International Labour Organization

NIGERIA GREEN JOBS ASSESSMENT REPORT

Measuring the Socioeconomic Impacts of Climate Policies to Guide NDC Enhancement and a Just Transition

ABOUT UNDP

UNDP's work on climate change spans more than 140 countries and involves US$3.7 billion in investments in climate change adaptation and mitigation measures since 2008. With the goal to foster ambitious progress towards resilient, zero-carbon development, UNDP has also supported implementation of the Paris Agreement on Climate Change by working with countries on achieving their climate commitments or Nationally Determined Contributions (NDCs).

THE NDC SUPPORT PROGRAMME

The NDC Support Programme provides technical support for countries to pursue an integrated, whole-of-society approach that strengthens national systems, facilitates climate action and increases access to finance for transformative sustainable development. The programme helps countries address financial barriers by deploying a structured approach for scaling up sectoral investments and putting in place a transparent, enabling investment environment. Beyond direct country support, UNDP facilitates exchanges and learning opportunities on NDC implementation at the global and regional level by capitalizing on our close collaboration with the UNFCCC and other strategic partners. The programme, which contributes to the NDC Partnership, is generously supported by the German Federal Minister of the Environment, Nature Conservation and Nuclear Safety (BMU), the German Federal Ministry of Economic Cooperation and Development (BMZ), the European Union and the Government of Spain.

ILO

ILO is spearheading a global Just Transition agenda through the Climate Action for Jobs Initiative. The Paris Agreement on Climate Change, adopted in 2015, acknowledges the imperatives of a just transition and the creation of decent jobs in a response to climate change. In the same year, ILO constituents adopted guidelines for a just transition towards environmentally sustainable economies and societies for all.

ILO GREEN JOBS PROGRAMME

The Green Jobs Programme signals ILO's commitment to act on climate change and to promote resource efficient and low-carbon societies. Decent work is a cornerstone for effective policies to green economies for achieving sustainable development. The Green Jobs Programme has gradually assisted over 30 countries by building relevant ILO expertise and tools.

ABOUT THIS JOINT INITIATIVE

This is a joint pilot initiative between UNDP's NDC Support Programme and ILO's Green Jobs Programme, assisting countries to measure the socioeconomic impacts of climate policies to guide evidence based NDC policy making and support a just transition.

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Executive Summary

One of the main questions in climate policymaking is to understand the economic and social costs and benefits. The potential to create employment that these policies offer is of particular concern to developing and emerging economies with a young population that face structural challenges to generating sufficient employment opportunities for a growing number of labour market entrants.

This study analyses the impacts of Nigeria's climate policies on employment, GDP and emissions in keeping with revised national determined contributions (NDCs). The short- to medium-term (primary) and long-term (secondary) effects are evaluated in terms of job creation and growth potential, as well as their expected impacts on greenhouse gas (GHG) emissions across the economy.

The 11 most relevant policies were selected from the NDCs for the analysis. Energy policies dominate the NDCs' climate policies, reflecting the need to promote economic development and address both energy poverty and climate change. Most investments planned in the NDCs are in the power and energy sector. Other policies target transport, agriculture, forestry and industry.

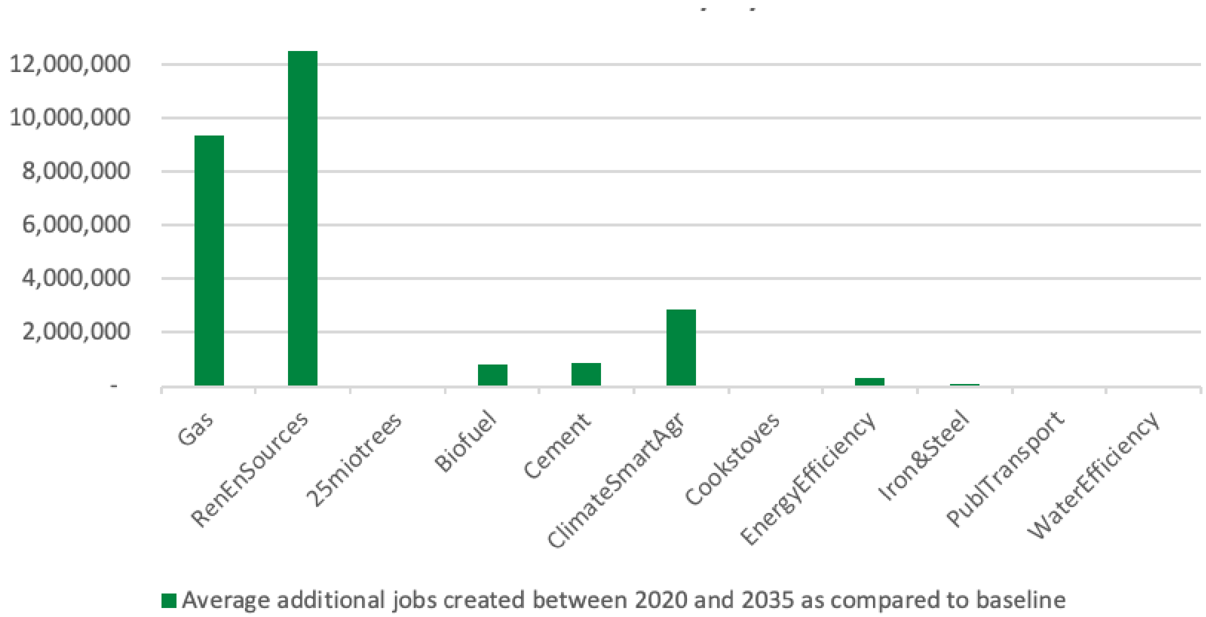
Policies to increase power generation have the greatest effect in terms of the total number of jobs created. Between 2020 and 2035, these policies are projected to add around 12 million net additional jobs across the economy compared to a baseline scenario. The significant increase in employment should be interpreted in light of the significant capital investments (US$80 billion), which generate massive job opportunities in construction and installation in the short to medium term.

It is important to note that after the short-term effects of investments ease, climate policies produce a structural change to the economy in the long term. Understanding the structural change effects in terms of aggregate employment, emissions and growth is key to evaluating the policies' long-term impacts.

Therefore, in addition to considering the initial short- to medium-term effects, the long-term structural change effects must also be assessed. Comparing the 11 policies reveals significant differences in terms of size, but all have overall positive employment and economic growth effects, which are projected beyond 2035.

Some policies offer significant employment creation potential even without major investments. The agricultural sector offers one example. A policy that would incentivize climate-smart agricultural production systems could add some 3 million net jobs across the economy. Policies in the industrial and transport sector are less ambitious and smaller in terms of investments compared to power sector policies. The resulting total employment in those sectors is therefore smaller, reflecting only that the investment in transport and industry is much smaller than in power.

Figure 1: Net jobs created by selected climate policies (NDCs) accross the economy by 2035



Source: Authors' calculation

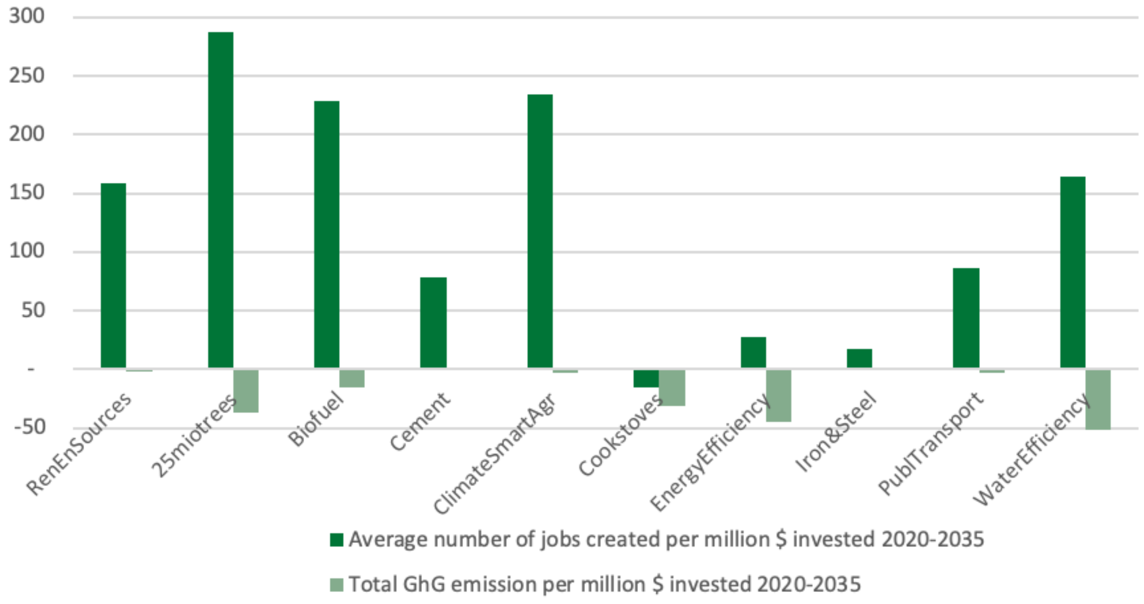
The cost of the climate policy compared to its expected benefits is another central consideration. Total economy-wide employment effects are different from the climate policies' relative effects. Clearly, the larger the total investment, the larger the total expected economic and employment stimulus. A climate-employment cost-benefit analysis highlights the relative employment creation potential across sectors to maximize positive outcomes and achieve the greatest impact in terms of investment. Taking this relative measure involves calculating the net employment effect per dollar invested, which is critical in assessing policies in a context of constrained budgets and multiple objectives.

For example, comparing the biofuel policy with the cement policy reveals that both add a total of around 800,000 jobs to the economy. However, investments in the cement industry ($11.3 billion) are more than triple those called for under in the biofuel industry ($3.6 billion).

This finding is important because it shows that while the total size of the investment matters, the type of investment is crucial. The type of economic structural change the investment produces will determine the number of jobs created, amount of GDP generated and level of emissions produced – whether greater or lesser.

This reveals the third important dimension of the policy effects (in addition to the *primary short-term* and *secondary long-term* effects): what is the total number of jobs created or lost in 2035 per dollar invested? The same question applies to the effects on GDP and emissions per unit of investment (see following chart).

Figure 2: Total economy-wide job and GHG multiplier per million dollars invested in selected climate policies



Source: Authors' calculation

Comparing the 11 scenarios in terms of their job creation and GHG emissions reduction potential per million dollars invested shows that a relatively high job multiplier of around 150 jobs in renewable energy. However, changes in the agriculture, forestry, and land use (AFOLU) sector create the highest job multiplier, with between 230 and 290 job opportunities across the economy per million dollars invested.

An analysis of the employment-climate link reveals the central nature of the AFOLU sector. The informal firewood and charcoal industry involves some 41 million workers and provides an estimated 530,000 full-time equivalent direct jobs. An additional 200,000 workers, most also full time, provide transport services for retail and wholesale trade. Comparing the contribution of the energy sector's sub-industries to employment, forests constitute the main share of employment and income. It is much more important than the oil and gas sector, which employs only a fraction of that (some 65,000 direct jobs).

The importance of the firewood and charcoal industry cannot be overstated as it also provides Nigeria's main energy source, specifically for daily food preparation. Biomass accounts for around 75 percent of total primary energy supply, compared to approximately 15 per cent for oil and gas. Biomass is thus also the main source of emissions.

This underscores the importance of climate policies that focus on the AFOLU sector and ensure a sustainable biomass and energy supply, while simultaneously addressing employment and labour market implications. Afforestation and reforestation offer a low-cost solution in terms of climate benefits. Investing $1 million in tree planting would reduce GHG emissions by some 37 tonnes, creating some 290 jobs at the same time. This compares to smaller or no effects on emission reductions in the power industry. This is because the power industry provides a much smaller share of total emissions and stimulates economic activity and growth in forward-linked sectors, adding emissions elsewhere in the economy.

Investing $1 million in the production and use of improved cookstoves is comparable to tree planting in terms of emission reductions (32 tonnes). However, this investment would lead to job losses in the firewood and charcoal industry. Because of its informal nature, drudgery and, often, lack of decent working conditions, and its negative impacts on forest degradation and water regulation, such an investment may be welcome. However, the sector provides direct and indirect jobs and income to close to one million Nigerians, which would need to be addressed. Alternative employment opportunities and social protections are required to compensate for lost work and income to ensure a just transition to a low-carbon, environmentally-friendly economy.

Thus, the potential positive contributions of these NDC climate policies to economic growth, employment creation and emission reduction depend on accompanying economic, social and labour market policies. Indeed, if climate policies are to be effective and make a positive contribution to development at the same time, they need to be accompanied by just transition policies.

Five key aspects of just transition policymaking require close attention. First, failing to address social consequences may lead to protests and the non-implementation and failure of climate policies. Second, the type of climate policy will have significant and very different effects on social and labour market outcomes. Integrating just transition policies at the design stage can maximize social inclusion, pro-poor growth and job creation. Third, well-intended climate policies and capital investments in the low-carbon economy require managers, workers, enterprises and entrepreneurs with the skills to finance, manage, construct, operate and maintain the capital asset or implement structural production changes, such as those required for climate-smart agriculture, and to make productive use of the asset in the long term. Fourth, social protection measures and social dialogue mechanisms are needed to address and signal the populations concerned that the government will buffer the policies' potential negative impacts. And fifth, accompanying fiscal, macro, sectoral and industry policies could support structural economic change and enhance economic growth and social development.

