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Implementation of Nationally Determined Contributions

Ethiopia Country Report

For our Environment

Umwelt Bundesamt

CLIMATE CHANGE 28/2018

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Implementation of Nationally Determined Contributions

Ethiopia Country Report

by

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Introduction to the project

This country report is part of the "Implementation of Nationally Determined Contributions" (NDCs) project (FKZ 3716 4111 80), which considers NDC implementation in 10 countries: Colombia, Ethiopia, Georgia, Indonesia, Iran, Kenya, Marshall Islands, Morocco, Peru, and Viet Nam. This project places a special emphasis on identifying potential barriers to NDC implementation and mitigation potentials which could go beyond the current NDCs.

The country reports analyze the NDCs in terms of their robustness and coherence with other national or sectoral plans and targets, and put them into the context of additional mitigation potentials and other national circumstances. For countries where coal plays a critical role in consumption or national production, the analysis covers further details on this sector, including the economic relevance and local impacts of coal production or consumption. The content is based on available literature from research and public sector information on policies and institutions.

To be able to analyze the content in more detail, the authors focus the research on a number of relevant fields of action. The fields of action were selected based on historic and projected sectoral emissions development, comprehensive literature on GHG mitigation potentials, identified barriers and emissions reductions as well as feasibility, costs, and co-benefits.

The project was suggested and is financed by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, supervised by the German Environment Agency and carried out by independent think tanks - NewClimate Institute and Wuppertal Institute. The country reports are a continuation of similar previous efforts (project numbers 3713 41 102, 3711 41 120, 360 16 022, 364 01 003 and 363 01 128) and aim to inform policy makers and the interested public about the implementation of NDCs in individual countries. The choice of countries is based on developing countries with which Germany works closely on climate change topics.

The country reports are scientific in nature, and all suggestions are derived by the authors from careful analysis, having in mind the individual backgrounds of countries. They aim to increase knowledge about implementation of mitigation potentials to meet the globally agreed goal of staying within a temperature increase of 1.5°C or well below 2°C above preindustrial levels, without intending to prescribe specific policies.

Overview

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List of abbreviations

AFOLU	Agriculture, forestry and land use
AGF	High-Level Advisory Group on Climate Change Financing
ATA	Agricultural Transformation Agency
BAU	Business as Usual
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit)
BMZ	German Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
BRT	Bus Rapid Transit
BUR	Biennial Update Report
cap	Capita
CDM	Clean Development Mechanism
COP	Conference of the Parties
DRM-SPIF	Disaster Risk Management Strategic Programme and Investment Framework
EPACC	Programme of Adaptation to Climate Change
GDP	Gross domestic product
GPG	Good Practice Guidance
GTP	Growth and Transformation Plan
HOF	House of Federation
HPR	House of People's Representatives
IKI	International Climate Initiative (Internationale Klimaschutzinitiative)
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
ktoe	Kilo tonnes of oil equivalent
LDC	Least Developed Countries
LRT	Light-rail transit
LULUCF	Land Use, Land Use Change, and Forestry
MANR	Ministry of Agriculture and Natural Resources
MEF	Ministry of Environment and Forest
mln	Million
MRV	Monitoring, Reporting, and Verification System
MSIP	Multi-Sector Investment Plan
$MtCO_2e$	Mega tonnes carbon dioxide equivalent

NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Programme of Action
NDC	Nationally Determined Contribution
NMA	National Meteorological Agency
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PM 2.5	Particulate matter with a diameter of 2.5 µm or less
R-PP	Readiness Preparation Proposal
RDPS	Agricultural and Rural Development Policy Strategies
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
SDPRP	Sustainable Development and Poverty Reduction Programme
SLMP	Sustainable Land Management Program
SNC	Second National Communication
SNNP	Southern Nations, Nationalities and Peoples
SRM	Sectoral Reduction Mechanism
TOD	Transit-oriented development
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund

1 Part I: Summary

1.1 Country background

Ethiopia is a landlocked country in the North East Africa region. The country is covered by equatorial rainforest in the south and southwest with high rainfall and humidity, whereas the summits of the Semen and Bale mountains are Afro-Alpine and the north-east, east and south-east lowlands are desert-like. During the last three decades, Ethiopia's population has grown significantly. Thus, in 2014, Ethiopia had a population of about 97 million, more than twice the inhabitants it had in 1990 (World Bank, 2017). While the majority of Ethiopians live in rural areas, about 19% live in cities and urban areas (FDRE, 2016a).

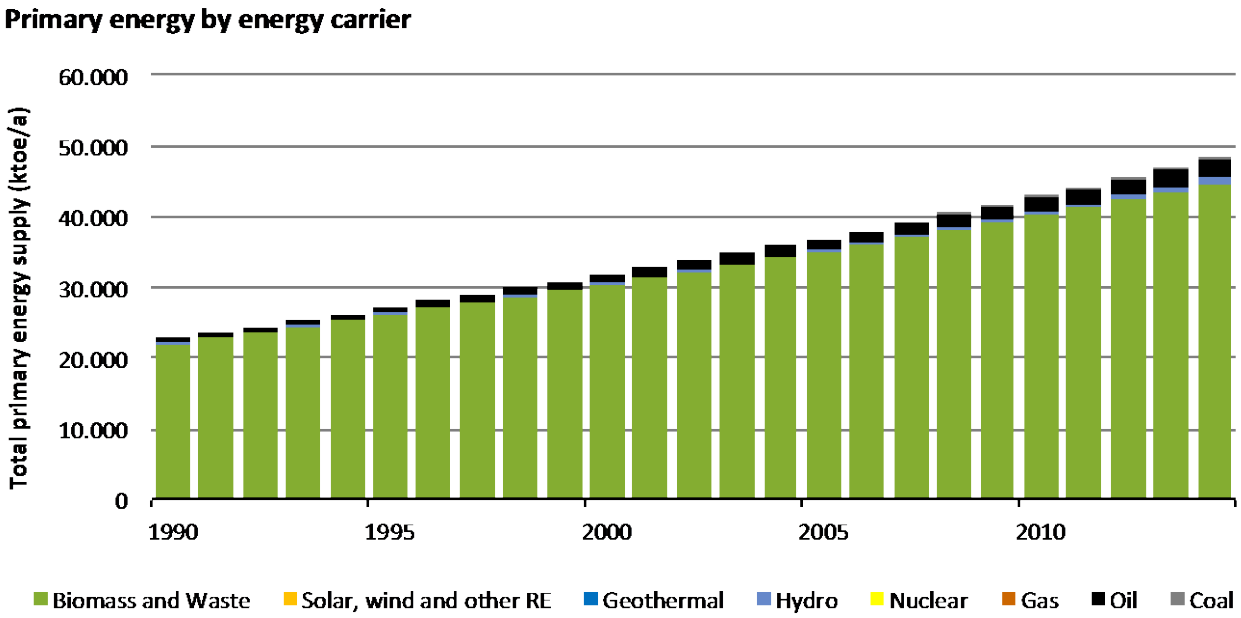
Until 2014, GDP per capita has grown by 127% and total GDP by 367% since 1990 in Ethiopia, making Ethiopia one of the fastest growning, non-oil based economies in the world. Nevertheless, GDP per capita in Ethiopia is still among the lowest in the world (574 USD/cap (2014)). With 80 to 85% of the working population working in agriculture, this economic sector is the backbone of Ethiopia's economy, contributing about 46% of total GDP in 2013. 95% of the cropped land are cultivated by smallholders working in subsistence agriculture and less than 1% of the total cultivated land is irrigated (FDRE, 2016a).

1.2 Energy sources and emissions

Ethiopia heavily relies on biomass fuels (firewood, charcoal, agro-residues) which made up about 92% of the total primary energy supply in 2014. Wind, solar and geothermal power as well as coal play a negligible part in the energy system, but there is huge potential for solar, wind, geothermal and hydropower as well as a further extension of the use of biomass resources and agricultural residues. Ethiopia is currently constructing the Grand Renaissance Dam on the Nile which is going to be the largest hydroelectric power plant in Africa when finished (FDRE, 2016a).

Climate change strategy	✓
Green growth strategy	✓
Energy strategy aligned with CC/GG strategy	✓
Institutional coordination on climate change	(✓)
Renewable energy targets	✓
Level of NDC ambition (CAT rating)	**medium**

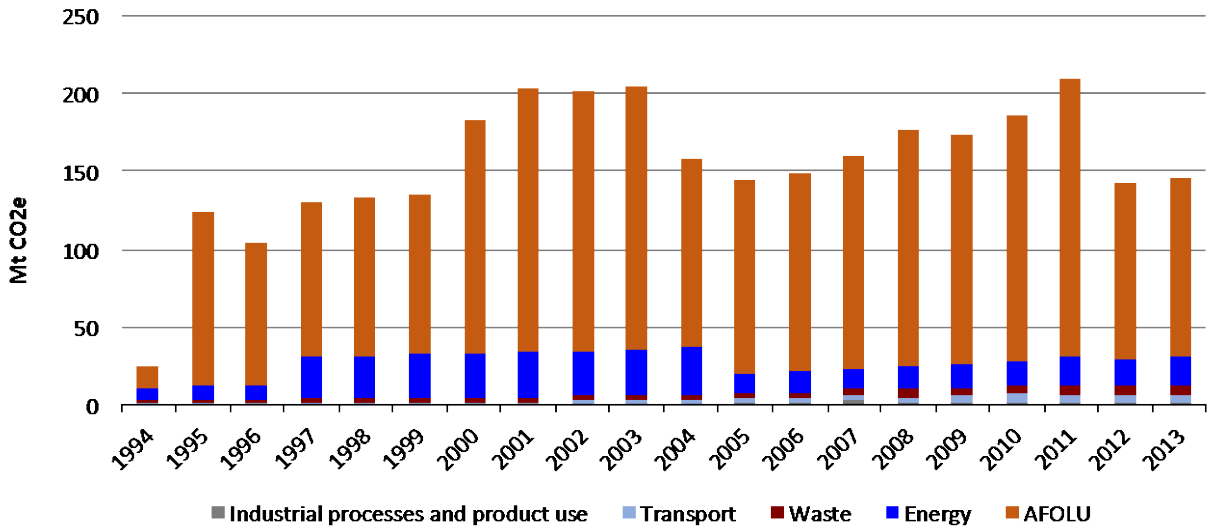
Figure 1: Ethiopia's historical energy profile



Data sources: IEA (2016a).

Agriculture, forestry and land use (AFOLU) are responsible for the largest share of greenhouse gas (GHG) emissions in Ethiopia, while the energy sector only plays a minor part in Ethiopia's emissions profile.

Figure 2: Ethiopia's historical emissions profile

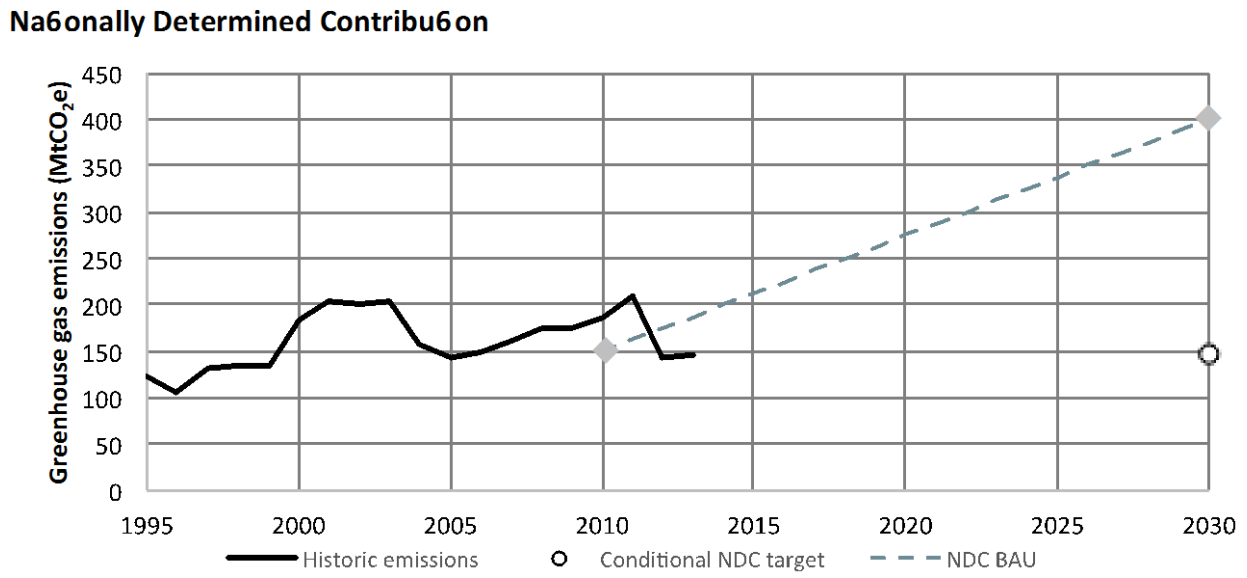


Data sources: FDRE (2016a).

1.3 NDC and ongoing activities

Ethiopia's nationally determined contribution (NDC) includes the conditional mitigation goal to limit net GHG emissions in 2030 to 145 Mt CO_2e or lower. This would reduce 2030 BAU emissions by about 64% and represent absolute emission reductions of 5 Mt CO_2e relative to 2010 emissions. While the largest share of envisaged emission reductions is to come from agriculture and forestry, transport, buildings and industry are also expected to contribute to NDC achievement. Power sector emissions are to remain constant (FDRE, 2017a).

Figure 3: Ethiopia's NDC mitigation target

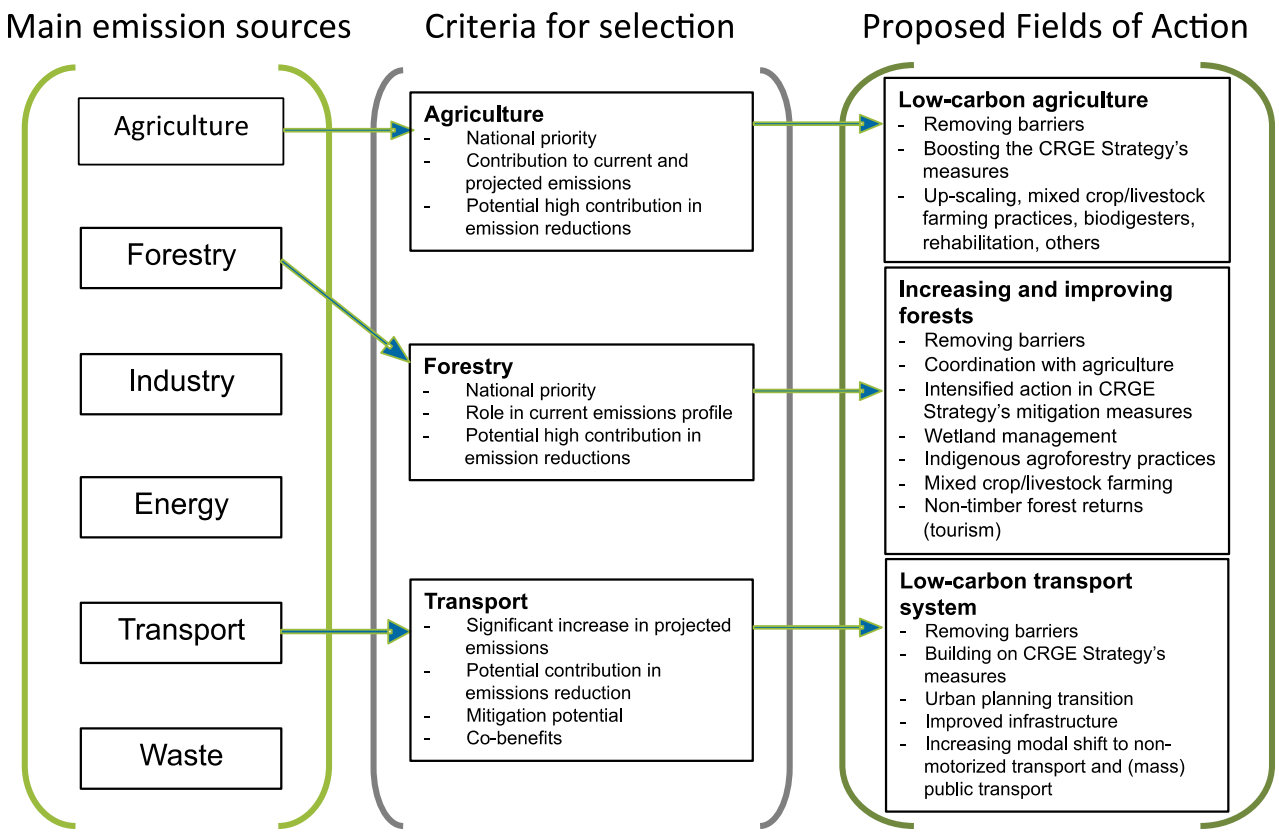


Data source: FDRE (2017).

