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Status, potential and challenges

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Abstract: South Africa Country Report

This report describes the current state of agriculture in South Africa with regard to the greenhouse gas (GHG) emissions it produces and the climate and other socio-economic policies that it faces. We identify options that could reduce agricultural emissions and estimate the mitigation potential of those options. Finally, we identify barriers to adopting these mitigation strategies and some possible solutions to overcoming those barriers.

Kurzbeschreibung: Länderbericht Südafrika

Dieser Bericht beschreibt den aktuellen Stand der Landwirtschaft in Südafrika im Hinblick auf die von ihr verursachten Treibhausgasemissionen sowie den aktuellen sozioökonomischen und klimapolitischen Rahmen für den landwirtschaftlichen Sektor. Wir identifizieren Optionen für Maßnahmen, die die landwirtschaftlichen Emissionen reduzieren könnten, und diskutieren das Minderungspotenzial dieser Optionen. Abschließend werden Hindernisse für die Umsetzung dieser Minderungsoptionen und einige mögliche Lösungen zur Überwindung dieser Hindernisse aufgezeigt.

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List of abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
CSA	climate-smart agriculture
CGCSA	Consumer Goods Council of South Africa
CO_2	Carbon dioxide
CH_4	Methane
DAFF	Department of Agriculture, Forestry and Fisheries (now DALRRD)
DALRRD	Department of Agriculture, Land Reform and Rural Development
DEA	Department of Environmental Affairs (now DFFE)
DFFE	Department of Forestry, Fisheries and the Environment
DTIC	Department of Trade, Industry and Competition
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross domestic product
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land-Use Change and Forestry
MRV	Measurement, reporting and verification
MtCO2e	Mega tonnes of CO2 equivalents
NCCAS	National Climate Change Adaptation Strategy
NDC	Nationally Determined Contributions (in Paris-Agreement)
NDP	National Development Plan
NSW	New South Wales
N_2O	Nitrous oxide
OECD	Organisation for Economic Co-operation and Development
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SOC	Soil organic carbon
SOM	Soil organic matter
UNFCCC	United Nations Framework Convention on Climate Change

Summary

The aim of this report is to identify possible emission mitigation options in the agricultural sector, the barriers towards implementing those options and provide some recommendations on how to overcome those barriers. The report begins with a description of the current state of agriculture in South Africa with regard to the GHG emissions it produces, and the climate and socioeconomic policies that shape the sector. We then identify three key options that could reduce agricultural emissions and estimate their mitigation potential. Finally, we identify barriers that act at the farm, national, international and consumer level along with possible steps to overcoming those barriers.

The agricultural sector in South Africa is highly diversified with maize, wheat, livestock, sugar cane and sunflower seeds being significant products (Tongwane *et al.*, 2016). While around 80% of the country's surface area is used for agriculture, only 14% of land in South Africa is considered arable, with only a fifth of that has a high agricultural potential (Republic of South Africa, 2018; Bese *et al.*, 2021). Although the contribution of the agricultural sector to the country's gross domestic product (GDP) is relatively low at 2% (Figure 1), agriculture is considered an important economic sector because it generates valuable export revenues and provides 5% of national employment (Mnkeni *et al.*, 2019; OECD, 2021).

The agricultural sector accounts for around 7% of South Africa's national emissions, equating to 37 Mega tonnes of CO_2 equivalents ($MtCO_2e$) in 2019, excluding Land Use, Land-Use Change and Forestry (LULUCF). The largest agricultural emissions sources include enteric fermentation (41%), on-farm energy use (22%), and manure left on pasture (21%) (FAO, 2022a). A significant extent of South Africa's agricultural land is only suitable for grazing cattle rather than crop production, meaning most subsistence cattle systems are predominantly pasture-based and feed supplementation is uncommon (Tongwane & Moeletsi, 2021).

Livestock related emissions have decreased over the last decade, partly due to the impacts of drought on production. However, the emissions intensity per tonne of product remains high relative to other countries with a similar environment and improving animal health and management practices could improve productivity and emissions intensity. Emissions from on-farm energy are a growing emissions source and have doubled over the last decade.

In the late 2000s, land expansion for crop cultivation, mining, forestry plantations, and urban development were drivers of land use change and corresponding GHG emissions. South Africa has lost 25% of its tree cover since 2000, equating to 1.48 million hectares and 902 $MtCO_2e$ of GHG emissions (Republic of South Africa, 2021a; Global Forest Watch, 2022). According to national data, the sink has been growing since 2012 due to increasing forest area, a decline in wood losses, and the reduced use of wood by households due to electrification (ibid).

Three mitigation options were identified for detailed analysis based on the contribution of different emission sources, the potential for socio-economic and environmental co-benefits, the country-specific context of the agricultural sector, and the general feasibility for implementation.

For South Africa, we selected the following three mitigation measures:

- Restoration of degraded pastures
- No-till cropping systems
- Livestock emissions intensity reduction

The implementation of these prioritised mitigation options could contribute to an overall emission reduction of 5 $MtCO_2e$/year below 2019 levels of 37 $MtCO_2e$ (assuming constant levels of production) and could result in additional carbon sequestration of 4–5 $MtCO_2e$/year by 2040. In addition to the mitigation measures described in detail here, the decarbonisation of on-farm energy use and a reduction in food loss and waste could help to further reduce emissions agricultural emissions in South Africa.

There are critical barriers that hinder the implementation of measures to achieve the outlined mitigation potentials and impair other activities to reduce GHG emissions in the agricultural sector. Farmers face substantial up-front costs in implementing mitigation measures and need some financial support, even for measures that have long-term economic benefits. South Africa is highly vulnerable to droughts, that are likely to increase in magnitude and frequency in the years ahead and negatively impact agricultural production. Measures for increasing soil carbon sequestration commonly have co-benefits in terms of soil health and erosion resistance, but quantifying sequestration remains technically challenging, and the mitigation achieved is therefore difficult to evaluate. Many existing policies and programmes are challenged by insufficient implementation, especially in the case of Black farmers who struggle with commercializing their production and achieving equitable land tenure.

To accelerate the uptake and implementation of the measures described in this report, it is key to 1) more clearly translate national mitigation priorities to the agricultural sector, 2) in turn ensure that all agricultural policies are aligned with mitigation objectives and 3) implement sector policies to comprehensively address the areas where most mitigation is possible. These mitigation policies and incentives should also foster co-benefits between adaptation and mitigation in the agricultural sector. More specifically, the South African government could foster mitigation through knowledge dissemination regarding sustainable practices, enhancing the resilience of the sector to an increased frequency of droughts, and strengthening cooperation with export companies to promote sustainable products.

Zusammenfassung

Ziel dieses Berichts ist es, mögliche Optionen zur Emissionsminderung im Agrarsektor zu identifizieren, die Hindernisse bei der Umsetzung dieser Optionen aufzuzeigen und einige Empfehlungen zur Überwindung dieser Hindernisse zu geben. Der Bericht beginnt mit einer Beschreibung des aktuellen Stands der Landwirtschaft in Südafrika im Hinblick auf die produzierten Treibhausgasemissionen und die klima- und sozioökonomische Politik. Anschließend werden drei wichtige Optionen zur Verringerung der landwirtschaftlichen Emissionen aufgezeigt und ihr Minderungspotenzial abgeschätzt. Abschließend werden Hindernisse auf betrieblicher, nationaler, internationaler und Verbraucherebene sowie mögliche Schritte zur Überwindung dieser Hindernisse aufgezeigt.

Der Agrarsektor in Südafrika ist stark diversifiziert, wobei Mais, Weizen, Viehzucht, Zuckerrohr und Sonnenblumenkerne wichtige Produkte sind (Tongwane et al., 2016). Während rund 80 % der Landesfläche landwirtschaftlich genutzt werden, gelten nur 14 % der Fläche Südafrikas als Ackerland, wobei nur ein Fünftel davon ein hohes landwirtschaftliches Potenzial aufweist (Republic of South Africa, 2018; Bese et al., 2021). Obwohl der Beitrag des Agrarsektors zum BIP des Landes mit 2% relativ gering ist (Abbildung 1), gilt die Landwirtschaft als wichtiger Wirtschaftszweig, da sie wertvolle Exporteinnahmen generiert und 5 % der nationalen Arbeitsplätze stellt (Mnkeni et al., 2019; OECD, 2021).

Der Landwirtschaftssektor ist für rund 7 % der nationalen Emissionen Südafrikas verantwortlich, was 37 $MtCO_2e$ im Jahr 2019 entspricht (ohne LULUCF). Zu den größten landwirtschaftlichen Emissionsquellen gehören die enterische Fermentation (41 %), die Energienutzung (22 %) und die Ausbringung von Dung auf Weiden (21 %) (FAO, 2022b). Ein beträchtlicher Teil der landwirtschaftlichen Flächen Südafrikas eignet sich nur für die Weidehaltung von Rindern und nicht für den Anbau von Pflanzen. Die meiste Subsistenzviehhaltung basiert überwiegend auf Weideflächen und Futterzusätze sind unüblich (Tongwane & Moeletsi, 2021).

Die mit der Viehhaltung verbundenen Emissionen sind in den letzten zehn Jahren zurückgegangen, teilweise durch ein Sinken der Produktion wegen Dürren. Die Emissionsintensität pro Tonne Produkt ist jedoch im Vergleich zu anderen Ländern mit ähnlichen Umweltbedingungen nach wie vor hoch, und eine Verbesserung der Tiergesundheit und der Managementpraktiken könnte die Produktivität und die Emissionsintensität verbessern. Die Emissionen aus der Energieerzeugung in landwirtschaftlichen Betrieben sind eine wachsende Emissionsquelle und haben sich in den letzten zehn Jahren verdoppelt.

