained, or shrink by ~37% if sustainable (low red meat), diverse, and nutritionally-balanced diets are adopted.***

b. ***Regardless of diet progression, ensuring farming and forestry best practice reduces emissions and builds resilience. Best practice livestock health, feed, manure, and breeding management can eliminate ~19% of annual emissions, while sustainable land and fertiliser management, and integration of renewable energy to meet energy demand can eliminate 17% and 19% of annual emissions, respectively.***

c. ***However, with farming and forestry best practices implemented, by 2050 emissions can only be reduced by ~40% versus the 2017 baseline with current diets, and by ~70% with sustainable, healthy diets, leaving 16–39 Mt CO_2e/a in residual emissions that would need to be addressed using new and more disruptive levers, such as hydroponics, and in the more distant future lab-grown meat.***

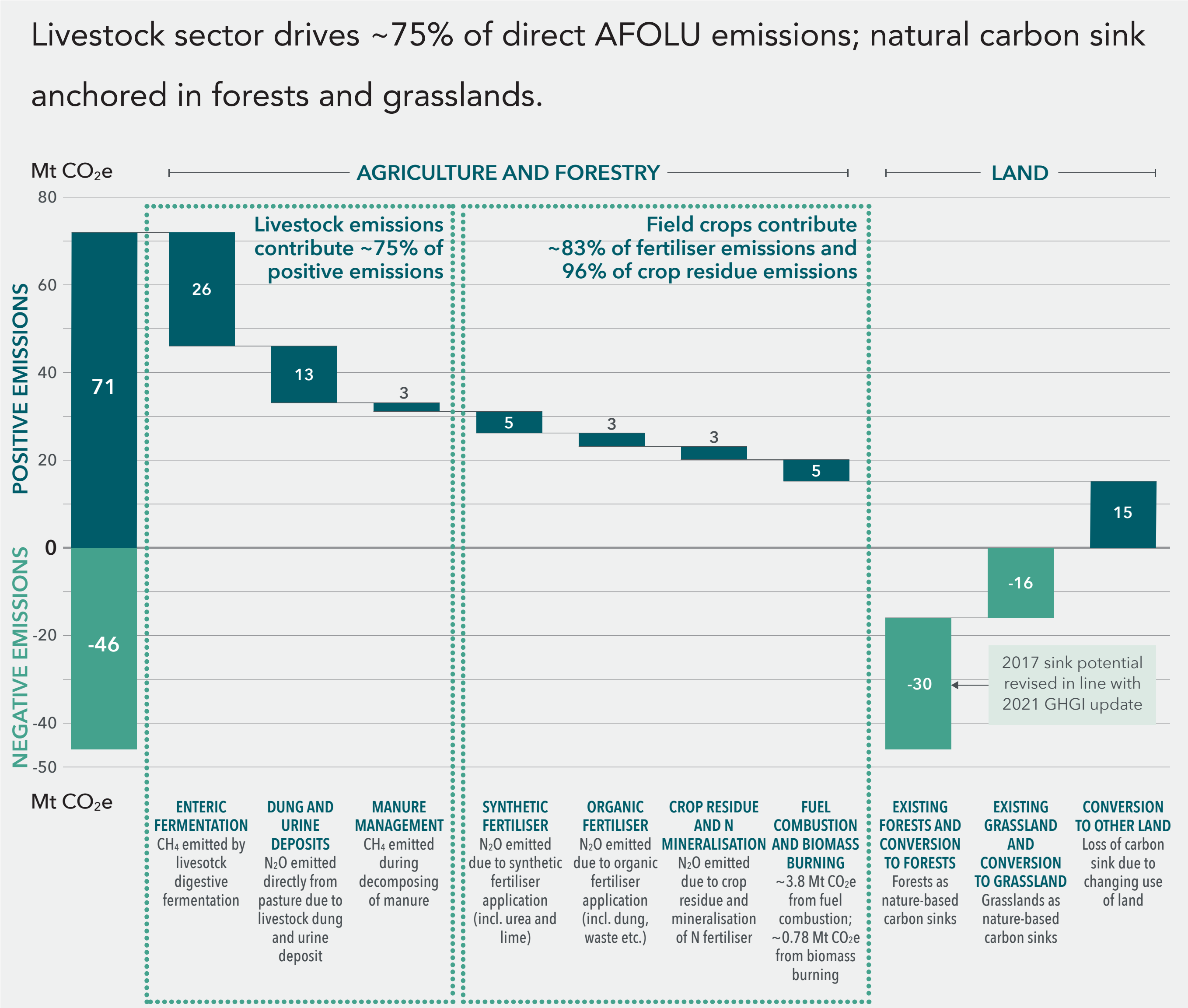
The AFOLU sector only contributes ~7 Mt CO_2e per annum from grid electricity use (Scope 2 emissions), or the equivalent of ~13% of the sector's Scope 1 emissions. Electricity usage is the only major emissions source from the forestry sector, which contributes ~1.4 Mt CO_2e in Scope 2 emissions. This excludes biomass-based self-generation of electricity in the forestry subsector. However, this is considered a renewable energy source,

70 Department of Forestry, Fisheries, and the Environment (DFFE). 2021. *National Greenhouse gas (GHG) Inventory Report, 2017.*

71 Estimated using emissions ratios from Tongwane et al. 2016. *Greenhouse Gas Emissions from Different Crop Production and Management Practices in South Africa.*

72 Blignaut et al. 2021. *An integrative bio-physical approach to determine the greenhouse gas emissions and carbon sinks of a cow and her offspring in a beef cattle operation.*

Figure 19: AFOLU emissions and sinks breakdown for South Africa



Notes: Synthetic fertiliser emissions split based on crop system emissions estimations by Tongwane et al. (2016).

Source: DFFE, GHG Inventory 2000–2017.

so long as the biomass consumed is regrown to ensure that the same amount of carbon is stored.[73]

A unique feature of the AFOLU emissions baseline is the prominence of greenhouse gases other than CO_2, primarily, CH_4 and N_2O. Figure 21 groups Scope 1 and Scope 2 AFOLU emissions according to emissions gas type – 45% of Scope 1 and Scope 2 AFOLU emissions are from CH_4, driven by livestock; 35% from N_2O, driven primarily by a combination of livestock and fertiliser use; and just 19% from CO_2, driven primarily by energy consumption. Here, all emissions are normalised using the CO_2-equivalent (CO_2e) measure, however, it should be noted that CH_4 and N_2O have global warming potentials (GWP) 25 times and 300 times that of CO_2, respectively, making them significantly more potent and important drivers of global warming.[74]

Emission baseline projections of AFOLU emissions with diet and population change

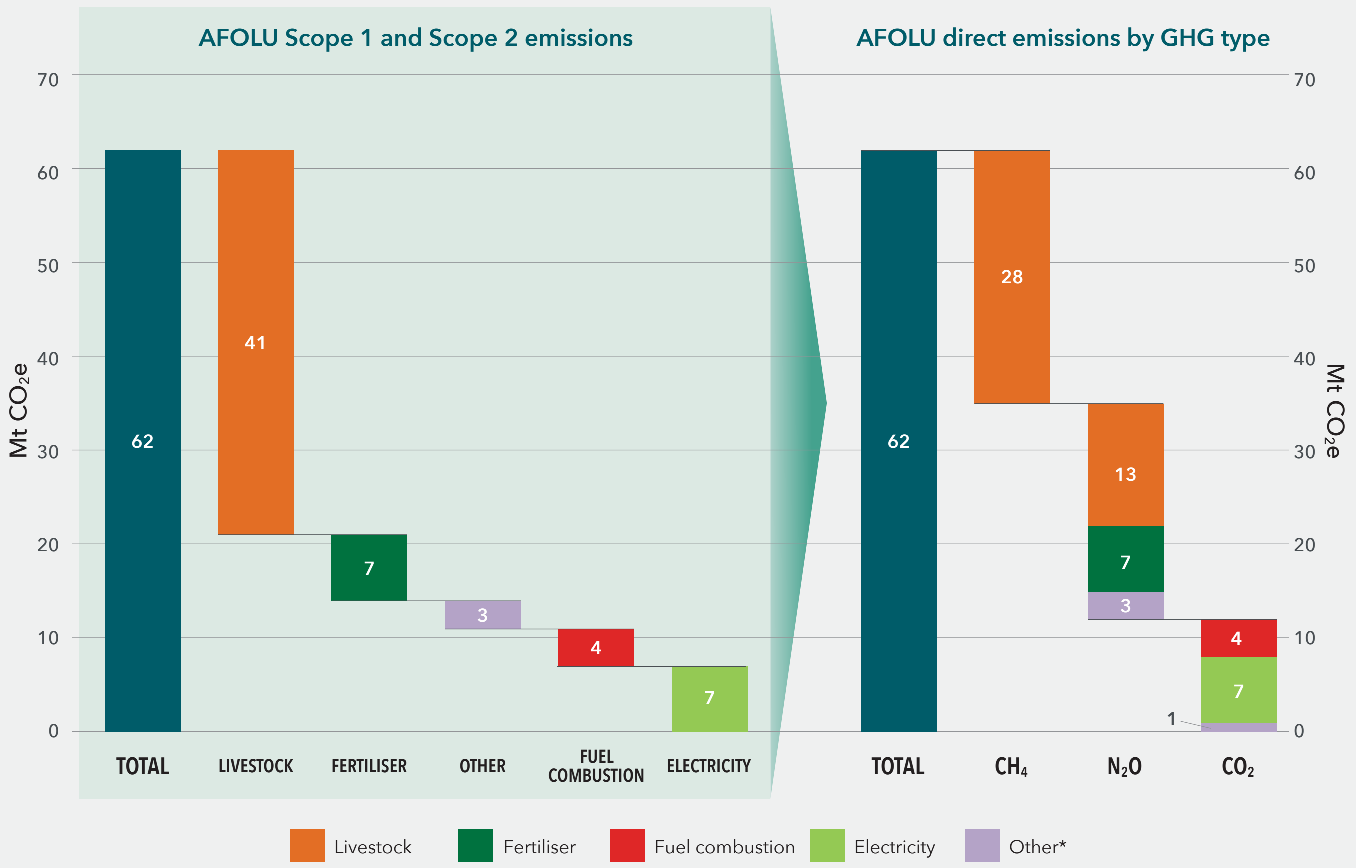
It is important to understand how emissions from the AFOLU could change, if the need to meet future demand – particularly food demand in the light of growing populations – is considered. The AFOLU emissions baseline for Scope 1 and Scope 2 emissions was projected

73 Department of Mineral Resources and Energy (DMRE). 2018. *Commodity Flow and Energy Balance.*

74 United States Environmental Protection Agency (EPA).

Figure 20: AFOLU Scope 1 and Scope 2 emissions breakdown by emission type

Today's AFOLU sector direct emissions are mainly (~80%) comprised of methane and nitrous oxide emissions.



Note: *Includes biomass burning, crop residue emissions and N mineralisation emissions.

Source: NBI-BCG analysis.