1.4 Additional mitigation potential and barriers

Ethiopia has a comprehensive set of climate change mitigation policies and strategies that already cover all relevant sectors for emission mitigation, focusing in particular on agriculture, forestry, transport, power, waste, and IPPU. Also, its NDC's emission reduction target is already quite ambitious. Nevertheless, there is still additional mitigation potential to tap even when the targets of Ethiopia's NDC are fully achieved. Due to their important part in Ethiopia's national emissions profile, agriculture and forestry were chosen as fields of action for this study. If ambitious policies are implemented early on in the transport sector before the rise of individual motorised transport that is likely to occur in light of the expected future economic development, low-emission transport could become a reality in Ethiopia, coming hand in hand with substantial co-benefits. Therefore, this sector was selected as the third field of action.

Figure 4: Selection process for proposed field of action in Ethiopia



Source: Own illustration.

Due to its huge relevance for the Ethiopian economy and its large share in national emissions, **agriculture** is high on the list of priorities for the Ethiopian government. The only document quantifying mitigation potentials in Ethiopia is Ethiopia's comprehensive Climate-Resilient Green Economy (CRGE) Strategy (FDRE, 2011). On the one hand, additional mitigation potential could be tapped building on measures already included in the CRGE Strategy, e.g. by increasing the shift to chicken or soy as a lower-emitting source of protein, extending the introduction of lower-emitting techniques for crop cultivation and mechanical equipment to additional households, and improved techniques and mechanisation. Also, there may still be room for further efficiency improvements in the cattle value chain, and efficiency increases could be transferred to other livestock. On the other hand, abatement could be increased by additional measures such as up-scaling, promoting mixed crop/livestock farming practices, promoting bio-digester construction, appropriate fertiliser application according to soil type, promoting conservation tillage techniques to sequester carbon in cultivated soils, and the rehabilitation of overgrazed watering points, hill sides and long-term settlement (FDRE, 2016a, Franks et al. 2017).

To tap the additional mitigation potential identified, barriers have to be removed. These include a lack of financial resources for improved inputs and equipment, existing consumption and production patterns, a lack of relevant supporting institutions at regional and federal level including animal health post and regional labs, and the suitability of available technologies for the land use in Ethiopia.

Forestry, too, plays a major part in Ethiopian efforts to mitigating climate change. As with agriculture, additional mitigation could consist in intensified action in measures portrayed in the CRGE Strategy, i.e. expanding irrigation and rural intensification to reduce deforestation, increased dissemination of even more efficient cooking and baking technologies to reduce forest degradation, and expansion of are to be afforested and/or reforested for increased sequestration. Additional measures include indig-

enous agroforestry practices, wetland management, mixed crop/livestock farming and providing economic returns from non-timber forest productions and forest uses not involving tree removal, such as tourism.

Barriers to the implementation of these measures include social and cultural barriers that may, inter alia, hamp the introduction of alternative cooking and baking devices. Furthermore, there are financial barriers for required investments. Also, the large scale production of the stoves needed may be a challenge and there is a lack of crops-related institutions in Ethiopia. Finally, long-standing practices in agriculture may be hard to change.

The main drivers of rising emissions in the **transport** sector are increases in passenger-kilometres travelled, in tonne-kilometres of cargo transported, and in construction and mining transport (FDRE, 2016a). The CRGE Strategy's emission reductions could be boosted by further improving and extending Ethiopian public transport and its electric rail network, including outside Addis Ababa, by raising efficiency standards as well as applying them to a larger share of vehicles in Ethiopia, and further expanding the use of alternative fuelds and propulsion systems. Additional measures range from avoiding traffic with an urban planning transition focusing, inter alia, on transit-oriented development and improving rural and urban transport infrastrucutre both for non-motorised and motorised transport to fiscal instruments.

To realise these options for emission reductions, several barriers have to be tackled. Thus, there is a lack of institutional capacity for enforcing efficiency standards as well as a lack of technical knowledge for the construction of electric rail networks. Furthermore, the measure may cause resistance among the population that may be displaced by the network. A further barrier consists in the high upfront costs that accumulate in several of these measures. For investments in public transport, however, they will be offset by future revenues (FDRE, 2011).

2 Part II: Full country analysis

2.1 Country background

2.1.1 Geography

Figure 5: Map of Ethiopia

Source: Google Maps

Ethiopia is a landlocked country in the North East Africa region. With 1,104,300 square kilometres it consists of a large share of the Horn of Africa, stretching between about 33°E to 48°E, and 15°N to 3°N. It borders Djibouti, Somalia, Sudan, South Sudan, Kenya and Eritrea.

With 126 metres below sea level, the Kobar sink in the Dallol Depression is the lowest, and with 4,520 metres above sea level, Ras Dajen in the Semien Mountains is the highest point in the country. The country is covered by equatorial rainforest in the south and southwest with high rainfall and humidity, whereas the summits of the Semen and Bale mountains are Afro-Alpine and the north-east, east and south-east lowlands are desert-like. Thus, at Masha in the Baro-Akobo Basin, annual rainfall amounts to about 3,000 mm while it barley reaches 200 mm along the Ethiopia-Djibouti and Ethiopia-Somali border in the Ogaden and Aysha Basins. Depending on the biophysical characteristics, the climate, soil type and cultural practices vary significantly across Ethiopia (FDRE, 2016a).

2.1.2 Population

During the last three decades, Ethiopia's population has grown significantly. Thus, in 2014, Ethiopia had a population of about 97 million, more than twice the inhabitants it had in 1990 (World Bank, 2017). While the majority of Ethiopians live in rural areas, about 19% live in cities and urban areas. More than 80% of Ethiopia's total population lives in the regional states of the Southern Nations, Nationalities and Peoples (SNNP), Amhara, and Oromiya. In the uplands, mixed crop and animal farming are the key economic activities while in the lowland areas, pastoral people depend mainly on livestock production and practice traditional nomadism (FDRE, 2016a).

Ethiopia entails around 80 ethnolinguistic groups with Oromo and Amhara being by far the largest, followed by Somali and Tigrayans.

Table 1: Key socio-economic figures

Indicator	Ethiopia	% change since 1990	World	Germany	Year
Population [million]	**97**	*102%*	7261	81	2014
GDP [2017 billion USD]	**56**	*367%*	78630	3879	2014
GDP/Cap [2017 USD/cap]	**574**	*127%*	10,829	47,903	2014
HDI [0 – 1]	**0.44**	-	-	0.92	2014
Electrification rate [%]	**27**	*170%*	85%	100%	2012
GINI index [0 – 100]	**33.2**	-	-	30.1	2010
Corruption index [1 – 6]	**3.0**	-	2.9	-	2014
Urbanization [% of total]	**19**	*46%*	53%	75%	2014

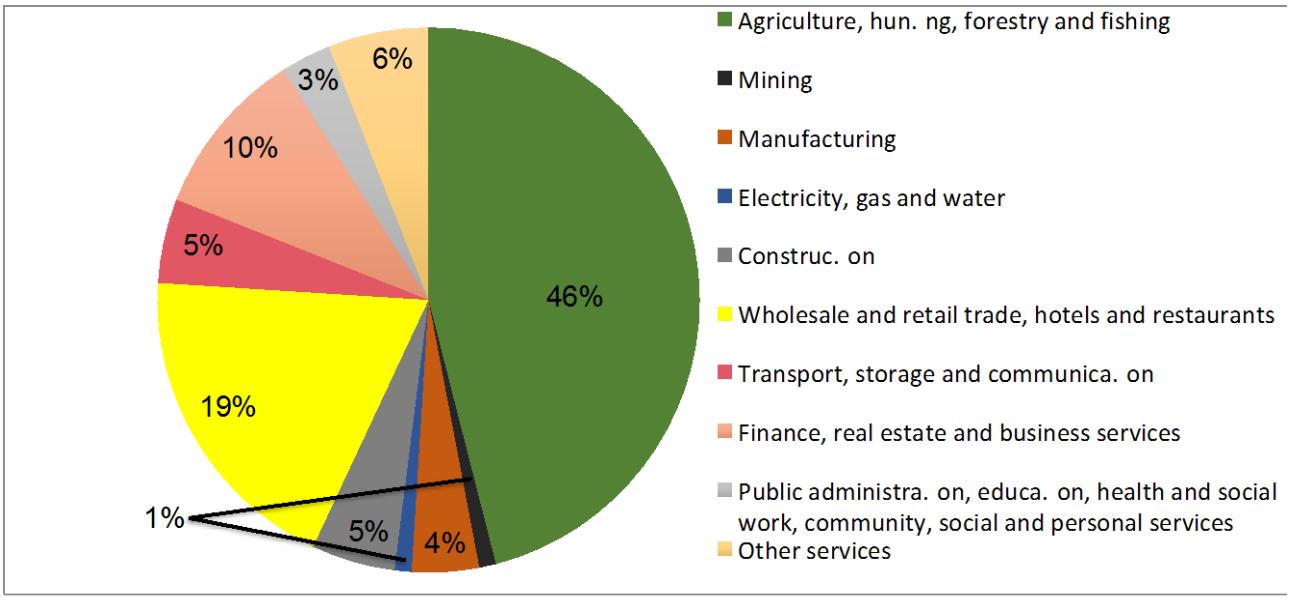
Data sources: UNDP (2015), United Nations (2014), ND-GAIN (2017), World Bank (2017, 2018), GDP per capita calculated based on World Bank (2017).

2.1.3 Economy

Until 2014, GDP per capita has grown by 127% and total GDP by 367% since 1990 in Ethiopia, making Ethiopia one of the fastest growning, non-oil based economies in the world. Nevertheless, GDP per capita in Ethiopia is still among the lowest in the world (574 USD/cap (2014)) and the country has a human development index of only 0.44 (2014). Thus, the Ethiopian government considers increasing the living standards of its population as the main challenge for Ethiopia and devotes a large share of its budget to pro-poor programmes and investments (FDRE, 2016a).

With 80 to 85% of the working population working in agriculture, this sector is the backbone of Ethiopia's economy, contributing about 46% of total GDP in 2013. 95% of the cropped land are cultivated by smallholders working in subsistence agriculture and less than 1% of the total cultivated land is irrigated. Wholesale, retail trade, hotels and restaurants contributed the second largest share to 2013 GDP (19%), followed by finance, real estate and business services (10%) and other services (6%) (see Figure 6 for further details). During the last decade, the service sector has been responsible for about half of total GDP growth. Also, there has been a significant increase in constructions as well as in mining and manufacturing, leading to high growth in the industry sector (FDRE, 2016a).

Figure 6: Contribution to GDP by economic sector (2013)



Source: FDRE (2016a).

2.1.4 Political system

Ethiopia is a federal parliamentary republic with a Prime Minister as head of government who is chosen by the parliament. The government shares federal legislative power with the two chambers of parliament, the House of Federation (HOF) and the House of People's Representatives (HPR). While the state assemblies choose the members of the HOF, the HPR is constituted as a result of direct elections, the last of which took place in May 2015 with the next due in 2020. The Ethiopian president is elected by the HPR for terms of six years and has largely ceremonial duties. The HPR is the main legislative authority and issues laws which are called proclamations in Ethiopia. Furthermore, the executive branch in form of the Council of Ministers and federal ministries may issue decrees, regulations and directives according to a mandate by the HPR. International agreements ratified by the parliament are also integral laws (LSE, 2017).

Efforts to decentralise the highly centralised system have led to powers and mandates being devolved to regional states below which are districts (Woredas) and villages (Kebeles). The states and city administrations in the Federal Democratic Repulic of Ethiopia are Tigray, Afar, Amhara, Oromia, Somali, Benshangul/Gumuz, Southern Nations, Nationalities and Peoples (SNNP), Gambela, and Harari Regional States), and, Addis Ababa and Dire Dawa (City Administrations) (FDRE, 2016a).

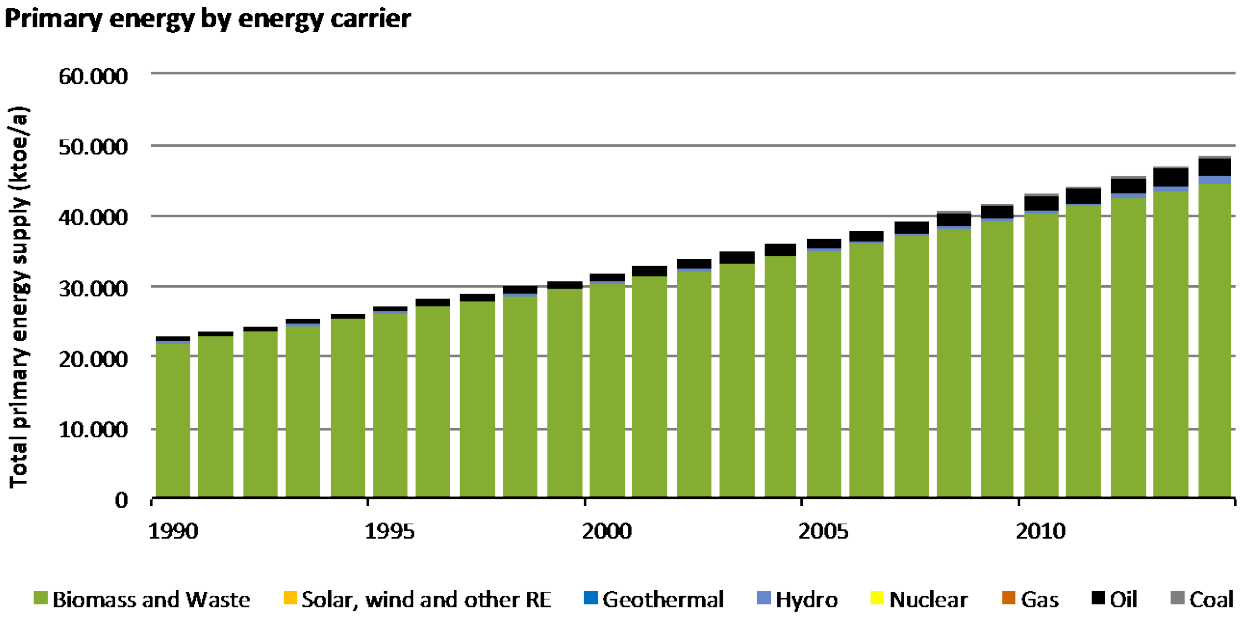
Ethiopia ranked 107th out of 180 countries in Transparency International's Corruption Perception Index 2017, scoring 35 out of 100 with 0 being a perceived high corruption in the public sector and 100 very clean (Transparency International, 2017).