In den späten 2000er Jahren waren die Ausdehnung der Anbauflächen für den Ackerbau, der Bergbau, die Forstwirtschaft und die Stadtentwicklung die treibenden Kräfte für die Veränderung der Landnutzung und die entsprechenden Treibhausgasemissionen. Südafrika hat seit dem Jahr 2000 25 % seines Baumbestands verloren, was 1,48 Millionen Hektar und 902 $MtCO_2e$ an THG-Emissionen entspricht (Republic of South Africa, 2021a; Global Forest Watch, 2022). Nationalen Daten zufolge ist die Senke seit 2012 aufgrund der zunehmenden Waldfläche, eines Rückgangs der Holzverluste und des geringeren Holzverbrauchs in den Haushalten infolge der Elektrifizierung gewachsen (ebd.).

Für eine detaillierte Analyse wurden drei Minderungsoptionen auf der Grundlage des Beitrags der verschiedenen Emissionsquellen, des Potenzials für sozioökonomische und ökologische Zusatznutzen, des länderspezifischen Kontexts des Agrarsektors und der allgemeinen Durchführbarkeit ermittelt.

Für Südafrika haben wir die folgenden drei Minderungsmaßnahmen ausgewählt:

- Wiederherstellung von degradiertem Weideland
- Direktsaat-Anbausysteme
- Verringerung der Emissionsintensität der Viehzucht

Die Umsetzung dieser vorrangigen Minderungsoptionen könnte zu einer Gesamtreduzierung der Emissionen um 5 $MtCO_2e$ gegenüber den Werten von 2019 (37 $MtCO_2e$) beitragen (unter der Annahme eines konstanten Produktionsniveaus) und könnte bis 2040 zu einer zusätzlichen Kohlenstoffbindung von 4–5 $MtCO_2e$/Jahr führen. Zusätzlich zu den hier detailliert beschriebenen Minderungsmaßnahmen könnten die Dekarbonisierung der Energienutzung in den landwirtschaftlichen Betrieben und die Verringerung von Lebensmittelverlusten und -abfällen dazu beitragen, die landwirtschaftlichen Emissionen in Südafrika weiter zu senken.

Es gibt kritische Barrieren, die die Umsetzung von Maßnahmen zur Erreichung der skizzierten Minderungspotenziale behindern und andere Aktivitäten zur Verringerung der Treibhausgasemissionen im Agrarsektor beeinträchtigen. Landwirtinnen und Landwirte haben erhebliche Vorlaufkosten für die Umsetzung von Minderungsmaßnahmen zu tragen und benötigen eine gewisse finanzielle Unterstützung, selbst für Maßnahmen, die langfristige wirtschaftliche Vorteile haben. Südafrika ist sehr anfällig für Dürren, die in den kommenden Jahren wahrscheinlich an Ausmaß und Häufigkeit zunehmen und die landwirtschaftliche Produktion negativ beeinflussen werden. Maßnahmen zur Erhöhung der Kohlenstoffbindung im Boden haben in der Regel auch Vorteile in Bezug auf die Bodengesundheit und den Erosionsschutz, aber die Quantifizierung der Kohlenstoffbindung ist nach wie vor eine technische Herausforderung, sodass der erzielte Minderungseffekt schwer zu bewerten ist. Viele der bestehenden Strategien und Programme werden nur unzureichend umgesetzt. Vor allem schwarze Kleinbäuerinnen und -bauern haben Schwierigkeiten, ihre Produktion zu vermarkten und gerechte Landrechte zu erhalten.

Um die Übernahme und Umsetzung der in diesem Bericht beschriebenen Maßnahmen zu beschleunigen, müssen 1) die nationalen Klimaschutzprioritäten klarer auf den Landwirtschaftssektor übertragen werden, 2) im Gegenzug muss sichergestellt werden, dass die gesamte Landwirtschaftspolitik mit den Klimaschutzzielen in Einklang gebracht wird, und 3) sektorale Maßnahmen müssen so umgesetzt werden, dass die Bereiche, in denen der größte Klimaschutz möglich ist, umfassend berücksichtigt werden. Diese Minderungsmaßnahmen und -anreize sollten auch den gemeinsamen Nutzen von Anpassung und Minderung im Agrarsektor fördern. Konkret könnte die südafrikanische Regierung den Klimaschutz durch die Verbreitung von Wissen über nachhaltige Praktiken, die Verbesserung der Widerstandsfähigkeit des Sektors gegenüber häufiger auftretenden Dürren und die Stärkung der Zusammenarbeit mit Exportunternehmen zur Förderung nachhaltiger Produkte fördern.

1 General characteristics of the agricultural sector and policy landscape

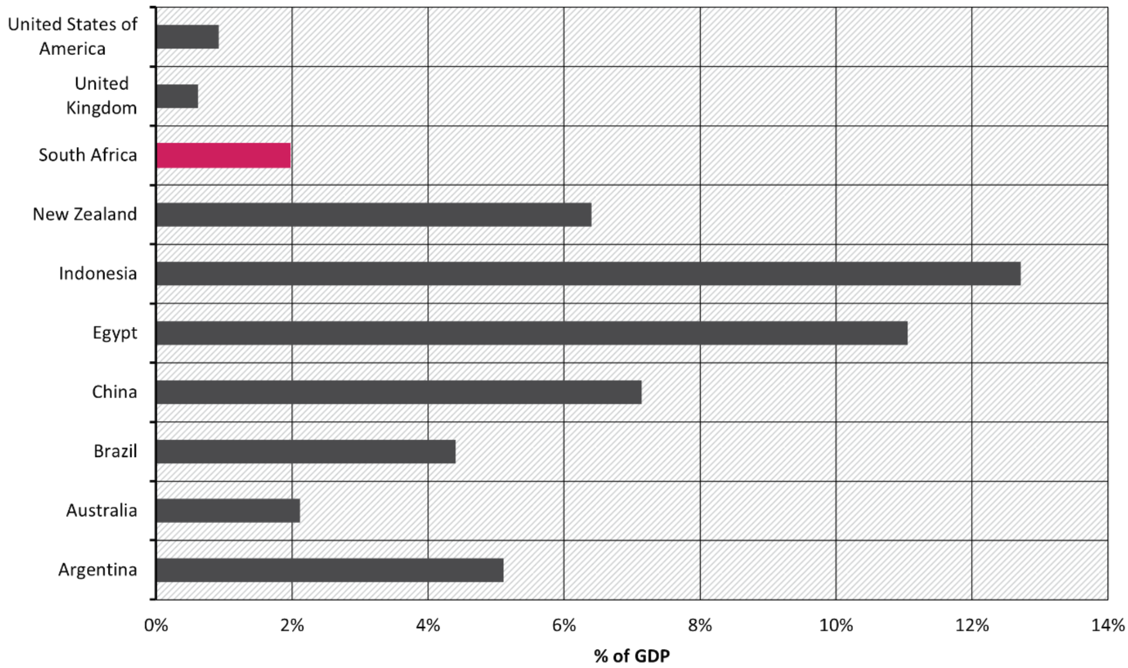
1.1 Characteristics of the agriculture sector in South Africa

South Africa is the most southern country of Africa and has a population of 60 million people. It is the third largest economy (after Nigeria and Egypt) and has the largest GDP per capita on the African continent.

The agricultural sector plays a distinct role in the South African economy, even though the country struggles with a lack of agricultural resources. While around 80% of the country's surface area is used for agriculture, only 14% of land in South Africa is considered arable, with only a fifth of that having a high agricultural potential (Republic of South Africa, 2018; Bese *et al.*, 2021). Land degradation is a significant environmental problem that affects rural livelihoods, food security, and ecosystem health across the country (Bese *et al.*, 2021).

While the contribution of the agricultural sector to the country's GDP is relatively low at 2% (Figure 1), agriculture is considered an important economic sector due to its backwards (purchaser of inputs) and forwards (supplier of raw materials) linkages to other industries (Mnkeni *et al.*, 2019).

Figure 1: Agriculture, fisheries, and forestry's contribution to GDP (2019)



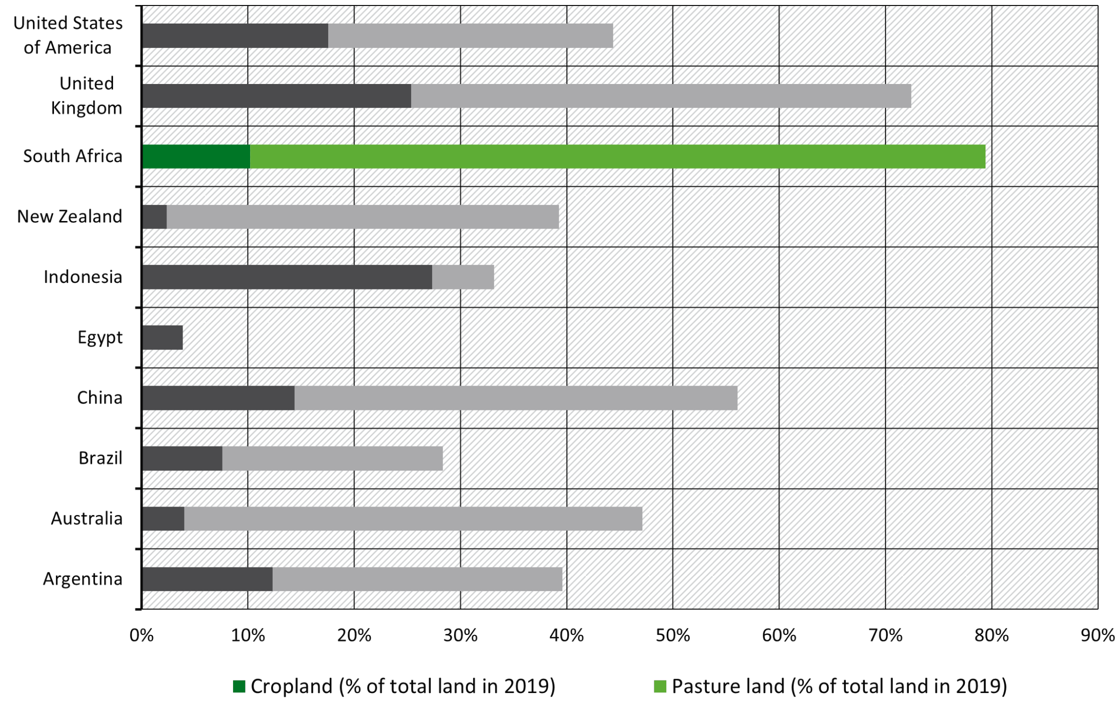
Source: **World Bank (2022)** data for all countries except New Zealand due to lack of data. Value for New Zealand was taken from **OECD (2021)**.