1 Objective of the Green Jobs Assessment Model

In response to the increasing risks associated with climate change, in general, and global warming, in particular, Nigeria, like most countries, is defining its climate policies and strategies. The latter often seek to set targets for the countries' total emissions to comply with international agreements, such as the Paris Agreement. [1] However, some of these strategies can also focus on developing mitigation and adaptation approaches that can help reduce the negative impact of climate change. Every country has inherent characteristics that must be considered when developing mitigation and reduction strategies. For example, will its climatic susceptibility and economic structure strongly influence the effects of implementing that strategy?

Different economic sectors experience the economic transition associated with meeting the Paris Agreement's targets differently. For example, while the oil and gas industry will likely benefit the least from climate change mitigation action, the agricultural industry will be most affected without such mitigation. Labour force data from the Nigeria's National Bureau of Statistics (2018) show that for every person working in the oil and gas industry, 200 people work in agriculture. The impacts on these two industries will differ significantly based on climate change mitigation policy goals.

The aim of the Green Jobs Assessment Model (GJAM) is to measure the social and employment impacts of NDC policies. The GJAM is based on detailed data about the Nigerian economy (supply and use table, SUT) and can reflect, in detail, the structural changes that follow implementation of climate change mitigation measures as envisioned in the NDCs. The model captures the policies' direct effects and their indirect impacts on upstream industries that supply those that will be strongly affected by the structural changes. These results can be used to inform policy design for the first NDC revision, which is about to begin.

The GJAM is based on the modelling approach described in the International Labour Organization's (ILO) GAIN Training Guidebook [2] and developed further to incorporate intertemporal dynamics and price effects.

2 Policy scenarios

2.1 Overview

Nigeria’s climate strategy and policies are detailed in the revised NDCs. The most important policies in terms of ambition and investment were selected for detailed quantitative analysis. Policy scenarios were developed and using the GJAM, projections were made to analyse their impact on social, economic and environmental development.

The most prominent policies address the energy system directly and/or involve the energy sector indirectly. Of the 11 climate policies selected, three relate directly to power generation, specifically, renewable energy, gas and energy efficiency. Another energy policy focuses on expanding clean cooking, with implications for the energy and agriculture and forestry sectors. Two policies address transport through investment in public transport infrastructure and biofuel production, with close links to the energy sector as well.

Two agriculture and forestry policies stand out: to plant 25 million trees and to promote climate-smart agricultural production systems. Last, two climate policies directly target the steel and cement industry, while one seeks to increase efficiency in the water sector.

2.2 NDC sectors and detailed policy scenarios

Nigeria's NDC climate change mitigation sectors are energy (power), oil and gas, agriculture, transport, industry, and water. Both agricultural and water sectors are also considered for adaptation actions. The Assessment of Investment and Financial Flows (I&FF) report [[3]] lists the following climate measures as key:

- end gas flaring by 2030;
- implement off-grid solar PV of 13GW (13,000MW);
- install efficient gas generators;
- achieve 2 percent per year energy efficiency improvements (30 percent by 2030);
- shift transport from car to bus;
- improve electricity grid; and
- implement climate-smart agriculture and reforestation.

The table below summarizes the main assumptions by scenario.

SCENARIO NDC Sector	DESCRIPTION
Renewable energy sources (RenEnSources) Power	Increase electricity generation by about 120% by 2030. Total investments of NGN 15,840 billion NGN. Targeted shares of electricity generation: 50% gas, 20% grid-solar and 5% off-grid solar, 17% hydro, 2% each biogas and wind, 5% off-grid generators. We also calculated two alternatives: one uses only the additional electricity generation (to distinguish that growth impulse from the investment impulse) and the other assigns all investments to gas power, resulting in an electricity mix of 83% gas, 12% hydro (no change) and 5% off-grid generators.
Energy efficiency Power	2% annual energy efficiency improvement in manufacturing industries, except iron & steel and cement. Total investment of 6.7% of manufacturing output in 2018 (same as in other literature).

SCENARIO NDC Sector	DESCRIPTION
Biofuels Transport	Establishment of a 65,000 million litres per annum biofuel plant with an initial investment funding of $3.6 billion. Replacement of about 10% fossil fuels over time.
Public transport Transport	Expansion of bus rapid transit lanes and purchase of 5,000 public mass transit buses, for total expenditure of $309 million (assuming $40,000/bus, 2/3 bus purchase and 1/3 investment in roads). Fuel switch in public transport: 25% of buses use compressed natural gas.
Efficiency in water production and use Water	Water use efficiency increase of 2% annually, reallocated to plumbing, heat and air-conditioning installation. Energy efficiency increase in water production (2% annually). Assumption: total investment = 5% of 2018 revenue
Climate-smart agriculture Agriculture	Investments of $27,195 million in research and development (R&D), education, infrastructure, equipment and machinery, irrigation, and drainage. 1/3 of farmers switching to climate-smart agriculture.
Clean cooking solutions Agriculture	6%/2% of households switch to more efficient wood/charcoal stoves annually, saving 66%/33% fuel. Switch from firewood to liquefied petroleum gas (LPG) in service sector, reducing firewood use by 66%. Investments in 6.5 million improved wood stoves (clay/metal) at NGN 350 each, 6.5 million modern efficient cookstoves at NGN 6,500 each, and 5 million LPG cookstoves at NGN 19,500 each.
Reforestation Agriculture	25 million trees at $2.70/tree (total investment $67.5 million), growing seedlings over two years, planting over two years. Assumption: tropical trees sequester 22.6 kg carbon per year
Efficiency in iron and steel production Industry	Total investments of $3,797 million. 50% energy efficiency (2% annually). 20% R&D for innovative steels. 30% carbon capture and storage (CCS). 10% emission reduction due to CCS.
Efficiency and material substitution in cement Industry	Total investments of twice that in iron and steel. 50% energy efficiency (2% annually). 20% R&D to develop cement alternatives. 30% CCS. 10% emission reduction due to CCS. Replacement of cement with clay, reduction in cement use, requiring additional architecture services.

3 Green Jobs Assessment Model methodology and data

The GJAM for Nigeria is an input-output model with an economic core based on the 2010 SUT. Economic development is driven by a combination of exogenous and endogenous macroeconomic parameters. The philosophy of the model is to represent economic development as simply and transparently as possible, while enabling the employment outcomes of structural economic changes that occur due to climate change mitigation and adaptation policies to be identified, as envisioned by, for example, the country's NDCs.

As presented in Figure 1, the GJAM combines a macroeconomic model that is solved iteratively moving forward one year at a time with a demand-driven input-output model with industry detail. Exogenous drivers are exports and population. Exports grow with the global GDP growth rate from the OECD's Longview [4] adjusted for short-term developments by recent International Monetary Fund (IMF) estimates. Population development is assumed to follow the UN Department of Economic and Social Affairs' (UNDESA) medium fertility scenario [5]. Household consumption expenditures per capita are modelled using income, own-price and cross-price elasticities from the US Department of Agriculture's international food comparison programme [6,7]. Value added (used as a proxy for income for the household demand model) is calculated endogenously using the industry-by-commodity commodity-demand-driven SUT model and changes from one iteration to the next. This in turn determines household consumption expenditures. The change in household consumption expenditures from one iteration to the next is the convergence criterium: once the change is smaller than 0.5 percent, the model moves on to the next year. Investment demand (gross fixed capital formation) is assumed to grow with last year's value-added growth rate. This was chosen to ensure model stability (investments are exogenous in the solution of a given year), while allowing for path dependency for the individual scenarios (investments grow faster with higher economic growth and in turn have a positive influence on economic growth).

For the baseline scenario, the economic structure is represented by the industries' market share coefficients, the import shares from the supply table and the technical coefficients from the use table. They are assumed constant. The emissions coefficients (GHG emissions per use of fossil energy carriers) and labour coefficients (number of workers per unit of value added) are also assumed constant over time. Differences in industry-specific growth rates (value added, emissions and employment) occur due to changing shares of product groups in household demand.

Schematic presentation of a supply and use table embedded in a simple macroeconomic model

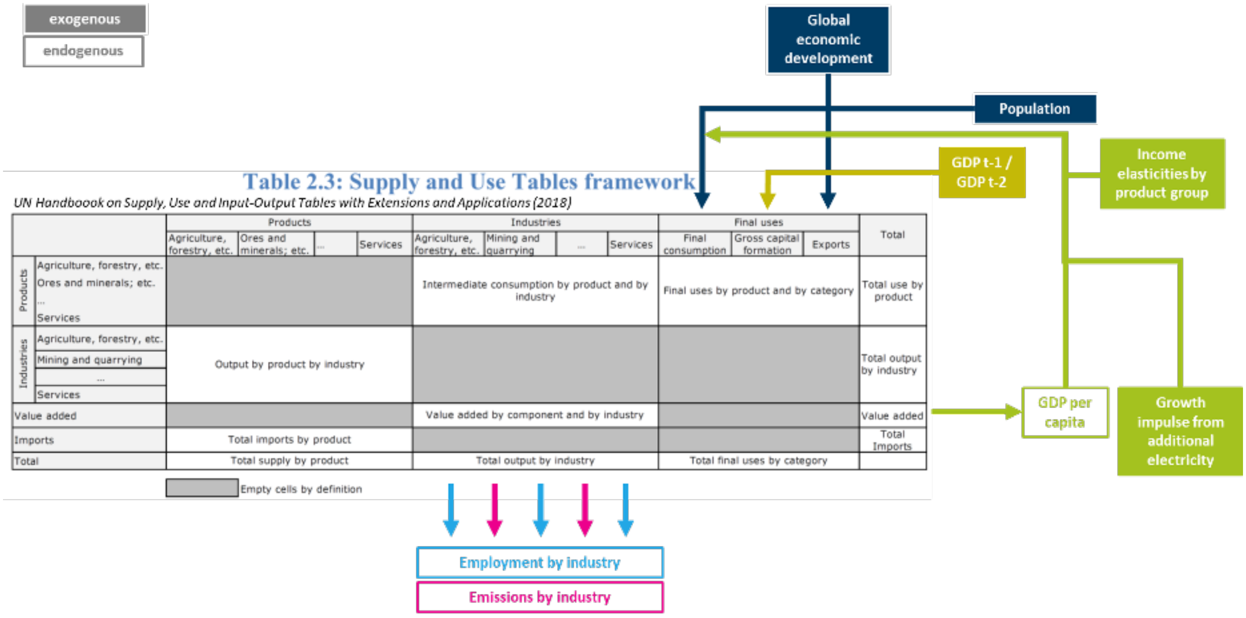


Table 2.3: Supply and Use Tables framework

UN Handboook on Supply, Use and Input-Output Tables with Extensions and Applications (2018)

		Products				Industries				Final uses			Total
		Agriculture, forestry, etc.	Ores and minerals; etc.	...	Services	Agriculture, forestry, etc.	Mining and quarrying	...	Services	Final consumption	Gross capital formation	Exports	
Products	Agriculture, forestry, etc.					Intermediate consumption by product and by industry				Final uses by product and by category			Total use by product
	Ores and minerals; etc.												
	...												
	Services												
Industries	Agriculture, forestry, etc.	Output by product by industry											Total output by industry
	Mining and quarrying												
	...												
	Services												
Value added						Value added by component and by industry							Value added
Imports		Total imports by product											Total Imports
Total		Total supply by product				Total output by industry				Total final uses by category			

▨ Empty cells by definition

Source: Own representation using Table 2.3 from the UN Handbook on Supply and Use Tables [8]

Data used for GJAM Nigeria are described in detail in the Technical Appendix. Figure 3 and Figure 4 show estimates of GHG emissions and employment by supply and use table industry. The 2018 structure of the economy, employment and emissions are empirically based on national data; specifically, the national accounts, labour force survey and emissions inventory are all harmonized for the single year 2018 (thus, referred to as estimates) and are the starting points for all scenario simulations of the GJAM. The gender composition of the total labour force is 50 percent men and 50 percent women.