2.1.5 Energy system

Ethiopia heavily relies on biomass fuels (firewood, charcoal, agro-residues) which made up about 92% of the total primary energy supply in 2014. While oil had a share of about 6% in Ethiopian energy supply, hydropower contributed the remaining share of 2% (see Figure 7 and Table 2 for details). Wind, solar and geothermal power as well as coal play a negligible part in the energy system, but there is huge potential for solar, wind, geothermal and hydropower as well as a further extension of the use of biomass resources and agricultural residues. Ethiopia is currently constructing the Grand Renaissance Dam on the Nile which is going to be the largest hydroelectric power plant in Africa when finished.

Furthermore, Ethiopia has coal and natural gas resources as well as oil shale deposits. So far, they have not been developed (FDRE, 2016a).

Figure 7: Ethiopia's energy profile (1990-2014)



Data sources: IEA (2016a).

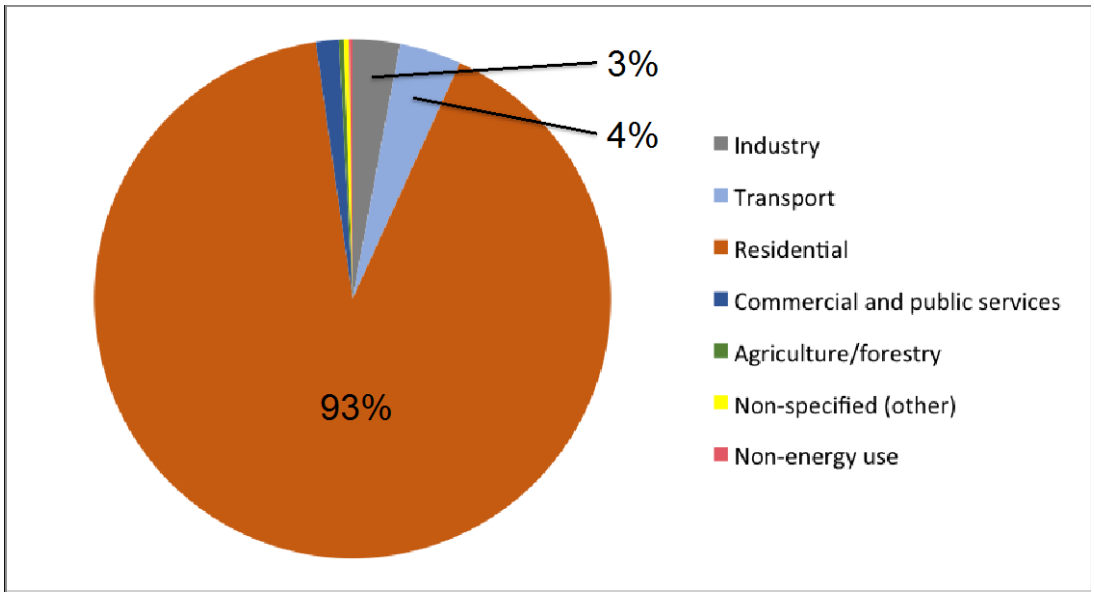
Table 2: 2014 total primary energy supply by fuel from IEA

Fuel	Value	Unit	Share in 2014
Biomass and waste	44,666	ktoe	92%
Solar, wind and other RE	34	ktoe	0%
Geothermal	16	ktoe	0%
Hydro	791	ktoe	2%
Nuclear	0	ktoe	0%
Gas	0	ktoe	0%
Oil	2,759	ktoe	6%
Coal	198	ktoe	0%

Data sources: IEA (2016a).

With 93%, the residential sector consumes by far the largest share of total energy in Ethiopia, followed by the transport sector with 4% and industry with 3% (see Figure 8). In 2012, the electrification rate in Ethiopia amounted to only 27% with the majority of Ethiopians lacking access to modern energy sources, relying on wood for fuel (World Bank 2018).

Figure 8: Ethiopia's total final energy consumption by sector (2015)



Data sources: IEA (2018).

2.1.6 Historic emissions

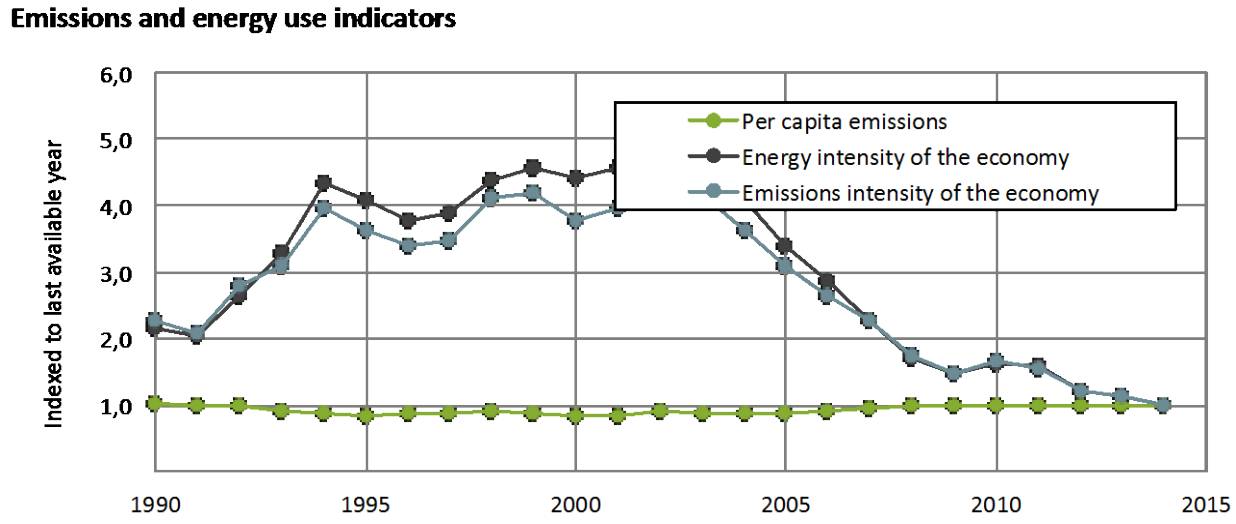
While Ethiopia's total emissions have been increasing steadily and have doubled between 1990 and 2013 (see Figure 10), per capita emissions have remained relatively constant at about 1.35 t CO_2e/cap and the energy intensity as well as the emissions intensity of the economy have dropped significantly (see Figure 9). In 2014, Ethiopia was responsible for about 0.3% of worldwide emissions. In 2017, the ND-Gain Country Index ranked Ethiopia the 22nd most vulnerable country to climate change and other global challenges and the 31st least ready country to improve resilience, pointing to a great need for investment and innovations to improve readiness and a great urgency for action (ND-GAIN, 2017).

Table 3: Key emissions, energy and environmental data

Indicator	Ethiopia	% change since 1990	World	Germany	Year
GHG/cap [tCO2e/cap]	**1.35**	*-1%*	6.42	10.8	2014
GHG/GDP [tCO2e/mln 2017 USD]	**2,356**	*-56%*	593	225	2014
Energy/GDP [ktoe/mln 2017 USD]	**0.87**	*-54%*	0.17	0.08	2014
Global share of emissions [%]	**0.3**	*50%*	100%	1.8%	2014
Air pollution index (PM2.5)	**31**	*3%*	42	14	2014
Vulnerability index [0 – 1]	**0.54**	-	-	0.23	2014

Data sources: IEA (2016b), World Bank (2017), ND-GAIN (2017), Gütschow et al. (2016), GHG indicators were calculated using PRIMAP data and exclude contributions from the LULUCF sector.

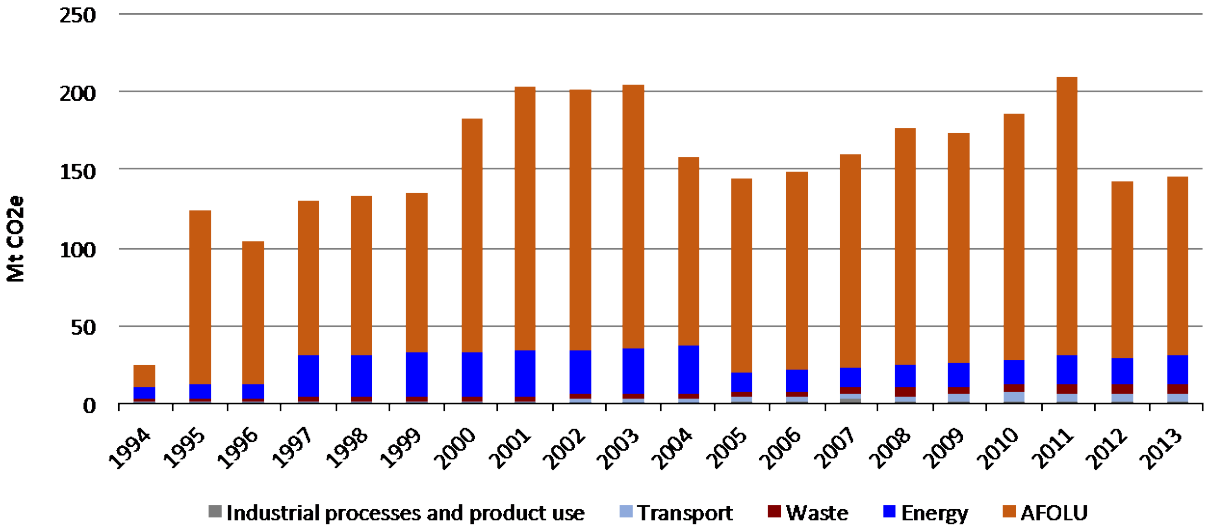
Figure 9: Emissions and energy use intensity over time



Data sources: Gütschow et al. (2016), IEA (2016a), World Bank (2017). GHG indicators were calculated using PRIMAP data and exclude contributions from the LULUCF sector.

In 2015, Ethiopia submitted its Second National Communication (SNC) to the UNFCCC. It puts total national emissions and removals at 146 $MtCO_2e$ for 2013. This includes about 1 $MtCO_2e$ from international bunkers. Agriculture, forestry and other land use (AFOLU) have been responsible for about 115 $MtCO_2e$, nearly 80% of Ethiopia's total greenhouse gas (GHG) emissions. With 22 $MtCO_2e$, the energy sector contributed a share of about 15%, followed by the waste sector (7 $MtCO_2e$, 5%). Industrial processes and product use only have a share of about 1% of Ethiopia's total emissions (nearly 2 $MtCO_2e$) (FDRE, 2016a).

Figure 10: Ethiopia's historical emissions according to its Second National Communication



Data sources: FDRE (2016a).

Table 4: Total emissions by sector in 2013 according to Ethiopia's Second National Communication

Sector	Value	Unit	Share of total national emissions in 2013
Energy	21.75	$MtCO_2e$	15%
Industrial Processes and Product Use	1.76	$MtCO_2e$	1%
Agriculture, Forestry, and Other Land Use	115.23	$MtCO_2e$	79%
Waste	7.42	$MtCO_2e$	5%
International Bunkers	1.08	$MtCO_2e$	-
Total National Emissions and Removals	**146.16**	**$MtCO_2e$**	**100%**

Data sources: FDRE (2016a).

2.1.7 UNFCCC negotiations

Ethiopia has been an important player in international climate negotiations for a long time. Thus, Ethiopia's Prime Minister from 1995 to 2012, Meles Zenawi, led efforts to fight climate change in Africa and the generation of green growth in the region, and was central to the African Union's positioning on climate change. From 2009 to 2012, Ethiopia represented the African group in international climate negotiations. In 2009, Ethiopia on behalf of Africa jointly with France called for an ambitious accord at the 15th Conference of the Parties (COP15) in Copenhagen calling for halving global CO_2 emissions by 2050 compared to 1990 levels, full transparency of commitments, and adoption of a "fast-start" three-year fund of 10 billion USD per year dedicated to adaptation and mitigation actions (LSE, 2017). Furthermore, Zenawi became one of the chairs of the High-Level Advisory Group on Climate Change Financing (AGF) which was tasked with evaluating options for how to mobilise the 100 billion USD pledged in the Copenhagen Accord (Sterk et al., 2010, 2011). At the following COP in Cancún, Ethiopia, Norway and the UK founded a strategic partnership focusing on, inter alia, forestry, agriculture, energy, MRV, and biodiversity (LSE, 2017).

Since January 2017, Ethiopia has been chair of the Least Developed Countries (LDC) Group at UN climate change negotiations, representing 47 nations with two aims: 1. Demanding that wealthier nations act in accordance with their responsibility for climate change and their capability for addressing it, and 2. Playing a leadership role in global efforts to prevent dangerous climate change (Embassy of Ethiopia Belgium, 2017a, LDC Group, 2018). On 9 March 2017, Ethiopia ratified the Paris Agreement.

2.1.8 Bilateral cooperation with Germany

Ethiopia is an important partner country for German development cooperation. In 2014, the German Federal Ministry for Economic Cooperation and Development (BMZ, Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung) pledged to Ethiopia 129 million EUR for German development cooperation for the years 2015 to 2017. Since 2014, cooperation has been prioritised in three priority areas:

- Education,
- Agriculture and food security, and
- Conservation and sustainable use of natural resources; biodiversity.

On top, the BMZ's ONE WORLD – No Hunger initiative will finance activities of about 60 million EUR in Ethiopia to ensure long-term food security. 14.5 million EUR have been committed by the BMZ for Ethiopia under the initiative "Tackling the root causes of displacement, reintegrating refugees" to improve services for displaced persons and support their integration into the workforce (BMZ, 2018).

Due to the food crisis in Southern and East Africa since the second half of 2015, currently, 13.5 million people are suffering from hunger in Ethiopia. The BMZ has supported food security, preventive health care, and water and sanitation programmes in Ethiopia with 73.8 million EUR and has announced to make further commitments, in particular for the United Nations Children's Fund (UNICEF) programmes as well as the World Food Programme (BMZ, 2018). Ethiopia is a pilot country under the joint programming scheme of the EU and its member states which aims at a cooperation between the EU and its member states to provide the best possible response to the situation at hand (capacity4dev.eu, 2015).

As of February 2018, the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) has supported Ethiopia via its International Climate Initiative (IKI, Internationale Klimaschutzinitiative) 3 bilateral and 17 transnational projects focusing on, inter alia, adaptation, sustainable consumption and production, biodiversity, bioenergy, forestry, cities, electric 2 and 3 wheelers, MRV, and NAMAs (BMU, 2018).

2.2 Institutional set up

Ethiopia's SNC lists several institutions related to climate change, inter alia:

The Government of Ethiopia has put the responsibility for environment, forest and climate change on the **Ministry of Environment, Forest and Climate Change (MEFCC)** and has made it the National Focal Point to the Kyoto Protocol and the UNFCCC. The MEF coordinates the country's reporting to the UNFCCC, formulates environmental laws and standards, and develops, coordinates and guarantees the implementation of sectoral programmes and plans regarding these issues including the CRGE Strategy.