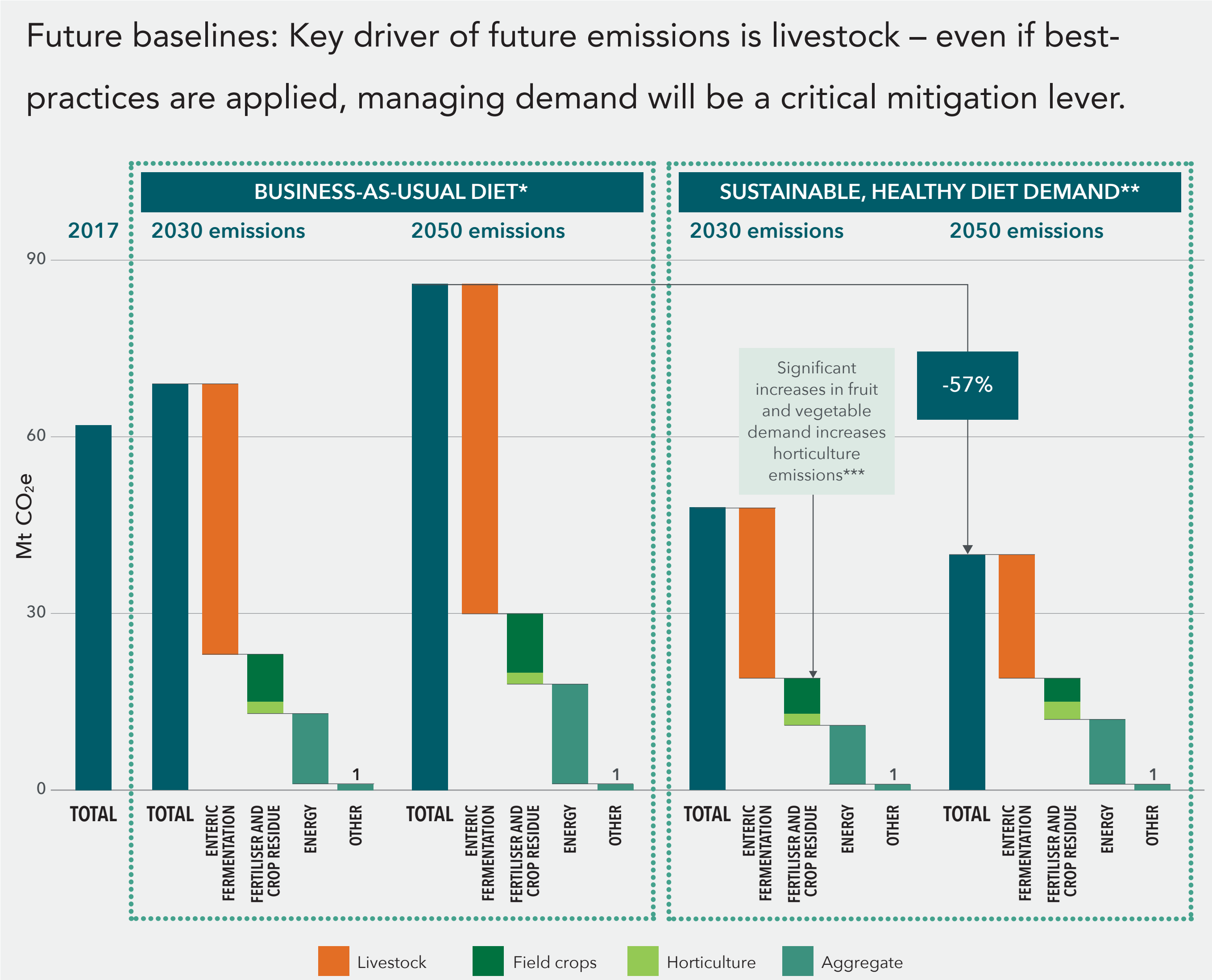
to 2050 in line with the *business-as-usual diet* and *sustainable, healthy diet* scenarios (described in Section 3.2.2). These scenarios take into account different diet progressions, but both assume the same population and income growth to 2050.

If the *business-as-usual diet* scenario is followed, AFOLU emissions will increase ~39% by 2050 versus the 2017 baseline (Figure 22). This increase is driven primarily by a 37% increase in livestock emissions, while fertiliser emissions only increase 14%, owing to reduced starchy staple consumption per capita as incomes rise. In contrast, a *sustainable, healthy diet* scenario results in a 37% decrease in AFOLU emissions by 2050 versus the 2017 baseline, and a 57% decrease versus the 2050 baseline for the *business-as-usual diet* scenario. This reduction is driven by a halving of livestock emissions versus the 2017 baseline, in line with the lower red meat consumption requirements of the sustainable diet. Although consumption of horticulture produce, including fruits and vegetables, increases 3–4 times in the *sustainable, healthy diet* scenario, this only translates into a 1.1 Mt CO_2e increase in fertiliser emissions from horticulture production. This is due to the low emissions intensity of horticultural production compared to that of livestock and, to a lesser extent, field crops. These results indicate that ~50% increases in local food demand can be met while still significantly reducing sector emissions and improving health if diet changes are driven.

Key decarbonisation levers deployed on the farm and timber plantation-level

Although diet change provides the largest emission reduction potential of any lever, its application in South Africa will be complex from a policy, behavioural and cultural perspective. Regardless of diet progression, there are several technology and farming and forestry best-practice levers that can improve production efficiencies and significantly reduce emissions per tonne of product.

Figure 21: AFOLU emissions baseline projections to 2050 with diet shifts



Notes: * Food demand scales with population and eating habits shift towards more red meat and less grain as the middle class in SA grows.
** Lancet-EAT healthy/sustainable diet adopted, reducing meat and grain demand and increasing fruit and vegetable demand significantly.
*** Although emissions intensity for these products is low – reducing overall impact.

Source: NBI-BCG analysis.

Disaggregation of baseline emissions

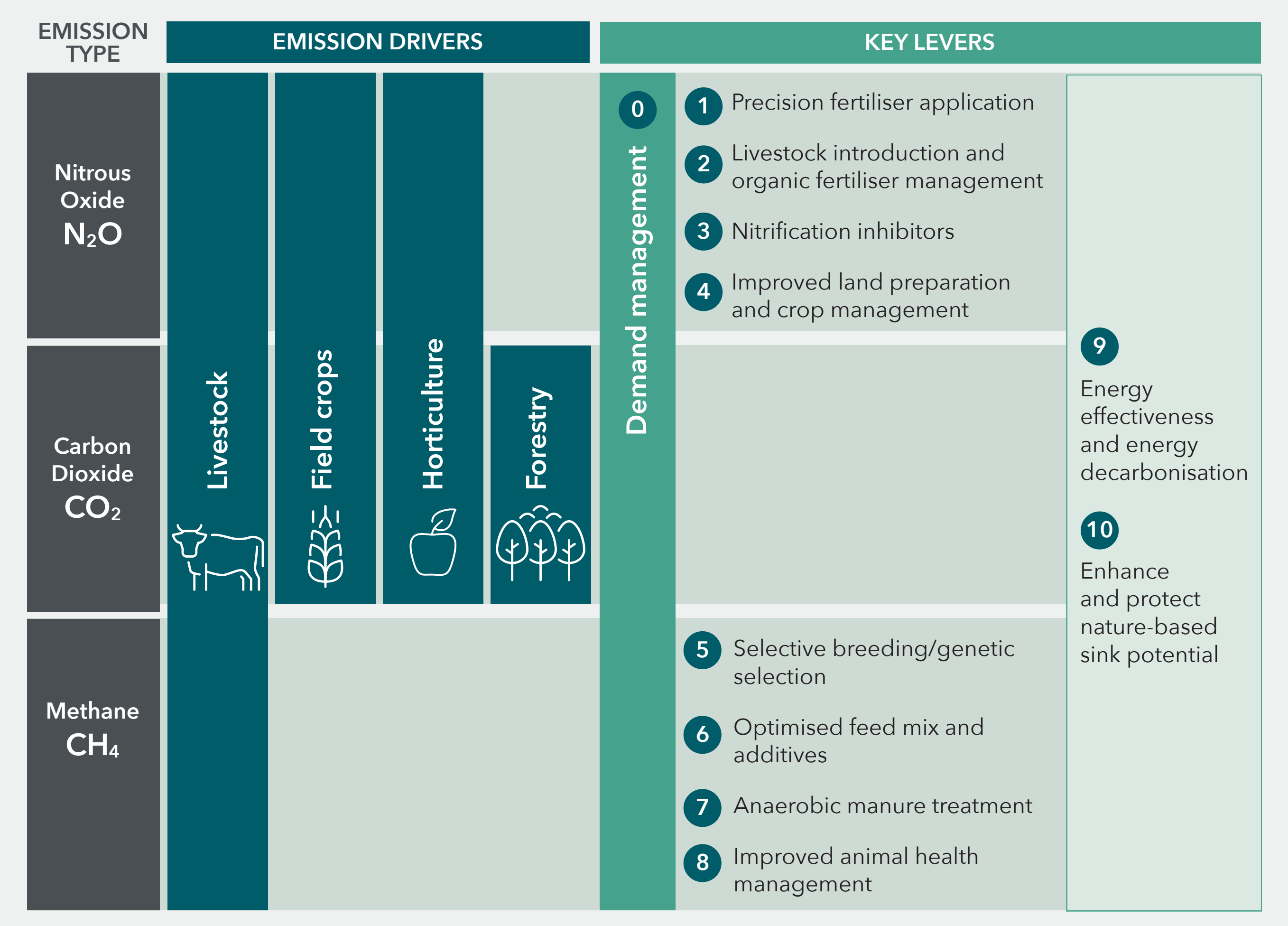
The top-down methodology used to disaggregate the 2017 emissions baseline by commodity (allowing emissions to be projected using commodity demand change values from the 2050 diet scenarios) is described below:

Livestock emissions: The Greenhouse Gas Inventory (GHGI) provides disaggregated enteric fermentation and manure management emissions by livestock type. Pasture deposit emissions were disaggregated by commodity by assuming the same percentage split as for enteric fermentation emissions.

Crop residue, nitrogen mineralisation and fertiliser emissions: Crop residue emissions were disaggregated by commodity, using crop residue emissions estimations from Tongwane et al. (2016), and nitrogen fertiliser emissions were disaggregated by commodity using nitrogen fertiliser consumption data from the Fertiliser Society of South Africa (FSSA).

Energy emissions: Fuel combustion and electricity use emissions are disaggregated into 'agriculture' and 'forestry' using National Energy Balance data (Department of Energy). Agriculture energy use emissions were then disaggregated by commodity using the relative income contribution of each commodity.

Figure 22: Demand-side and farm and timber plantation-level mitigation levers must both be implemented across the key commodity buckets to address all emissions sources



Source: NBI-BCG analysis.

Figure 22 summarises the key farm and timber plantation-level levers that can be implemented to address each emissions type in the South African AFOLU sector.

When considering the abatement potential of levers applied in isolation, it should be noted that emission reduction potential from multiple levers applied to the same operation cannot simply be superimposed to calculate the total emission reduction potential for an operation.

Nitrous oxide abatement: The reduction of N_2O emissions requires reducing the amount of fertiliser applied, reducing the emissions intensity of the fertiliser that is applied, and treating livestock deposits on pasture. Targeted application of fertiliser, fertiliser-free zones, and tissue testing to determine optimal nitrogen application can reduce N_2O fertiliser emissions by up to 26%.[75] Best-practice application of organic fertiliser (e.g., ensuring the correct consistency) and the introduction of livestock to crop systems can reduce N_2O fertiliser emissions by up to 14%. Combining low-disturbance preparation of land (low or no tillage), crop cycling with nitrogen-fixing crops (such as legumes), and use of fertiliser-efficient crop breeds improves soil quality and can reduce N_2O fertiliser emissions by up to 20%. If all fertiliser and crop management levers are deployed appropriately, fertiliser N_2O emissions can be reduced by a total of ~47%. Lastly, livestock dung and urine deposits on pasture can be treated with nitrification inhibitors to reduce the release of N_2O by up to 38%.[76]

Methane abatement: Reducing CH_4 emissions is largely rooted in improving livestock production efficiencies and health to maximise the amount of product from each animal, while minimising their emissions intensity.