The agricultural sector in South Africa is highly diversified. Maize production is dominant since it is both the major feed grain and staple food of the country (Tongwane *et al.*, 2016). Additionally, wheat production and, to a smaller extent, sugar cane and sunflower seed production are significant outputs (ibid). Livestock also plays an important role with animal products making up half of South Africa's gross production value, led by poultry and followed by cattle, sheep, and pig products (USDA, 2019).

While the agricultural sector's contribution to overall GDP is small, it generates valuable export revenues. The share of agricultural exports in relation to total exports was 11% in 2019 (OECD, 2021). Citrus, wine, table grapes, corn, and apples are the largest export products by value (U.S. ITA, 2021).

The South African agricultural sector accounts for a significant extent of the country's land use. Agricultural land comprises approx. 79% of the country's total land area, with pastureland making up a staggering 69% of land use and cropland 10% (Figure 2).

Figure 2: Agricultural land as a share of total country area (2019)

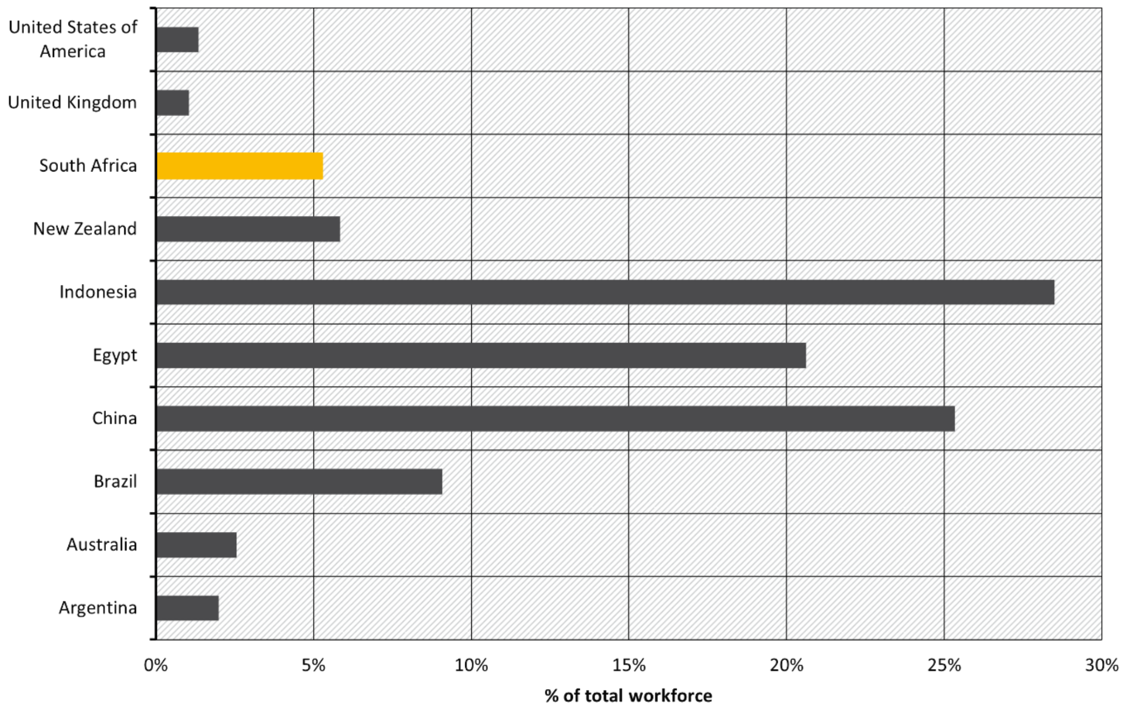


Source: **FAO (2022b)** data for all countries. Data includes "Cropland" and "Land under permanent meadows and pastures".

1.2 Socio-economic dimensions

Formal employment in the agricultural sector is low compared to other countries in the region, making up only 5.3% of South Africa's total workforce (Figure 3). However, a large extent of the rural population depends on agriculture for their livelihood. High levels of agricultural unemployment, driven by increased mechanisation in the sector and substantial increases in the labour force post-Apartheid, have exacerbated the ongoing rural poverty crisis (DAFF, 2010; Ranchhod, 2019).

Figure 3: Agricultural employment as a share of the total workforce (2019)



Source: **World Bank (2021)** data for all countries except Argentina due to data discrepancy. Value for Argentina was taken from **OIT (2021)**.

Agriculture is purported to be one of the most effective pathways out of poverty. In South Africa, GDP growth in agriculture is around four times more effective in reducing poverty than GDP growth in other sectors (FANRPAN, 2017).

Smallholder and subsistence agriculture are the predominant forms of agricultural land use in South Africa. Smallholder farmers make up 1.3 million farming households and hold around 14 million hectares of the country's agricultural land (Nciizah and Wakindiki, 2015). However, most of this is marginal land with poor productivity and infrastructural support. The lack of financial resources causes many smallholders to resort to poor agricultural practices, which has resulted in extreme losses of topsoil (ibid).

South Africa faces considerable struggles with poverty, food insecurity, and unemployment, which is negatively impacted by climate change and natural resource degradation. Approx. 50% of the total population are classified as poor, most of whom live in rural areas and depend on subsistence agriculture. Close to a third of the population are said to be food insecure, and the unemployment rate exceeds 30% (Bese *et al.*, 2021).

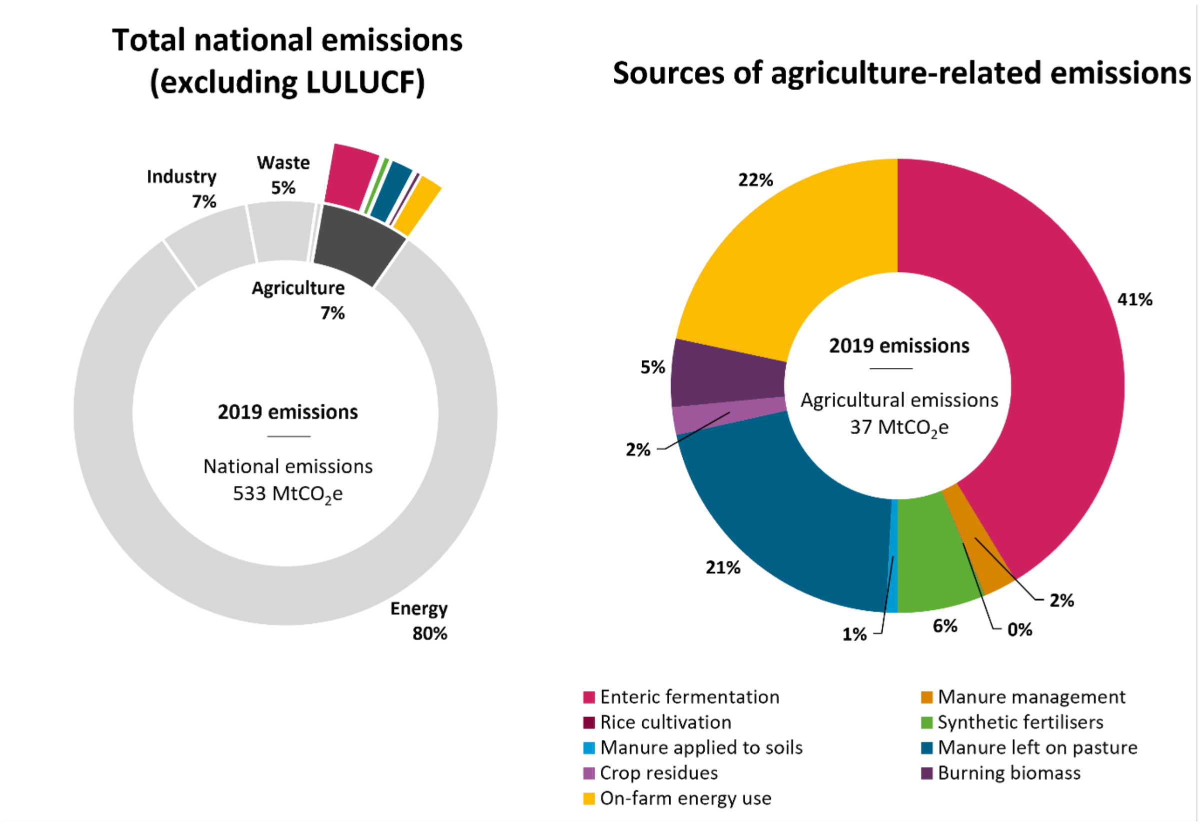
South Africa is a water-scarce country. More than 60% of the country's rivers are being overexploited, and agriculture is responsible for almost two-thirds of South Africa's water consumption (Donnenfeld *et al.*, 2018). The recent drought episodes (2015–2016 and 2018–2020) highlighted the vulnerabilities in South Africa's water system and have sparked national conversations on water security. While the South African government aims to increase irrigation infrastructure as per the National Development Plan (NDP), stakeholders are questioning the extent to which this is possible given the prevailing water constraints (ibid).

1.3 Greenhouse gas emissions from the agriculture, forestry and other land use (AFOLU) sector and drivers

The agricultural sector accounts for approx. 7% of South Africa's national emissions, equating to 37 $MtCO_2e$ excluding LULUCF (Figure 4). The largest agricultural emissions sources include enteric fermentation (41%), on-farm energy use (22%), and manure left on pasture (21%).