The **Ethiopian Institute of Biodiversity Conservation (IBC)** is to conserve and promote the development and sustainable utilization of Ethiopia's biodiversity.

The **National Meteorological Agency (NMA)** collects, exchanges and disseminates information and advice on meteorological data as well as adverse effects of weather and climate in Ethiopia.

The **Ministry of Agriculture (MoA)** is tasked with creating a modern and highly productive agricultural system that uses advanced technology to reduce poverty including conservation, development and sustainable use of natural resources.

The **Agricultural Transformation Agency** is tasked with rapidly transforming Ethiopian agriculture through adapting new technologies and innovative approaches including climate smart agriculture in support of the MOA.

The **Ethiopia Wildlife Conservation Authority (EWCA)** is responsible for the proper protection, development, rational utilization and management of wildlife and forest resources as well as for the establishment of National Parks and Game Reserves.

The **Ministry of Transport** is tasked with planning, construction, and maintenance and contract administration for road construction. Its objectives include improving and expanding the road network in an environmentally friendly manner. The Environmental Monitoring and Safety Branch is an integral part of the ministry. It is responsible for environmental monitoring activities for contract and own workforce projects of the Ministry.

The **Ethiopian Electric Power Corporation (EEPCO)** oversees the development of Ethiopia's energy infrastructure and the provision of hydroelectric power. Its Environmental Monitoring Unit has published Environmental Guidelines for the Power sector as well as the Environmental and Social Management Framework (ESMF) which deals with potential impacts and mitigating measures to be taken in electric power generation projects.

The **Ministry of Water, Irrigation and Energy (MoWIE)** is striving for the achievement of the GTPs' targets for the water, irrigation, and energy sector.

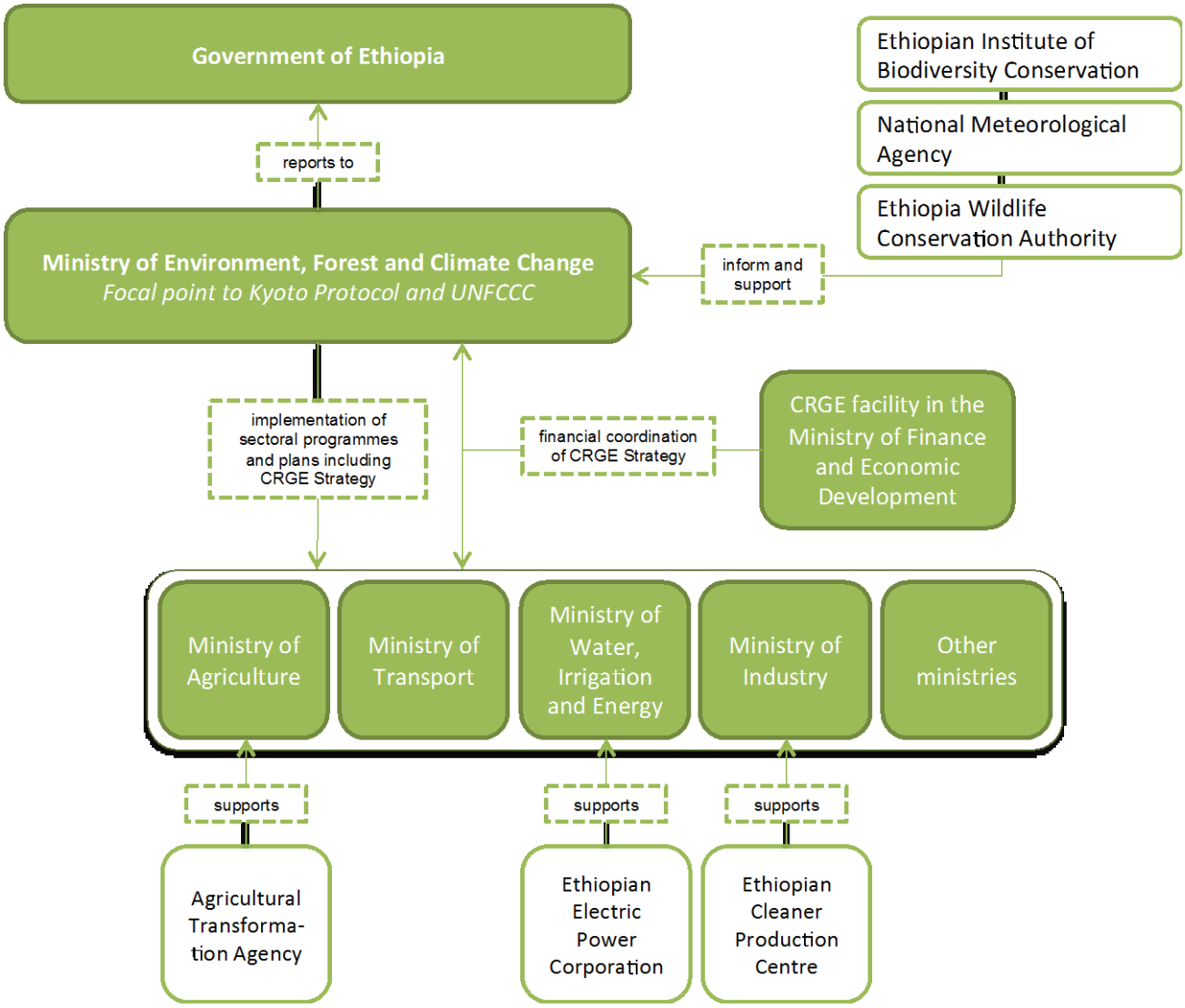
The **Ministry of Industry** has several institutions which are responsible for different subsectors (e.g. leather, textile, chemical, metal, food, beverage and pharmaceutical industry). Environmental Impact Assessments are required for the establishment of new industries, environmental audits in already operational industrial plants.

The **Ethiopian Cleaner Production Centre (ECPC)** under the standards agency ensures cleaner production projects supporting industries to conserve raw materials, eliminate toxic raw materials and reduce toxicity of emissions and wastes (FDRE, 2016a).

The **Ministry of Finance and Economic Development** houses a CRGE facility which ensures financial coordination among all sectors implementing the CRGE Strategy and is tasked with establishing a national climate fund to mobilise finance from varied sources.

Figure 11 portrays the institutional set up for climate action in Ethiopia.

Figure 11: Institutional set up for climate action in Ethiopia



Source: Own illustration.

2.3 MRV of GHG emissions

The MEFCC is hosting a national MRV system which has been developed in the period from 2013 to 2015. However, it is not yet fully functional. Additionally, MEFCC issued a directive to establish sectoral CRGE directorates at the national level, and accordingly signed an MoU with all sector ministries to establish MRV systems. So far, MOA has developed an agriculture and forestry MRV framework and database. An MRV report for the transport sector excluding water and air transport has been commissioned by the transport authority and completed. However, the established databases and systems are not open and accessible to the public.

Ethiopia submitted its Second National Communication (SNC) in 2016. As of February 2018, no Biennial Update Report has been submitted.

The National Greenhouse Gas Inventory included in the SNC reports GHG emissions for the years 1994 to 2013 and provides projections until 2030.

The inventory was prepared using methodology and procedures from the Intergovernmental Panel on Climate Change's (IPCC's) 1996 Guidelines for National Greenhouse Gas Inventories, its Good Practice Guidance (GPG) for 2000 and 2003, and its 2006 guidelines. Data for all the years from 1994 to 2013 were collected and applied, covering the sectors energy, industrial processes and product use (IPPU), agriculture, forestry and land use (AFOLU) and waste.

The National GHG Inventory for Ethiopia was compiled using the IPCC's Tier I methodology. Tier I is applied when country-specific emission factors or activity data are not availabe. This method entails the risk of not reflecting national circumstances adequately, as the Ethiopian government noted in its SNC (FDRE, 2016a).

Ethiopia's capacity regarding data requirements, collection, archiving and general procedures for operating a national GHG Inventory management system has advanced significantly. Furthermore, a basic infrastructure for online data collection, entry and access has been set up to improve the preparation of future National Communications and Biennial Update Reports (BURs) to the UNFCCC. The SNC points out, that formalising and mainstreaming the arrangements for data collection within the key sectoral institutions could considerably improve institutional arrangements. Moreover, integrating the process for data collections into annual statistical data collection and updates is called for. The SNC stressed the need to further build capacities to standardise formats and units of measurement, accelerate data processing, and improve quality (FDRE, 2016a).

The SNC warns that there are significant data gaps for adequately monitoring, reporting and verifying (MRVing) GHG emissions, in particular regarding:

- **IPPU:** clinker production, the non-energy use of lubricants, bitumen, asphalt, HFCs
- **Waste:** municipal solid waste sent to solid waste disposal sites, industrial solid waste, the wastewater treatment systems and the population serviced
- **Agriculture:** nitrogen management in animal waste management systems, the prescribed burning of crop residues, the burning of savannah, enhanced livestock characteristics, livestock fractions managed under different systems, flooding of rice fields
- **Land Use Change and Forestry:** land use, land cover, area covered by plantation forests, unmanaged grassland, and perennial cropland (FDRE, 2016a).

Furthermore, high uncertainty levels exist in all four categories, inter alia, for example, with default uncertainties for glass production emission factors of 30-60%, uncertainties of ±100% in waste generation rates sent to solid waste disposal sites and of ±58% for domestic wastewater, and uncertainty in livestock population of ±32% (FDRE, 2016a).

2.4 Climate change mitigation policies and strategies

The priciple of environmental rights is entailed in **Ethiopia's Constitution** of 1995 which directly point to the right to a clean and healthy environment and the principle of governmental responsibility to ensure this right (FDRE, 1995). Two years later, the **Environment Policy** of Ethiopia was published, defining policy guidelines on atmospheric pollution and climate change as well as on land use, forest, woodland and tree resources, biodiversity, water resources, and energy resources (FDRE, 1997).

Ethiopia has made great efforts to transform its economy during the last decade. The overarching national policy framework to achieve this economic transformation is Ethiopia's **Growth and Transformation Plan (GTP)** for the years 2010 to 2015 which governs developmental policies, budgets and government organisations. The GTP includes targets that support a low-carbon economy. Thus, it aims at generating an additional 8,000 MW electricity from renewable energy sources for domestic use and export, increasing the electricity customer base from 41 to 75%, and expanding the transmission and distribution system. Furthermore, it sets the targets to expand bio-ethanol production and bio-diesel usage, and develop additional bio-fuel blending facilities (FDRE, 2010).

The government of Ethiopia has been well aware of the negative impacts of climate change on health, economic growth and natural resource conservation for a long time. Thus, it underlines its commitment to undertake ambitious action using its domestic resources (FDRE, 2017). To this end, in 2011, Ethiopia has published its framework legislation for both its mitigation and adaptation policy, the **Climate-Resilient Green Economy (CRGE) Strategy.** Recognising that the conventional development path would result in a sharp increase in GHG emissions and unsustainable use of natural resources, its vision is to achieve middle-income status by 2025 in a climate-resilient green economy, achieving economic development in a sustainable way (FDRE, 2011). The CRGE Strategy was the first of its kind in Africa (LSE, 2017).

To achieve its vision, the CRGE Srategy follows a sectoral approach and bases its green economy plan on four pillars: improving crop and livestock production practices, protecting and re-establishing forests for their economic and ecosystem services, expanding renewable power generation, and leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings. These pillars are echoed in the mitigation measures included in Ethiopia's NDC. Moreover, the CRGE Strategy already includes the target to limit 2030 emissions to around 2010's 150 Mt CO_2e, laying the foundation for the Ethiopian NDC's slightly lowered intended emission limit of 145 Mt CO_2e for 2030 (FDRE, 2011).

Furthermore, the CRGE establishes the targets to reduce domestic electricity demand by 30% by 2030 and increase renewable generating capacity by 25 GW by 2030 (22,000 MW hydropower, 1,000 MW geothermal, 2,000 MW wind). It includes programmes replacing wood fuel for domestic use with less polluting fuels, such as biogas, and distributing 9 million efficient stoves by 2015 and 34 million by 2030. Furthermore, it entails a policy substituting imported fossil fuels with domestically produced bio-diesel and bio-ethanol. A national financial mechanism, the CRGE Facility, has been established to mobilise, access, sequence, and blend domestic and international finance from public and private sources to support institutional building and implementation of the strategy (LSE, 2017). The Ministry of Environment and Climate Change is to oversee and coordinate the implementation of the CRGE Strategy (FDRE, 2016b). Sector strategies such as the Climate Resilient Transport Sector Strategy complement and detail the CRGE Strategy's targets and measures, ensuring that the sectors promote Ethiopia's national development, poverty reduction and climate resilience goals (Ministry of Transport, n.d.).

The GTP was updated in 2016 with the **Growth and Transformation Plan II (GTP II)** for the period 2015/16 to 2019/20. While the first GTP focused on agricultural production, GTP II aknowledges that agriculture will remain the main driver of economic growth and development but includes a new vi-

sion to render Ethiopia a leader in light manufacturing in Africa (FDRE, 2016b). The CRGE is integrated into GTP II (FDRE, 2017).

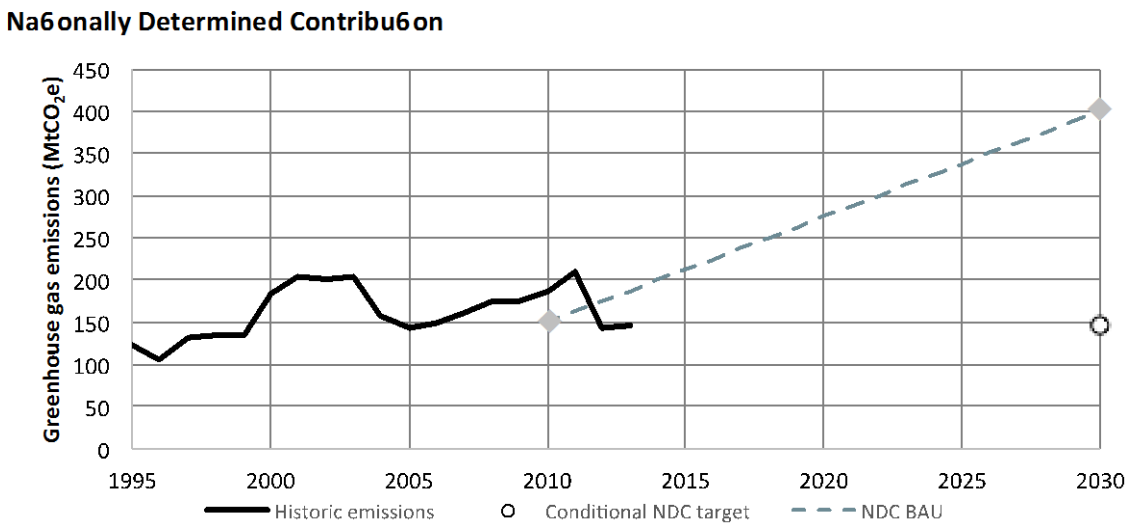
Ethiopia has prepared and submitted **nationally appropriate mitigation actions (NAMAs),** i.e. voluntary emission reduction measures undertaken by developing country parties and reported to the UNFCCC. The Ethiopian NAMA comprises projects in the energy, transport, forestry, agriculture and urban waste management sectors (FDRE, 2016a). Ethiopia has submitted its nationally determined contribution (NDC) which will be analysed in the following chapter.