Figure 3: 2018 GHG emissions by industry (estimates) and industries grouped into subfigures by order of magnitude

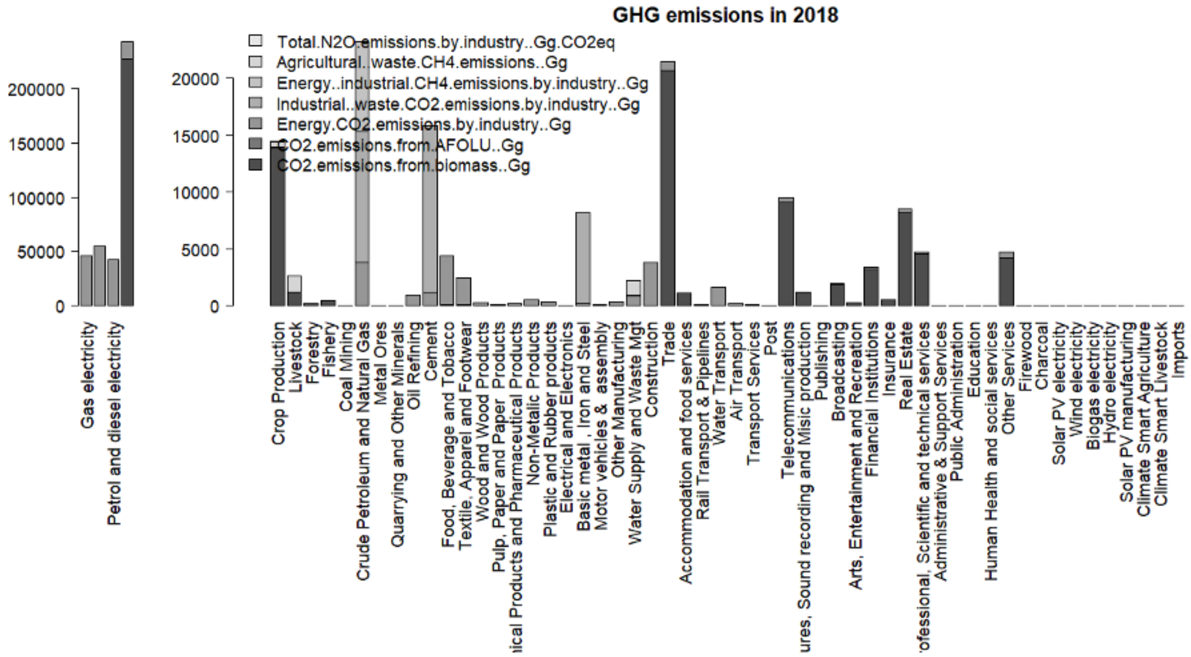
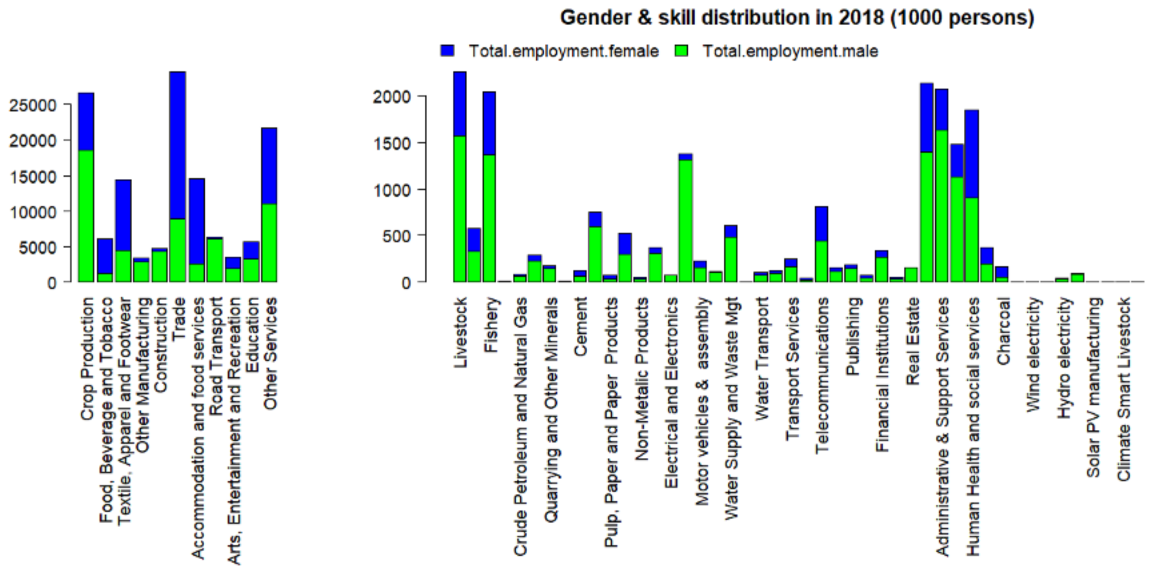


Figure 4: 2018 employment (self-employed and employees) by industry (estimates), industry groupings into subfigures by order of magnitude



NOTE

GJAMs are not economic forecasting models. Rather, these models are tools that provide information about the possible effects of "what-if" scenarios on emissions and labour demand by industries, assuming that the remaining structure of the economy does not change. The results should be assessed relative to the baseline scenario. They indicate the direction and possible size of the effects but should not be taken as definitive. For example, actual labour market outcomes also depend on other factors, as well as dynamic labour market adjustments, that are not considered here. Nonetheless, these models provide an indication of how to design measures and policy goals to maximize the positive implications of climate policies and minimize the negative ones. The merit of input-output and supply- and-use based models is their ability to assess indirect effects on the entire economy of measures that change production technology, consumer behaviour or investments, among others. Note that investments are modelled as additional economic activity, not as crowding out other investments.

"The term 'scenario' is often used in decision-making to represent an imagined future" A scenario aims at being self-consistent and plausible, but "is not a prediction" of the future [9].

3.1 Modelling the climate policy scenarios

One to three scenarios are developed for each NDC sector (power, oil & gas, transport, industry, agriculture & forestry, and water). The following questions must be answered for each scenario:

1. What is the **greenhouse gas emission reduction target**? How will it be achieved? (Or, what is the adaptation action?)
2. Which type of **investments** in which industries/products are necessary? How much is needed per industry/product? And over which time periods? Is the necessary technology produced domestically or must it be imported? (Note that investments are modelled as additional economic activity, not as crowding out other investments.)
3. How does the **industrial structure** change in response to the policy? How do both the structure of production (e.g., fewer energy inputs, but more labour inputs) and the structure of demand change (e.g., what happens if more electricity is available?)
4. How does **demand by households and government** change in response to the policy?

Data and information for answering these questions for scenario design were obtained primarily from the I&FF report [3], which is based on the sectoral NDC plans [10], the Third National Communication [11], supplemented by literature and specific expert knowledge from workshops held with different stakeholders through 2020.

The outcome indicators assessed relate to the policies' economic, employment and emission impacts. Table 1 presents them by industry and year. No data were available for other labour indicators, such as employment by skill level, age group and industry. However, those and other indicators (for example, labour by household income group) can be incorporated into the model if data is available for the base year (2018).

Table 1: List of outcome indicators assessed for each policy scenario

EMPLOYMENT INDICATORS (in number of persons)	GHG EMISSION INDICATORS (in Gigagrams CO_2 equivalents)	ECONOMIC INDICATORS (US$ million)
Total employment	CO_2 emissions from biomass	Value Added total (vaNtot)
Female employment	CO_2 emissions from AFOLU	Value added at basic prices (vaNtot)
Male employment	Energy CO_2 emissions	Employee compensation
	Industrial waste CO_2 emissions	Other net taxes on production
	Energy industrial CH_4 emissions	Consumption of fixed capital
	Agricultural waste CH_4 emissions	Operating surplus, net
	N_2O emissions	

3.2 Baseline Scenario

The results of the policy scenarios should be assessed in comparison to the baseline scenario. The baseline scenario has a rather conservative economic growth rate and does not model any structural change. Figure 4 displays key macroeconomic indicators.

The top panel of the figure shows both historic and modelled baseline macroeconomic variables: GDP, household consumption expenditures, government expenditures and gross fixed capital formation. The lower left panel shows the relative development of population, GDP from the production side (= value added), GHG emissions and number of workers (employment). The lower right panel shows respective annual growth rates.

Based on the pandemic-induced global recession in 2020, the model is calibrated to have a negative growth rate in 2020, recovering slowly in 2021. No structural changes due to COVID-19 are currently modelled due to a lack of data.

A relatively conservative growth baseline scenario is the starting point and no substantial electricity capacity additions are modelled. We modelled significant electricity capacity additions and related higher economic growth for the renewable energy sources and gas scenarios. In addition, the fact that total emissions will rise under either scenario shows clearly - and convincingly - that additional economic activity will always create emissions if it adds to, rather than replaces, more polluting existing activity.

Developing countries, particularly those with very low levels of GDP per capita, such as Nigeria, need to grow their economies (as compared to replacing existing productive capital). Rising emissions will follow, specifically in sectors such as construction, where initial and additional investments are made. However, today's decisions regarding the type of economic assets to invest in will have significant medium-to long-term effects on the emissions growth path in the future, as the comparison of the renewable energy source (RenEnSource) and gas scenarios show.

Figure 5 shows the increase in employment. The left panel shows the relative increase between 2018 and 2025 (dark)/2030 (light) by industry and the right panel shows the absolute increase by gender. The difference in growth by industry is determined by changing household demand for goods and services. As income per capita increases, households spend a higher share of their income on recreational activities, for example, than food. These differences in economic growth across industries produces a different composition of the labour force. If the demand for services rises, and there is a relatively large share of females working in services, this group will see the greatest increase in jobs. As the right panel in Figure 5 shows, employment gains are distributed equally across genders.

Figure 5: Macroeconomic trends in the baseline scenario

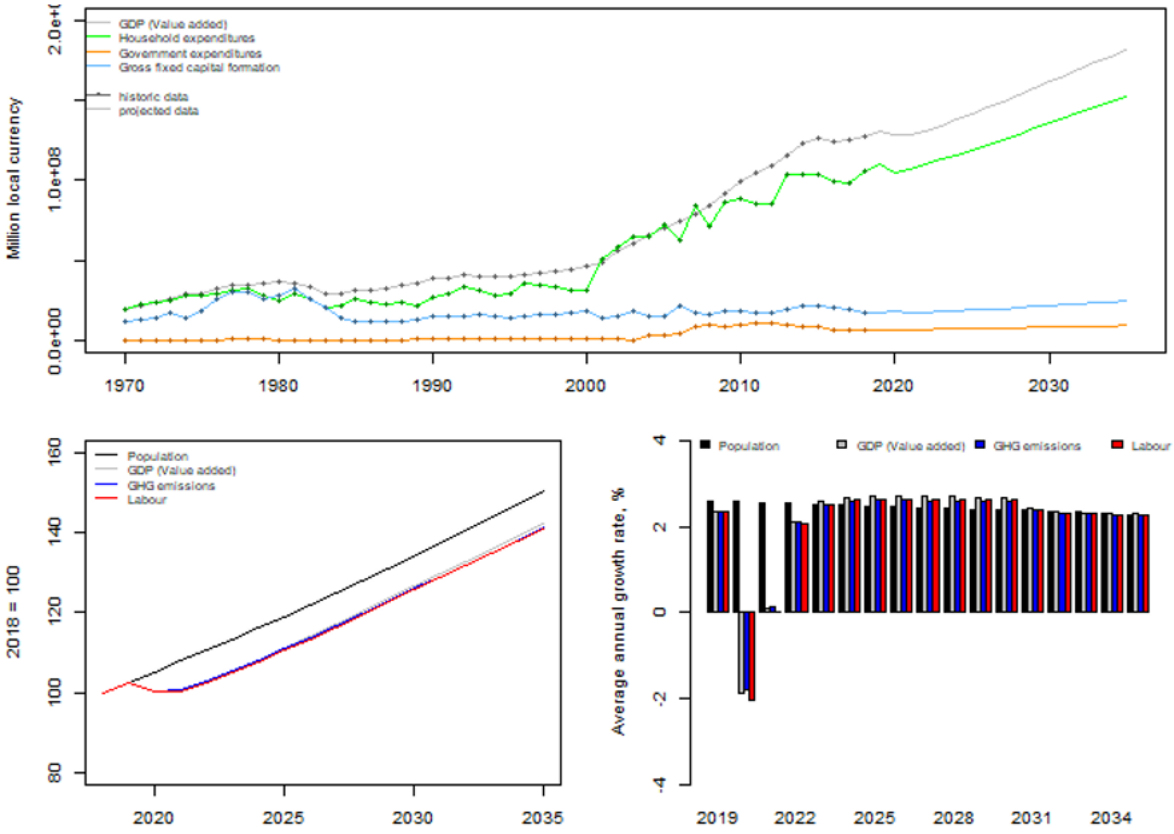
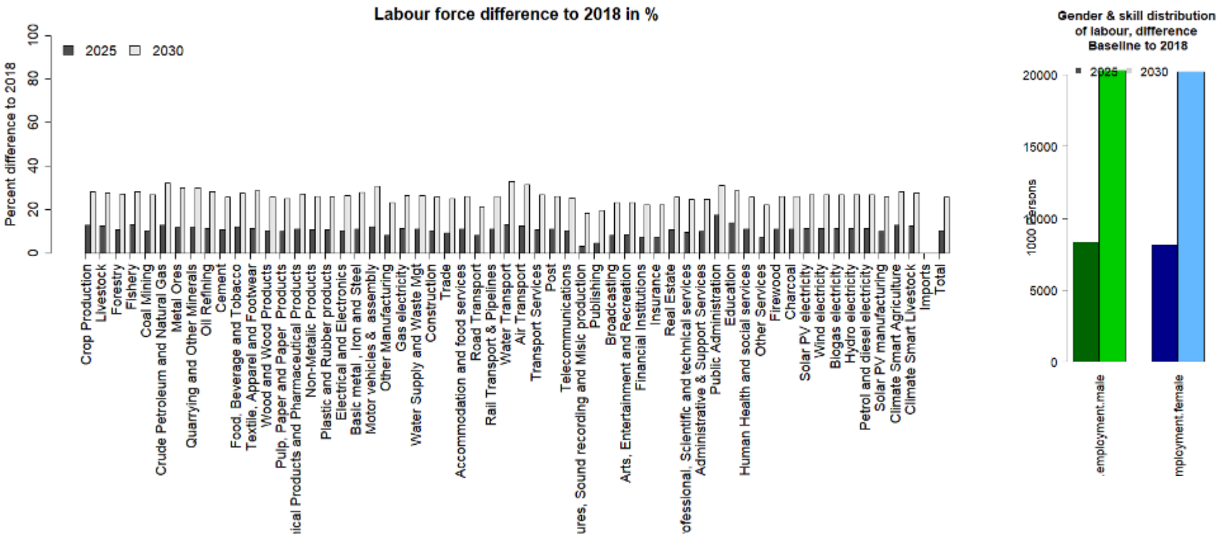


Figure 6: Employment differences in baseline, 2030-2018, by industry



NOTE: GENERAL FOR ALL SCENARIOS

We only implement changes up to 2030, but the figures show the years up to 2035. In some cases, there is a drop after 2030. This is because investments have larger short-term than long-term effects. The long-term effects are reflecting the structural changes in the economy.