FAO estimates of enteric fermentation emissions from cattle are significantly lower than country-reported estimates. Where FAO reports enteric fermentation emissions from cattle of 12 $MtCO_2e$ in 2017, South Africa reports emission levels of almost 20 $MtCO_2e$ in the same year (Republic of South Africa, 2021b; FAO, 2022a). The two sources report different totals due to the use of different emissions factors in their calculations. FAO relies on the more general, Tier 1 approach for all countries using default emissions factors whereas country-reported data primarily applies a Tier 2 approach with emissions factors based on national data.

Figure 4: South Africa's GHG emissions profile (2019)



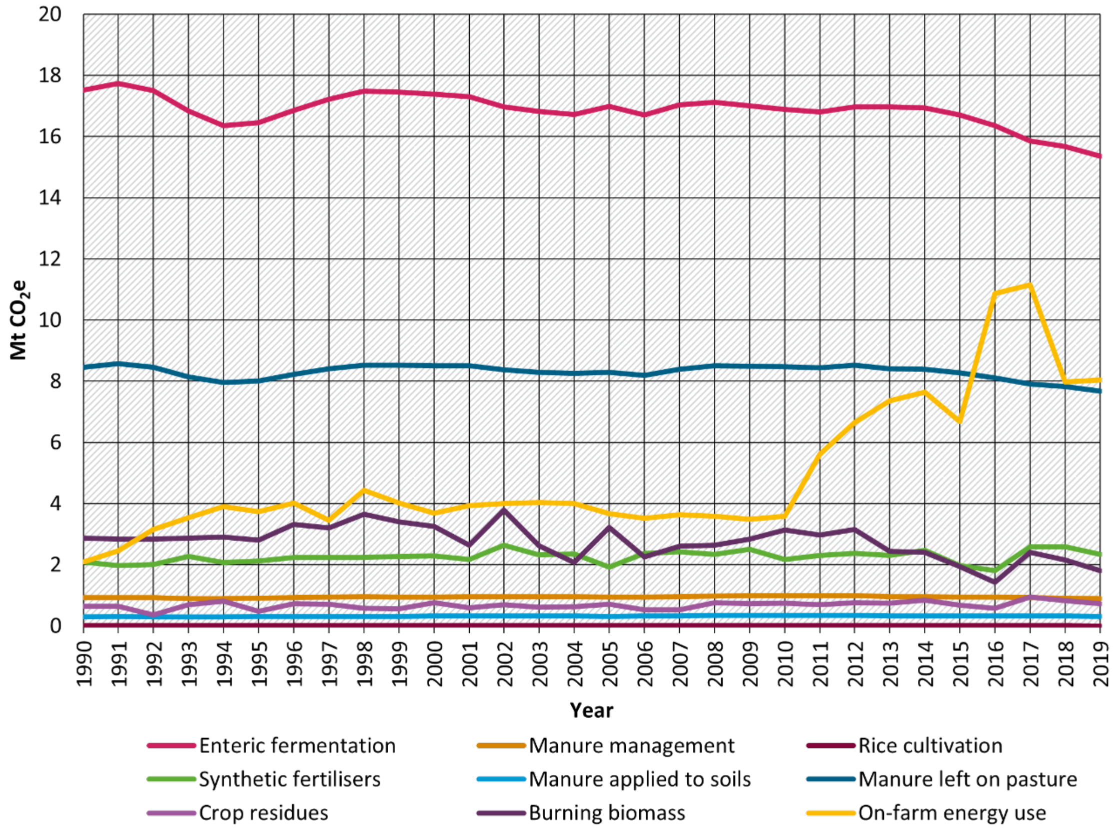
Source: **Gütschow et al. (2021)** for energy (excl. on-farm energy use), industry, waste, and other sectors. **FAO (2022a)** for agriculture and agriculture-related emissions.[1,2]

[1] The PRIMAP-hist dataset used for all non-agriculture-related emissions combines multiple datasets but prioritises country-reported data (Gütschow *et al.*, 2016, 2021). FAO data may differ from nationally reported agricultural emissions under the UNFCCC, and thus agricultural emissions reported under PRIMAP-hist, as a result of data uncertainties and differing methodological approaches to reporting emissions in this sector. We use FAO for these graphs for non-Annex I countries since it includes a complete time series from 1990 to 2019, has a higher level of detail for non-Annex 1 countries (e.g. enteric fermentation emissions per category of animal), and to maintain consistency across the assessed countries.

[2] While on-farm energy use is generally reported under the energy sector emissions for both PRIMAP-hist (Gütschow *et al.*, 2021) and national data, we include it as an agriculture-related emissions source in this study because it is part of agricultural production (fuel use in harvesters, stable heating, grain drying etc.) and its relevance in several countries in terms of magnitude and mitigation potential. We refer to 2019 instead of 2020 data which was the latest data available at the time of writing, due to COVID-related economic dynamics that affected national emissions in 2020.

Apart from on-farm energy use, most agricultural-related emissions in South Africa have decreased since the 1990s (Figure 5). This minor decrease is attributed to a reduction in livestock numbers (Republic of South Africa, 2021b). Livestock owners have struggled to rebuild their herd following the consecutive droughts in 2015 and 2016 in addition to losses from disease (Republic of South Africa, 2021a). The increase in on-farm energy use emissions is likely related to economic growth and an increase in agricultural output (ibid). A large amount of energy is consumed by intensive livestock production (e.g. feed processing, machinery, milk storage, electrical fencing, etc.) and high irrigation demand (Magama *et al.*, 2022).

Figure 5: Agriculture-related emissions in South Africa (1990–2019)



Source: **FAO (2022a)**

A significant extent of South Africa's agricultural land is only suitable for grazing cattle rather than crop production, meaning most subsistence cattle systems are predominantly pasture-based and supplementation with cereals is uncommon (Tongwane & Moeletsi, 2021). Despite beef cattle farming in subsistence, pasture-based systems being widespread, more than 75% of cattle slaughtered in the commercial sector are finished on maize in feedlots (Scholtz *et al.*, 2013). The cattle in South Africa, especially in subsistence systems, have a comparatively low fitness performance in terms of reproductive rate and longevity. Thus, there is significant potential to reduce the extent of GHG emissions per unit of output by improving the health and reproductive performance of livestock (ibid).

In comparison with other countries in this analysis, emissions from on-farm energy use account for a large share of agricultural emissions in South Africa (~22%). In 2015, the energy demand in the agricultural sector consisted of coal (2%), petroleum product (66%), and electricity (32%) (Nathaniel *et al.*, 2019). Petroleum products made up a significant part of agricultural energy demand due to its use in transporting raw materials, feed, and intermediary and final products

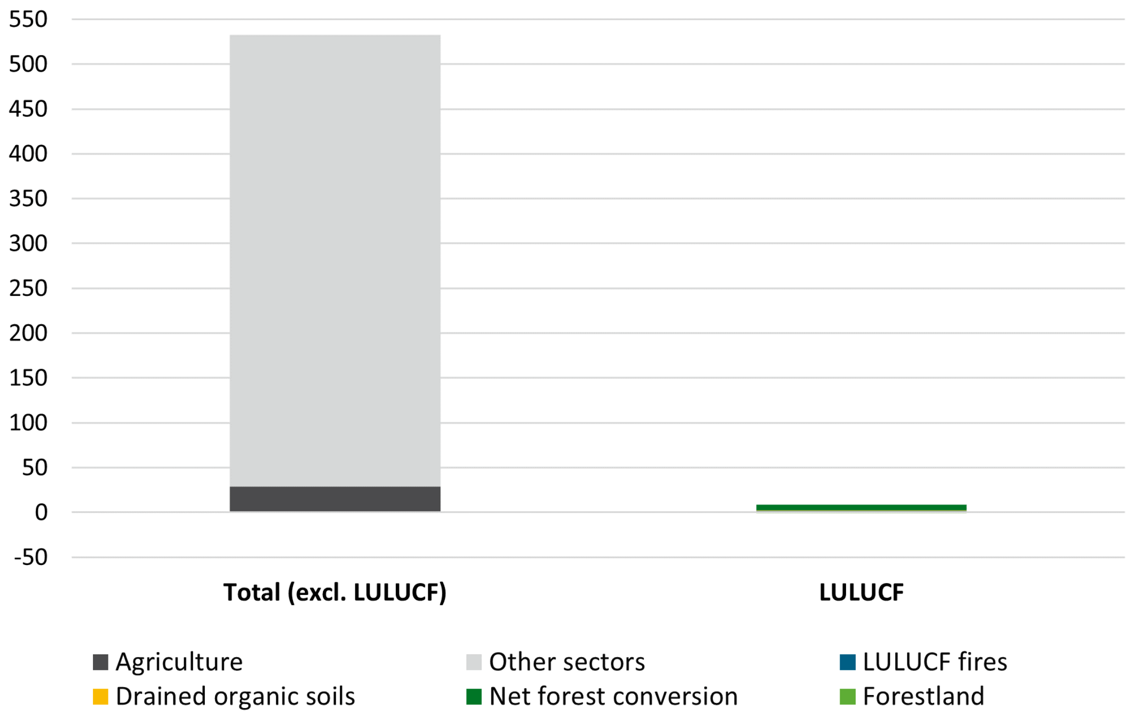
(Ratshomo and Nembahe, 2019). There is significant potential for the country to expand renewable energy's share in its energy portfolio, since it only made up 2.4% of South Africa's primary energy in 2020 (not including biofuels) (Ritchie *et al.*, 2020).

Nitrogen amendments, such as fertilisers or manure, are used to improve crop productivity, but their use results in nitrous oxide emissions, especially when overapplied (Menegat *et al.*, 2021). Synthetic fertiliser usage in South Africa is about two times higher compared to the average in Africa, but is relatively low compared to other emerging economies. The nitrogen fertiliser application rate was approx. 30.7 kilograms per hectare in 2019, compared to a value of 77.3 kg/ha for Brazil or 57.1 kg/ha for Indonesia (Ritchie *et al.*, 2022). Almost three-quarters of total synthetic fertiliser emissions come from cereal crop production (Tongwane et al., 2016).