75 ?????
76 Akiyama et al., 2010; Dickie et al. 2014.; Graus et al., 2004; Bates et al., 2009; Moran et al., 2008.

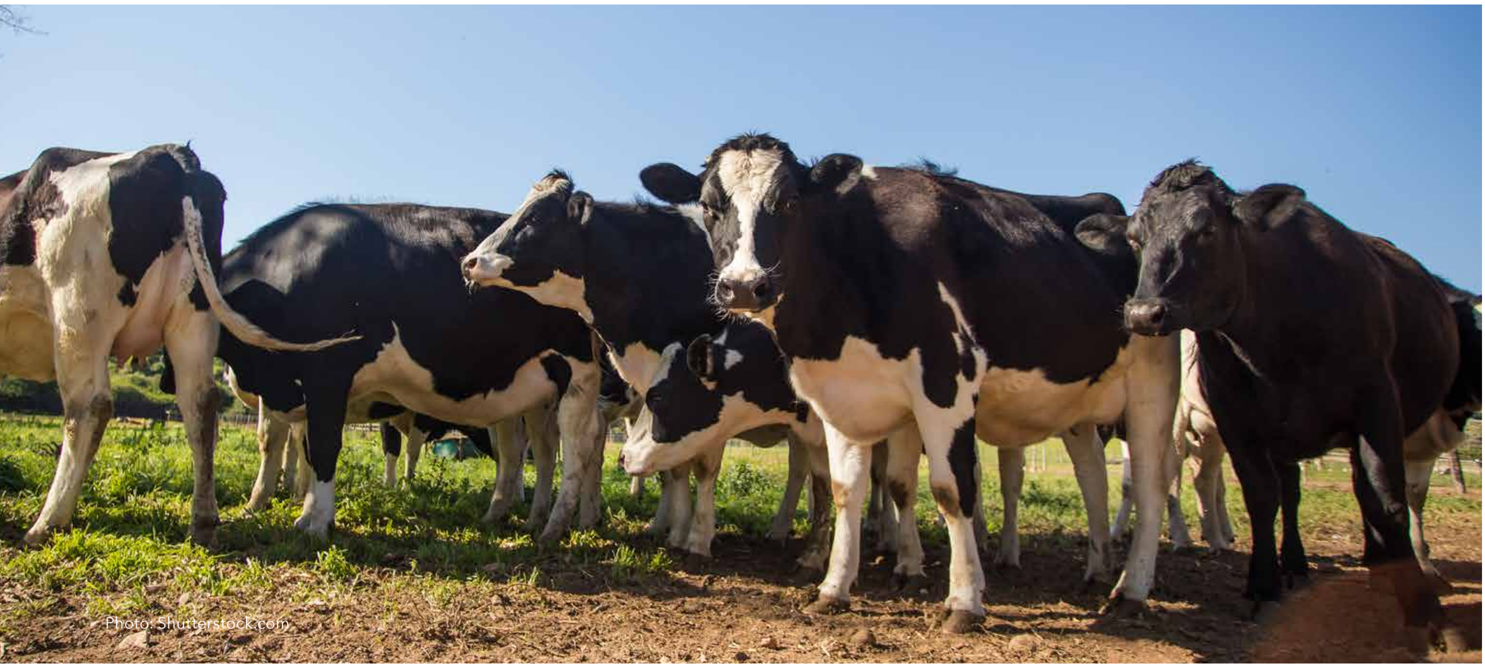
Ensuring that animals receive all required vaccinations and are subject to regular health checks can reduce enteric fermentation CH_4 by up to 10%. Ensuring fine processing of feed and using appropriate supplementation in feed can reduce enteric fermentation CH_4 by up to 14%. The use of indigenous genotypes that are adapted, selective breeding and genetic selection of livestock, in favour of lower emissions-intensity specimens that are better suited to local ecosystems, can reduce enteric fermentation emissions by up to 21%. In combination, implementation of livestock production best practices can reduce enteric fermentation CH_4 by a total of ~41%. Lastly, deployment of anaerobic digestors to effectively manage livestock manure can reduce manure management CH_4 emissions by up to 50–75%.[77]

Carbon Dioxide abatement: Given that fossil fuel use accounts for most CO_2 emissions in the AFOLU sector, these emissions can be fully eliminated. Applications already using electricity as the primary energy source (e.g., sawmills or production lines) could be switched to a renewable energy supply, including biomass-based energy. Tractors, harvesters and other heavy mobile machinery could be converted to battery electric vehicles (BEVs) or fuel cell electric vehicles (FCEVs), depending on the operational requirements of the machine. Lastly, fossil fuel powered stationary machinery, such as irrigation pumps or dryers can be electrified. Handheld equipment, such as chainsaws, may be also electrified, with cordless electric variants already on the market.

AFOLU sector emission reduction potential

While international studies have been performed to determine the emission reduction potential of various combinations of farm and timber plantation-level levers, no such studies have been performed on a large-scale in South Africa. While this analysis employs emission reduction potentials determined through credible, international studies, a unified research effort is required in South Africa to provide local emission reduction potentials to inform policy-making and investment.

Regardless of diet progression, farm and timber plantation-level levers addressing N_2O, CH_4 and CO_2 emissions can reduce the 2050 AFOLU baseline emissions projection by 55%. This means that, if a *business-as-usual diet* scenario is followed, and all farm and timber plantation-level levers are pulled, AFOLU Scope 1 and 2 emissions can be reduced by ~37% versus the 2017 baseline. Conversely, if those same farm and timber plantation-level levers are pulled, but a *sustainable, healthy diet* scenario is followed, AFOLU Scope 1 and 2 emissions can be reduced by ~74% versus the 2017 baseline (Figure 25). This range aligns with the Intergovernmental Panel on Climate Change (IPCC) benchmark, which sees AFOLU Scope 1 and 2 emissions declining by ~50% versus the 2017 baseline. Significant residual emissions are likely to remain in either diet scenario. By 2050, 39 Mt CO_2e per annum are still produced in the *business-as-usual diet* scenario, and 16 Mt CO_2e in the *sustainable, healthy diet* scenario. Cumulatively, AFOLU emissions over the 2020–2050 period will therefore range from 0.92 – 1.41 Mt CO_2e.



77 Eory et al., 2016; Hristov et al., 2013.; Bell et al., 2010.; Graus et al., 2004.

Assessment of emission reduction potential: Approach and key assumptions

As indicated in Figure 23, national AFOLU emissions were projected, in both *business-as-usual diet* and *sustainable, healthy diet* scenarios, in line with aggregate lever emission reduction potentials from a range of studies performed in various climates and operational contexts.

To provide a benchmark for result validation, IPCC Integrated Assessment Modelling (IAM) national AFOLU decarbonisation pathway targets were applied to South Africa's emissions baseline. These targets included, by 2050, a 30% N_2O emissions reduction, a 50% CH_4 emissions reduction, and a 100% CO_2 emissions reduction.

Figure 23: Analytical approach for top-down AFOLU emissions assessment

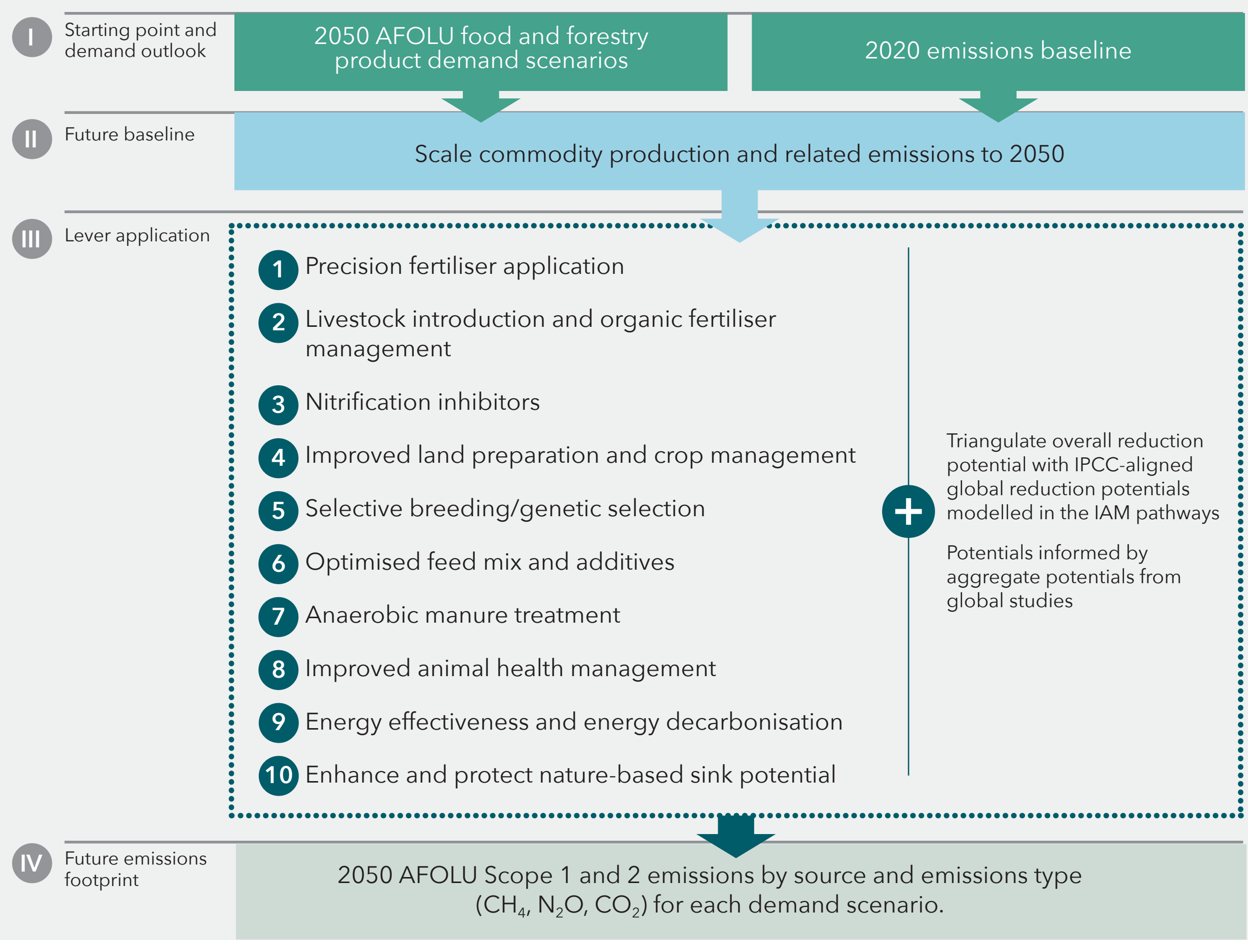
Emissions modelling assumptions, boundary conditions and logic

Boundary conditions

- No change in structure of South African agricultural industry:
  - Export as a percentage of production remains constant.
  - Proportion of local demand met by local production remains constant.