4 Policy analysis of scenario results and policy implications

4.1 Overview

One of the main questions in climate policy making is to understand the economic and social costs or benefits. The potential to create employment that these policies offer is of particular concern to developing and emerging economies with a young population that face structural challenges to generating sufficient employment opportunities for a growing number of labour market entrants. Key questions then address the *primary short-term* and *secondary long-term effects*, as well as the *total effect* as compared to the *relative effect*, applying a cost-benefit analysis. The questions will be explained and addressed further below.

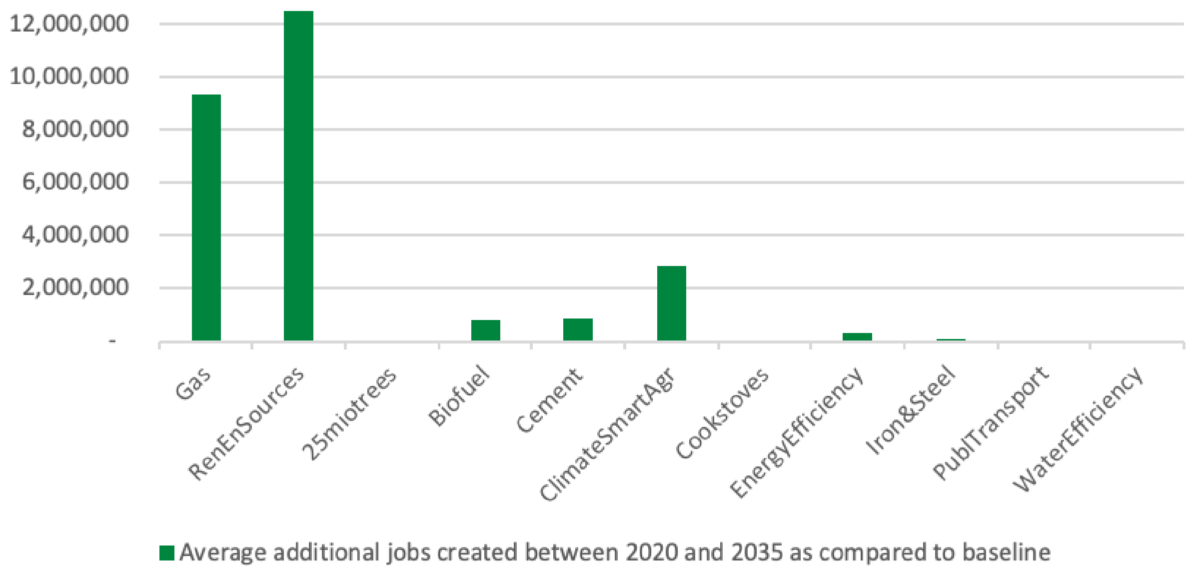
One of the first key questions addresses the total economy-wide employment creation potential of alternative climate policies. Policies to increase power generation have the greatest effect in terms of the total number of jobs created. Between 2020 and 2035, the policies are projected to add around 12 million net additional jobs across the economy as compared to a baseline scenario. The significant increase in employment should be interpreted in light of the significant capital investments ($80 billion), which generate massive job opportunities in construction and installation in the short to medium term. An alternative power scenario - investing the $80 billion in gas power generation rather than renewables - creates some 9 million net jobs, which is 3 million fewer than in the case of renewables. This is because renewable power generation creates more jobs throughout the supply chain and operation and maintenance than does gas-based electricity.

The second question relates to longer-term effects. It is important to note that power generation policies, similar to the other climate policies, bring about a structural change in the economy. Once a source of power is installed, it is used productively in forward-linked sectors across the economy. Applying historic trends, power availability is closely linked to overall economic activity and employment, as reflected here, and creates employment and economic growth into the future.

In addition to the short-term effects of investments, climate policies have important long-term structural change effects in terms of employment, emissions and growth. Therefore, in addition to the initial short- to medium-term effects, long-term structural change effects should also be considered. They vary across the 11 policies analysed here, but all have overall positive employment and economic growth effects, which are projected to last beyond 2035.

Some policies offer significant employment creation potential even without major investments. The agricultural sector offers one example. A policy that would incentivize climate-smart agricultural production systems could add some 3 million net jobs across the economy. Job creation would occur in the climate-smart agricultural sector, as field preparation, growing, harvesting and post-harvest work require more labour compared to conventional or subsistence production systems. In addition, climate-smart agriculture requires extension services, training for farmers, and investments in efficient irrigation systems and fertilizer production, which add a significant number of jobs across the agricultural supply chain. With the right skills, entrepreneurship and enterprise policies in place, additional forward-linked jobs could be created in climate-smart agro-processing. (That scenario is not modelled here.)

Figure 7: Net jobs created by selected climate policies (NDCs) across the economy by 2035



Source: Authors' calculation

As planned investments in the industrial and transport sector are smaller compared to those in the power investments, total employment effects are smaller as well. However, a significant number of jobs are created through biofuel and cement policies, which are projected to create some 800,000 jobs each, while investments in energy efficiency would increase total job opportunities across the economy by some 350,000. Investing in efficiency in the iron and steel industry and the water industry would create some 65,000 jobs and 35,000 jobs, respectively. Public transport adds some 25,000 net additional employment opportunities. The tree planting initiative would create around 20,000 jobs and the roll-out of clean cookstoves would generate 10,000 net jobs. The cookstove policy has a very small effect on net employment, but job creation in the cookstove manufacturing industry is significant. This would be offset by massive job losses in the agriculture and forestry sector, notably in firewood collection and retail, as a result of reduced demand for firewood once the stoves are in operation. It will be important to link any climate policy that reduces firewood use with social and labour market policies to ensure that potential income losses in the firewood industry are addressed. Just transition polices should accompany the energy and AFOLU sector policies and will be discussed in more detail.

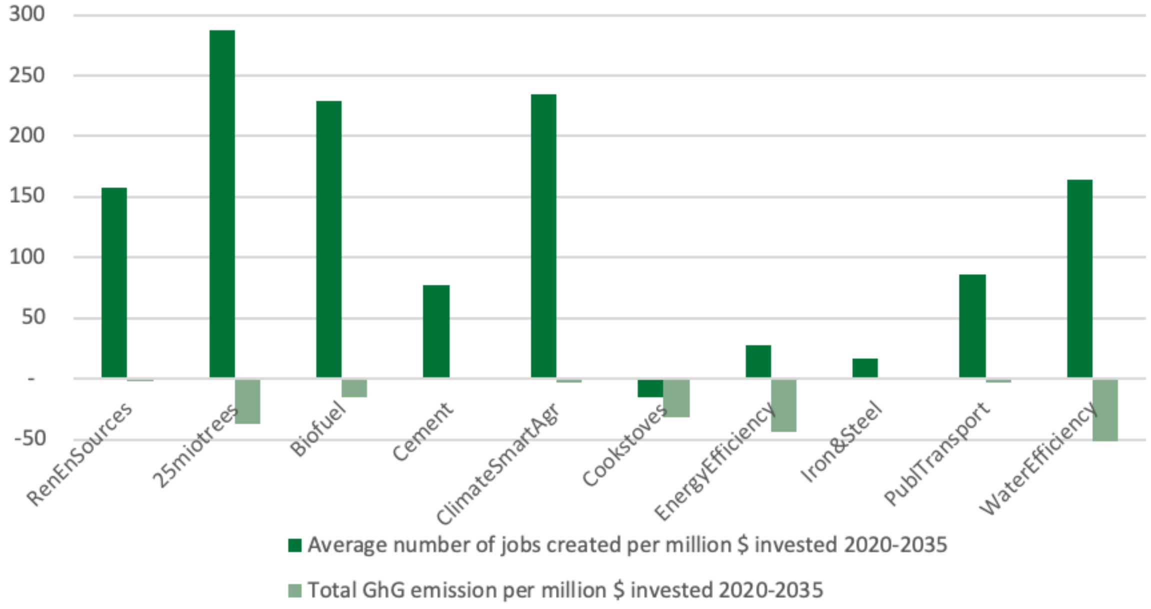
The total effect of the climate policies can now be compared to the effect of the policy in relative terms. This is important as it is obvious that the larger the total investment, the larger the expected economic and employment stimulus. The relative measure involves calculating the net employment effect per dollar invested.

For example, comparing the biofuel policy and investments in efficiency in the cement industry shows that both policies add some 800,000 jobs across the economy. However, the investments in the cement industry ($11.3 billion) are more than triple those called for in the biofuels policy ($3.6 billion).

This finding is important because it shows that while the total size of the investment may matter in the short and long term, the type of investment is crucial. The type of economic structural change the investment produces will determine the number of jobs created, amount of GDP generated and the level of emissions produced – whether greater or lesser.

This reveals the third important dimension and question with respect to policy effects (in addition to the *primary short-term* and *secondary long-term effects*): What is the total number of jobs created or lost by 2035 per dollar invested? The same question applies to the effects on GDP and emissions per unit of investment.

Figure 8: Total economy-wide job and GHG multipliers per million dollars invested



Source: Authors' calculation

Comparing the 11 scenarios in terms of their job creation and GHG emissions reduction potential per million dollars invested shows that the agriculture, forestry and fishery sector (combining the Climate Smart Agricultural policy and the 25 million tree planting programme) generates the highest job multiplier. Forestry has the highest job creation potential, notably for low-skilled agricultural workers. Tree planting is highly labour-intensive and creates close to 290 net full-time equivalent jobs per million dollars invested up to 2035. A $1 million investment in biofuels production stimulates the economy-wide creation of around 230 jobs in total.

This compares to between 17 and 28 jobs resulting from energy and efficiency investments in iron and steel. Cement and public transport policies create some 78 and 86 jobs, respectively, per million dollars invested. Water efficiency investments, which are categorized together with waste management, have a similar job multiplier as renewable energy, creating some 164 and 158 jobs, respectively, per million dollars invested.

The largest sources of Nigeria's emissions are the biomass burning, deforestation, forest degradation and agriculture. This underscores the importance of climate policies that address the AFOLU sector. Afforestation and reforestation offer low-cost solutions, as does implementing the widespread use of improved cookstoves. A $1 million investment in the production of energy efficient cookstoves and tree planting would reduce GHG emissions by some 32 and 37 tonnes, respectively. A biofuels policy would reduce GHG emissions by some 15 tonnes. Energy and water efficiency investments have even larger effects - more than 40 tonnes of GHG per million dollars invested. This compares to smaller to zero effects from power, industry and public transport policies. This is because power and industry policies stimulate economic activity and growth, adding emissions elsewhere in the economy, resulting in a net zero or, at best, a minor reduction.

If the NDC climate policies are to support development and create jobs, climate and development objectives must be linked and the project climate benefits - specifically, emissions reductions - must be compared with employment gains and projected economic growth. Policy analysis must next consider adopting accompanying just transition policies to enable and maximize the potential positive social and economic benefits while minimizing and addressing potential negative effects.

Figure ES1: Employment and GHG emissions relative to baseline for the energy/transport scenarios

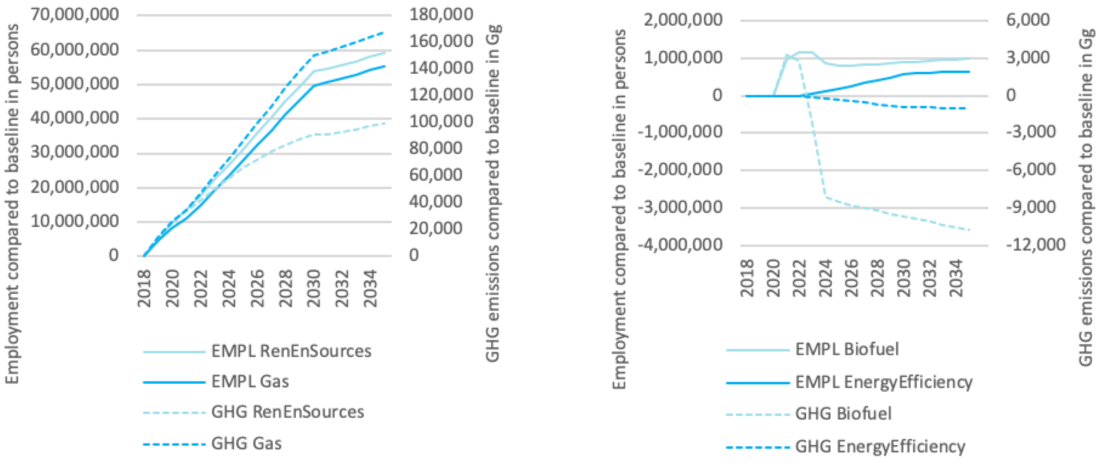


Figure ES2: Employment and GHG emissions relative to baseline for the transport, water, and industry scenarios