To coordinate **adaptation** activities across sectors, Ethiopia prepared its National Adaptation Programme of Action (NAPA) in 2007. Ethiopia's Programme of Adaptation to Climate Change (EPACC) of 2011 links adaptation to the country's economy as well as its physical well-being and points to key adaptation measures, strategic priorities, and intervention areas addressing the adverse effects of climate change. Furthermore, Ethiopia has prepared adaptation strategies and programmes for agriculture, water, health, and a Sectoral Reduction Mechanism (SRM) which is to direct sectors in their mitigation and adaptation activities (FDRE, 2016a). Additionally, Ethiopia completed its National Adaptation Plan (NAP-ETH) on September 2017 under UNFCCC guidelines. The plan focuses on agriculture, forestry, health, transport, power, industry, water and urban sectors with a timeline of 15 years. Like the EPACC, it is linked to economic development and identifies integration into the GTP as a strategic priority. Furthermore, the 18 adaptation options of the plan provide mitigation co-benefits (FDRE, 2017b). A Multi-Sector Investment Plan (MSIP) is to enhance climate reslience in the agriculture and forestry sectors (FDRE 2017c).

2.5 Description and evaluation of the NDC

Ethiopia submitted its intended nationally determined contribution (INDC) on 9 March 2017, the same day it ratified the Paris Agreement, turning its INDC into its NDC. Ethiopia's NDC is founded on its CRGE Strategy. It intends to limit Ethiopia's net GHG emissions in 2030 to 145 Mt CO_2e or lower. This would reduce 2030 BAU emissions by about 64% and represent absolute emission reductions of 5 Mt CO_2e relative to 2010 emissions according to the NDC. The full implementation of Ethiopia's NDC is conditioned upon an ambitious multilateral agreement among Parties enabling Ethiopia to get international support in the form of finance, capacity building and technology transfer. The NDC does not specify an unconditional target. It states, however, that future research will be conducted to quantify the unsupported and supported contributions (FDRE, 2017a).

Figure 12: Ethiopia's NDC mitigation target



Data source: FDRE (2017a).

Ethiopia outlines the emissions mitigation contribution for six sectors in its NDC: agriculture (livestock and soil), forestry, transport, industry (including mining), power, and buildings (including waste and green cities). Due to these sectors' high relevance in the country's mitigation profile, mitigation abatement in Ethiopia's NDC strongly focuses on the forestry sector as well as on agriculture. However, emission reductions are also to be achieved in transport and industry sectors as well as in buildings (see Figure 13). Total envisaged emission reductions in 2030 relative to BAU amount to

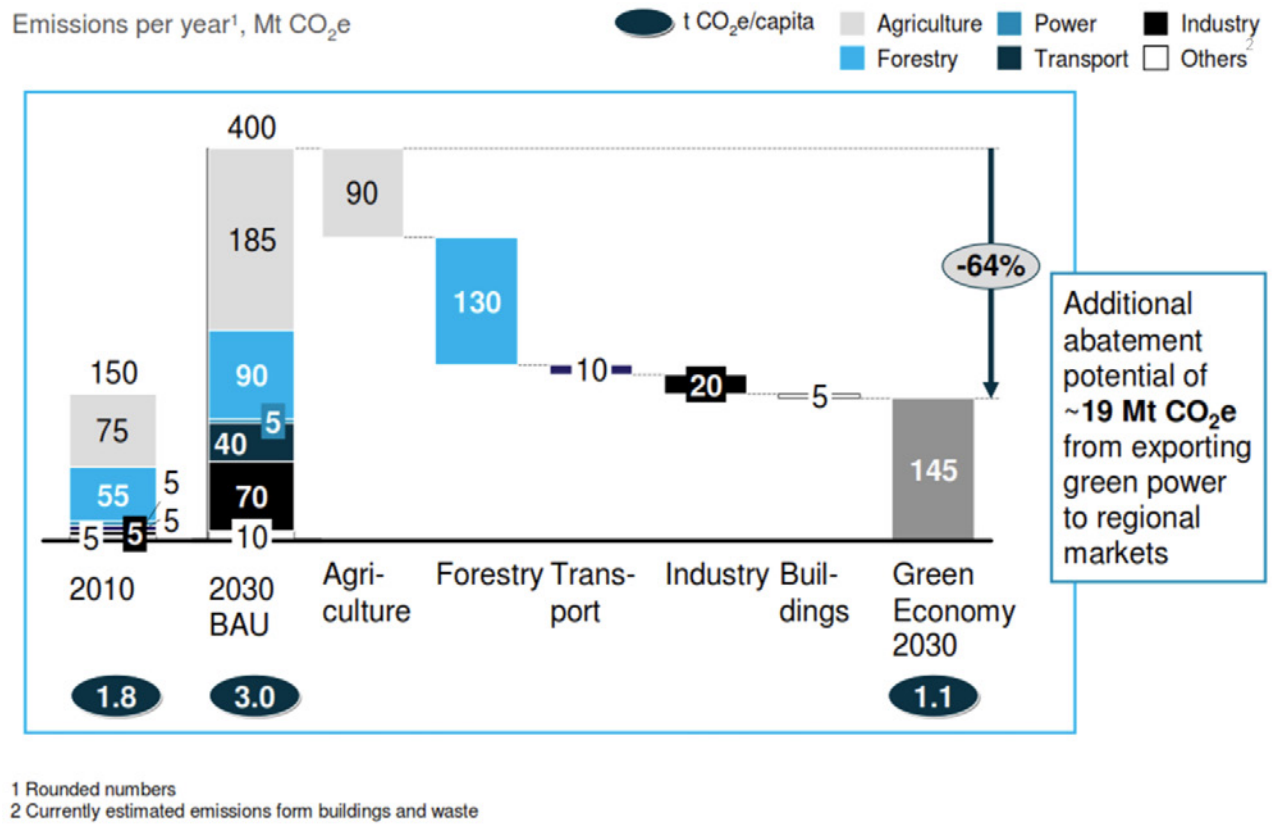
- 90 Mt CO_2e in agriculture,
- 130 Mt CO_2e in forestry,
- 10 Mt CO_2e in transport,
- 20 Mt CO_2e in industry, and
- 5 Mt CO_2e in buildings.

Emissions in 2030 would then be at

- 95 Mt CO_2e in agriculture,
- 30 Mt CO_2e in transport,
- 5 Mt CO_2e in buildings,
- 5 Mt CO_2e in the power sector,
- 50 Mt CO_2e in industry, and
- negative emissions of -40 Mt CO_2e in forestry.

On top, Ethiopia points to an additional abatement potential of about 19 Mt CO_2e from exporting green power to regional markets (see Figure 13) (FDRE, 2017a).

Figure 13: Sectoral contributions to the NDC target



1 Rounded numbers
2 Currently estimated emissions form buildings and waste

Source: FDRE (2017a).

Table 5: Mitigation Measures in Ethiopia's NDC

Mitigation Measures in Ethiopia's NDC
► Improving crop and livestock production practices for greater food security and higher farmer incomes while reducing emissions ► Protecting and re-establishing forests for their economic and ecosystem services, while sequestering significant amounts of carbon dioxide and increasing the carbon stocks in landscapes ► Expanding electric power generation from renewable energy ► Leapfrogging to modern and energy efficient technologies in transport, industry, and buildings

Source: FDRE (2017a).

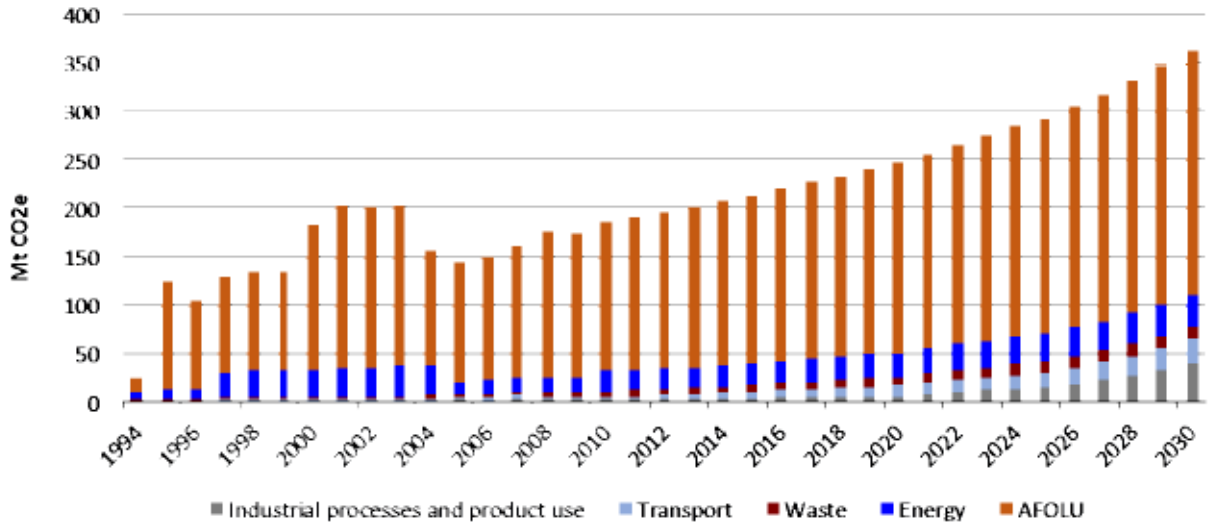
Ethiopia intends to use international carbon credits to meet its target (FDRE, 2017a). The Climate Action Tracker rates Ethiopia's NDC as "2°C compatible", indicating that it is in the range of what it considers to be a fair share of global effort but is inconsistent with the "well below 2°C" goal contained in the Paris Agreement (Climate Action Tracker, 2017).

2.5.1 Analysis of NDC and SNC emission projections

Ethiopia's Second National Communication (SNC) contains historic emissions until 2013, and emission projections until 2030. To allow for a better comparison with Ethiopia's nationally determined contribution (NDC, see explanation below the following figures), in the following, projections are explained using 2010 as base year.

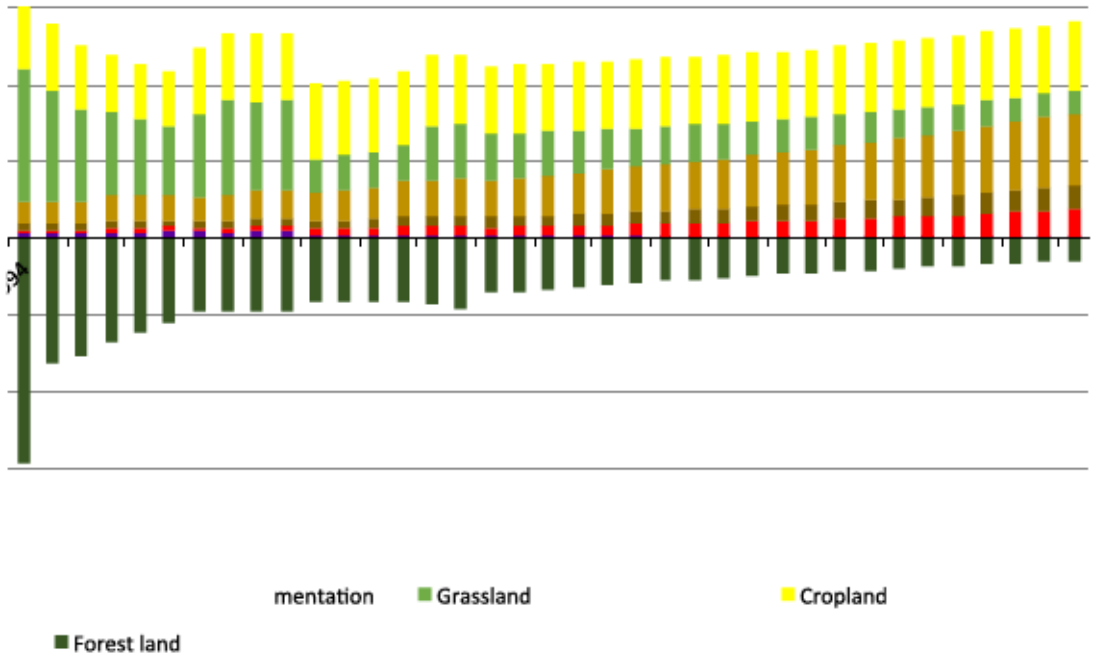
Between 2010 and 2030, total national emissions are projected to increase significantly from 185 $MtCO_2e$ to 363 $MtCO_2e$ (+96%) with all sectors contributing to this development. Figure 14 shows that AFOLU are expected to continue to be responsible for the largest share of emissions until 2030 with emissions rising from 154 $MtCO_2e$ in 2010 to 253 $MtCO_2e$ in 2030. Zooming in on AFOLU reveals that still in 2030, forest land is projected to be a sink with negative emissions of -71 $MtCO_2e$ in 2010 and of -29 $MtCO_2e$ in 2030 (Figure 15). In relative terms, industry emissions are projected to increase most starting with nearly 2 $MtCO_2e$ in 2010 and reaching 39 $MtCO_2e$ in 2030. Until 2030, transport emissions are expected to multiply by six from 4 $MtCO_2e$ in 2010 to 25 $MtCO_2e$ in 2030, and waste emissions to double (5 $MtCO_2e$ in 2010 to 13 $MtCO_2e$ in 2030) while the energy sector's emission are to increase by 59% (20 $MtCO_2e$ in 2010 to 25 $MtCO_2e$ in 2030) (FDRE, 2016a).

Figure 14: Historical emissions 1994-2009 and projected emissions 2010-2030 (Mt CO_2e)



Source: Own illustration based on intrapolations from FDRE (2016a).

Figure 15: Historical emissions 1994-2009 and projected emissions 2010-2030 in AFOLU (Mt CO_2e)



Source: Own illustration based on intrapolations from FDRE (2016a).

Ethiopia's NDC of 2017 includes a business-as-usual (BAU) scenario which differs significantly from the emission projections in its SNC, in particular regarding emissions in forestry. Dividing emission sectors into the six categories agriculture (livestock and soil), forestry, transport, industry (including mining), power, and buildings (including waste and green cities), it projects a significant increase of

emissions until 2030 in all sectors, except for the power sector where emissions remain constant at 5 Mt CO_2e. While putting 2010 total emissions at 150 Mt CO_2e, BAU emissions are expected to reach 400 Mt CO_2e in 2030, with agriculture emissions rising from 75 to 185 Mt CO_2e, forestry emissions from 55 to 90 Mt CO_2e, transport emissions from 5 to 40 Mt CO_2e, industrial emissions from 5 to 70 Mt CO_2e, and emissions in buildings from 5 to 10 Mt CO_2e (see) (FDRE, 2017).

Table 6: Projected change in sectoral emissions between 2010 and 2030 according to Ethiopia's NDC

Sector	2010 ($MtCO_2e$)	Share in 2010 (%)	NDC baseline: 2030 ($MtCO_2e$)	Share in 2030 (%)
Agriculture	75	*50%*	*185*	*46%*
Forestry	55	*37%*	*90*	*23%*
Transport	5	*3%*	*40*	*10%*
Industry	5	*3%*	*70*	*18%*
Buildings	5	*3%*	*10*	*3%*
Power	5	*3%*	*5*	*1%*
Total	**150**	***100%***	***400***	***100%***

Data sources: FDRE (2017).