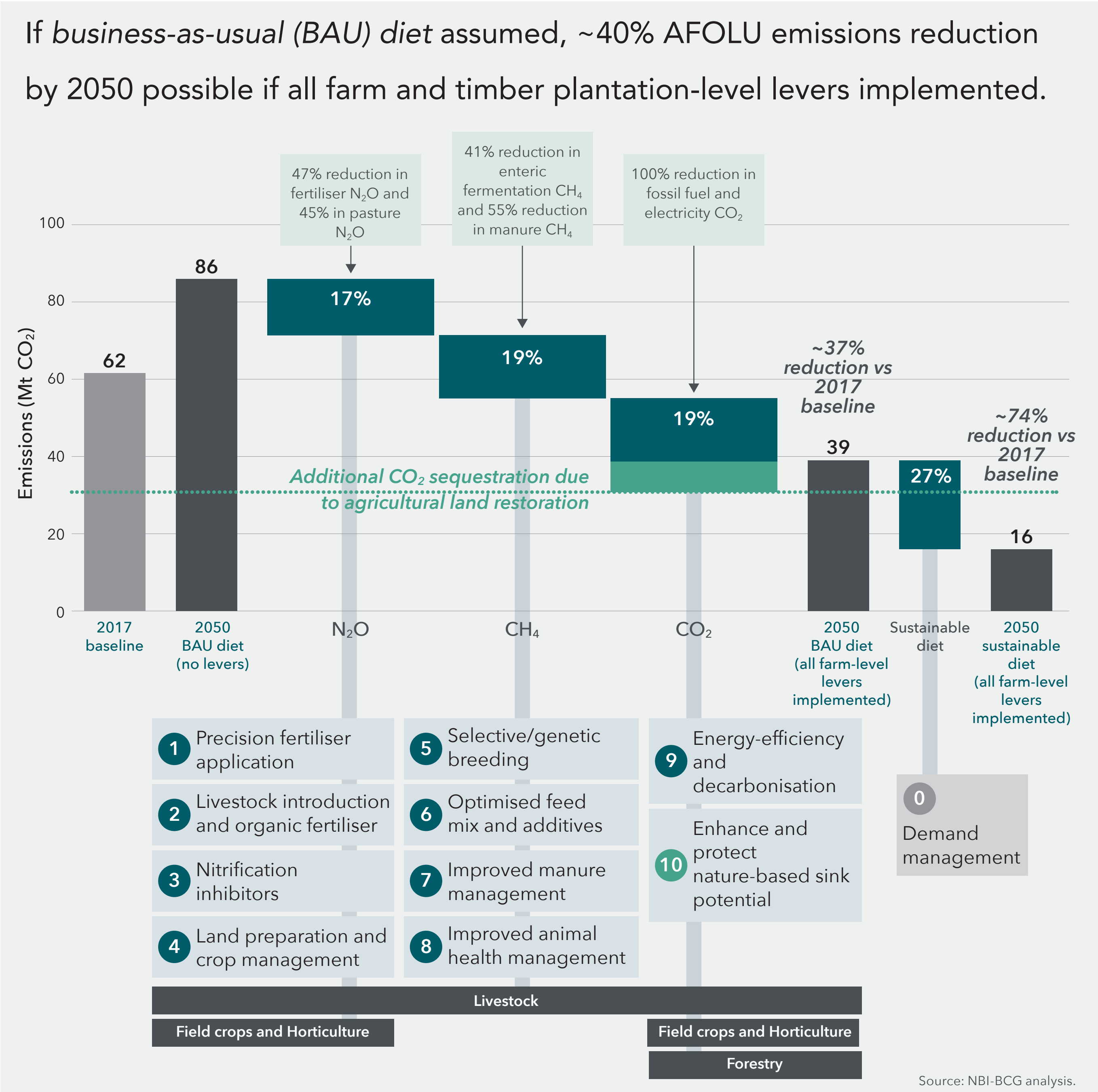
Assumptions

- No disruptive levers applied (e.g., meat replacements, hydroponics).
- Levers are applied fully to all cultivated land in South Africa by 2050.
- Current lever implementation is assumed to be negligible in South Africa, and thus full emissions reduction potentials are assumed.



Source: NBI-BCG analysis.

Figure 24: Emissions reduction pathways for the AFOLU sector in South Africa



Source: NBI-BCG analysis.

Addressing residual emissions in the AFOLU sector

Residual AFOLU emissions of 16–39 Mt CO_2e by 2050 would equate to 50–130% of the country's current sink potential (30 Mt CO_2e). This is a concern given that hard to abate industrial sectors, such as the concrete sector, will likely require carbon credits to reach net-zero emissions, and land degradation, if not appropriately managed, could lead to decreases in the size of South Africa's natural carbon sink. Efficiency improvements and disruptive farm-level levers (for example, methanogen vaccines to reduce enteric fermentation in cattle) will not be able to eliminate the remaining livestock emissions by 2050. To eliminate these residual AFOLU emissions, disruptive meat production methods will be required, such as lab-grown meats (in scenarios where meat is still consumed) – which can be produced with zero emissions if renewable energy sources are used. While lab-grown meats currently costs as much as 100 times more to produce per kg than conventionally produced meat, it is expected that lab-grown meat will reach price parity within the next decade (2030–2035), with process-efficiency improvements and increasing scale. As a result, lab-grown meats are projected to reach a ~10–12% share of the global protein market by 2035. Equally important in minimising cumulative emissions will be short- and medium-term

CASE STUDY 4: MEAT NATURALLY – REDUCING LIVESTOCK EMISSIONS AND RESTORING LAND

Meat Naturally is a social enterprise owned by farmers and operated by conservationists, based in Mpumalanga, which aims to address two problems: 1) Communal farmers in South Africa own ~40–50% of the national beef cattle, but only supply ~5% of the meat market; and 2) Many of South Africa's rangelands are being degraded by overgrazing, alien plant species invasion, and the killing of natural predators – particularly in communal farming systems.

Meat Naturally aims to empower emerging livestock farmers with the expertise and resources to implement sustainable livestock cultivation practices to reduce emissions per kilogram of product and aid in the restoration of South Africa's rangeland ecosystems, improving the carbon sequestration and biodiversity of ecosystems in communal farming regions.

The model:

In exchange for training, equipment and market access, communal farmers commit to preserving rangelands and providing quality meat products that are sustainably produced. Meat Naturally takes a leadership role in the following engagements along the livestock production value chain to facilitate this exchange:

1. Supporting non-governmental organisations (NGOs) to negotiate conservation agreements with farmers and monitor adherence to these agreements using remote sensing systems that allow biomass concentration to be tracked
2. Consulting and training services for implementation of sustainable grazing practices, cattle management, disease prevention, and tagging and stock antitheft

Providing NGOs and farming communities with bulk purchasing power and access to critical farming equipment, vaccinations, and nutritional supplements to improve animal health

Organising mobile auctions and abattoirs that bring rural farmers and commercial buyers together.

Impact:

Today, over 2 400 communal farmers are part of the system in South Africa. Revenue from sustainably produced meat sales in 2020 reached ~ZAR18 mn, providing an invaluable source of additional income to farmers who were previously unable to sell any product due to the poor quality of livestock. Furthermore, as of 2019, regenerative grazing management has been implemented on ~320 000 ha of rangeland.

switches from beef to lamb and pork which produce 2.5 times and 7 times lower emissions per 100 g of protein than beef, respectively.[78]

While the introduction of green ammonia and organic fertiliser will enable decarbonisation of fertiliser usage for commercial farmers who are able to pay the price premium, the development of more efficient cultivation techniques, such as hydroponics, will still be critical to ensure climate-resilience, competitiveness in global agricultural markets in the long-term, and decarbonisation of the sector. Hydroponics involve the growing of crops in a water-based solution, through which nutrients are delivered directly to the plant, without soil. This means there is no fertiliser requirement, inputs and climates can be precisely managed to mitigate water use and climatic risks, and yields can be optimised in confined, urban growing areas, minimising transport requirements.

For example, hydroponics have allowed land-constrained countries like the Netherlands to achieve average tomato yields of ~510 kg/ha – almost 7 times South Africa's average of 67 kg/ha. Currently, hydroponics is limited by the high start-up cost and the lack of power supply reliability and increasing grid tariffs. There is also a risk to farmworker livelihoods that could arise if production were to be largely centralised.

The role of waste reduction in reducing the AFOLU sectors emissions footprint and environmental impact

Each year a third of all food produced in South Africa (by weight) is wasted.[79] Recently updated research from the CSIR has shown that 92% of food waste in South Africa occurs in the downstream stages in the AFOLU value chain, after the agricultural production stage. The processing and manufacturing stage accounts for almost

78 University of Oxford. 2021. *Our World in Data – Carbon Footprint of Foods.* (Data represents the global average emissions of food products based on a large meta-analysis of food production covering 38 700 commercially viable farms in 119 countries).

79 World Wildlife Foundation (WWF). 2017. *Food Wastage: Facts and Futures.*

half of all wastage, with retail and consumers accounting for a further ~25%.[80] Although not within the scope of this analysis, this highlights a significant opportunity to reduce AFOLU emissions further and improve food availability.

Overview of decarbonisation pathways for the AFOLU sector

Figure 25 indicates key farm and timber plantation-level mitigation actions that should be implemented in the short-, medium-, and long-term in South Africa, to both build resilience and reduce the sector's emissions footprint.

Many decarbonisation levers provide cost savings for farmers and forestry planters with minimal capital input required in most cases. Farm and timber plantation-level implementations that will reduce emissions and provide negative abatement cost (i.e., savings for each tonne of CO_2e abated), if implemented correctly, include, for example:[81]

Horticulture and field crops:

- Precision fertiliser application, organic fertiliser usage, and no- or low-till; due to reduced synthetic fertiliser input requirement.

Livestock:

- The use of indigenous genotypes that are adapted, selective breeding and genetic selection of livestock, in favour of lower emissions-intensity specimens that are better suited to local ecosystems; due to selection of healthier, better suited animals that produce more product per kg CO_2e and selection of animals with lower average enteric fermentation emissions.
- Best practice livestock health management (including vaccination and pest and disease management) which ensures improved livestock health and therefore increases product output on a per kg CO_2e basis.

All sub-sectors:

- Electrification of fossil fuel machinery and renewable energy supply (results in savings of ~US$170/t CO_2e over the 2020–2050 period);[82] due to reduced fuel

Deep-dive: The limitations of livestock intensification as a decarbonisation lever in South Africa

Another means of potentially reducing cumulative livestock emissions and improving resilience in the short- to mid-term, is intensification of livestock production. Global livestock emissions data indicates that, on average, grassland cattle systems produce 2.6 times more emissions per kg of protein produced than feedlot systems, even when land conversions for feed production are considered. Grassland beef cattle systems produce, on average, 392 kg CO_2e per kg of protein (276 kg CO_2e in direct animal emissions and 116 kg CO_2e in feed, land use and energy use emissions). Conversely, intensive beef cattle systems produce, on average, 149 kg CO_2e per kg of protein (99 kg CO_2e in direct animal emissions and 50 kg CO_2e in feed, land use and energy use emissions). However, in the South African context, additional considerations around communal ownership, land availability and livestock as an enabler for decarbonisation must be considered when deciding between a predominantly intensive versus extensive livestock system:

- Firstly, ~45% of South Africa's cattle herd is owned by communal farmers, largely in under-resourced historic labour-sending regions. Lack of access to capital and experience limits their ability to transition to intensive systems due to, for example, higher antibiotic requirements.
- Secondly, intensive livestock systems require feed to be grown in competition with human food. Only ~12% of South Africa's land is suitable for rainfed feed production, whereas ~69% of South Africa's land is suitable for livestock grazing – pointing to grassland systems potentially being a more suitable use of South Africa's land.
- Thirdly, the inclusion of extensive livestock in crop systems is a critical component of reducing synthetic fertiliser requirement. Furthermore, extensive livestock are embedded in the environments, cultures, and economies of rural South Africa and extensive systems generally provide broader dispersions of income to feed back into communities. As with other food sources, analyses on a local level will be required to determine whether livestock production intensification will produce net benefits in terms of local environmental and economic resilience and food security.