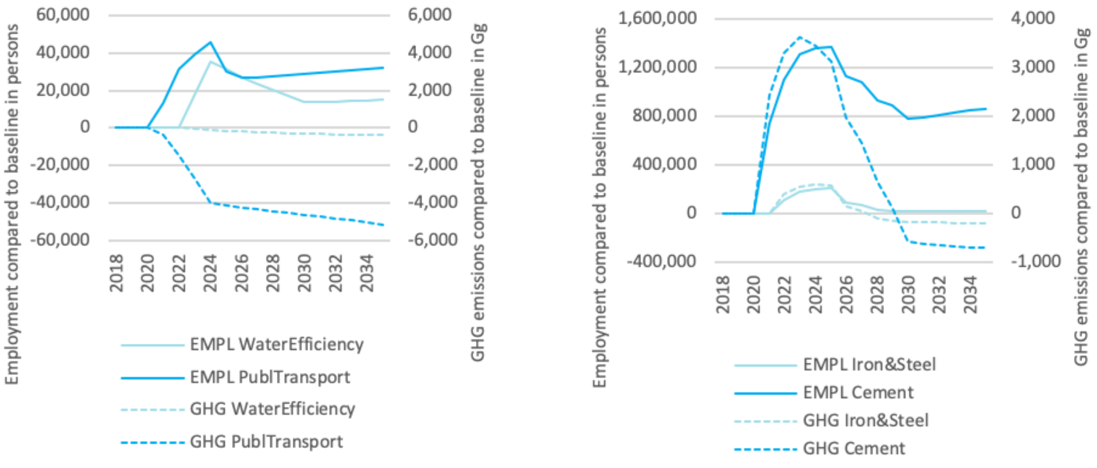
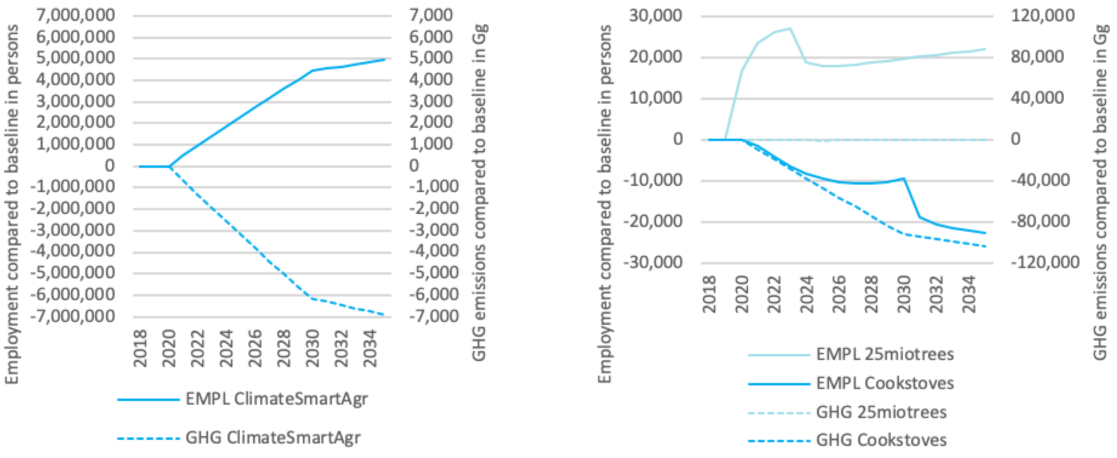


Figure ES3: Employment and GHG emissions relative to baseline for the AFOLU scenarios



4.2 Accompanying just transition polices

The analysis above shows that Nigeria's NDC climate policies can boost economic growth and create jobs. However, for those policies to be effective, climate and development objectives must be analysed in tandem. As a first step, the expected climate benefits – specifically, emissions reductions - should be compared with employment effects and projected economic development.

The climate-smart agricultural scenario holds great promise in that regard. Agriculture is Nigeria's largest sector and employer. A policy that encourages a shift towards climate-smart farming systems entails several significant labour market effects, requiring relatively small investments and, if linked to agro-forestry and afforestation, resulting in significant emission reductions. It requires increased organic fertilizer use and production (which creates jobs in supplying industries) and less use of chemical fertilizer, which reduces imports while boosting economic growth. Some 10 percent additional direct agricultural-related jobs are created in soil preparation, management, harvesting and post-harvest activities. And because the investment requirements are small compared to those in renewables, for example – and relate more to training and up-skilling for farmers than actual capital - the job multiplier is very high. When linked to forestry and clean cooking policies, the effect on GHG emission reductions and the non-monetary benefits, such as biodiversity, water retention and soil improvement, are significant.

Renewable energies are also of interest when focusing on economic growth as well as job creation. The planned clean power investments would add some 0.6 percentage points to GDP per year over the period 2020-2035 or around 10 percentage points to today's GDP by 2035. The significant economic stimulus does have drawbacks in terms of emission reductions; emissions would rise due to the growth stimulus, although by much less than if the energy came from fossil fuels.

It is important to stress that the positive contribution of NDC climate policies highlighted above to economic growth, employment creation and emission reduction depend on accompanying economic and labour market policies. In fact, for climate policies to be both effective and contribute positively to development, they need to be accompanied by a range of just transition policies. Four main areas in just transition policy making require detailed attention.

First, failing to address social consequences may lead to the non-implementation and failure of the climate policies. This could occur because of social protest (for example, mass protests against fossil fuel subsidy reform). If social assistance programmes do not offset the additional burden on poor households when basic prices increase, those households will face severe economic hardship. Non-compliance with climate policies may also result when, for example, a ban on charcoal production is not accompanied by policies that provide viable alternatives. Economic and social hardship may prevent households from shifting away from harmful economic activities. If well targeted and designed in tandem, social protection measures and social dialogue mechanisms would address the populations concerned and signal that the government intends to buffer the policies' potential negative impacts. Social policies include, but may not be limited to, extending social protection floors, insurance, public employment programmes, unemployment guarantees or (un)conditional cash transfer programmes.

Second, the *type* of climate policy has significant and very different effects on social and labour market outcomes. Integrating just transition policies at the design stage can maximize social inclusion, pro-poor growth and job creation. As the above analysis shows, climate policies promoting climate-smart agriculture have very high job creation potential per million dollars invested. The low-skilled and rural poor would benefit most from a well-conceived agricultural conservation policy when accompanied by decent work policies and significant training and upskilling. Conversely, an industrial policy would benefit mainly urban and industrial workers, but would require decent work conditions that could be met through social dialogue, social protection and skills training. The type and focus of climate policy thus have different effects on inequality, income distribution and urban-versus-rural development and potential long-term effects on industrial, agro-processing and aggregate GDP growth. Government and policymakers should consider these effects ex-ante to make informed decisions in terms of their NDCs, the national development strategy and accompanying just transition policies.

Third, well-intended climate policies and capital investments in the low-carbon economy require that managers, workers, enterprises, and entrepreneurs at large have the skills to finance, manage, construct, operate and maintain the capital asset or implement the structural production changes (such as climate-smart agriculture) and make productive use of the asset in the long term. A lack of skilled managers and workers may hinder climate projects and investments and job creation in forward-linked sectors such as agro-processing. To address this, a skills development strategy should be developed for each prioritized sector as an ad-hoc approach would not produce the long-term changes required. A systems approach is called for to integrate the needed skills and professions into the country's education and training system at large. An institutionalized mechanism – involving government, employers and workers - would ensure continued discussion and decisions regarding skills requirements. Such an institutionalized body would guide and supervise the development and regular updating of the curricula, training of teachers and trainers, the integration of curricula in schools, technical vocational education and training institutions and universities. Apprenticeship systems and on-the-job learning systems could complement the skills strategy.

Fourth, once priority sectors and policies are chosen and aligned to the government's overall development strategy, accompanying fiscal, macroeconomic, sectoral and industry policies are needed to support the economic development policy focus. These accompanying policies can support structural economic change and enhance economic growth and social development. The instruments include a fiscally-neutral policy reform that offers a double dividend: tax carbon while lowering labour costs. This could shift economic growth to low-carbon activities and industries and, simultaneously, lower the cost of employment, thereby enhancing overall national employment creation. A well-designed local content, foreign direct investment and sustainable procurement policy, in combination with policies that support green infant industry, such as tax breaks, special economic zones or R&D support, would strengthen employment creation and long-term structural change.

In summary, the dimensions of just transition policymaking highlighted here require a sequenced and balanced inter-ministerial approach. At the initial stage, priority should be given to determining the *type* of climate policies and investments to focus on, fast track and frontload. The national development strategy could guide such assessment and prioritization. The accompanying just transition policies would ensure that positive effects are maximized and negative impacts are minimized.

5 Detailed short- and long-term results by type of climate policy

5.1 Promotion of renewable electricity (power as well as agriculture, industry, oil and gas)

Nigeria has ambitious plans to increase power generation from today's level of about 66 000 GWh (50/50 on- and off-grid) [12] to 92,000 GWh in 2025 and 145,000 GWh in 2030 [11]. To achieve this, total investments of NGN 15,840 billion in biogas, wind, on- and off-grid solar power, and hydro power are envisioned [3]. Electricity generation shares targeted are approximately 50 percent gas, 20 percent grid-solar and 5 percent off-grid solar, 17 percent hydro, 2 percent each biogas and wind, and 5 percent off-grid generator [11].

Table 2 presents the assumptions regarding investment shares for renewable energy technologies. Total investments are divided over the years 2019–2030. These investments create direct effects in the industries producing the goods and services needed to build hydropower, wind power, solar power and biogas power installations and indirect effects in the rest of the economy through the requirements for intermediate inputs into the production of these goods and services.

Table 2 Assumptions regarding investment cost shares for renewable energy technologies

TOTAL	BIOGAS	PV	ONSHORE WIND	HYDRO
Manufacture of cement, lime and plaster	27%	0%	0%	2%
Manufacture of structural metal products	0%	0%	0%	0%
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	34%	0%	66%	5%
Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	4%	25%	7%	0%
Construction of utility projects	21%	17%	14%	78%
Freight transport by road	5%	0%	0%	2%
Wired telecommunications activities	0%	0%	0%	0%
Other financial service activities, except insurance and pension funding activities, n.e.c.	3%	0%	3%	13%
Real estate activities on a fee or contract basis	1%	3%	2%	0%
Legal activities	1%	3%	2%	0%
Accounting, bookkeeping and auditing activities; tax consultancy	1%	3%	2%	0%
Management consultancy activities	1%	3%	2%	0%
Architectural and engineering activities and related technical consultancy	1%	3%	2%	0%
PV panels	0%	43%	0%	0%

Source: own estimations based on MacDonald [13,14]

The investment of NGN 15,840 billion generates a significant amount of additional economic activity, such that both short- and long-term effects on emissions and labour are dominated by this additional activity and are significantly higher than under the baseline (left panel of Figure 8). To control for this, we implemented the same investments, but in new gas power instead for renewables, with electricity generation shares targeted at 83 percent gas, 12 percent hydro (no change) and 5 percent off-grid generators. Comparing the left and right panels in Figure 8 shows that investing in renewable energy creates more jobs, while generating significantly fewer emissions. The number of employees (red line) for renewables is 27 percent higher than the baseline, compared to about 25 percent higher for gas. Deployment of renewable electricity generation technologies increases emissions (blue line) by only 10 percent, despite a 25 percent increase in economic activity (grey line). For gas, emissions and economic activity increase at the same rate. **The renewable scenario does result in a weak decoupling of economic growth from GHG emissions.**

Effects on employment and emissions by industry are displayed in Figure 9 and Figure 10, respectively. The overall higher economic activity due to high investments and increased availability of electricity increases employment and emissions in all industries except the fossil fuel electricity (gas and diesel and petrol generators). Here, the induced effects of higher income can be seen, with households demanding more services, rather than food products.

Employment effects are distributed equally between men and women, as shown by the green and blue bars of nearly equal length in the right panel in Figure 9.

Figure 9: Renewable electricity and alternative gas scenarios compared to baseline: total employment/emissions/value added

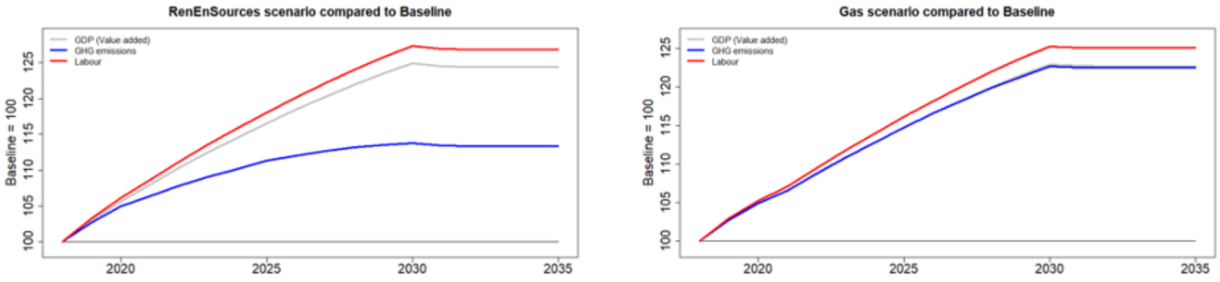


Figure 10: Renewable electricity scenario compared to baseline: employment by industry and gender