The South African government recognizes the need to reduce synthetic fertiliser use, and promotes organic farming, regular soil testing, and precision agriculture to improve nutrient management and reduce fertiliser application (ibid). At the same time, there are areas in the country that show negative nutrient balances from the underutilisation of nitrogen fertiliser, so that the government must also facilitate sufficient supplies of crop nutrients by promoting fertiliser use in such areas (OECD, 2021).

Emissions from crop residues across southern Africa are quite low since residues are usually grazed during dry seasons, burned for space heating, or removed for cooking rather than left on the field (Tongwane et al., 2016). For example, over 90% of South African sugarcane residue is burned for harvesting (Pryor *et al.*, 2017). This practice could be shifted to green cane harvesting to utilize biomass for energy and use residues as soil cover (ibid).

Figure 6: South Africa's land use, land use change and forestry (LULUCF) emissions (average over the period 2015–2019) relative to total national emissions in 2019 (excl. LULUCF)



Source: **Gütschow et al. (2021)** for emissions from 'Other sectors' (energy excl. on-farm energy use, industry, waste, and other emissions). **FAO (2022a)** for agriculture-related and LULUCF emissions. LULUCF fires includes the FAO categories

"Forest fires," "Fires in humid tropical forests," and "Savanna fires"[3]. Emissions from LULUCF have high interannual variability so average emissions over 5 years (2015-2019) is presented to avoid outliers.

The LULUCF sector is an emissions source in South Africa, but only accounts for a small portion of total emissions (Figure 6). Nearly all emissions from the sector are derived from forests converted to other land uses (ibid). LULUCF emissions under FAO differ from national data, which reports the sector as an emissions sink due to extensive removals from forestland (Republic of South Africa, 2021a). This is due to differences between FAO and United Nations Framework Convention on Climate Change (UNFCCC) on what can be classified as forest.

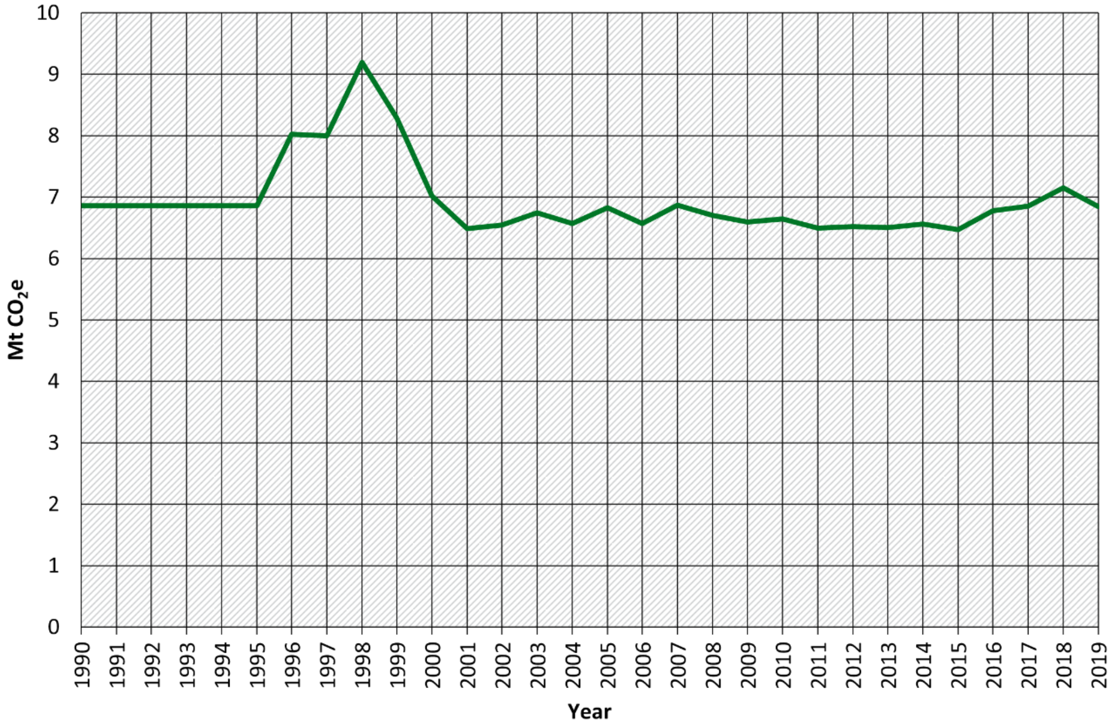
According to FAO, South Africa's LULUCF sector has historically been a minor source of GHG emissions of under 10 $MtCO_2$/year (Figure 7). This is opposed to national data, which accounts for the sector as an emissions sink in most years, amounting to approx. -30 $MtCO_2e$ in 2017 (Republic of South Africa, 2021a).

In the late 2000s, land expansion for crop cultivation, mining, forestry plantations, and urban development were drivers of land use change and corresponding GHG emissions. South Africa has lost 25% of its tree cover since 2000, corresponding to 1.48 million hectares and 902 $MtCO_2e$ of GHG emissions (Republic of South Africa, 2021a; Global Forest Watch, 2022). According to national data, the sink has been growing since 2012 due to increasing forest area, a decline in wood losses, and the reduced use of wood by households due to electrification (ibid).

One of the key outcomes of the South African Government's National Terrestrial Carbon Sink Assessment was that over 60% of the terrestrial carbon stock is stored in grassland and savanna ecosystems (DEA, 2015). This indicates that the restoration and management of pastures is a significant opportunity for additional carbon sequestration that would provide several benefits in terms of rural livelihood and ecological infrastructure (ibid).

[3] In some countries, "Savanna fires" (which includes the prescribed burning of grassland) is accounted for in agricultural emissions under the burning biomass category instead of in the LULUCF sector. In this case, we followed national accounting standards based on UNFCCC reports to allocate the "Savanna fires" category under agriculture or LULUCF emissions. Savanna fires are reported under LULUCF for Australia, Brazil, New Zealand, and the United States, while they are reported under burning biomass for China and Indonesia. South Africa and Argentina report CO_2 emissions from savanna fires under LULUCF, but CH_4 and N_2O emissions under burning biomass. Since all emissions from savanna fires in both countries are non-CO_2 gases, they are accounted for under burning biomass.

Figure 7: LULUCF emissions in South Africa (1990–2019)



Source: **FAO (2022a)**. Includes FAO categories "Forestland," "Net forest conversion," "Forest fires," "Fires in humid tropical forests," "Forest fires," "Savanna fires,"[3] and "Drained organic soils". Note that FAO data differs from national data and uses forest activity data in 5-year intervals, meaning data is averaged over the 5-year periods and can highly fluctuate between those intervals. This report uses FAO data for consistency with the other non-Annex I countries in this report series.

1.4 Government structures and agricultural policy framework

The South African Government's Department of Forestry, Fisheries and the Environment (DFFE), previously the Department of Environmental Affairs (DEA), is the designated authority for environmental protection in the country. They play a central coordinating, monitoring, and policy-making role in climate change matters (Republic of South Africa, 2021b). This includes the administering of AFOLU mitigation measures, such as afforestation and woodland restoration (ibid). The Department of Agriculture, Land Reform, and Rural Development (DALRRD) is another government agency that supports the implementation of climate-smart agriculture and agricultural extension programmes.

South Africa updated their first NDC submission in September 2021. The country aims to reach an absolute emissions level in the range of 398–510 MtCO_2e in 2025, and a range between 350–420 MtCO_2e in 2030, including LULUCF (Republic of South Africa, 2021c). The NDC does not include a specific mitigation target for agricultural sector emissions. South Africa's domestic emission reduction target is not yet consistent with the Paris Agreement's 1.5°C temperature limit, but could become compatible with minor improvements (Climate Action Tracker, 2021). To achieve a 1.5°C pathway, future agricultural emissions must be kept at or below current levels, LULUCF emissions should be reduced to 95% below 2010 levels by 2030, and net deforestation should be stopped at the latest by 2025 (Climate Action Tracker, 2018).

South Africa has several key policies or frameworks related to climate change mitigation in the AFOLU sector. For instance, The National Forests Act supports carbon sequestration activities such as the sustainable management and conservation of natural forests (Republic of South

Africa, 2018). The Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries outlines mitigation principles for the sector, including low- or no-tillage and other conservation agriculture practices, grazing and grassland management, and minimal land use changes (DAFF, 2015).

The Climate Smart Agriculture Strategic Framework, initiated by the DFFE, outlines how climate-smart agriculture (CSA) can be mainstreamed into South Africa's agriculture, forestry, and fisheries sector (DAFF, 2018). It focuses on capacity building, stakeholder partnerships, and investment in research for measures such as nutrient management, soil and water conservation, agroforestry, and improving livestock productivity (ibid).

Existing land use mitigation activities focus on afforestation and degraded land restoration, e.g. the Bamboo for Africa programme to plant bamboo on marginal lands on township outskirts (Republic of South Africa, 2021b). The mitigation impacts to date are minimal and two of the four projects listed are sponsored by carbon offsetting schemes.

Mitigation actions in the AFOLU sector primarily aim at enhancing sinks, with conservation agriculture having the largest contribution to date. The DFFE estimates a mitigation potential for forest and woodland rehabilitation of 22 $MtCO_2e$ over 20 years from 2020. Conservation agriculture has the highest potential at 75 $MtCO_2e$, with grassland rehabilitation at 40 $MtCO_2e$ over the same period (ibid).

South Africa's carbon tax is integral to the implementation of government policies on climate action, but Phase 1 (2019–2022) does not include primary agriculture (OECD, 2021). However, inputs such as electricity and fertiliser are included in the first phase and are meant to incentivise farmers to efficiently use them or look for alternatives (ibid). Primary agriculture will potentially be included in Phase 2 of the tax bill.