The different categories of emission sectors employed in Ethiopia's NDC complicate a direct comparison of its BAU scenario to projected emissions in the SNC. Nevertheless, some differences are apparent.

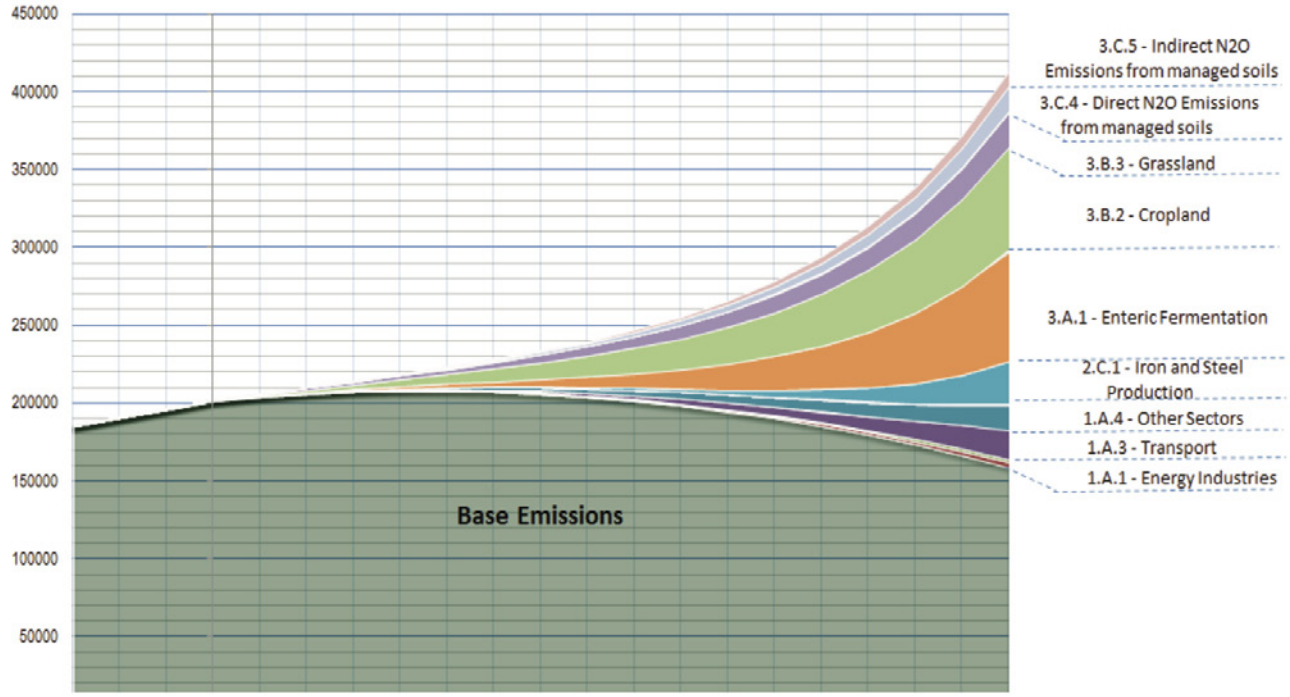
- **Regarding 2010 data:** While emissions in agriculture are put at a much lower figure for 2010 (75 Mt CO_2e), forestry emissions are much higher (55 Mt CO_2e) in the NDC than in the SNC for forest land (225 Mt CO_2e, and negative emissions of -71 Mt CO_2e, respectively). This, however, may be attributed to the different sector classification, as the total amount of the two sectors' emissions is nearly equal between the two scenarios (about 150 Mt CO_2e). Both industry and transport emissions are higher for the NDC BAU's 2010 emissions than in the SNC.
- **Regarding 2030 projections:** Total emissions in 2030 in NDC BAU are about 10% higher than in the SNC (400 Mt CO_2e versus 363 Mt CO_2e). Nearly the same, combined emissions of agriculture and forestry are about 9% higher in NDC BAU than AFOLU emissions in the SNC (275 Mt CO_2e versus 253 Mt CO_2e). However, agriculture emissions in NDC BAU are only about 66% of SNC projected emissions (185 Mt CO_2e versus 282 Mt CO_2e) while instead of negative emissions of -29 Mt CO_2e for forest land in the SNC, NDC BAU emissions are at 90 Mt CO_2e in 2030. Also, transport and industry emissions are significantly higher in NDC BAU than in SNC projections (58% and 81%, respectively).

Different categories of emission sectors aside, differences between projected emissions in the SNC and the BAU scenario in Ethiopia's NDC may be explained by uncertainty regarding data (in particular regarding forest emissions) as well as the availability of new data and calculations.

2.6 Additional mitigation potential

Ethiopia has a comprehensive set of climate change mitigation policies and strategies that already cover all relevant sectors for emission mitigation, focusing in particular on agriculture, forestry, transport, power, waste, and IPPU. Also, its NDC's emission reduction target is already quite ambitious. The CRGE Strategy is Ethiopia's framework legislation for both its mitigation and adaptation policy. It sets ambitious mitigation targets. Figure 16 shows the emission reductions required to meet the CRGE Strategy targets by 2030 which are only slightly above the NDC's and may therefore be a good indicator for a more detailed display of the different sectors'envisaged contribution to achieving Ethiopia's NDC over the time period 2010 to 2030.

Figure 16: Emission reductions required to meet the CRGE Strategy targets by 2030 (Gg)



Source: FDRE (2016a).

2.6.1 Selection of proposed fields of action

Even though Ethiopia's mitigation strategies and policies already cover all relevant sectors, there is still additional mitigation potential to tap even when the targets of Ethiopia's NDC are fully achieved. To identify interesting fields of action for additional mitigation activities, first, the main sources of emissions in 2030 under the assumption that the NDC is fully achieved as envisaged were considered.

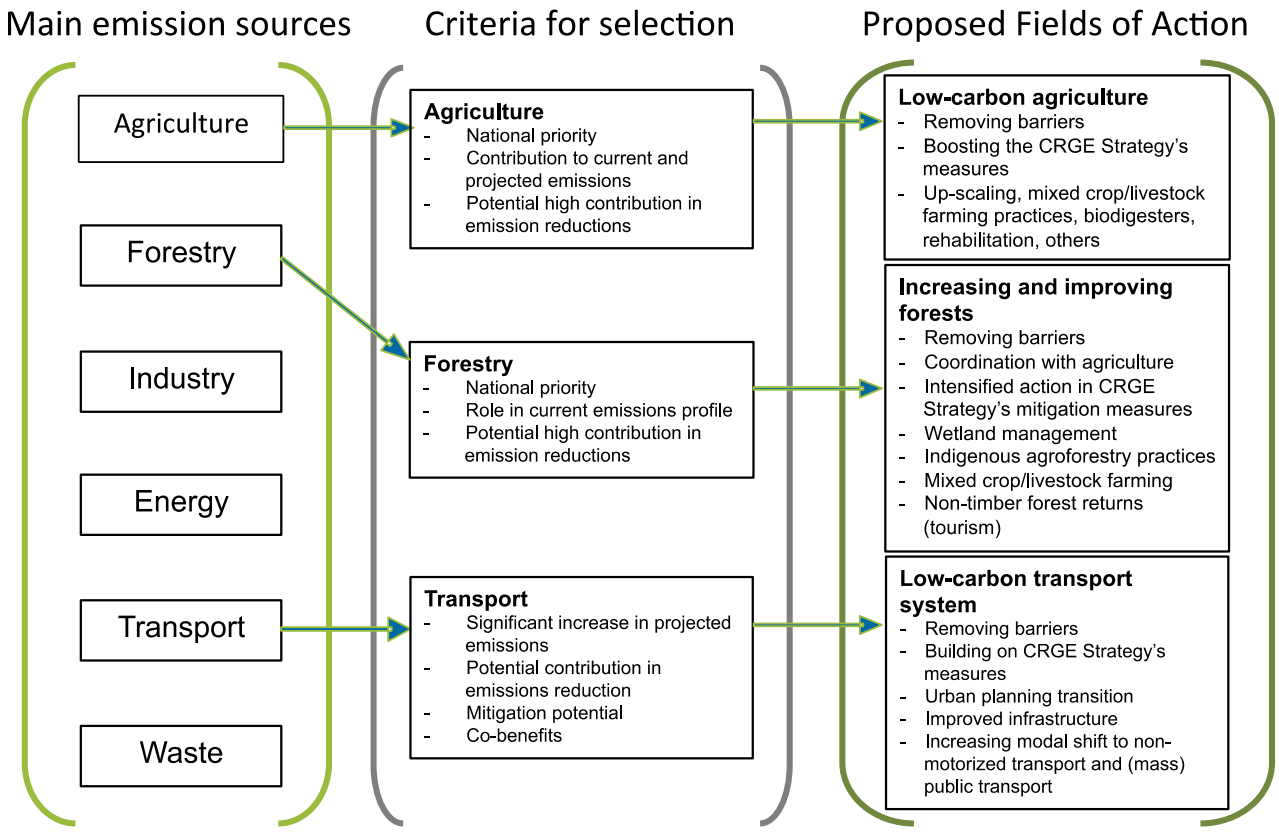
In projected BAU emissions, by far the largest share of emissions would result from the agricultural sector with 95 Mt CO_2e in 2030, making agriculture a prime candidate for a field of additional action. This sector has a high priority in Ethiopia due to its role in the latest economic upturn. Furthermore, a screening of existing strategies and plans reveals that there is still mitigation potential to be tapped in the sector and that these activities would have substantial co-benefits.

The second sector chosen as a field of action is forestry. Forestry is projected to contribute negative emissions of -40 Mt CO_2e to achieving the NDC's targets and reduce its emissions by 130 Mt CO_2e below BAU in 2030. However, in 2013, the sector accounted for negative emissions of -62 Mt CO_2e, and even of -224 Mt CO_2e in 1994. It is therefore highly attractive to push activities in this sector even fur-

ther. Also, the sector ranks high on Ethiopia's list of priorities. On top, significant co-benefits can be expected from mitigation in forestry.

Last but not least, emissions in the transport sector are expected to rise considerably until 2030, reaching 30 Mt CO_2e in 2030 under the assumption that Ethiopia's NDC is achieved. Looking at government documents it is apparent that there are still policy areas in transport that have so far been disregarded. If ambitious policies are implemented early on in the transport sector before the rise of individual motorised transport that is likely to occur in light of the expected future economic development, low-emission transport could become a reality in Ethiopia, coming hand in hand with substantial co-benefits that already make most measures attractive on their own. Therefore, this sector was deemed highly interesting for consideration in this study.

Figure 17: Selection process for proposed fields of action in Ethiopia



Source: Own illustration.

Emission reductions required to achieve the CRGE Strategy's mitigation goal for 2030 focuses on four pillars:

1. Agriculture: Improving crop and livestock production practices for higher food security and farmer income while reducing emissioins,
2. Forestry: Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks,
3. Power: Expanding renewable power generation, and
4. Transport, industrial sectors and buildings: Leapfrogging to modern and energy efficient technologies.

These pillars as well as the CRGE Strategy's mitigation goal are echoed in Ethiopia's NDC. Furthermore, the CRGE Strategy provides details on measures envisaged to achieve the targets. While performance under the GTP I has been assessed in GTP II, government documents available online do not provide clear insights into progress in achieving the CRGE Strategy's mitigation goals. Some information on progress can be transferred from government documents, in particular GTP II. Overall, achieving the CRGE Strategy's mitigation goals – and therefore Ethiopia's NDC target – is already quite ambitious and may be hindered by existing barriers.

The following assessment of fields of actions therefore not only provides an overview of the three sectors selected and their emission sources, but also of mitigation measures that would lead to NDC achievement alread included in the CRGE Strategy. After pointing towards co-benefits of these measures, barriers to implementation are presented. Achievement of Ethiopia's NDC target depends on overcoming these barriers. International cooperation may be necessary for successs. Concluding, room for additional action is presented.

2.6.2 Low-carbon agriculture

After Ethiopia's Sustainable Development and Poverty Reduction Programme (SDPRP, 2002/03 to 2004/05) named agriculture as the country's main source of economic development and poverty reduction, the Plan for Accelerated and Sustained Development to End Poverty (PASDEP, 2005/06 to 2009/10) focused on agricultural development-led industrialisation promoting technology and agro-industry to drive economic growth. The GTP I continued this idea, aiming at the continuation of smallholder agriculture as the main driver of agricultural growth. However, subsistence agriculture was to be transformed into market-led production, striving for increases in agriculture GDP as well as agricultural land and productivity. On this basis, the GTP II added sustainable agriculture in its strategic direction, aiming at emissions reductions in agriculture through low-emission inputs and the expansion of small-scale irrigation. More detailed plans for subsectors are, for example, included in Ethiopia's livestock master plan (Shapiro et al. 2015). To transform agricultural production, the government established the Agricultural Transformation Agency (ATA) under the Ministry of Agriculture and Natural Resources (MANR), which is responsible for administering and managing rural land (Franks et al., 2017).

Agriculture in Ethiopia is mainly rain-fed, small-scale subsistence farming using traditional farming techniques. The main agricultural crops in Ethiopia are cereals, pulses, coffee, oil seeds, spices, herbs, vegetables, fruits, and sugarcane. Ethiopia's livestock population is the largest in Africa, comprising about 53 million cattle, 26 million sheep, 23 million goats, 2 million camels and 50 million poultry (FAO, 2017, FDRE, 2016a). Livestock cultivation mainly uses traditional techniques such as mixed farming and pastoralism (FDRE, 2016a). After food-crop yields had been relatively low in Ethiopia for a long period of time, yield per hectare has increased lately. However, rising food demand is likely to continue to be met by area expansion and increased imports (Franks et al., 2017).

2.6.2.1 Emission sources

Agriculture has been and is projected to be responsible for the largest share of Ethiopia's GHG emissions until 2030.[1] The largest share of emissions from agricultural production activities consists of methane and nitrous oxide emissions. While methane is emitted in manure management, enteric fermentation and rice cultivation, nitrous oxide is generated by cultivating and managing soils. Further

[1] Besides data gaps and uncertainties in the agriculture sector (see chapter 2.4), there are inconsistencies in Ethiopia's SNC between tables on actual and projected BAU Emission Trends on the one side (SNC pp. 102-105 and 122-123), and the accompanying text on the agriculture sector, on the other side (SNC pp. 116-117 and 128-130). In case of deviations between the two, the tables are taken as point of reference in this text.

emission sources include biomass burning, crop production, and land conversion to cropland (FDRE, 2016a).
In 2013, 31% of the agriculture sector's emissions resulted from livestock, 39% from cropland and 24% from grassland. The remaining share of emissions includes direct and indirect nitrous oxide emissions from managed soils, biomass burning, urea application and rice cultivation. In 2030, the share of livestock emissions is projected to rise to 45% while cropland emissions account for 32% of the sector's total emissions, and grassland for only 11%. Beside livestock emissions, the main sources of agriculture's projected emissions are land clearing for agriculture, biomass burning in grasslands, and conversion of grasslands to cropland (FDRE, 2016a).

2.6.2.2 Abatement potentials identified by national strategies

Ethiopia's CRGE Strategy forms the basis for the country's NDC. The actions contained in that strategy are already very ambitious, and cover potentials throughout the agricultural sector.