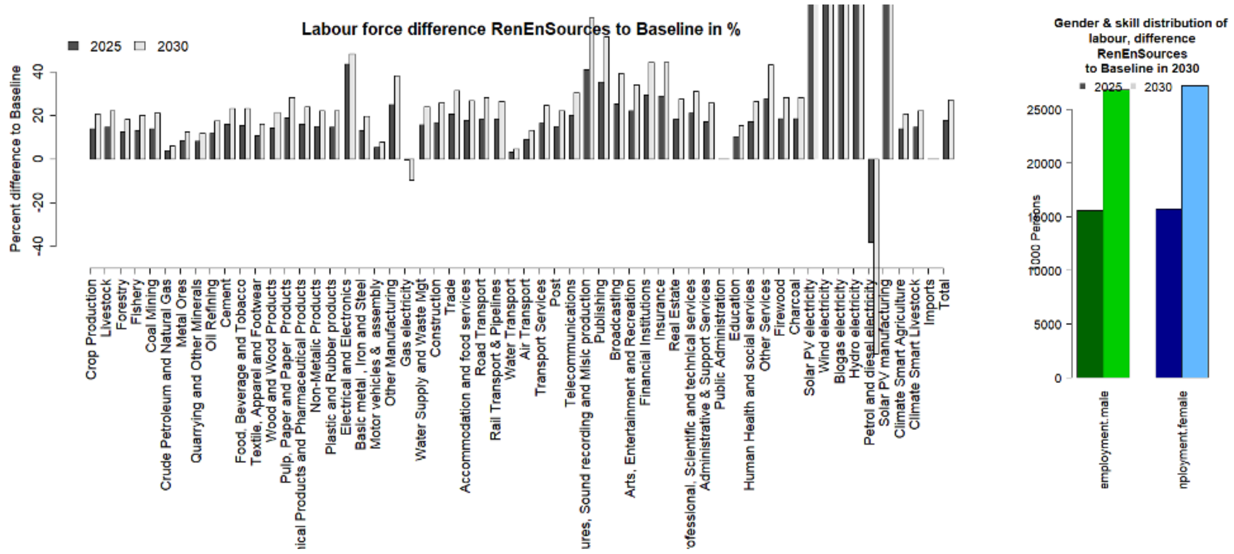
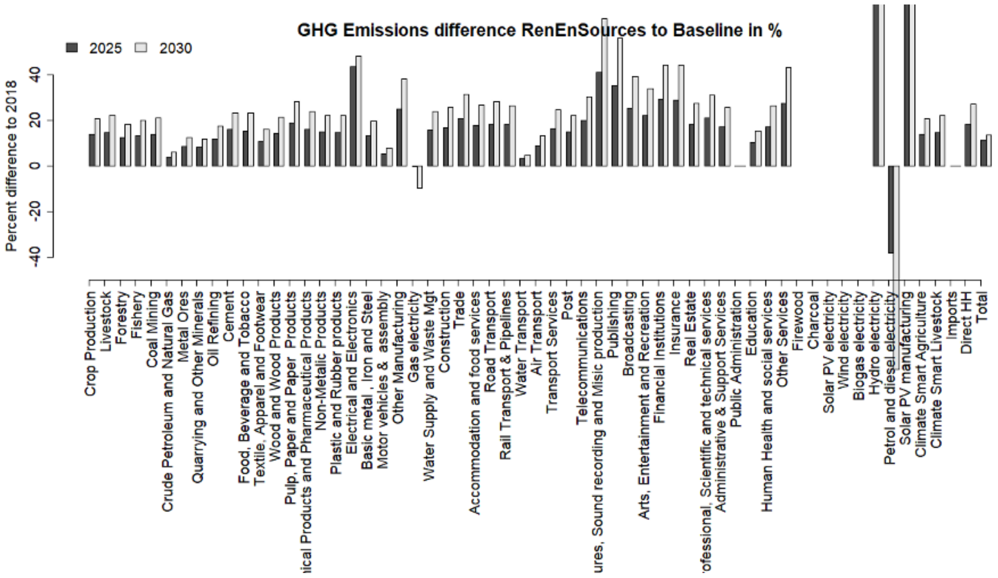


Figure 11: Renewable electricity scenario compared to baseline: GHG emissions by industry



5.2 Energy efficiency (power, industry)

Energy efficiency improvements can reduce emissions significantly, while also cutting energy costs in the long run. In the short term, of course, investments in energy efficiency measures incur costs. In that case, we assume that they total about 7 percent of manufacturing industries' output in 2018 (based on estimates for relative investment costs of energy efficiency improvements in manufacturing industries in Zimbabwe [[15]]). Total investments of NGN 2,336 billion are spread over the period 2021 – 2030 and based on the assumptions presented in Table 3.

We modelled a 2 percent annual energy efficiency improvement in the following manufacturing industries:

- Food, beverage and tobacco
- Textile, apparel and footwear
- Wood and wood products
- Pulp, paper and paper products
- Chemical, chemical products and pharmaceutical products
- Plastic and rubber products
- Electrical and electronics
- Motor vehicles & assembly
- Other manufacturing.

Table 3: Assumptions regarding investments for energy efficiency scenario in NGN million per year and product/service group

SUT PRODUCT/SERVICE GROUP	2021-22	2023-27	2028-2030
Manufacture of other electrical equipment	0	38,942	77,883
Manufacture of other general-purpose machinery	0	38,942	77,883
Electrical installation	0	38,942	77,883
Architectural and engineering activities and related technical consultancy	77,883	38,942	0
Technical testing and analysis	77,883	38,942	0
Research and experimental development on natural sciences and engineering	77,883	38,942	0

While economy-wide effects on emissions and employment are rather small (less than 1 percent reduction and increase, respectively, see Figure 11), the effects differ more significantly across individual industries. Employment in manufacturing industries increases in the short term (dark bars for 2025), as workers are needed to produce energy efficiency technologies and in the long run, due to lower production costs and related higher demand for the products.

As manufacturing industries are expected to show the highest additional employment, where male workers predominate, we expect that more of the typically “male” jobs will be created (right panel in Figure 12, men in green, women in blue). However, women could certainly be trained for manufacturing employment and benefit from increased job opportunities in manufacturing industries.

Emissions decrease in all but the plastics and rubber industry (Figure 13), where increased production more than offsets emissions reductions from energy efficiency improvements. It should be noted here that the underlying economic data is from 2010. Thus, the economic structure may not be represented accurately in the model and the price-demand effects might be too high.

Figure 12: Energy efficiency scenario compared to baseline: total employment/emissions/value added

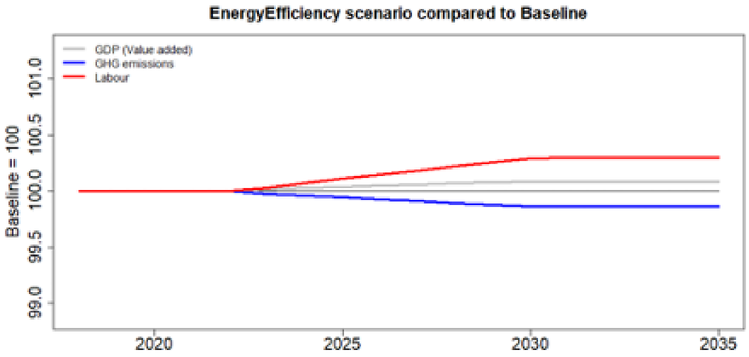


Figure 13: Energy efficiency scenario compared to baseline: employment by industry and gender

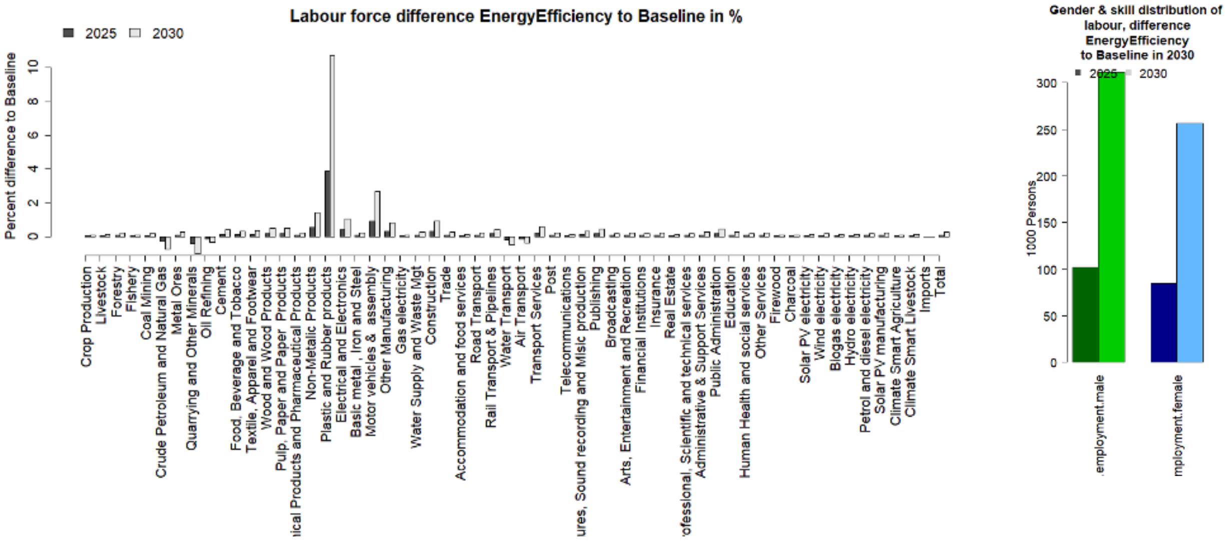
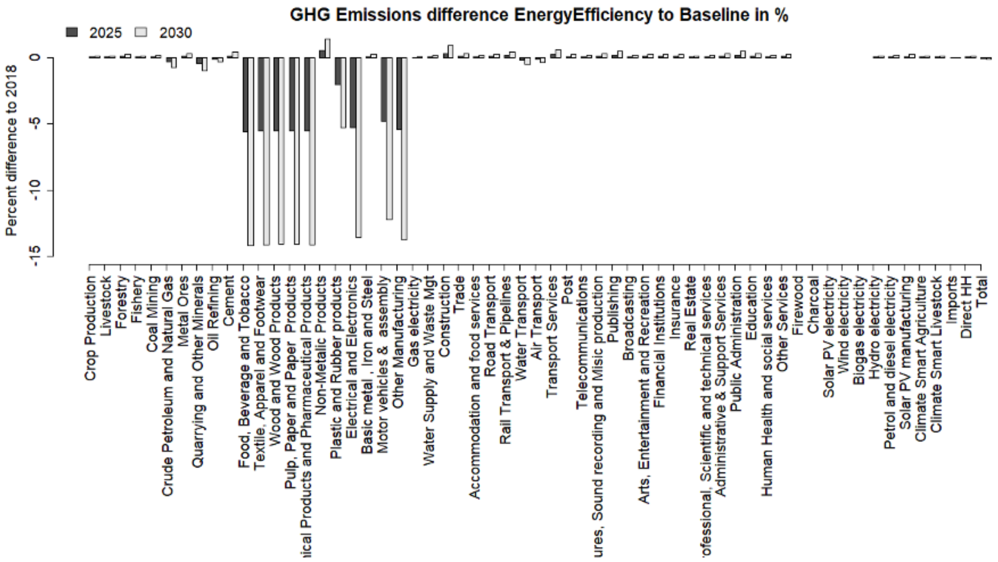


Figure 14: Energy efficiency scenario compared to baseline: GHG emissions by industry



5.3 Biofuels (transport, energy)

According to the I&FF report [3], construction of a 65,000 million-litres/year biofuel plant will require initial investment of $3.6 billion and, over time, will replace approximately 10 percent of fossil fuels used in transport.

Investments in a biorefinery involve primarily the following: manufacture of tanks, reservoirs, and containers of metal (27 percent); manufacture of electric motors, generators, transformers and electricity distribution and control apparatus (63 percent); construction of utility projects (2 percent); freight transport by road (3 percent); and other financial service activities, except insurance and pension funding activities, n.e.c. (5 percent). We assume that 70 percent of electric motors, transformers and electricity distribution and control apparatus will need to be imported and that investments are spread equally across the years 2021-2023.

Bioethanol is produced by the chemical industry and blended into conventional fuels. We therefore replace 10 percent of the demand for refined petroleum products for transport with inputs from the chemical industry distributed over 2022-2024, simulating a gradual uptake of production.

Employment increases by 0.3 percent throughout the economy in the long run, while emissions decrease by about 0.1 percent (Figure 14). Employment effects are positive for almost all industries, except for crude petroleum and natural gas mining, oil refining and pipeline transport. Employment effects are equally distributed across men and women.

Emissions are reduced significantly in those industries where refined petroleum products are the dominant source of emissions. However, we cannot distinguish between petroleum product use for transport and for other industrial purposes, so the emission reduction possibilities may be overstated. In addition, we assume that biofuel is carbon neutral. In fact, biofuels also produce GHG emissions when burned, but if the biomass comes from sustainably managed sources, it is generally considered carbon neutral [16].

It should be noted that biomass for energy uses land. This may create a conflict for growing biomass for food; the model does not capture this effect.