80 CSIR. 2021. *Increasing reliable, scientific data and information on food losses and waste in South Africa.*

81 Harmsen. 2019; Emory et al., 2016; Henderson et al., 2015; Graus et al., 2004; Basak. 2015.

82 NBI-BCG team.

cost as diesel prices rise and renewable energy prices continue to fall.

However, certain farm and timber plantation-level decarbonisation levers will come at positive abatement cost (i.e., additional cost for each kg CO_2e abated), but will still be critical to decarbonise livestock production (the driver of AFOLU emissions in South Africa). These include, for example:[83]

Horticulture and field crops:

- Application of nitrification inhibitors (costs ~US$15/t CO_2e); due to cost of the inhibitor and labour, without significant efficiency gains to balance cost.

Livestock:

- Optimised animal feed mix:
  - Inclusion of tannins costs ~US$50/t CO_2e
  - Fine grain processing costs ~US$180/t CO_2e
  - Nitrate supplementation costs ~US$390/t CO_2e.
- Optimised manure management:
  - Digestors cost ~US$100/t CO_2e
  - Best-practice manure storage costs ~US$300/t CO_2e
  - Manure acidification costs ~US$320/t CO_2e.

Figure 25: Timeline for farm-level emission mitigation lever implementation

Lever implementation timing will be dictated by progression of techno-economic feasibility and degree to which small-holders are supported.

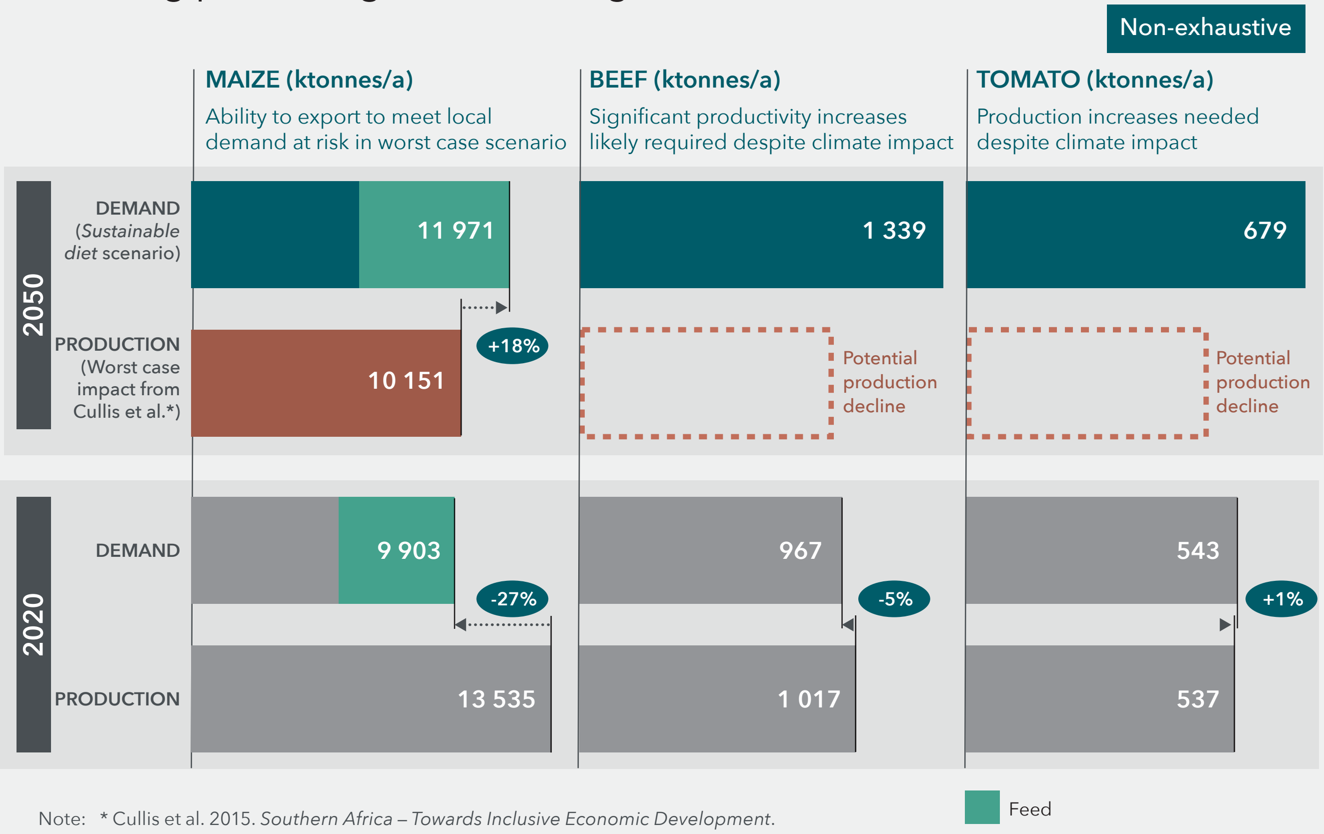
Gas	Sector	#	SHORT-TERM (within the next 24 months)	MID-TERM (by 2030)	LONG-TERM (beyond 2030)
N_2O	Horticulture & Field crops	1	Targeted fertiliser application, no-fertiliser zones		Introduce green ammonia
N_2O	Horticulture & Field crops	2	Introduce livestock to existing systems	Provide broader access to organic fertiliser	
N_2O	Horticulture & Field crops	3	Scale-up use of nitrification inhibitors	Lower cost, more efficient inhibitors	
N_2O	Horticulture & Field crops	4	Targeted fertiliser application, no-fertiliser zones	Fully implement no-till cultivation	
CH_4, N_2O	Livestock	5	Selective breeding and culling	Genetic selection of specimens with lower emissions intensity	
CH_4, N_2O	Livestock	6	Young forage, more maize silage	Tannin forage, finer processing	
CH_4, N_2O	Livestock	7	Anaerobic manure digestors, nitrification inhibitors	Sophisticated manure storage and use systems	
CH_4, N_2O	Livestock	8	Regular checks, vaccination, parasite control	Matching genotypes to biomes	Methanogen vaccines
CO_2	All AFOLU	9	Increased energy-efficiency and switching to own production	Replacement of existing electricity supply with RE; begin machinery electrification	Full switch to RE
CO_2	All AFOLU	10	Improving soil carbon sequestration potential on croplands and grazing pastures, polyculture forestry, maintaining plantations in growing phase to maximise 'carbon pump'.		

Source: NBI-BCG analysis.

83 Harmsen. 2019; Emory et al., 2016; Henderson et al., 2015; Graus et al., 2004; Basak. 2015.

Figure 26: Food supply risks in a *business-as-usual diet* scenario

A *business-as-usual diet* scenario may put meat and staples production under increasing pressure, given increasing feed demand.



Note: * Cullis et al. 2015. *Southern Africa – Towards Inclusive Economic Development*.

Source: FAOSTAT; CSIR; Former Department of Environmental Affairs, *3rd National Communication*; NBI-BCG analysis.

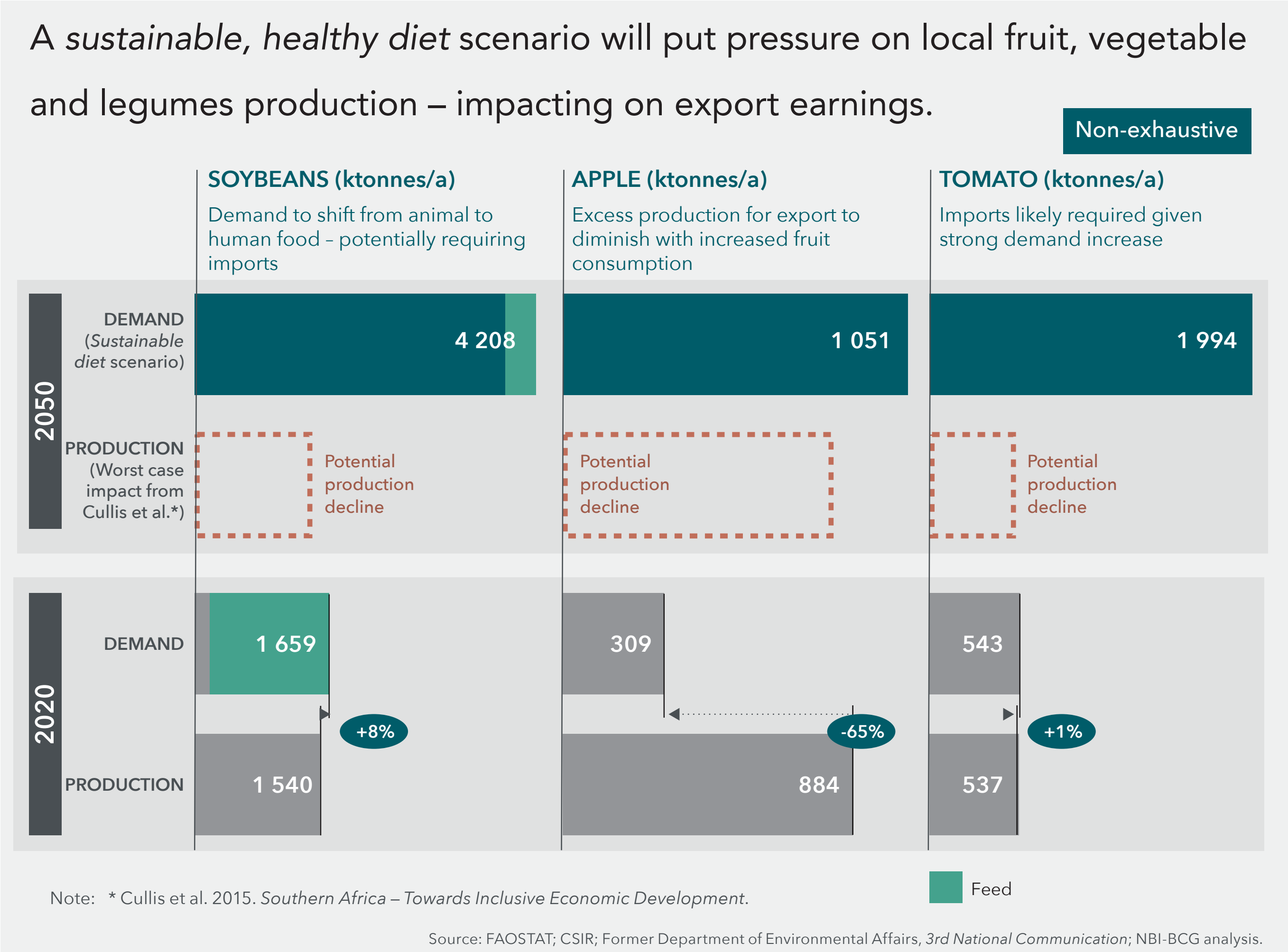
Pursuing integrated adaptation and mitigation

Examples of integrated farm and timber plantation-level adaptation and mitigation can already be seen in South Africa's AFOLU sector (see Case Studies 2 and 3). However, most projects are concentrated in the commercial sector – particularly in deciduous fruit production where export earnings provide clear incentive and the capital required to adapt and preserve the volume and quality of produce. Similarly, commercial field crop producers will plant cultivars with increasing resistance to drought and increased heat.