1.5 Current developments and trends

The adoption of conservation agriculture in South Africa is being actively promoted by the Department of Forestry, Fisheries and Environment. This includes measures such as new cropping practices focused on water and fertiliser management, integrated crop-livestock systems, agro-ecology practices such as crop rotation and cover crops, and adapted livestock and pasture management (FANRPAN, 2017).

Soil organic matter (SOM) is naturally low in South Africa, where an estimated 60% of soil contains less than 0.5% SOM. Low SOM is associated with poor soil structure, low water infiltration, and low nutrient levels (Swanepoel *et al.*, 2017). Poor management practices have further reduced the extent of SOM, and contributed to an average overall loss of 46% of soil organic carbon in croplands (Swanepoel et al., 2016). Conservation agriculture practices such as no-till, organic soil cover, and crop diversification are linked to improved soil health and higher SOM levels. However, uptake of these practices is still quite low. For example, only 7% of South African cropland is under no-till cultivation (Swanepoel et al., 2017).

South Africa's expansive livestock systems provide opportunities to integrate them with cropping systems. The eastern side of the country already contains large areas of mixed rainfed humid and arid crop-livestock farming systems with rather high crop diversity (Thornton and Herrero, 2015). The emission intensities of mixed crop-livestock systems tend to be 24–37% lower than that of grazing systems due to higher-quality diets, and mixed systems can also improve food security and livelihoods (ibid).

1.5.1 Diets and food waste

Demand-side and external factors have also shaped South Africa's agriculture system in terms of production volume, resource use, and economic activity. Meat production and consumption are increasing in trends in South Africa, as a result of urbanisation, rising wealth, and a growing middle class. Average broiler chicken and pork consumption have risen by 5% and 4%, respectively, per year between 2007 and 2015 (Jankielsohn, 2015). Despite food security concerns, approx. 40% of maize grown in South Africa is used for animal feed (ibid).

The country generates a relatively high amount of food waste at 210 kilograms per capita per year (WWF, 2017). Around half of this waste occurs at the primary production stage, while fruits and vegetables and cereals make up 70% of total supply chain food waste. Around a fifth of total water withdrawals are used to produce food that is subsequently wasted, which is significant in a high water-stress country like South Africa (ibid). In line with Sustainable Development Goal 12.3, South Africa aims to halve its food waste by 2030.

1.5.2 Recent developments in national context

The COVID-19 pandemic has had considerable impacts on South Africa's agriculture sector. Smallholder farmers struggled to sell their fresh, perishable products due to demand fallout and the closure of local markets, made worse by the rise in unemployment, while commercial farmers incurred losses as a result of restricted export markets (Tripathi et al. 2021). The impacts of COVID were compounded by climactic challenges such as early frost and drought conditions, that were exacerbated by the lack of access to inputs such as seeds, chemical fertilisers, and livestock medicine (ibid).

1.6 Vulnerability and adaptation

Climate change impacts will exacerbate the extent of environmental degradation, disease outbreaks, and higher input costs imposed on the South African agriculture sector (World Bank Group, 2021). Generally speaking, climate change will adversely impact cereals production, high-value export crop production, and intensive livestock systems, while improving the productivity of tropical crops such as sugarcane, though this may be offset by increased pest outbreaks (ibid).

South Africa is already under high water-stress, and climate change will further constrain water supply. Crop yields will be impacted by reduced water availability, and increased soil moisture deficits may change the suitable areas for agriculture and the crops grown (ibid). South Africa has high vulnerability to drought, as evidenced by the 2015–2016 drought (and later 2018–2020 drought) caused by El Niño conditions (Republic of South Africa, 2018). Drought periods are expected to increase in magnitude and frequency under climate change. The majority of maize (83%), wheat (53%), and sugarcane (73%) is grown in dry-land conditions, making them particularly vulnerable to periods of drought (ibid).

South Africa's National Climate Change Adaptation Strategy (NCCAS) was approved by the government in 2020. The strategy outlines adaptation measures such as providing support to farmers to implement climate-smart and conservation agriculture practices, enhancing extension services to provide pertinent adaptation information, and improving water management sustainability (Republic of South Africa, 2019b).

2 Key areas with high mitigation potential

2.1 Introduction

In this section, we quantify the potential of three mitigation options and explore the co-benefits and barriers to their implementation in a country-specific context. In selecting which three mitigation options to quantify, the contribution of different emission sources was considered, along with the potential for socio-economic and environmental co-benefits, the country-specific context of the agricultural sector (see Section 1) and the general feasibility for implementation.

2.1.1 Selection of priority mitigation actions

The livestock sector in South Africa accounts for most of South Africa's agricultural GHG emissions (see Figure 4). Most South African cattle is pasture-raised, which is associated with high emissions intensities in terms of CO_2e emitted per tonne of milk or meat produced. While pasture-based systems generally have higher emissions intensities per tonne of product compared to mixed or feedlot systems due to their low to no grain feed supplementation, South Africa's low calving percentages and high cattle mortality rates further contribute to high emission intensities. As such, there is considerable scope for potential emission reductions by implementing good practices in livestock rearing, which can also result in improved productivity. However, South Africa should simultaneously avoid shifting towards highly intensified livestock production, which is associated with significant environmental degradation, increased manure management emissions, and high indirect emissions resulting from feed production and associated land use change.

Pastureland makes up a significant component of South Africa's land use at 69% of total land area (Figure 2). Over 60% of South Africa's terrestrial carbon stocks are found in grassland or savanna ecosystems, meaning there is considerable scope to preserve and enhance such natural carbon sinks (DEA, 2015). At the same time, SOC stocks have severely diminished over the years due to overgrazing and anthropogenic activities. Implementing improved grassland management practices such as rotational grazing can help to restore degraded pastures and replenish soil carbon stocks.

South Africa has relatively high on-farm energy use emissions, attributed to the high share of petroleum products that make up agricultural energy demand (Ratshomo and Nembahe, 2019). While mitigation options that specifically address on-farm energy use are outside the scope of this study, the adoption of no-till cropping systems can significantly reduce on-farm diesel usage and in turn, result in GHG emissions reductions.

For South Africa, we therefore selected the following measures:

- Restoration of degraded pastures
- No-till cropping systems
- Livestock emissions intensity reduction

2.1.2 Overall mitigation potential

According to our calculations[4], the implementation of the prioritised mitigation options could contribute to an overall emissions reduction of 5 $MtCO_2e$ compared to 2019 levels (assuming

[4] Further methodological details can be found in the final report for this project, available at https://www.umweltbundesamt.de/publikationen/ambitious-ghg-mitigation-opportunities-challenges.

constant levels of production), or 14% of total agricultural emissions, and could result in additional carbon sequestration of 4–5 $MtCO_2e$/year by 2040. However, there is high uncertainty in terms of overlaps between mitigation options and in long-term soil carbon dynamics that can affect the extent of sequestration. In general, carbon sequestration options should not replace the deep decarbonisation needed in GHG emissions to meet climate pledges and 1.5°C compatible emissions levels.

In addition to the mitigation measures described in detail here, the decarbonisation of on-farm energy use and a reduction in food loss and waste could help to further reduce emissions agricultural emissions in South Africa. No literature that estimates the full mitigation potential of agricultural emissions in South Africa was found.

2.2 Prioritised mitigation options

2.2.1 Restoration of degraded pastures

Measure	There is significant potential to restore degraded pastureland in South Africa through improved livestock management practices. For instance, rotational grazing systems move livestock from one portion of pasture (paddocks) to another to ensure even grazing based on forage availability and allow paddocks to rest and recover (Sanderman *et al.*, 2015). Managing the stocking rate, intensity, and duration of grazing can potentially increase soil organic carbon (SOC) stocks and in turn enhance carbon sequestration on grasslands, since it provides a more favourable environment for vegetation growth and organic matter inputs (FAO and ITPS, 2021).
Status	Over 60% of South Africa's terrestrial carbon stocks are found in grassland or savanna ecosystems, representing the importance of preserving and enhancing existing carbon sinks (DEA, 2015). There is potential to restore over 1.2 million hectares of severely degraded grasslands located in the Eastern Cape, Western Cape, and Kwa-Zulu Natal (The Cirrus Group, 2014).
Potential	According to a study by The Cirrus Group (2014), restoring the severely degraded 1.2 million hectares of grassland found in the Eastern Cape, Western Cape, and Kwa-Zulu Natal can lead to additional carbon sequestration of 3–4 $MtCO_2e$/year when assuming a sequestration rate of 0.7–1.0 tC/ha/year. This rate is relatively high when compared to other studies that estimate the additional sequestration gains of improved grazing management to be around 0.1–0.3 tC/ha/year (Tessema *et al.*, 2020). However, the former study referenced may consider grassland restoration options beyond livestock grazing. Sequestration rates are also highly site dependent and highly uncertain. Evidence of the sequestration benefits of rotational grazing is extremely mixed and at times contradictory (Sanderman *et al.*, 2015; Garnett *et al.*, 2017).
Co-benefits	Rotational grazing practices usually result in improved soil structure, protection against soil erosion, and enhanced soil biodiversity, all important facets of general soil health and functioning (FAO and ITPS, 2021). The restoration of grasslands are in line with South Africa's development priorities as it provides skill development and employment opportunities, greater water security, and more resilience to climate change impacts (ACDI, 2015).
Barriers	**Economic barriers:** Rotational grazing practices require increased labour and infrastructure needs, which may result in high upfront and maintenance costs

that deter farmers from adoption (FAO and ITPS, 2021). By keeping plots of pastureland empty for rest and recovery, farmers may also perceive lost opportunity costs (Abdalla *et al.*, 2022).

Biophysical/environmental barriers: Disruptive weather patterns and climactic changes can pose challenges to maintaining rotational grazing practices, especially in drought-vulnerable countries like South Africa. Several factors need to be considered when implementing rotational grazing practices, including current SOC stocks, topography, vegetation, soil type, etc. (FAO and ITPS, 2021).