Figure 15: Biofuel scenario compared to baseline; total employment/emissions/value added

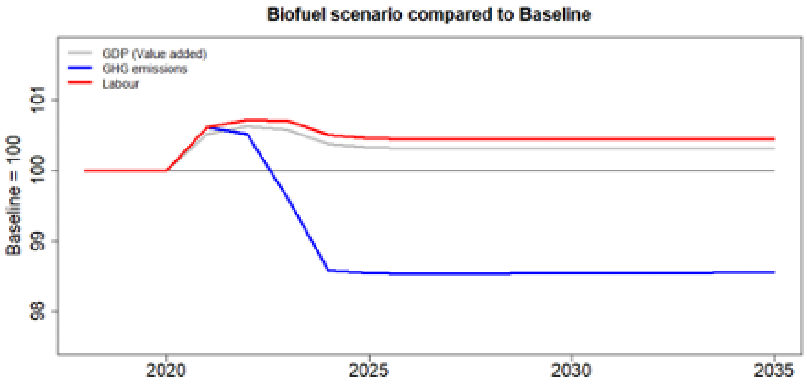


Figure 16: Biofuel scenario compared to baseline: employment by industry and gender

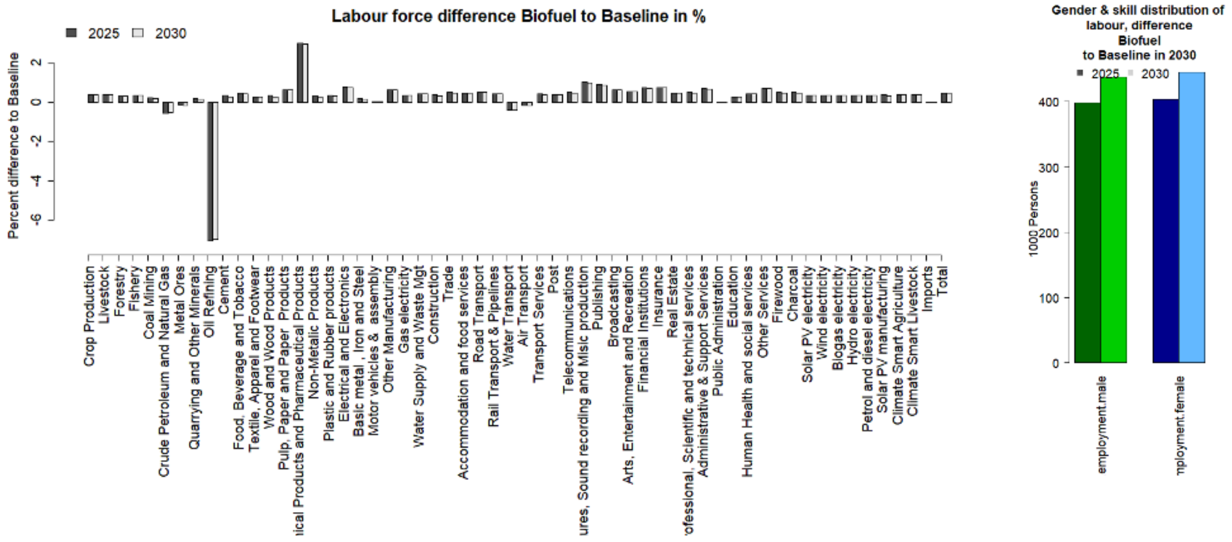
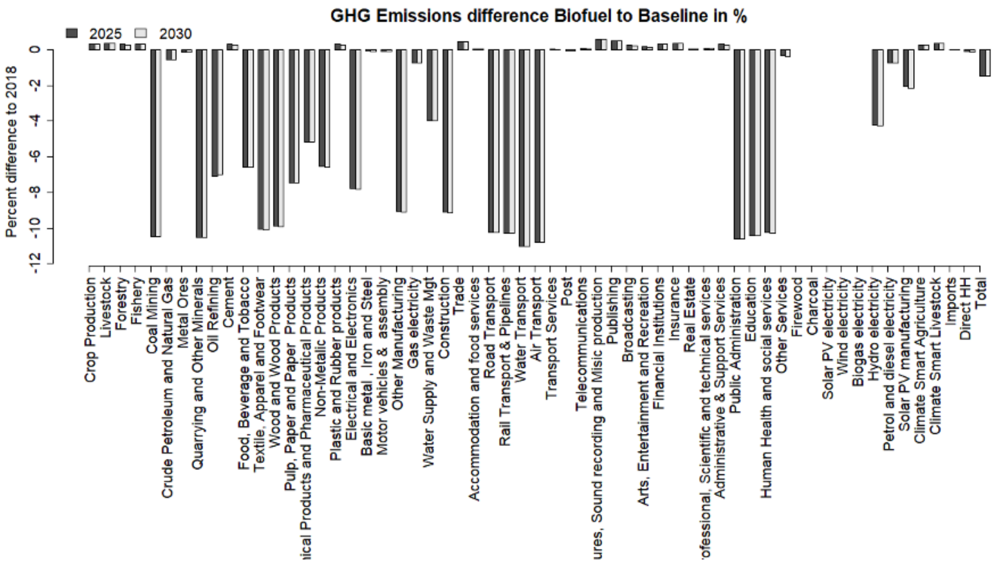


Figure 17: Biofuel scenario compared to baseline: GHG emissions by industry



5.4 Public transport (transport)

Expanding the public transport system is important not only in terms of climate change, but also to reduce local pollution and ensure smoother travel, particularly during rush hours. This, in turn, improves quality of life, enables easier work commutes and frees up time.

The expansion of BRT lanes and the purchase of 5,000 public mass transit buses is expected to require investment of $309 million [3]. We assume that one bus costs about $40,000 and that two-thirds of total investment costs are spent on bus purchases and one-third on building bus lanes and improving roads. In addition, we envision a fuel switch in public transport, with 25 percent of buses using CNG.

We assume that the investments in new buses and bus lanes starts slowly in 2021 and continues until 2025. Travelers will gradually replace 1 percent of their spending on fuels with public transport spending.

The economic effects of the investments will be minimal because they will be used primarily to purchase buses, which will be imported. Nonetheless, some jobs will be created because the wholesale and retail trade industry will serve as an intermediary between foreign manufacturers and Nigerian transit agency customers. The investment in roads will require local construction materials and services, which will create ripple effects throughout the entire economy.

Most jobs will be created in the transport industries, while some will be lost in the oil industry as a result of more efficient buses and the switch to CNG (Figure 18). The fuel switch is also the main driver for emission reductions (Figure 19).

Men dominate employment in the transport sector, so the increase in employment for men is almost twice as high that for women (right panel of Figure 18, men in green, women in blue). However, with the right training and skills, women can also become bus drivers, although their share in the estimated 2018 data was effectively zero (as shown in the left panel in Figure 3, where the "Road transport" bar is entirely blue, which indicates male employment).

Figure 18: Public transport scenario compared to baseline: total employment/emissions/value added

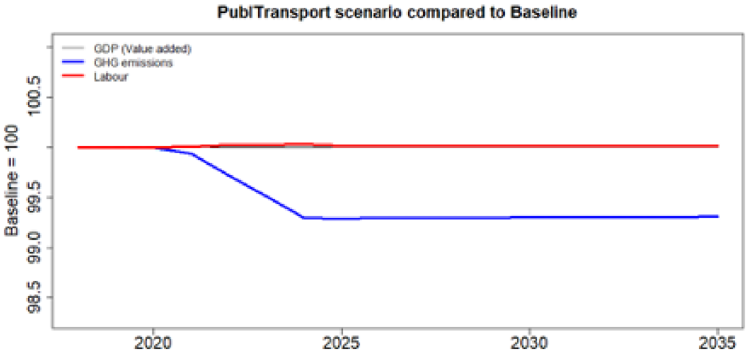


Figure 19: Public transport scenario compared to baseline: employment by industry and by gender

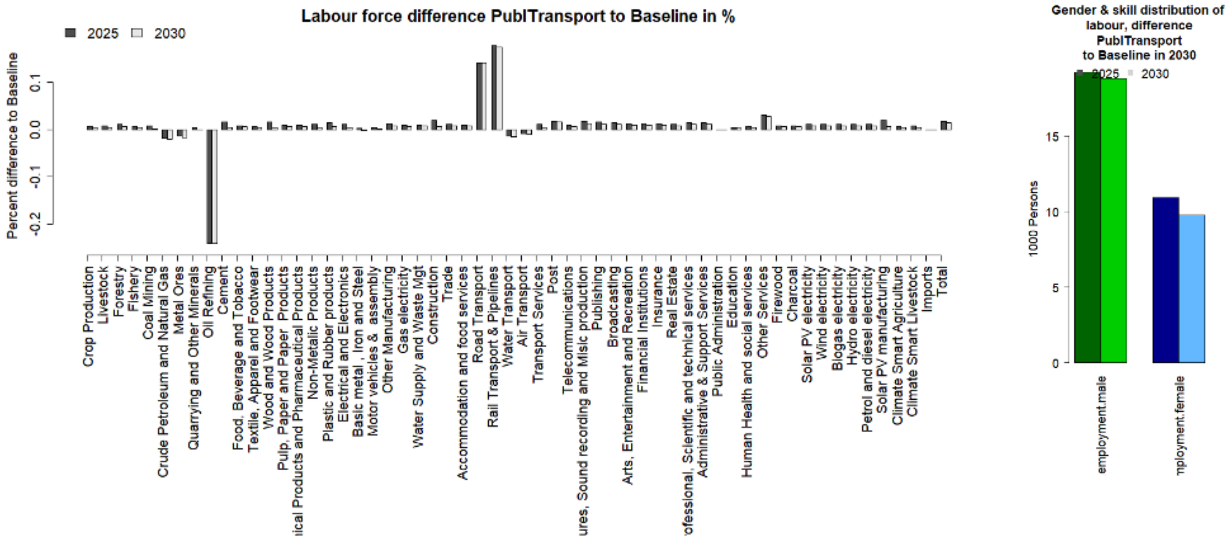
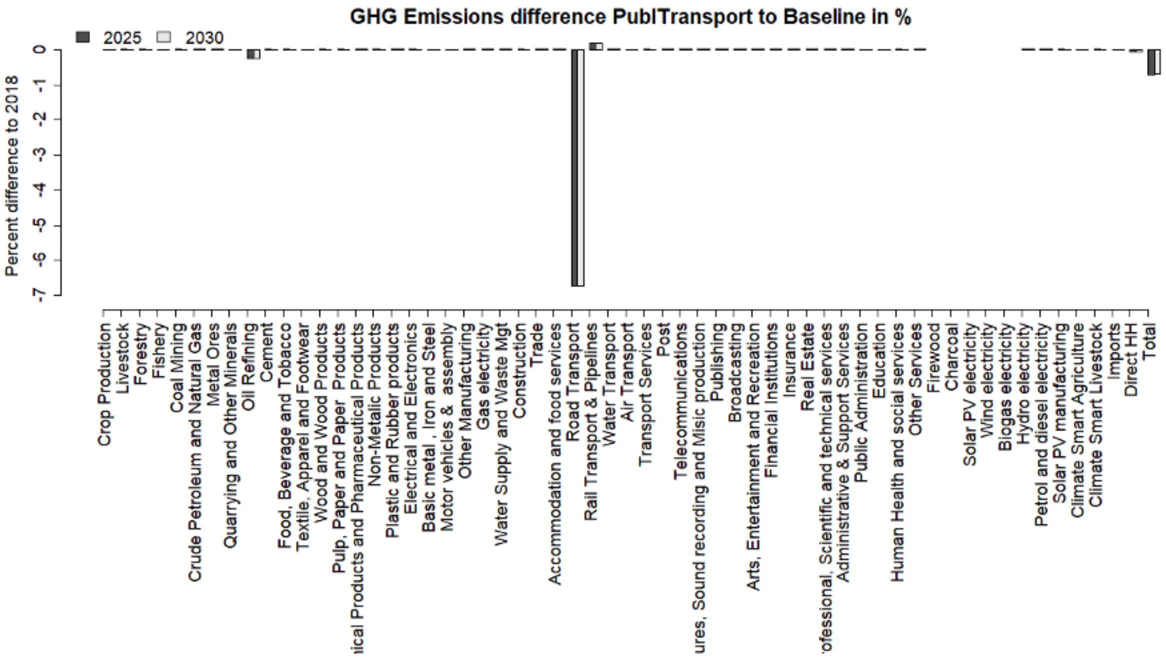


Figure 20: Public transport scenario compared to baseline: GHG emissions by industry



5.5 Efficiency in water production and use (water)

The water sector is important for climate change mitigation and climate change adaptation activities. Water is relevant as a resource in terms of mitigation actions (for hydro power, covered in the renewable energy scenario) and as an energy-intensive sector that should be decarbonized. The water supply industry is crucial for climate change adaptation, as it must ensure water availability for agriculture in the growing seasons.

A draft consultancy report, 'National Mitigation Programme Emissions Reduction in the Water Sector,' [17] lists the following elements of such a programme:

- Decarbonise the electricity industry for water supply and use;
- Expand the use of renewable energy sources available within the water industry;
- Decentralise the water management systems to enable the use of off-grid renewable energy sources for water supply and use;
- Explore the use of treated water industry 'waste' as renewable energy sources through the development of new technologies; and,
- Encourage cultural change among consumers to improve efficiency in both supply and use.

Most adaptation measures require investments rather than a structural change in the Nigerian economy. The investment effects are generally positive for the economy, especially if the investments constitute additional spending and do not crowd out other investments. Many of the actions rely on nature-based solutions, which are not properly captured in the economic GJAM model. We therefore focus on the climate change mitigation options.

It should be noted that the economic data aggregate the two sectors, water and waste management, so that the overall industry has a high share (30 percent) of Nigeria's total CH_4 emissions. Emissions from energy use represent only about 40 percent of total emissions from the water supply and waste management industry. Therefore, efficiency in water production and use affects a smaller share of total emissions.

The water sector needs to increase energy efficiency, use less chemicals and substitute biogas electricity for petroleum products. Investments are assumed to be 5 percent of annual revenues[1] (NGN367,406 million in 2018) over two years (that is, about NGN 9,185 per year) to achieve a 20 percent increase in energy efficiency. In addition, we assume a 2 percent annual increase in water use efficiency, which is achieved through spending on plumbing, heat and air-conditioning installation services.

The economy-wide effects are very small overall (Figure 20), with no significant effect on employment and value added and an approximately 0.1 percent reduction in GHG emissions. Long-run employment effects are positive, especially for women (right panel in Figure 21, male in green, female in blue), while male employment is higher during the initial investment phase. As water production is lower and male employment predominates in the water industry, long-term effects on male employment are close to zero. Emissions are significantly reduced in the water industry and slightly reduced in the oil refining and fossil electricity industries (Figure 22).

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[1] The assumption is 7 percent, as in manufacturing energy efficiency improvements (Section 5.2). However, water is only about 80 percent of the water and waste management industry and we target a 20 percent improvement in energy efficiency, rather than 30 percent.