Fully tapping the CRGE Strategy's abatement potentials for the agriculture sector in 2030 would entail a complete transformation of the sector which would have little in common with its mostly small, subsistence farming tradition:

- **Lower-emitting techniques for crop cultivation** such as conservation agriculture, watershed management, and nutrient and crop management in 75% of rural households by 2030 (40 Mt CO_2e).
- **Efficiency increases of the cattle value chain:** Major levers in this regard are the increase of the productivity of cattle for both meat and milk as well as an increased off-take rate, i.e. a reduced age for livestock to be sold. The CRGE mentions improving the market infrastructure, health facilities, and feeding for livestock as possible measures serving this purpose. The measure is targeted at two groups: pastoralists and farmers. Regarding the former group, coverage of productivity-improvements is 100% of the pastoralist population and better feeding techniques would reach 20% of pastoralists. Regarding the latter group, 90% of the rural population is covered by productivity improvements while 25% of farmers would benefit from the full impact from better feeding techniques (15 Mt CO_2e).
- **Increasing the share of chicken** in Ethiopia's protein mix from 15 to 30%, as poultry is a lower-emitting source of protein (20 Mt CO_2e).
- **Introduction of mechanical equipment for ploughing/tillage** (e.g. manual tools and tractors) for 75% of all households increasing work efficiency and thereby substituting about 50% of animal draft power (10 Mt CO_2e).
- **Improving 5 million hectares of pastureland and rangeland** by introducing and promoting appropriate techniques to increase soil carbon contend and the productivity of pastureland and rangeland with pastoral areas through bush clearing, reseeding, paddocking, rotational grazing, improving and adoption of traditional ways of managing rangelands, and water point development (3 Mt CO_2e).
- **Further abatement levers with limited abatement potential:** improved manure management, improved rumen ecology to lower per animal emissions, switching to lower-emitting cattle breeds, small-scale processing plants/technologies to improve livestock productivity, value chain efficiency and productivity improvements in other livestock, such as sheep, goats, and camels (not quantified) (FDRE, 2011).

2.6.2.3 Co-benefits

The measure described have various co-benefits, in particular:

- Boosting yields as well as milk and meat production not only raises the income of farmers but also improves regional food security.

- Improved pasture- and rangeland counteracts erosion.
- Proper fertilizing practices avoid deleterious effects on water and air quality from noxide pollutants.
- Nutrient management helps conserve energy.

2.6.2.4 Barriers to implementation

Some of the mitigation measures mentioned have relatively low barriers to implementation. Thus, lower-emitting techniques for crop cultivation are generally available, suitable for Ethiopian agriculture, and their success has been tracked in pilots. Therefore, the CRGE evaluates this measure as highly feasible (FDRE, 2011). Nevertheless, full implementation is lacking due to significant **knowledge and capacity** barriers: despite efforts to make the agricultural extension system effective and efficient, including with a National Strategy for Ethiopia's Agricultural Extension System, the system is not producing the desired results yet and there is still a lack of grassroots agricultural extension systems, specifically for mitigation activities (Ethiopian Agricultural Transformation Agency / Ministry of Agriculture, 2014). Furthermore, barriers exist in a lack of the regional and federal crops-related **institutional setup**. Furthermore, **financial resources** for improved inputs and equipment may not be available to farmers, and farmers may be hesitant to change their agricultural practices. Community-level adoption of lower-emitting techniques is hampered by **fragmented land use** in the highlands (FDRE, 2011).

For enhancing and intensification of animal mix diversification, technologies and vaccines are available, feed processing plants are expanding, there is good institutional capacity in Ethiopia, and the measure involves only limited financial risk. However, Ethiopia lacks **chicken grandparent farms**, which is a key barrier. Another significant barrier consists in **consumption patterns**. On the one hand, beef cannot be substituted without major changes in many traditional beef dishes. Chicken consumption patterns may be difficult to change because of long preparation times of traditional chicken recipes (FDRE, 2011). On the other hand, even if Ethiopian consumption patterns were changed, cattle production in Ethiopia is largely for export and dairy production purposes (Shapiro et al., 2015).

Most technologies for increasing value chain efficiency are generally feasible and there is strong institutional support for these kinds of measures. However, there is a lack of **local supporting institutions** such as animal health posts and clinics, regional labs, among others. Due to the long-standing and valued traditions of farming methods in Ethiopia, proposals to change breeds and reduce herd size face **resistance among pastoralists** . Raising **awareness** regarding the measure with pastoralists is therefore a crucial challenge (FDRE, 2011).

Availability of technology, its **affordability** for local farmers, and the **suitability of available technologies** for the land use in Ethiopia are significant barrier to mechanising rural farming. While rangeland management is technically feasible, pastoralists have **negative perceptions** of it, and rangeland management is associated with relatively **low direct economic benefits**, which may be a barrier to its implementation (Behnke et al., 2013, FDRE, 2011, Save the Children, 2009). Further barriers to implementing mitigation measures in agriculture consist in a **tradition** in Ethiopia that favours huge animal numbers, a **lack of government subsidies**, **inadequate information**, and a lack of **capacity and skills** among farmers (FDRE, 2016a).

2.6.2.5 Suggestions for deepened and further action

As outlined above, the measures required for NDC achievement are already quite ambitious. Therefore, we suggest to focus additional action in the agriculture sector on overcoming existing barriers for measures already suggested by the Ethiopian government. While there is very little current and specific information on the status of implementing Ethiopia's CRGE strategy, Mitike et al. (2016) found across Ethiopia's policy, regulatory, and organisational frameworks of environment and health that

even though "many policies and regulatory provisions are already on paper, there is inadequate implementation of the policies/strategies and their regulatory provisions" (Mitike et al., 2016).

Specifically in the agriculture sector, we suggest to focus on removing key barriers to full implementation of the CRGE strategy by

- improving the regional and federal crops-related institutional setup,
- awareness raising regarding the benefits of alternative agricultural practices for farmers, and
- capacity building for farmers.

Additional mitigation potential in Ethiopia could be tapped by further boosting the measures already included in the CRGE Strategy, heightened uptake, fast and efficient implementation, or with additional measures. Boosting the measures could include extending measures to additional households or land, employment of improved techniques and more efficient mechanisation, and further increases in livestock value chains, as well as additional shifts to lower-emitting sources of protein such as poultry, or soybeans. Moreover, abatement could be increased by additional measures such as up-scaling, promoting mixed crop/livestock farming practices, promoting bio-digester construction, appropriate fertiliser application according to soil type, promoting conservation tillage techniques to sequester carbon in cultivated soils, and the rehabilitation of overgrazed watering points, hill sides and long-term settlement (FDRE, 2016a, Franks et al. 2017).
While the CRGE Strategy is the only source available that quantifies mitigation potentials for Ethiopian agriculture comprehensively, Rimhanen et al (2016) find that Ethiopian agriculture has greater potential for soil carbon sequestration than previously estimated, and Brown et al. (2012) provide information on mitigation potentials through changes in agricultural practices:

- Converting rainfed cropland with reduced tillage practices and low inputs to native ecosystems is expected to increase the annual carbon stock in soil at 30 centimetres depth from between 1.1 to 3.9 t CO_2e per hectar depending on the region.
- Converting severely degraded grazing land to improved grazing land could increase the annual carbon stock in soil at 30 centimetres depth by between 3.2 and 4.4 t CO_2e per hectar depending on the region and inputs used.
- Converting mosaic vegetation to native ecosystems could increase the annual carbon stock in soil at 30 centimetres depth by between 2.0 and 13.2 t CO_2e per hectar depending on the region.
- Converting rainfed cropland from full tillage to reduced tillage is not quantified.

2.6.3 Increasing and improving forests

After responsibility for the forest sector was handed over from the MANR's Natural Resources Management Directorate to the newly founded Ministry of Environment and Forest in 2012/13, the sector gained importance in Ethiopian policy-making. In 2015, the Ministry was renamed the Ministry of Environment, Forest and Climate Change (MEFCC). While the first Growth and Transformation Plan (GTP I) for the years 2010 to 2015 had already set targets to increase forest coverage, the GTP II (2015/16 to 2019/20) extended them and listed related activities under „climate change" rather than under „natural resources conservation and utilisation". Additional targets for forests have been set in Ethiopia's REDD+ initiative as well as the CRGE Strategy (see below, Franks et al. 2017).

Forests in Ethiopia range from tropical moist forests (high forests) in the south-west and the Bale Mountains to desert shrubs in the east and north-east, and parkland agroforestry in the southern highlands. With only limited and conflicting data sources, forest cover and change in Ethiopia can only be estimated. Ethiopia's SNC point out that during the 1990s, carbon stocks in Ethiopia's land-use change and forestry (LUCF) sub-sector have been decreasing significantly. Due to intensive afforestation and re-afforestation campaigns by the government, Ethiopia's forest cover has then been able to recover.

Cover with dense forests in high-rainfall areas to dense woodlands in drylands increased from 7% in the late 1990s to 15.5% in 2015. However, pressure on forestlands are likely to increase hand in hand with Ethiopia's steadily growing population (FDRE, 2016a, Franks et al. 2017).

Reducing Emissions from Deforestation and Forest Degradation (REDD+) allows monetising the abatement potential of forestry abatement levers in a structured way. Ethiopia has started developing its REDD+ programme in 2008. Its Readiness Preparation Proposal (R-PP) was prepared in 2011 and its implementation began in 2013. The CRGE strategy selected REDD+ as one of four initiatives for fast-track implementation. The SNC points out that REDD+ and related activities are envisaged to support reaching the target to reduce emission from forestry by 130 Mt CO_2e in 2030 relative to BAU (FDRE, 2016a).

2.6.3.1 Emission sources

Despite the CO_2 emissions caused by deforestation, in 2013, forest land still yielded negative emissions of -62 Mt CO_2e due to its sequestration potential. However, removals decreased continuously and significantly over the last two decades, from -224 Mt CO_2e in 1994. The SNC puts removals from forest land by 2030 at only -29 Mt CO_2e (FDRE, 2016a). According to Ethiopia's CRGE strategy, after removal, forestry has been responsible for emissions of almost 55 Mt CO_2e in 2010. 50% of these emissions resulted from deforestation for agricultural land, 46% from forest degradation due to fuelwood consumption, and 4% from informal logging (FDRE, 2011). According to the SNC, further drivers of deforestation are forest fires and large-scale agricultural investment promoted until recently by the Government to develop rural Ethiopia (FDRE, 2016a).

2.6.3.2 Abatement potentials identified by national strategies

The CRGE strategy is the only comprehensive study of mitigation potentials for Ethiopia's forestry sector available. As with the agricultural sector, the potentials identified in the CRGE strategy form the basis for the country's NDC. The strategy points to significant abatement potentials in the forestry sector, provided the activities outlined within the CRGE strategy are fully implemented:

- **Reduced deforestation** through lowering the pressure on existing forests by expanding agriculture through capture of 1.7 million hectares of new agricultural land in un-cultivated, non-forest arid areas through irrigation (11 Mt CO_2e) and agricultural intensification (27 Mt CO_2e). Agricultural intensifiction entails enhancing use of best practice yield-increasing techniques for agriculture and agronomics such as harvest and post-harvest management, improved seeds, basic, low-cost irrigation systems, increased use of fertiliser and manure. 75% of farmers would be targeted. It should, however, be kept in mind
- **Reduced forest degradation** by reducing demand for fuelwood through dissemination of efficient cooking and baking technologies (34 Mt CO_2e through fuelwood efficient stoves, 1 Mt CO_2e through LPG stoves, 2 Mt CO_2e through biogas stoves, 14 Mt CO_2e through electric stoves). Overall, 90% of the rural and 72% of the urban households are targeted.
- **Increased sequestration** through mainly large- and small-scale afforestation/reforestation/area closures (32 Mt CO_2e) and forest management of woodlands and forests (10 Mt CO_2e) in an area of 7 million ha by 2030. Further levers envisaged for increased sequestration are agro-forestry and protected-area management (FDRE, 2011)

2.6.3.3 Co-benefits

Reducing forest degradation and increasing sequestration can have a number of positive impacts on economic development:

- The use of efficient stoves boosts the available income and creates employment. Furthermore, it improves health.

- Afforestation/reforestation and forest management may lead to additional income from sustainable forestry and employment, and improve links beetween forest industry and forest development. This may even increase exports and public revenues.
- Improved forest management also has significant non-emission ecological co-benefits such as reduced erosion and the improved provision of ecosystem services.
- The use of enhanced yield-increasing techniques for agriculture as well as the creation of new agricultural land in arid [illegible] preserve forestland and improve labour productivity on the newly intensified land, potentially yielding significant cost savings per hectar of agricultural land (FDRE, 2011).

2.6.3.4 Barriers to implementation

Several of the mitigation measures presented have only low barriers to implementation, in particular those reducing forest degradation and increasing sequestration. Thus, efficient cooking-stoves are available, have proven their applicability and have already been deployed on a larger scale in Ethiopia, guaranteeing the basic functioning of required institutional infrastructure and capacity to scale up the initiative. There may, however, be **cultural barriers** hampering the introduction of efficient cooking and baking devices as well as **financial barriers** due to the required investments to be made. Also, the **large scale production of the stoves needed** may be a challenge. LPG stoves may raise the **dependency on imported technologies and fuel** (FDRE, 2011).

For both afforestation/reforestation and forest management to increase sequestration, no complicated technologies are necessary and Ethiopia is experienced with both of them. For long-term success, a continuing **forest data inventory** would be useful (FDRE, 2011).

Forests in Ethiopia are not only an indispensable source of wood fuel and burning materials, but are also an extremely important locus of agriculture. In addition, the forestry and agriculture sector are often in competition for land use, with forest cover being continuously reduced in favour of new arable land. A reduction of forest cover loss can be daunting, as Bekele et al. (2015) note: "Notwithstanding the current focus on mitigation of GHG emissions, past experiences have demonstrated the challenges that such a 'green revolution' can pose to smallholder agriculture and as such, significant change has remained elusive" (Bekele et al., 2015).

Measures to reduce deforestation include irrigation and agricultural intensification. Therefore, many of the barriers identified for low-carbon agriculture regarding associated measures (chapter 2.6.2.4) are also relevant for increasing and improving forests. Thus, while lower-emitting and yield-increasing techniques are generally available, suitable and have been proven to be successful, the grassroots agricultural extension system as well as the regional and federal crops-related institutional setup need improvement, constituting a barrier for reducing deforestation via agricultural intensification. Furthermore, high upfront costs may be a significant barrier for small-scale irrigiation and there is a lack of financial provisions for farmers for improved inputs and equipment in general. Furthermore, as noted above, long-standing practices in agriculture may be hard to change and the fragmentation of land use in the highlands impedes the easy adoption of technologies and practices at community-level. Additionally, the inavailability of land in the highlands for new entrants into agriculture further exacerbates fragmentation. Due to substantial technical and institutional implementation challenges as well as high costs, large-scale irrigation was evaluated to be only moderately feasible (FDRE, 2011). Water availability in general may be another significant barrier for irrigation.

2.6.3.5 Suggestions for deepened and further action

However, mitigation and sequestration potentials in forestry envisaged by the CRGE Strategy already set a high bar for action and are the only comprehensive potential studies for mitigation in Ethiopia's forestry sector. Before targeting additional mitigation potentials, international support should there-

fore first ensure that existing mitigation targets and plans are implemented, as the most promising measures for mitigation in forestry are already included in the CRGE Strategy. To support achievement of the CRGE Strategy's mitigation target for forestry, international cooperation could focus on reducing existing barriers for implementation of the measures already envisaged, e.g. by

- providing financial support for investments in low-carbon cooking and baking devices,
- providing financial support for small-scale irrigation,
- establishing financial provisions for farmers for improved inputs and equipment, and
- supporting setting up a continuing forest data inventory.