Technical barriers: The measurement, reporting, and verification (MRV) of emissions reductions from gains in soil carbon stocks is challenging due to its uncertainty and complexity. It is difficult to measure small changes in soil carbon relative to total carbon stocks and relative to large areas (OECD, 2019). The high costs of current MRV systems has further limited grassland restoration activities in South Africa (ACDI, 2015).

Institutional barriers: The UNFCCC's Reducing Emissions from Deforestation and Forest Degradation (REDD+) framework provides technical and financial support to developing countries to reduce emissions and enhance removals from forests. However, REDD+ does not cover the considerable carbon stocks in grassland, meaning there is little international support to mitigate LULUCF emissions in non-forest ecosystems (ACDI, 2015).

2.2.2 No-till cropping systems

Measure

Shifting from conventional tillage systems, where soil is turned to control for weeds and pests and for seeding preparation, to low- or no-till systems with minimal to no soil and residue disturbance. No-till systems generally result in increased soil organic carbon (SOC) stocks, which can increase soil carbon sequestration rates on cultivated land in the near term (Swanepoel *et al.*, 2018). No-tillage should be combined with other conservation agriculture practices such as cover crops and crop rotation to achieve its full benefits and maximum mitigation potential (ibid). No-till cropping systems can result in additional, possibly greater, emissions reductions from decreased on-farm energy use (ACDI, 2015).

Status

South Africa has naturally low soil organic matter (SOM), which has been exacerbated by poor management practices. The uptake of no-till practices has been quite low and represented only 7% of cultivated land (Swanepoel *et al.*, 2017).

Potential

Implementing reduced tillage on 20% of South Africa's arable land (~3 million hectares) could result in additional carbon sequestration of 1 $MtCO_2e$/year (The Cirrus Group, 2014). The largest emission reductions from no-till would likely come from the concurrent reduction in diesel usage, but this additional mitigation potential was not quantified in this study. No-till production systems can use up to 60% less diesel than conventional systems (ACDI, 2015).

Co-benefits

Reduced or no tillage improves soil health and function through reduced erosion, enhanced biodiversity, and increased water infiltration. The additional moisture retention improves adaptation to climate change impacts. Under most circumstances, no-till in combination with other conservation agriculture practices increases yields and profitability, but this is highly dependent on site-specific conditions (FAO and ITPS, 2021).

Barriers

Biophysical/environmental barriers: The impact of no-till agriculture is highly dependent on soil type and climate, and actions must be tailored towards specific on-farm conditions (Swanepoel *et al.*, 2018). Further, no-till agriculture can also pose challenges to yields, particularly from higher weed growth. The most common approach to weed control in the absence of tillage is to use herbicides, which themselves have negative impacts on soils and biodiversity (Fortuna, 2021). Eliminating or reducing both tillage and herbicide use would require other adaptations, such as alternative crop varieties, cover cropping and crop rotations, that are still being researched and present their own barriers and challenges to implementation (Colbach and Cordeau, 2022).

Technical barriers: Knowledge is a major limitation for implementation, as adopting low- or no-till systems requires new knowledge on weeds, pest control, and fertilisation as conventional practices change (FAO and ITPS, 2021). The MRV difficulties for SOC gains and improvements in soil quality poses further challenges to assessing yield and profitability impacts in the short- to medium-term (Swanepoel *et al.*, 2018).

Natural carbon sequestration: Risks and uncertainties

The estimated carbon sequestration potential of below- or above-ground land-based mitigation measures, such as rotational grazing, cover crops, agroforestry, or silvopastoralism, is quite high and often overshadows the overall mitigation potential of agricultural systems. However, its effectiveness is highly uncertain and dependent on multiple site-specific factors (Nabuurs *et al.*, 2022). In general, carbon accumulation in soils or vegetation carries risks of non-permanency and reversibility. Increased carbon stocks will eventually reach a new equilibrium in the long-term when net CO_2 removals from the atmosphere reach zero and will no longer be an active sink (Garnett *et al.*, 2017; Landholm *et al.*, 2019). Soil carbon gains are reversible and can be undone if improved management practices are not maintained or stocks decrease due to climactic factors. In agroforestry systems, as with all natural systems, there is a risk that fires, climate change, or disease could cause carbon to be re-released into the atmosphere (Meyer *et al.*, 2020). While natural carbon sequestration measures should not replace the decarbonization needed in the agricultural sector to meet climate targets and 1.5°C compatible emissions levels, they have numerous co-benefits, are an effective climate change adaptation measure, and should therefore continue to be supported and implemented.

2.2.3 Livestock emissions intensity reduction

Measure

The emission intensity per tonne of meat or milk from cattle can be improved by employing good practices in livestock rearing, including improved health monitoring and disease prevention, breeding optimisation, diet and nutrition optimisation, and improvements in manure management and manure handling. This measure does not consider any changes from the current livestock production systems in South Africa (i.e. shifting from pasture to feedlots). While maize-finished, feedlot cattle make up a large portion of the commercial beef sector, South Africa has significant subsistence livestock systems that could improve their management practices on their pasture-based systems with technical and financial assistance.

Status	South Africa's enteric fermentation emissions intensity per tonne of beef varies significantly across different sources. While data from FAO (2022) estimates an emissions intensity of around 10 tCO_2e/t product in 2019, Tongwane & Moeletsi (2021) estimated it to be double that at 20 tCO_2e/t product. The latter applies a Tier 2, management system- and country-specific approach to emissions estimates that has less uncertainty (ibid). For the purpose of our calculations, we used the 20 tCO_2e/t product emissions intensity value based on national data since it more accurately represents South Africa's specific livestock production system. Considering the country-specific data, South Africa's enteric fermentation emissions intensity per tonne of beef is relatively high compared to most high-producing countries. The country has a low rate of cattle sold or consumed relative to total population, which is attributed to low calving percentages and high mortality rates (Meissner *et al.*, 2013).
Potential	South Africa's livestock production systems are very similar to Australia's in terms of the available feed types and environmental conditions (Republic of South Africa, 2019a). Based on our own calculations[5] and data from Tongwane and Moeletsi (2021), if South African livestock systems applied good practices to at least achieve Australia's current beef emissions intensity levels (around 15 tCO_2e/t product), it would result in emission reductions of 6 $MtCO_2e$/year in 2030 compared to 2019 levels (20% reduction in enteric fermentation emissions, 28% in manure management emissions), assuming meat and dairy production remain constant at 2019 levels. If beef and milk production continued to increase following the 10-year historical trend, it would result in considerably smaller emissions reductions of 2 $MtCO_2e$ compared to 2019 levels (4% reduction in enteric fermentation emissions, 28% in manure management emissions). The estimates outlined above represent a maximum emission reduction potential based on decreasing the emissions intensity per tonne of beef or milk produced. While our calculations aim to not consider changes to existing livestock production systems, there is a risk that further grain supplementation to achieve higher yields and lower emission intensities would result in increased indirect emissions from feed production and associated land use change. Intensive livestock production also contributes to significant environmental pollution and rising manure management emissions.
Co-benefits	Livestock health monitoring generally improves animal welfare conditions, which has positive implications for food safety and biodiversity conservation (Llonch *et al.*, 2017). Increased productivity per unit of livestock can help meet the rising demand for animal products and benefits food security, while improving farmer's incomes and livelihoods (Dickie *et al.*, 2014). Improved livestock management will generally increase adaptive capacity and resilience to climate change impacts (Rojas-Downing *et al.*, 2017).
Barriers	**Technical barriers:** There are practical barriers to applying good practices to extensive, pasture-based livestock systems since cattle are able to move around freely (Kipling *et al.*, 2019). Smallholder farmers in particular lack access to

[5] Further methodological details can be found in the final report for this project, available at https://www.umweltbundesamt.de/publikationen/ambitious-ghg-mitigation-opportunities-challenges.

financial and information services to improve their farming efficiency (Tongwane and Moeletsi, 2020).

Biophysical/environmental barriers: Climate change impacts have already affected livestock systems in South Africa, including a severe drought in 2015 that decimated livestock numbers. Poor quality forage conditions and pest and disease outbreaks are expected to be exacerbated with climate change, which can impede the adoption of good practices in livestock management (Kriel, 2017).

Policy/legal barriers: Subsistence livestock farming is common in South Africa and plays a critical role in sustaining rural livelihoods. Reducing their emissions would require major changes in the socio-economic structure of the agricultural sector (Dickie *et al.*, 2014). Black farmers, who own a significant share of subsistence cattle, have struggled to increase and commercialize their output due to the poor implementation of policies, and poorly designed and administered programs (Sihlobo and Kirsten, 2021).

Economical barriers: South African livestock farmers lack the access to funds needed to improve their management practices for a number of reasons, the main being land ownership requirements, which further disadvantages poor farmers with insecure land tenure. High levels of stock loss, driven by theft and natural predators, has also affected the economic viability of livestock farms (Meissner *et al.*, 2013).

3 Barriers to implementing mitigation potential

In this section, we examine the main barriers to mitigation of agricultural emissions identified for the country, building on the findings of a report on general barriers prepared under this research project[6] and the country-specific circumstances described in Section 1 of this report. The analysis of barriers below follows the clustering proposed in WP2 report, according to the relevant governance level for taking action, while taking into account the classification from the Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change and Land (IPCC, 2019) within each of the governance levels.

3.1 Farm level

The mitigation options suggested in this report are synergetic with economic benefits for farmers in the medium term. However, they require upfront investments in infrastructure, machinery, and equipment, as well as capacity building to transition from current practices to alternative, more sustainable ones (e.g. low tillage agriculture or implementing techniques for managing and restoring degraded pastures). These potentially high costs, if not mitigated by the government, will represent a significant barrier for implementation.

Especially in the context of the National Land Reform Programme[7] in South Africa, the beneficiaries of the programme struggle to get access to credits, equipment and technical assistance which is then reflected in their decision whether to adopt climate-friendly practices or sometimes even whether to farm the land at all. Recent surveys show a significant decrease in land being used for crop production since it was transferred as part of the land reform (Financial and Fiscal Commission, 2016).