The key to ensuring adaptation in this context will be communicating clear messages regarding the latest findings on regional rainfall and temperature events, setting up blended finance mechanisms that account for extreme weather events to reduce the risk of adaptation on farmers and foresters, and ensuring that irrigation networks are expanded and better managed to facilitate an increasingly larger irrigated production segment. Conversely, rural communal producers (particularly livestock systems) face a significantly more challenging baseline, including an average cattle mortality rate of ~39%, 6 times higher than local commercial systems (6%), and an average calving rate of 35%, almost half that of the local commercial sector (62%). This is largely a result of lack of access to knowledge and quality extension services, lack of access to long-term land tenure and financing, and a cultural view of livestock as a store of wealth, rather than a source of production income.[84] Across the AFOLU sector, effective adaptation and mitigation strategies will crucially require accurate, real time and long-term weather and climate information that are accessible to the range of stakeholders.

84 Meissner et al. 2013. *Sustainability of the South African Livestock Sector towards 2050 Part 2: Challenges, changes and required implementations.*

Figure 27: Food supply risks in a *sustainable, healthy diet* scenario



3.2.7 IMPLICATIONS OF PATHWAYS TOWARDS A MORE CLIMATE-RESILIENT AFOLU SECTOR

Meeting a sustainable, healthy diet for all South Africans could require >170% increase in soybean and vegetable production, and ~20% increase in deciduous fruit production by 2050, even if production for export and livestock is diverted to local food demand. This would require land use prioritisation for hardier, nutritionally-dense foods and import strategies for starchy staple commodities that are expected to be in shrinking demand.

In a *business-as-usual diet* scenario, local supply of field crop, livestock and horticulture products would all come under increasing pressure to meet local demand. For example, local maize production exceeded local demand by 27% in 2018, however, with demand rising 21% by 2050, driven by increased animal feed requirements, and climate impact potentially reducing maize production by 25%, a production shortfall of ~20% may emerge by 2050. Similar shortfalls may emerge in, for example, beef and tomato production by 2050, as current production only just meets local demand, indicating that decreased production due to climate change would have significant consequences by 2050 (Figure 26).

In a *sustainable, healthy diet* scenario substantial shifts in production will be required to meet local demand. For example, even with livestock soya-based feed demand decreasing by ~75% by 2050, over 2 times more soybean than currently produced in South Africa would be required to meet local 2050 demand. This poses a substantial challenge given the likely impact of climate change on production. Local production of deciduous fruits, such as apples, currently far exceeds local demand, given that a large proportion is sent for import. However, with healthy diets adopted, meeting local demand by 2050 will require a full diversion of current production for export and an additional ~20% production increase (Figure 27).

Furthermore, climate impact is likely to result in shrinking arable land area in South Africa. Optimal livestock, field crop and forestry growing areas are all likely to converge along the eastern escarpment, where rainfall and temperature impacts are expected to be the least severe, potentially causing competition and requiring clearer policy on land use prioritisation. Such policy and planning should critically assess trade-offs between, for example, forestry's contribution to the national sink, field crops' and livestock's contributions to food security and stores of wealth, and horticulture's contribution to export earnings. Furthermore, prioritisation of arable land for cash crops versus staples, such as maize will require thorough analysis of the balance of payments implications.

> ***A Just Transition needs to unlock sustainable and healthy diets for all South Africans. However, sustainable, nutritional diets currently cost ~4 times more than the average, nutritionally-inadequate, local diet, and ~1.5 times more than the cheapest nutritional, carbon-intense diet in South Africa. Measures to build a climate-resilient food supply could further increase production costs – therefore it will be critical to ensure affordability of future food supply.***

South Africa's current average diet is nutritionally-inadequate, driven by the low cost of unhealthy foods, as highlighted in Section 3.2.1. Consequently, healthier diets are more expensive, with the cheapest nutritionally-adequate food basket costing ~ZAR2 900/month per household, or almost 3 times the current average household food expenditure in South Africa (ZAR1 027 per month per household).[85] If it is assumed that all South African households spend 35% of total household income on food (expenditure is generally lower than this), then only half of South Africa's households would be able to afford the lowest-cost nutritionally-adequate diet.

Furthermore, a sustainable and nutritionally-adequate diet costs 1.5 times more than a non-sustainable, nutritionally-adequate diet. This difference in cost between a sustainable, healthy diet and a non-sustainable, healthy diet is driven by lower consumption of cheap staples, such as maize (which only costs ~ZAR2/kcal) in the sustainable diet, and higher consumption of more expensive legumes, nuts, and fruit and vegetables (some pulses cost ~ZAR17/kcal and some nuts cost ZAR50/kcal) to replace nutrients from animal protein (Figure 28). Furthermore, food commodities that will see the greatest increases in demand in a *sustainable, healthy diet* scenario are also currently largely imported. For example, imports of pulses make up ~58% of local consumption. Furthermore, the implementation of adaptation and mitigation measures could also increase production costs to some degree during the transition period. However, cost differences between sustainable and non-sustainable diets may decrease as a global shift to sustainable, healthy diets would require >300% global legume production increases and 25–30% fruit and nut production increases by 2050, as indicated in the demand projections in Section 3.2.2. Such an increase in scale may reduce unit costs.

Ensuring affordability of food supply will be critical. Subsidising the additional cost of healthy diets could yield significant savings for South Africa's economy, with over ZAR275 bn estimated to be lost each year due to obesity – largely driven by health care costs and productivity losses attributable to the effects of obesity.[86] However, household incomes would likely need to increase for South African's – highlighting the need for a Just Transition which does not just ensure job creation but also drives the development and growth of higher income employment.

3.2.8 THE AFOLU SECTOR AS AN ENABLER TO ECONOMY-WIDE DECARBONISATION

The AFOLU sector will be critical in enabling decarbonisation across sectors, via for example the provision of sustainable construction materials and biomass for industrial use (see 'Deep-dive: Biomass in South Africa'). Furthermore, the AFOLU sector also provides natural carbon sinks, which will be critical in addressing potentially remaining residual emissions across sectors.

Maximising South Africa's natural carbon sink potential

Grasslands contribute 35% of South Africa's land carbon sink potential, while forests contribute the largest share (~65%). In total, South Africa is estimated to possess a national land carbon sink of ~30 Mt CO_2e,[87] or the equivalent of ~6% of South Africa's total emissions in 2017.[88] This indicates that South Africa should only allocate the sink to emissions that will be the costliest to abate. It is likely that the carbon sink in South Africa will decrease in future without significant intervention. Only 12% of South Africa's land area is arable and the country is estimated to lose 13 tonnes of soil per hectare per annum – producing

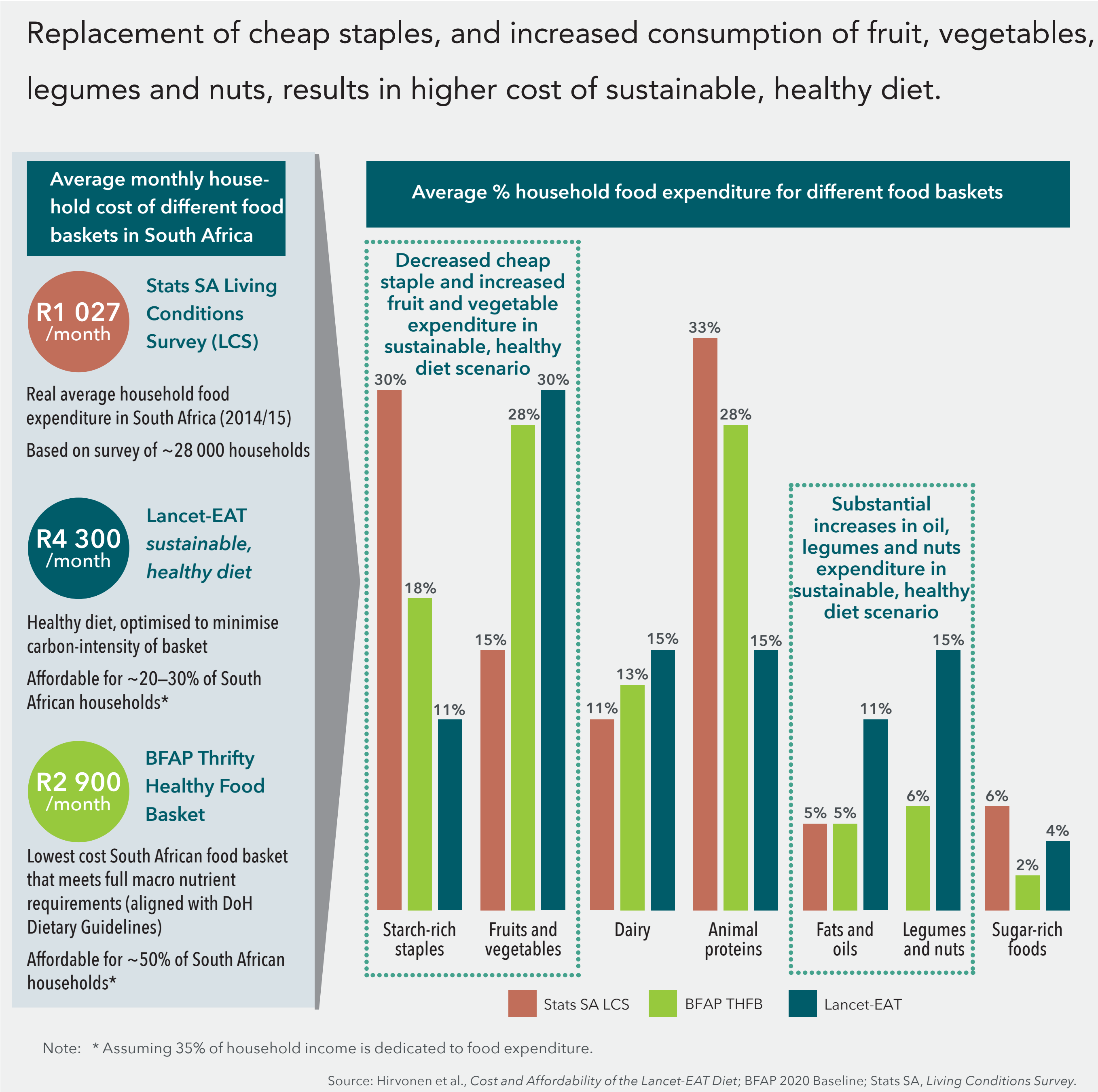
85 Bureau for Food and Agriculture Policy (BFAP). 2021. *Baseline (2020).*

86 Discovery Vitality. 2017. *2017 ObeCity Index.*

87 When all land emissions sources and sinks are considered

88 Department of Forestry, Fisheries, and the Environment (DFFE). 2021. *National GHG Inventory Report, 2017*

Figure 28: Comparison of the costs of current, healthy, and healthy-sustainable food baskets



a net soil loss rate 3 times that of Australia.[89] Furthermore, it is unlikely that currently unforested land will be forested in South Africa's future, due to restrictive water licensing and likely rainfall decreases across most of the country to 2050. It will therefore be critical to take steps to preserve and augment South Africa's natural carbon sink, in a way that generates additional economic value, employment and arable land. If sustainable soil management practices are adopted on all cropland, grassland for livestock, and shrubland in South Africa, it would be possible to improve soil carbon sequestration by ~13 Mt CO_2e (or ~43%) by 2040 versus a business-as-usual scenario.[90] These measures would include the sustainable cultivation best-practices outlined in Figure 23 (including low- and no-till farming), appropriate livestock stocking and rotational grazing to prevent overgrazing (particularly in rural, communal land settings), and better management of catchments to minimise erosion and restore degraded soil.