Many of the measures aiming at reduced deforestation and forest degradation are located in the agriculture sector. Close coordination between the two sectors is therefore highly important for efficient action in order to synergistically explore options to remove barriers in both sectors.

Further mitigation potentials could be tapped with intensified action in the fields already covered by the CRGE Strategy, i.e. further reducing deforestation and forest degradation, and increasing sequestration. Thus, irrigation could be optimised and expanded, yield increasing techniques could be further improved, the use of fuelwood in cooking and baking could be reduced further (e.g. by further improving fuelwood-efficient stoves or by switching to cooking and baking technology based on renewable energy from wind and hydro power), the targeted population of the measures could be increased, larger areas could be afforested/reforested or closed, and forest management of woodlands and forests could be expanded. Additional mitigation could also be reached with indigenous agroforestry practices or mixed crop/livestock farming, and wetland management. Providing economic returns from non-timber forest productions and forest uses not involving tree removal such as tourism could also delay or reduce deforestation and degradation.

2.6.4 Low-carbon transport system

The topographical variations in Ethiopia pose a significant challenge to transport. About 90% of transportation in the export and import sectors as well as 95% of public transportation services are handled by road transport. In 2011/12, Ethiopia had a federal and regional total road length of 56,190 kilometres. Due to its cost effectiveness and time efficiency for transporting bulk inputs and produce, the Growth and Transformation Plan (GTP I) aims at the construction of 2,395 kilometres railway line in three corridors and five lines (FDRE, 2016a).

2.6.4.1 Emission sources

Transport emissions have been increasing continuously: while only 1.0 Mt CO_2e in 1994, transport was responsible for emissions of 5.5 Mt CO_2e in 2013. According to the SNC's BAU scenario, these emissions are projected to multiply five-fold until 2030, reaching 25.4 Mt CO_2e. Ethiopia's NDC puts transport emissions under BAU at 40 Mt CO_2e, the CRGE and Ethiopia's Climate Resilient Transport Sector Strategy at 40.7 Mt CO_2e in 2030 (FDRE, 2011, 2016a, 2017a, Ministry of Transport, n.d.). The main drivers of rising emissions in the transport sector are increases in passenger-kilometres travelled, in tonne-kilometres of cargo transported, and in construction and mining transport (FDRE, 2016a).

2.6.4.2 Abatement potentials identified by national strategies

While the CRGE Strategy includes ambitious mitigation measures, they focus on specific policy areas and still leave room for additional action. Nevertheless, the abatement potentials presented in the

CRGE Strategy for transport (12.2 Mt CO_2e in 2030 relative to BAU[2]) are slightly above the targeted emission reduction contribution envisaged for the transport sector in Ethiopia's NDC (10 Mt CO_2e) and therefore already seem to entail additional mitigation potentials compared to the NDC, assuming that numbers have not just been rounded down for the NDC:

- **Improvements in Addis Ababa's public transit** by building a light-rail transit system (LRT) with 35 kilometres route length (0.1 Mt CO_2e) and a bus rapid transit system (BRT) using electric trolley buses of 32 kilometres route length (0.04 Mt CO_2e), both powered by renewable energy (wind and hydro power). The CRGE estimates a shift of 7% of passenger-kilometres travelled within Addis Ababa to LRT, and of 3% to BRT (FDRE, 2011). At the beginning of 2015, the LRT system was completed with 37 kilometres and 41 stations (FDRE, 2016a). Implementation of plans to extent the LRT lines are currently under threat from pressing technical and financial challenges in the existing network. Addis Ababa's LRT system is the first light rail transit in sub-Saharan Africa (Nallet, 2018). In April, a feasibility memorandum of understanding has been signed for a BRT project in Addis Ababa (BUCG, 2018).
- **Fuel efficiency standards** for new and used vehicles imported into the country are assumed to improve fleet efficiency by 30% for passenger vehicles and by 10% for freight vehicles by 2030 instead of 10% and 3.3% respectively in the BAU scenario (3.1 Mt CO_2e).
- **Alternative fuels and propulsion systems:** In particular incorporating 5% of biodiesel into the national diesel fuel mixture (0.7 Mt CO_2e), increasing the share of ethanol in the gasoline mixture from 10% in Addis Ababa to 15% nationally (0.2 Mt CO_2e), and increasing the share of hybrid (0.1 Mt CO_2e) and plug-in electric vehicles (0.04 Mt CO_2e) to 13.0% and 2.2% respectively (FDRE, 2011). Currently, a small project piloting battery charged electric cars is being implemented (FDRE, 2016a). Energy Co-Invest Corp plans to assemble electric vehicles and set up inductive charging stations in Ethiopia (Ezega News, 2017).
- Shifting 50% of dry and liquid cargo freight transport from road transport using diesel vehicles to an **electric rail network** of seven lines totalling 5,196 kilometres powered by electricity from renewable sources of energy (8.9 Mt CO_2e) (FDRE, 2011). 756 kilometres of electric rail line between Addis Ababa and Djibouti has started commercial operations at the beginning of 2018 (Olinge, 2018). The line is part of a railway network which is to connect with Sudan, Kenya, and South Sudan (Nallet, 2018).

2.6.4.3 Co-benefits

Tapping the abatement potential in the transport sector has significant co-benefits:

- The CRGE Strategy calculates all of its abatement options in transport to have negative or zero costs.
- All of the mitigation measures mentioned reduce the amount of fuel used. This, on the one hand, reduces air and noise pollution and leads to considerable health benefits. On the other hand, reduced fuel imports have a positive effect on Ethiopia's balance of payments.
- Fuel efficiency standards reduce the lifetime cost of vehicle ownership leading to monetary savings in the medium- to long-term.
- Improving public transit in Addis Ababa as well as the electric rail network for freight transport both reduce the use of individual motorised transport and thus lead to less road congestion and a decrease in traffic accidents. Moreover, these measures reduce passenger travel times and costs, and accelerate transporting cargo and make it less costly.

[2] The CRGE Strategy's identified abatement potential for the transport sector is by 1 Mt CO_2e lower than the sum-total of the added levers' abatement potentials as some of these levers are not entirely additive.

- Lowered transport cost as well as faster transport of cargo, again, improve the international competitiveness of Ethiopia's industrial as well as its agricultural production.
- Jobs are created both in the construction and operation of the BRT, LRT and railway systems, boosting the economy (FDRE, 2011).

2.6.4.4 Barriers to implementation

There are several barriers to the implementation of the mitigation measures in transport described. First of all, due to its low share in national emissions, the transport sector is currently **not among the high priority sectors** for emissions mitigation in Ethiopia. Moreover, a **lack of institutional capacity** could hamper enforcing fuel efficiency standards. For the construction of the electric rail network for freight transport, there is a significant **lack of technical knowledge** in Ethiopia (FDRE, 2011). It is, however, bridged with Turkish and Chinese contractors (Embassy of Ethiopia, 2017b). Also, Addis Ababa's LRT system is currently being run by professionals from China and Ethiopia, targeting transfer of skills for solely Ethiopian management by 2019. This transfer, however, is challenging. Further challenges for the LRT system exist regarding **maintenance of the rolling stock, management of daily traffic,** and repaying the loan (Nallet, 2018). Knowledge transfer to locals will be necessary to allow for running and maintaining the rail lines in the future. Furthermore, the measure may cause **resistance among the population** that may be displaced by the network. A further barrier consists in the **high upfront costs** that accumulate in the construction of the network. They will, however, be offset by future revenues (FDRE, 2011).

2.6.4.5 Suggestions for deepened and further action

Fully realising the mitigation potentials of the CRGE Strategy's mitigation measures for transport would overachieve the NDC's mitigation target for the sector. While some of the measures included in the CRGE Strategy are already under way, they still face barriers to their implementation. Support to overcome these barriers could focus on

- improving institutional capacity to allow for efficient enforcement of fuel efficiency standards,
- technical capacity building and knowledge transfer regarding electric rail network for freight transport,
- stakeholder involvement to reduce resistence among the population that may be displaced, and
- financial support regarding the high upfront costs for constructing the rail network.

Moreover, mitigation in Ethiopia's transport sector could be increased by building on the CRGE Strategy's measures. As an example, during rush hour, the LRT system in Addis Ababa is overcrowded (Nallet, 2018). Extending the current LRT lines and higher frequencies as well as accelerated implementation of plans for the construction of BRT would not only improve the comfort of public transport in Addis Ababa but would also lead to additional emission reductions. Furthermore, public transit could be extended and improved in other big cities in Ethiopia, such as in Dire Dawa and Mek'ele, focusing on bus operation systems.

Similarly, transport capacity in the rail network could be boosted by increasing railway-kilometres and frequencies as well as with additional lines, attracting larger cargo to be transported by rail and higher passenger numbers.

The CRGE Strategy's measures only cover part of the available portfolio of mitigation options for Ethiopia's transport sector and there are various options to achieve mitigation beyond the Ethiopian NDC's and the CRGE Strategy's mitigation targets. Many of these options are included in Ethiopia's SNC, its NDC, the CRGE Strategy, and Ethiopia's Climate Resilient Transport Sector Strategy, which complements and details the CRGE Strategy's targets and action in this sector (Ministry of Transport of Ethio-

pia, n.d.). Additional mitigation in Ethiopia's transport sector could be achieved by employing the following measures:

- **Avoiding traffic with and urban planning transition** towards mixed use, compact, and polycentric cities, focusing on a transit-oriented development (TOD) that results in shorter distances travelled. Measures include strongly enforced land use policies (urban codes and land regulations), density controls, eliminating minimum parking regulations, setting boundaries for urban growth, and spatial planning.
- **Improving rural and urban transport infrastructure.** On the one hand, infrastructure for bicycles and pedetrians could be expanded. On the other hand, roads could be changed from gravel to asphalt or high albedo pavement blends, and dry ports could be established. Also, recycled materials could be used for road surfacing.
- **Increasing the modal shift to non-motorised transport and (mass) public transport** compared to BAU. Measures include providing sufficient park and ride facilities and improved public transport links, particularly between higher density growth centers, but also raising awareness about options and benefits of alternative modes of transport. For a modal shift, public transport accessibility and safety as well as non-motorised transport mode use have to be improved in Ethiopia (FDRE, 2011, 2016a, 2017a, Ministry of Transport of Ethiopia, n.d.).

2.7 Conclusions

With its CRGE Strategy, Ethiopia has ambitious plans to achieve middle-income status by 2025 in a climate-resilient green economy, achieving economic development in a sustainable way. Accordingly, its **NDC sets a high emission reduction target of -64% below BAU levels in 2030** and defines each sectors' envisaged contribution in this effort. The Climate Resilient, Green Economy (CRGE) Strategy outlines mitigation measures that are envisaged to reduce emissions accordingly.

All in all, Ethiopia has a **comprehensive set of climate change mitigation policies and strategies that already cover all relevant sectors** for emission mitigation, focusing in particular on agriculture, forestry, transport, power, waste, and IPPU. Nevertheless, there is still additional mitigation potential to tap.

The largest share of remaining emissions projected for 2030 is in the **agricultural sector** with 95 Mt CO_2e. The analysis of the CRGE Strategy's mitigation measures reveals that Ethiopia is already embarking on an ambitious mitigation pathway in that sector. However, for full effect it may be advisable to focus on removing implementation barriers especially in the crops-related instutional set-up, the provision of information on benefits of alternative agricultural practices for farmers, as well as additional capacity building on the ground.

Going further, additional actions may include. upscaling of existing measures, conversion of rainfed cropland back to native ecosystems or at least introduction of lower tillage rates, improving degraded grazing land, and converting mosaic vegetation areas back to full native ecosystems.

The measures described have various co-benefits, reaching from additional income and food security to counteracting erosion. Furthermore, they avoid deleterious effects on water and air quality and conserve energy.

The second sector chosen as a field of action is **forestry.** Forestry is projected to contribute negative emissions of -40 Mt CO_2e to achieving the NDC's targets and reduce its emissions by 130 Mt CO_2e below BAU in 2030. However, in 2013, the sector accounted for negative emissions of -62 Mt CO_2e, and even of -224 Mt CO_2e in 1994. Similarly to the agricultural sector, Ethiopia's planned activities in the forestry sector can be considered quite ambitious and comprehensive. Again, barrier removal for a full implementation of proposed measures may be the most promising avenue for effective mitigation in the sector. Because of the strong interdependence of the agriculture and forestry sectors, the removal

of some of the most important barriers in forestry would also be at least as beneficial for agriculture in Ethiopia. Provision of financial support for investments in low-carbon cooking and baking devices, support for small-scale irrigation, financial provisions for farming equipment and improved inputs are among these measures. In addition, a continuation and improvement of forest data inventory systems would aid in better keeping stock of existing forest areas in the country.

The measures contained in Ethiopia's CRGE strategy contribute to overall sustainable development in several ways.. The dissemination of efficient stoves, in particular, creates additional income and employment and has positive effects on health. Afforestation and reforestation may create additional income and employment, and lead to increased exports and public revenues. Furthermore, they prevent erosion and improve ecosystem services. Yield-increasing techniques lead to higher labour productivity and cost savings while preserving forested lands..

Emissions in the **transport sector** are on the rise and are expected to reach 30 Mt CO_2e in 2030 under the assumption that Ethiopia's NDC is achieved. If ambitious policies are implemented early on in the transport sector before the rise of individual motorised transport that is likely to occur in light of the expected economic development, low-emission transport could become a reality in Ethiopia, particulary for regions outside of the capital with low density of vehicles. Interestingly, the measures proposed in Ethiopia's CRGE strategy would already go beyond the NDC target if they are fully implemented.

However, to reach the fullpotential identified in the CRGE strategy, a number of barriers need to be overcome. Among others, institutional capacity for efficient enforcement of fuel efficiency standards needs to be strengthened, and technical capacity in electric rail and freight transport needs to be improved. In order to improve acceptance of relocations due to rail construction, strong stakeholder processes need to be put in place. Finacial assistance to ovecome high investment costs fo the rail network would greatly help in speeding up construction.

Additional mitigation potential could be levered through increasing the shift to LRT and BRT as well as other public transport in Addis Ababa and other cities and villages. Furthermore, Ethiopia's rail network could incorporate passenger transport. Capacity of rail cargo could be increased (railway-kilometres and additional lines). So far, measures aiming at avoiding traffic through integrated land-use planning and transport demand management reducing the need to travel and/or trip length have not been employed yet. Furthermore, specific measures for non-motorised modes of transport could prove beneficial for Ethiopia's emissions balance.

Mitigation measures in the transport sector have high to very high co-benefits. Thus, all of the transport abatement options in the CRGE Strategy are calculated to have negative or zero costs. Fuel saved have a positive effect on Ethiopia's balance and payments. Moreover, it leads to reduced air and noise pollution and has significant health benefits. Furthermore, improving public transport and rail cargo reduce congestion and traffic accidents, and safe travel/transporting time and cost. This may improve international competitiveness.

Ethiopia has put in place a comprehensive approach to reduce its emissions without tradeoffs for sustainable development. The country's CRGE Strategy would actually go beyond the country's NDC if fully implemented. Even though up-to-date information on implementation progress is currently still sparse, we see Ethiopia on a good path to NDC achievement provided the country receives a modicum of bi- and multilateral support to overcome some key barriers.

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