The effect of droughts also endangers the ability of farmers to transition effectively to new practices and benefit from such a transition.

Food loss rates in South Africa are relatively high at 210 kg per person per year, with 50% occurring at the agricultural and post-harvest stage (WWF, 2017). A challenge to reducing food loss is a lack of data on the causes and primary pathways (ibid). Current barriers to reducing on-farm food waste in developing countries include a lack of infrastructure, managerial and technical difficulties, and limitations to harvesting techniques. These can primarily be addressed by capacity building and knowledge dissemination of good practices and economic investments in improved infrastructure (e.g. storage, harvesting) and technologies (Parfitt *et al.*, 2010).

3.2 National level

Despite water scarcity and limited agricultural potential of the country's land, South Africa's National Development Plan aims at expanding irrigated agriculture and land production. This plan was published in 2013, and such targets are being questioned by stakeholders after drought periods highlighted the country's high vulnerability in this regard. These events are only expected to increase in magnitude and frequency as a result of climate change and national targets to expand agricultural production might need to be revised to reflect the current and forthcoming climate impacts.

Regarding data monitoring and reporting systems, there are a few studies mapping soil organic carbon stocks and trends for South Africa, aiming to help inform decision-making around soil

[6] See https://www.umweltbundesamt.de/publikationen/barriers-to-mitigating-emissions-from-agriculture.

[7] The Land Reform Programme aims at a "deracialisation of the rural economy and democratic and equitable land allocation and use across gender, race and class". Over the last decades, the South African government has implemented different pieces of legislation to support this reform (Republic of South Africa, 2023).

productivity and meeting climate change mitigation targets (Venter *et al.*, 2021). However, the government needs to take up these methodologies and data to reflect the impact of mitigation actions related to sustainable pasture management in the national emissions inventory. Given that pastureland makes up around 70% of the country's land use, improving data monitoring and reporting systems for soil organic carbon stocks will increase the recognition that the government can gain from implementing policies around restoration of degraded pastures.

At the policy level, there is a limited number of agriculture policies that are related to climate change mitigation. The country's second Biennial Update Report specifies only two mitigation measures for the sector (reducing enteric fermentation emissions and reducing tillage in cropland) and there is no information on their state of implementation (Department of Environmental Affairs, 2017). More coordination between government levels and offices is needed to create incentives for farmers to change their current management practices and improve the design and implementation of coherent and ambitious climate policy with specific targets for the agriculture sector.

3.3 International level

South Africa is a major exporter of agricultural products, generating important export revenues. This is an incentive to maintain or increase production, potentially including that of currently unsustainable products. Possible import restrictions of other countries on unsustainably produced products, or more international demand for ecologically certified products, might change these incentives but it is unclear how they will develop.

3.4 Consumer level

Depending on how the suggested changes in agricultural practices are financed, they could result in increased prices, particularly during the transition towards a sustainable model. Sensitivity of the consumers towards fluctuations in prices (entailing further threats for food security) could thus be a barrier for farmers to risk the transition, if they fear that they cannot sell their products at increased prices.

While shifting demand patterns is not a focus of this report, increasing trends in meat consumption in South Africa and the sociocultural values tied to braais (BBQs), deter the adoption of a more environmentally friendly diet. Food waste (see section 1.5.1) is considerably high in the country, leading to avoidable GHG emissions from both the agricultural production of surplus, wasted food and the release of methane during food waste management.

4 Recommendations

In a world compatible with the Paris Agreement, the agricultural sector will need to meet the growing food demand of people and animals, while contributing to other equally relevant climate and development objectives and adapt to a changing climate. Mitigation action in South Africa, one of the large emitters globally, is essential for limiting global temperature increase, including in the agricultural sector. The mitigation of climate change is also essential to South African agriculture, where droughts have become a frequent, acute threat to food supply and lead to further deterioration of soils. The productivity of the land in South Africa is already low and many measures can improve the soil quality and increase the resilience of the agricultural sector, additionally to reducing GHG emissions, while maintaining the diversity of agricultural production in the country.

This study identified and quantified three mitigation actions in South Africa's agricultural sector that would improve productivity and provide environmental and economic co-benefits: The restoration of degraded pastures, the expansion of no-till cropping systems and the reduction of livestock emission intensity.

To maximise emission reductions in the agricultural sector, South Africa would need to take a multi-faceted approach. Based on our own calculations, reducing livestock emission intensity through improvements to animal health and optimising diets could mitigate about 5 $MtCO_2e$/year, or 14% of current agricultural emissions, at current production levels. An additional carbon sequestration of 4–5 $MtCO_2e$/year could also be achieved by 2040 through restoring degraded pastures and implementing no-till cropping systems.

Apart from GHG reductions, these measures can play an important role in improving the productivity of soils in the long run and reduce irrigation needs, which is urgently needed to supply the population with food and guarantee production for export. Increasing the area covered by no-till cropping systems not only improves soil quality, but also reduces diesel use from on-farm machinery. This element is not quantified here, but could be a relevant amount, given that almost a quarter of emissions from agriculture are energy related.

Despite the relatively small amount of emissions from the AFOLU sector compared to the energy sector, the reductions can make a contribution to achieving the NDC target, which would not be achieved with current policies (Climate Action Tracker, 2022b).

The implementation of more sustainable practices in the sector currently faces various challenges: The exact approach to restore degraded pastures is determined by local characteristics of the soil, climate, water availability and other factors, so a one-size-fits-all approach will not work. This makes the knowledge dissemination and targeted support more difficult. New practices may also require more labour and upfront investments, and the perception of farmers may be that measures such as rotational grazing do not bring sufficient returns, given part of the area is always kept idle.

To accelerate the uptake and implementation of the measures described in this report, it is key to enhance the national mitigation framework in the agricultural sector and reconcile agricultural and development goals and mitigation options, while strengthening the international competitiveness of the sector and protecting it from environmental and economic risks. Some concrete options are outlined in the following paragraphs:

1. Enhancing the national climate mitigation framework in agriculture

While South Africa does not mention agricultural mitigation objectives in its NDC, it has other strategies for addressing the GHG emissions of the agricultural sector and forestry in place. Most important are the National Forests Act, the Draft Climate Change Sector Plan for Agriculture, Forestry and the Climate Smart Agriculture Strategic Framework. The extent to which these strategies get implemented is not always clear. For example, one objective of the Draft Climate Change Sector Plan for Agriculture is to reduce tillage, yet this practice has only been implemented on a small share of land so far.

One key improvement for the national framework is a better data monitoring and reporting system for soil organic carbon stocks. Pastureland makes up around 70% of the country's land use and seeing more clearly where measures lead to positive changes in carbon stocks (and as a result higher soil quality), will increase the recognition of the importance of measures. In addition to improvements in measuring soil carbon, MRV systems should be made more accessible to farmers, as high costs currently limit their use (ACDI, 2015).

The agricultural sector suffers from a divide that the apartheid system has left behind, and which has not been overcome by land reform policies. Most commercial farming is held by white people, while most subsistence farming is by Black people. Addressing these important distributional issues should go hand-in-hand with ensuring that farmers have access to sufficient funds and knowledge to implement sustainable practices.

2. Align overall agriculture framework with climate mitigation objectives

The main policy objectives of the South African government are a secure and stable supply of food and export revenues, and potential GHG emission reductions are rather a side-effect. The National Development Plan suggests the expansion of production on irrigated and dry land, beginning with smallholder farmers (National Planning Commission, 2012). The Department of Forestry, Fisheries and Environment actively promotes the adoption of conservation agriculture in South Africa. To avoid additional N_2O emissions it is important that the productivity of soils increases through sustainable practices, rather than increased fertiliser use.

3. Selected ideas for how mitigation could be strengthened

Building on existing policy structures and initiatives, the South African government can foster mitigation in the agricultural sector. Many activities are already in place and can be complemented, expanded, and potentially improved. Some more concrete, non-exhaustive ideas are:

- **Expand knowledge dissemination on sustainable practices**, particularly to smallholder farmers, also encouraging exchange of local and traditional knowledge in local language as needed, to acknowledge the diverse conditions of soils and type of crops.
- **Plan agricultural production under increased frequency of droughts**, to increase the resilience of the sector and decrease volatility of food supply. This can also improve the carbon sequestration of the soils.
- **Strengthen cooperations with exporters of sustainable products**, which can often generate higher revenues and is likely a growing market going forward, e.g. organic fruit or wine. The increased revenues could be used for covering investment costs of more sustainable practices.
- **Leverage international support, including capacity building and technology transfer**, particularly in electrifying and increasing the share of RE in the transport sector to decrease on-farm energy consumption.

While this report focuses on improvements on the production of agricultural products, it is essential to highlight that without changes to dietary patterns mainly in developed countries, a sustainable and just 1.5°C pathway is not feasible. In South Africa, 40% of maize is fed to animals (Jankielsohn, 2015) and meat consumption is already above world average (Climate Action Tracker, 2022a). Discussing alternative narratives could help understand the implications of a shift to largely plant-based diets and potentially avoid disruptions in the sector in the medium to long term. International research reports that demand-side measures, such as shifting to less meat intensive diets and reducing food waste, have a high mitigation potential while contributing to other co-benefits at relatively lower costs (Roe *et al.*, 2021).

Food waste in South Africa is relatively high, and the Food Loss and Waste Voluntary Agreement intends to respond to this challenge through a public, collaborative declaration of intent to reduce food and beverage waste and redistribute or enable markets for nutritious surplus food. The Consumer Goods Council of South Africa (CGCSA) and the national Department of Trade, Industry and Competition (DTIC) initiated dialogues on this subject and together with the Department of Forestry, Fisheries and the Environment (DFFE) have been working with South Africa's food supply chain (from farm to fork), to develop and implement a national Food Loss and Waste Agreement. Less food waste would make more food available for consumption, reduce water needs, and avoid emissions from the decomposition of waste.

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