89 Grain South Africa. 2014. *Soil erosion in South Africa – Its nature and distribution*

90 DALRRD, FAO. 2021. *South Africa: Soil Organic Carbon Sequestration Potential National Map.*

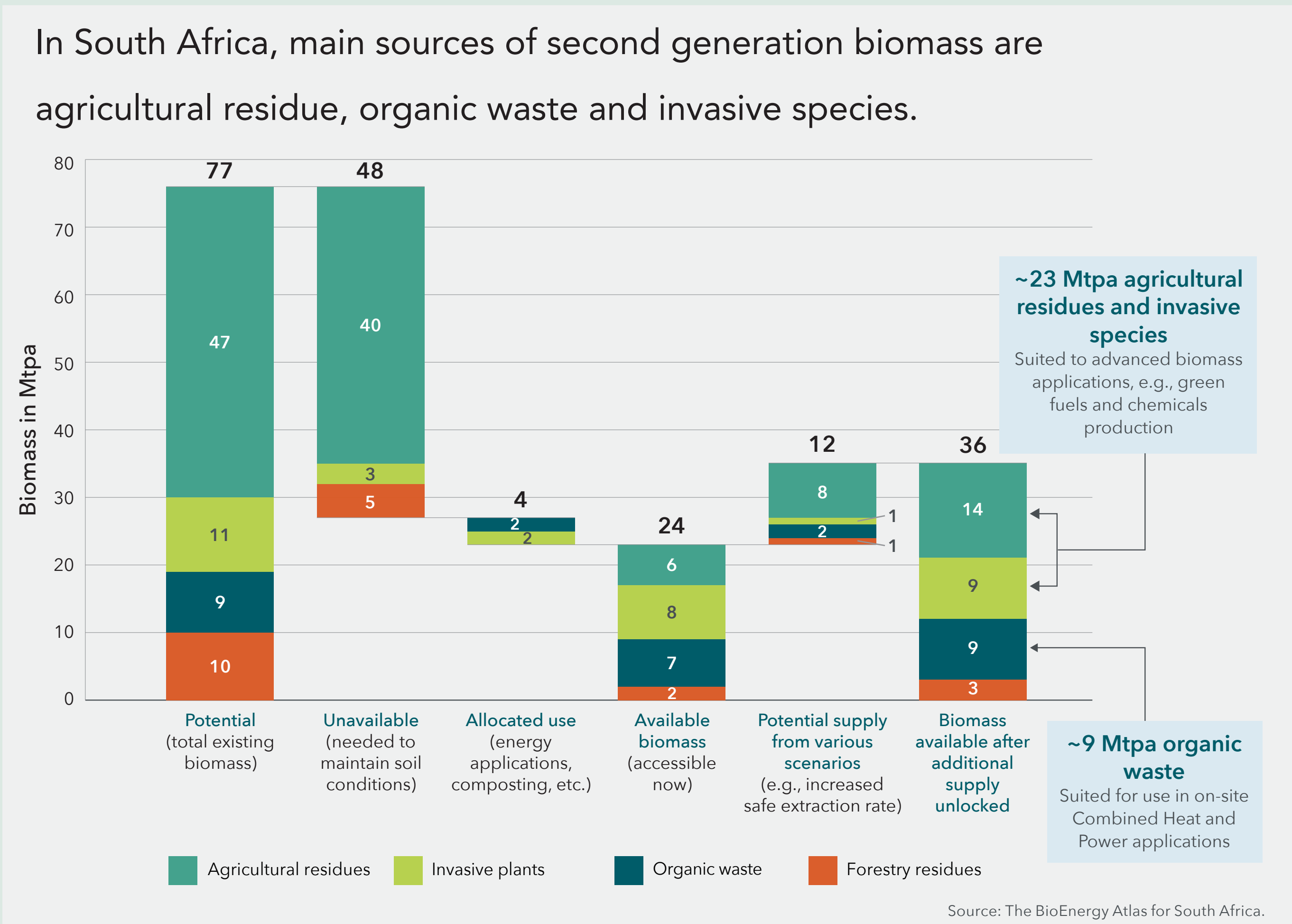
Deep dive: Biomass as a sustainable source of carbon in South Africa

Production of low- and zero-carbon fuels and chemicals will require sustainable sources of carbon. Biomass, alongside captured carbon via Carbon Capture and Utilisation (CCU) and Direct Air Carbon Capture (DACC), could serve as a sustainable source of carbon. Three types of biomass are usually considered:

- **First generation biomass:** Agricultural crops grown on arable land (e.g., corn, soybeans, sugarcane)
- **Second generation biomass:** Sustainable biomass sources that do not result in land use change or compete with food crops. This includes: non-edible agricultural waste (e.g., maize, sugarcane); invasive alien plants (e.g., prickly pear, eucalyptus); organic waste (e.g., sewerage, wastewater, solid waste); and forestry waste (e.g., sawmill, plantation, pulp and paper waste).
- **Third generation biomass:** Algae engineered to harvest oil, produced in ponds, tanks or the sea.

While **first generation biomass** has previously played a large role in the production of lower-carbon fuels, it is no longer seen as the main source of biomass, given that it poses a risk to food security and food prices due to direct competition with food crops. The EU, for example, emphasises in its Renewable Energy Directive II and certification bodies requirements, that the use of biomass should 'maintain food security', which would already exclude a large scope of first-generation biomass – particularly in a future where populations and hence food demand grow. **Third generation biomass** is currently still techno-economically unfeasible and questioned with regards to its sustainability. Therefore, **second generation biomass** is the most promising and relevant biomass source today and in the short- and mid-term future.

Figure 29: Biomass availability in South Africa



It is important to note, that if biomass is used in synthetic processes, the carbon content of dry biomass will be an important metric, which determines how much biomass will be actually required to meet the carbon demand of the respective industrial process. Hence, the higher the carbon content of the considered biomass, the less biomass will be required if compared to biomass with very low carbon content.

Currently, there is a significant lack of data and analysis around the availability of second generation biomass in South Africa. Based on currently available data, second generation biomass in South Africa is mainly anchored in organic waste, agricultural residue and invasive species amounting to ~77 megatonnes per annum (Mtpa) accessible biomass. Hence, biomass that is not yet used on site or needed to maintain soil conditions, is estimated to be around ~24–36 Mtpa (Figure 29). Agricultural residue is predominantly maize residue within a ~500 km region in the eastern Highveld, whereby only ~15% of those are estimated to be available for collection. Invasive species are primarily located in sparsely populated areas in KwaZulu-Natal, the Eastern Cape and Mpumalanga. Organic waste is mostly produced in major urban regions in Johannesburg, Pretoria, Durban and Cape Town. Forestry residue is mainly concentrated in KwaZulu-Natal and eastern Mpumalanga. Regional, cross-border availability of second generation biomass is uncertain given the lack of data.

Alone, ~15–20 Mtpa of biomass would be needed to decarbonise the existing coal-to-liquid (CTL) synfuels plant – provided CCU (e.g., use of carbon from other industrial emission sources) and green H_2 are introduced at scale. Without CCU (or other, alternative carbon sources, such as atmospheric carbon via DACC) and green H_2, the biomass demand would increase to ~40–45 Mtpa biomass (assuming a 30% carbon content of biomass). Hence, the current 24–36 Mtpa accessible biomass potential could serve this demand, but only if additional, alternative sources of carbon (e.g., via CCU or DACC) and green H_2 are unlocked (Figure 30).

Three key challenges need to be addressed to leverage second generation biomass as a sustainable carbon source in South Africa:

- First, there is a lack of data and analysis around the availability and accessibility (e.g., how much biomass can be extracted from the soil without causing soil degradation or reducing the soil's capacity to capture carbon) of second generation biomass in South Africa and regionally. Further studies need to be conducted to close the current 'data gap'.

Figure 30: Location of second generation biomass in South Africa

Agricultural residue

- Predominantly maize residues within ~500 km region on the eastern Highveld
- Only ~15% of residue available for collection

Invasive species

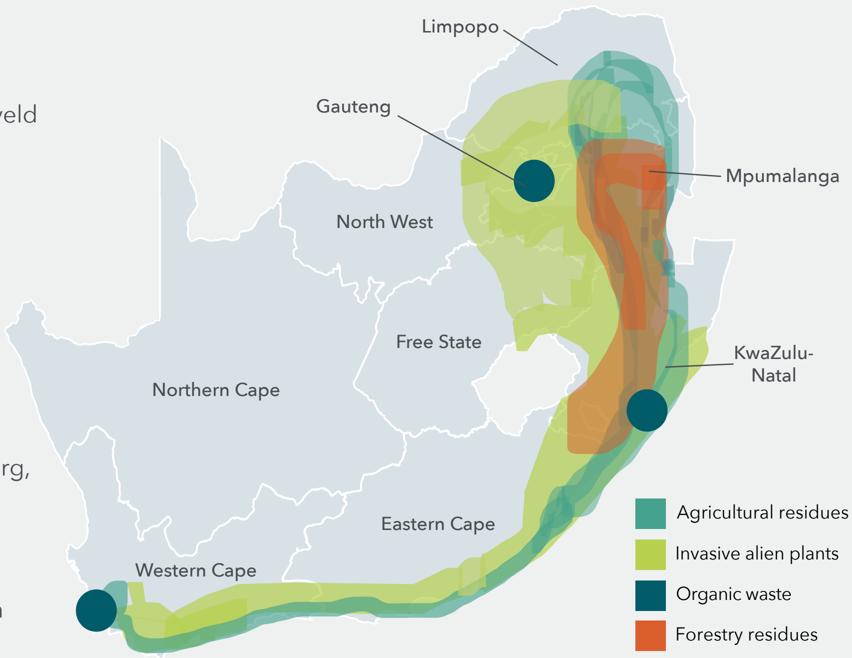
- Primarily in sparsely populated rural areas in KwaZulu-Natal, Eastern Cape and eastern Mpumalanga

Organic waste

- Mostly in urban regions (Johannesburg, Pretoria, Durban and Cape Town)

Forestry residues

- Largely in KwaZulu-Natal and eastern Mpumalanga



Source: Department of Forestry, Fisheries and Environment; Stats SA, *Census of Commercial Agriculture*: 2017.

- Second, the local impact of climate change needs to be considered in the continued assessment of second generation biomass availability and measures taken to ensure sufficient second biomass availability. Policy measures which unlock further biomass supply should also be considered to expand the scale of biomass available for industrial use.
- Third, if better certainty around the availability and accessibility of second generation biomass is established, infrastructure and services need to be established, which collect, process and transport the biomass to the respective end users. It will be important to assess the carbon footprint associated with the required logistics. Collection of biomass will be a challenge, given the multiple, dispersed locations of biomass sources. Processing biomass will be critical, given that it is not in a form where it can be fed directly into the respective industrial processes. However, collection, processing and transport of biomass could also create new job opportunities.

Photo: Shutterstock.com

3.3 HOW TO DEVELOP A CLIMATE-RESILIENT AFOLU SECTOR IN SOUTH AFRICA

3.3.1 KEY ENABLERS FOR THE DECARBONISATION AND ADAPTATION OF THE AFOLU SECTOR

> *To ensure a Just Transition, small-scale producers must be supported to increase productivity and gain both agricultural and business skills. This requires improved extension services and climate monitoring, access to finance and off-take incentives for sustainable practices. It may also require tenure reform; farmworkers require new work opportunities and agri-dependent communities need to be identified and plans made to diversify economic opportunities.*

Enablers for farm and timber plantation-level lever implementation

Three key areas must be developed to enable widespread and effective farm and timber plantation-level lever implementation. Although not exhaustive, these are some of the enablers that require immediate action and that will provide a critical foundation for other actions going forward:

1. **Water management and renewable energy deployment**: Treasury recommends that a ZAR670 bn investment to repair and expand national water networks be made before 2030. Furthermore, accelerated decarbonisation of farming and forestry power supplies and machinery (particularly in the commercial sector where cost savings can be realised) will require a ~ZAR200 bn investment in embedded generation and electric farm and forestry equipment, before 2050.

2. **A unified climate and crop modelling effort**: The development of a coordinated, local climate and crop impact modelling effort is needed to ensure clear messaging to farmers, foresters and policy-makers. A consistent body of South African-focused literature studying, for example, regional lever effectiveness and cost, municipal climate risks (using the latest ensemble modelling), and changes in national land suitability to inform crop prioritisation, is needed.

3. **Rehabilitation of national extension services**: Provincial extension services are currently dysfunctional in some regions but will be critical to ensure that the latest climate modelling and lever development is translated on a farm and timber plantation-level. Increased funding and the deployment of regional specialists will be required. Effective allocation of extension resources will require accurate, real time and long-term weather and climate information.

Enablers to bolster the adaptive capacity of the small-holder segment and diversify rural economies

Three key demand-side steps have been identified as crucial for unlocking the economic and food security potential of emerging agricultural operations:[91]

1. **Develop the industrial value chain for rural agricultural produce and commercialise emerging farmers and foresters.**

   Developing downstream agri-businesses drives demand and provides higher skilled, higher paying work opportunities for rural small-scale producers who currently operate economically unviable operations. The goal should not be to maintain distinctions between commercial and small-holder farmers and foresters, but rather to maximise production at the lowest prices possible and thus maximise opportunities created along the value chain. Running a financially viable staples cultivation operation on less than 2 ha of land either requires very high yields or very high output prices (both of which will be difficult to achieve for South African small-holders who lack access to appropriate fertilisers and irrigation networks). Growing staples on small plots will only keep small-holder farmers in poverty (for example, over 50% of people in Africa who suffer from hunger are small farmers) and increasing land fragmentation should therefore not be pursued. Rather, government should focus on building consensus on the detriments of 'too-small' farms and helping emerging farmers to increase their landholding and form cooperatives.

   Clearer land titles may be needed to facilitate easier resolution of legal disputes that may arise, and new technologies applied to formalise newly commercialised operations and ensure strong yields. For example, *Hello Tractor* and *IBM* have partnered to provide a tractor-sharing service for newly commercialised, rural farmers. Shared tractors are equipped with sensors and software services that allow farmers to monitor fuel consumption, weather events, and even market pricing projections to improve planning and performance.

91 Boston Consulting Group (BCG). 2021. *Transforming Africa's Agricultural Systems from the Demand Side.*

2. **Support the establishment of rural markets by putting the required infrastructure, market mechanisms and policy frameworks in place.**

   A significant barrier to small-holder commercialisation is the lack of transport infrastructure, such as rail networks and cold chain infrastructure in rural communities. The former makes it difficult to get products efficiently from the producers to customers. The latter increases waste, particularly of nutrient-dense, fresh foods, and steers rural consumers towards less healthy alternatives.

   More broadly, a lack of access to markets is driven partly by the fact that retail orders are generally too large for rural emerging producers to meet. Aggregated purchasing platforms, such as *Khula* in South Africa, use software to provide the logistics and storage required to quickly aggregate rural production to fulfil orders from medium- and large-scale vendors, providing greater market access. Furthermore, these platforms are using the internet to disseminate knowledge of proper fertiliser and irrigation practices to rural producers. Generally, local municipalities should support the establishment of local markets, by for example, putting the required infrastructure and conducive and supporting policies in place.

3. **Diversify and localise demand and drive mechanisation and efficient irrigation.**

   Roughly 75% of the world's food supply comes from 12 plant species and 5 animal species.[92] This endangers the resilience of the agricultural sector to climate impacts and reduces biodiversity. In the South African emerging farmer and forester context, government should incentivise the consumption of local food varieties, particularly cash crops that can be produced more viably by emerging farmers and which will reduce the cost of healthier, less starch-dependent diets. This could be accompanied by the conversion of small-holding sole owners into fractional owners of large holdings. In Kenya, *Cinch* runs a land-aggregation-as-a-service, which allows small-holders to become part of commercial, cash crop operations to drive higher incomes, food diversity, and increased climate resilience.

   Furthermore, mechanisation and irrigation of emerging farming operations should be prioritised ahead of fertiliser and seeds, given their role as key enablers of more efficient and competitive production. Across Sub-Saharan Africa, *SunCulture* offers an off-grid, solar-powered irrigation system that can be configured with low-cost, high-efficiency sprinklers and drip irrigation systems that help reduce water usage and increase yields. To provide easier access, farmers can pay for the system in monthly instalments.

3.3.2 RECOMMENDED NO-REGRET ACTIONS

A series of low-risk actions can be taken in the short- to long-term to facilitate and drive the adaptation and mitigation of the AFOLU sector in South Africa while ensuring food security, environmental-resilience and socio-economic development. Although these actions do not directly address the suite of land use issues, such as land transformation and sequestration potential development, these topics should be further studied in a coordinated local research effort. Distilling the near-term actions needed in these areas will be key to ensure biomass availability, carbon sink development and appropriate prioritisation of land use.

92 FAO. 2000. *What is happening to agrobiodiversity?*

Key actions to ensure effective implementation of the considered levers and to maximise food security, environmental and socio-economic benefits

	SHORT-TERM (WITHIN NEXT 3–4 YEARS)	LONG-TERM (AFTER 2030) – SIGNIFICANT CLIMATE IMPACT
Sector-wide	■ **Incentivise sustainable practices**: Deploy certification schemes, roll-out user-pays irrigation, and develop granular monitoring of irrigation flows. ■ **Enhance farmer capacity to implement**: Grant title deeds and promote cooperative formation for small-holders; implement DAFF extension strategy; develop a centre of agricultural research excellence to ensure consistent messaging. ■ **Align financing options to AFOLU challenges**: Deploy blended finance mechanisms, index-based insurance products, and water-risk filters in agriculture financing.	■ **Drive demand shifts**: Tax to incentivise more diverse, locally-grown foods and subsidise healthy, sustainable diets using savings in health care sector. ■ **Develop regional land use prioritisation hierarchies**: Develop clear hierarchies, prioritising high-value, hardier foods. ■ **Diversify employment opportunities and income sources**: Develop agro-industrial value chains around emerging farmer cooperatives and build strategies to transition livestock farmers to alternate roles.
Livestock	■ **Develop local knowledge**: Fund breeding programmes and the development of a local breed database to inform targeted extension deployment. ■ **Develop demand-side decarbonisation incentives**: Deploy mobile auction sites.	■ **Drive breed shifts**: Promote switches from cattle to hardier and lower emissions goat and sheep; drive demand changes using taxation.
Field crops and horticulture	■ **Improve contribution of emerging farmers**: Roll-out crop aggregation platforms, giving small-holders access to medium-to-large retail markers. ■ **Drive innovative solutions**: Double national spending on local research to develop more resilient cultivars and pilot green NH_3 projects in the commercial sector to provide off-takes for green chemicals production.	■ **Enable emerging farmer commercialisation**: Develop legal and policy framework to develop small-holder cooperatives that produce resilient cash crops (e.g., olives or dates, millet).
Forestry	■ **Develop viable second generation biomass economy**: Fund a conclusive study of usable biomass availability in South Africa; use biomass collection to provide employment and pilot biomass hubs to facilitate commercialisation with petrochemicals sector.	■ **Enable expansion**: Review water licensing process to expand biomass, sequestration and sustainable timber availability in South Africa.
Other land use	■ **Demand-side incentives for sustainable land management**: Develop a carbon crediting market and ecosystem services incentivisation framework and increase carbon taxes to increase carbon credit value. ■ **Increase funding to LandCare programmes**. ■ **Drive restoration and enhancement of natural ecosystems** to ensure increased carbon sink productivity.	■ **Secure international green financing**: Leverage appetite for international biodiversity finance to drive integrated land rehabilitation and agriculture decarbonisation and adaptation programmes.

4. OUTLOOK

As was stated in the Foreword of this report, South African business commits unequivocally to supporting South Africa's commitment to find ways to transition to a net-zero emission economy by 2050. Furthermore, business would support an enhanced level of ambition in the NDC that would see the country committing to a range of 420–350 Mt CO_2e by 2030. However, this enhanced ambition would have to be conditional on the provision of the requisite means of support by the international community. In this light, the business community will play its part to work with international and local partners to develop a portfolio of fundable adaptation and mitigation projects that would build resilience and achieve deep decarbonisation.

A managed Just Transition is important, and such a transition is impossible without a broad multi-stakeholder effort. National Government, through the Presidential Climate Commission and the National Planning Commission, and supported by key government ministries, are leading this effort.

In support of this national programme, the NBI membership together with BCG and BUSA are running a multi-year project to understand net-zero decarbonisation pathways, sector by sector. This will provide a solid input into national and local dialogues, as well as identify critical investment areas. Furthermore, this level of detail enables policy frameworks and engagement with providers of international support to maximise the potential to leverage concessional finance and trade support to attract local public and private finance.

This work is ongoing and is intended as a basis for further consultation and a foundation for future work. The work on each sector will be released in stages as it is completed and will form a basis on which others can build. Ultimately a final body of work of the combined sector content will be made up of reports on:

- An introduction to the project and to a managed Just Transition, including analysis from our economic modelling
- Electricity
- Petrochemicals and chemicals
- The role of gas
- The role of green H_2
- Mining
- Transport
- Agriculture, Forestry and Other Land Use
- Construction
- Heavy industry
- A concluding chapter highlighting key investment opportunities and no-regret decisions.

Each of these reports will be published via our Just Transitions Web Hub (http://jthub.nbi.org.za). Please monitor this website for the latest report versions, supporting data and presentation material, as well as news of other Just Transition initiatives and a wide range of current opinion and podcasts on a Just Transition for South Africa.

We invite you to engage with us and to provide comment and critique of any of our publications via info@nbi.org.za.

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