Figure 21: Water scenario compared to baseline: total employment/emissions/value added)

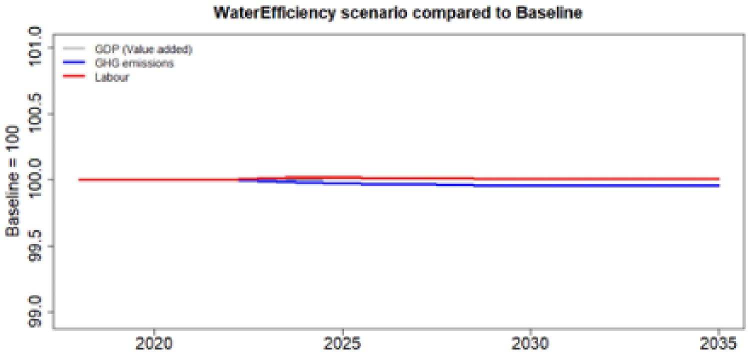


Figure 22: Water scenario compared to baseline: employment by industry and gender

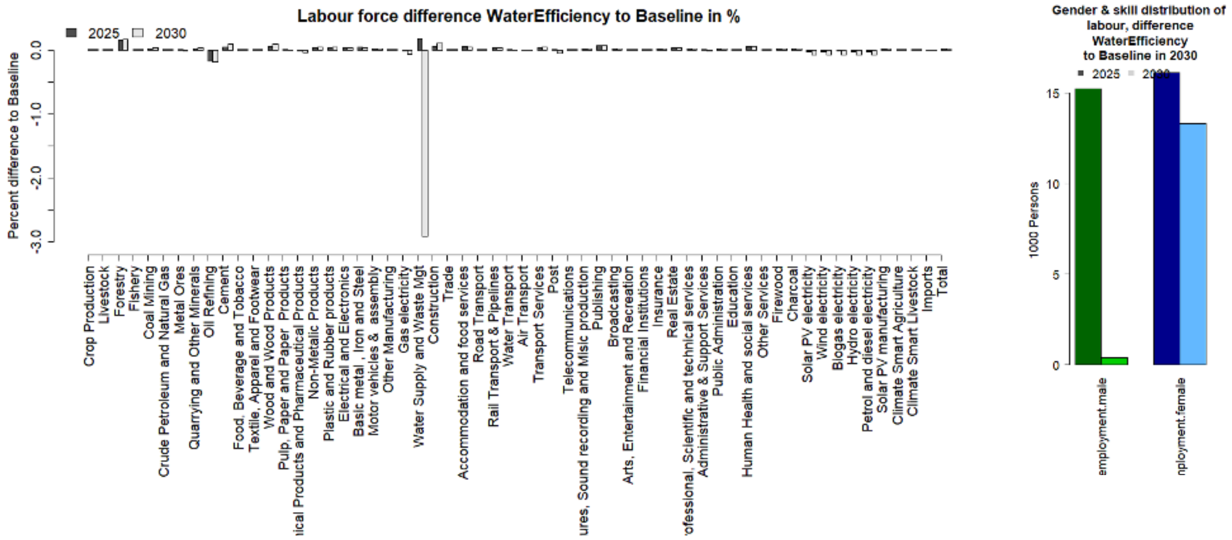
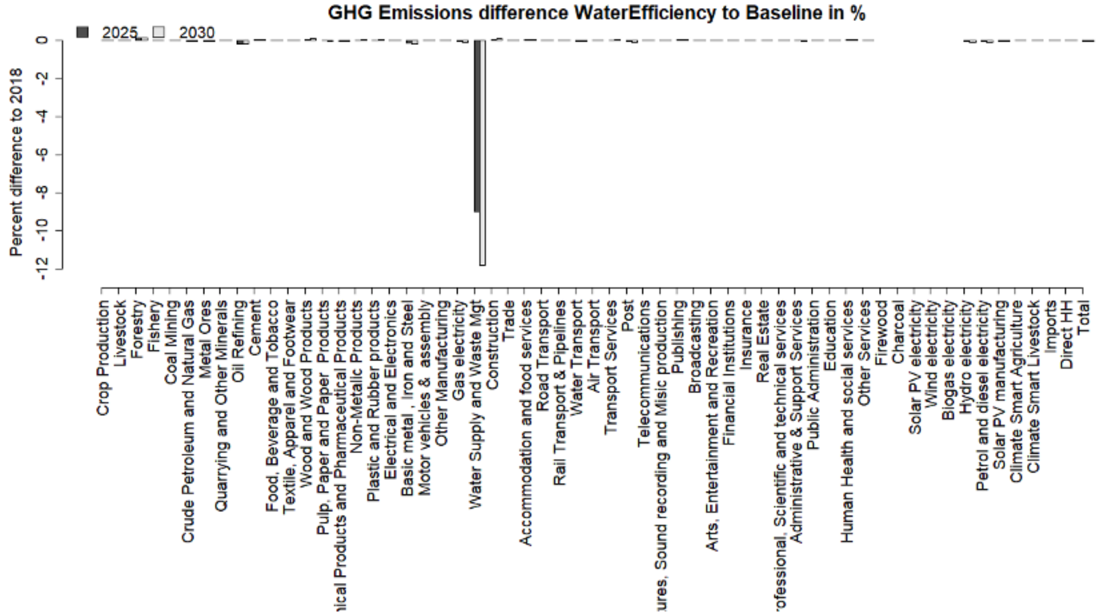


Figure 23: Water scenario compared to baseline: GHG emissions by industry



5.6 Climate-smart agriculture (AFOLU)

Climate-smart agriculture (CSA) involves practices that aim to optimize agricultural production while minimizing GHG emissions. It includes measures to improve productivity and income, increase resilience of agricultural production and rural livelihoods (adaptation to climate change), and reduce emission intensity from agricultural products. This scenario considers growth in two new industries - climate-smart agriculture (crops) and climate-smart livestock - which include measures such as improved soils and nutrient management through tillage and grassland systems, efficient use of fertilizers, agro-forestry, crop rotation, higher use of storage and transport services to reduce post-harvest losses, use of drought-resistant crops and livestock feed, and better use of irrigation systems.

CSA is assumed to increase to up to half of total agricultural production in Nigeria by 2030 [18], with 7 percent of agricultural production assumed to switch to climate-smart production per year. To achieve this will require an estimated $12 billion in investment [3], divided between infrastructure and services (57 percent), irrigation and drainage (38 percent), and equipment and machinery (5 percent). Investments in infrastructure and services include activities related to research and education, training, testing and improved fertilizers and pesticides, provision of water, and infrastructure for crop rotation, agro-forestry, and livestock management. Investments in irrigation and drainage include construction and research and technical support. Investments in equipment and machinery are allocated equally among the production of agricultural and forestry machinery, other general-purpose machinery, and the manufacture of tanks, reservoirs, and containers of metals. CSA investments total NGN 2,425 billion (exchange rate of NGN195/$1) and are allocated to research, education, and training (50 percent), services (27 percent), construction (5 percent), machinery and equipment (8 percent), and agriculture and forestry industries (10 percent). The investments are spread equally across the years between 2021 and 2030.

CSA-based agricultural production generates more employment with lower emissions (Figure 23). These reductions are achieved through changes in the use of inputs (less chemicals), but especially through lower direct methane emissions from livestock production and lower direct nitrogen emissions from soils. Due to lack of data, this model does not capture emissions from reduced prescribed burning (from forest or crop residues). Additionally, other aspects related to chemical processes in CSA, such as those due to minimal soil disturbances and carbon sequestration in agro-forestry systems, are significant contributors to reducing GHG emissions, but are not captured in the economic GJAM model.

CSA is more employment intensive. In the long run, increased labour inputs for agricultural practices, such as adoption of low-tillage agriculture, are provided primarily by household labour (especially women). This does not necessarily result in increased paid farm labour [19]. In the short run, more male workers profit (Figure 24). The industries where labour demand increases – mostly in agriculture – are currently dominated by male workers, which is reflected in the gender distribution in the right panel of Figure 24. The left panel of that figure shows significant employment loss in conventional agriculture, but all of those jobs are absorbed by conservation agriculture (where the relative increase is huge, given the small size of the industry today). In addition, there is a large effect on employment creation due to investments. This is reflected in higher employment in all industries in the Nigerian economy.

Figure 24: CSA scenario compared to baseline: total employment/emissions/value added

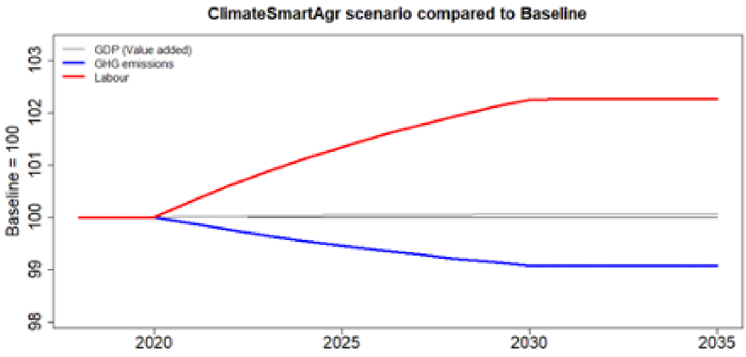


Figure 25: CSA scenario compared to baseline: employment by industry and gender

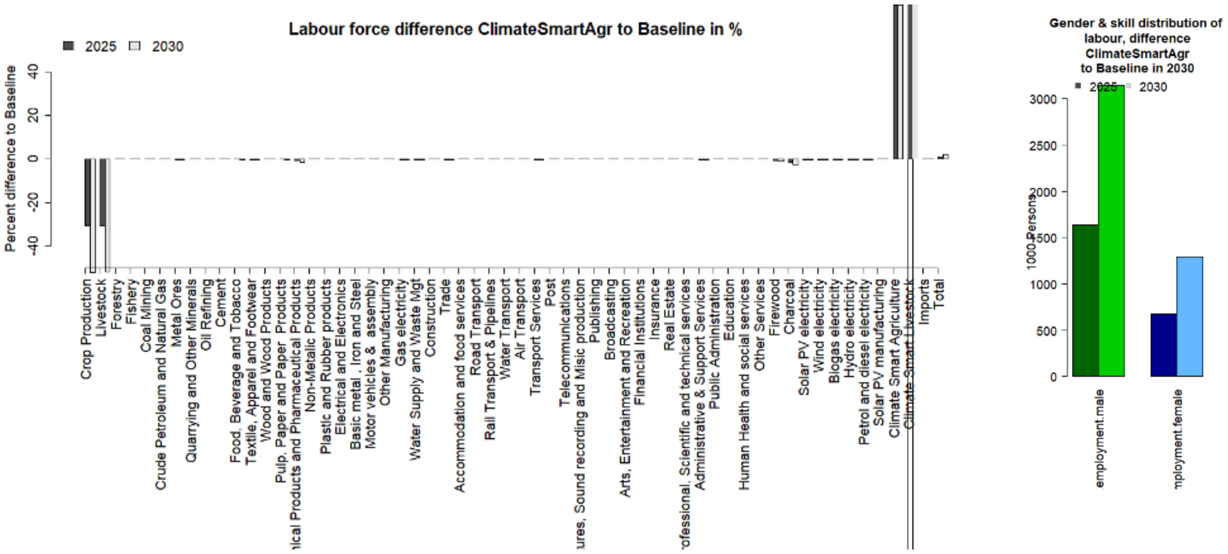
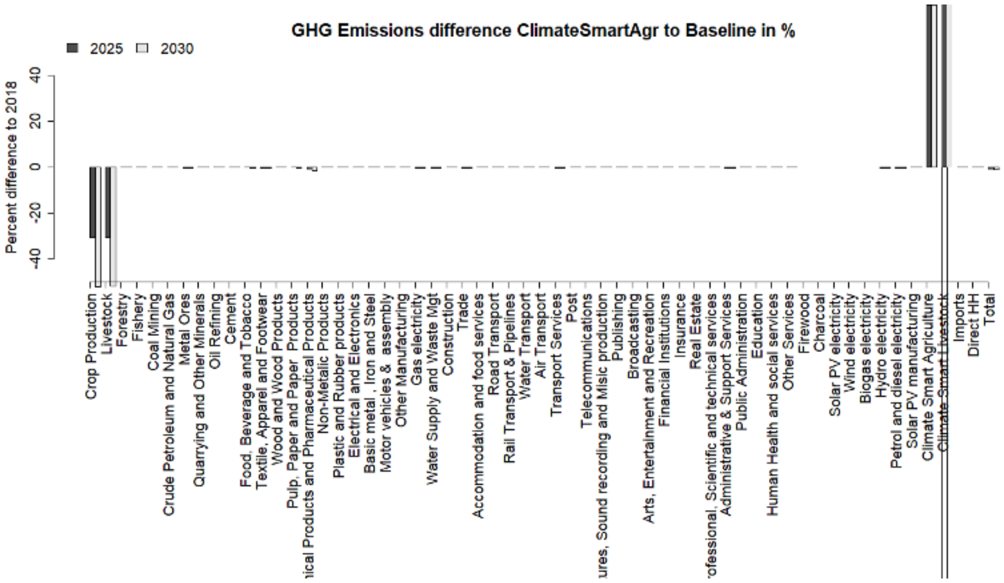


Figure 26: CSA scenario compared to baseline: GHG emissions by industry



5.7 Clean cooking solutions (AFOLU)

The firewood and charcoal sector provides work and income based on an estimated 530,000 full-time equivalent jobs and thus constitutes an important share of the Nigerian labour market. However, it does not appear in official labour or economic statistics due to its informal nature and lack of international standard industry classification.

Firewood collection is typically a part-time activity for some 41 million rural households, including farmers, livestock herders and workers in the agricultural and forest sector. Collecting firewood takes between one and five hours of work per week, divided fairly equally between women and men.

The charcoal industry is a male-dominated, well-structured business. It typically provides full-time work and is the main source of income for those in the industry. They are comprised of three categories: *alaake*, producers in the forests; *olowo*, bulk buyers (*olowo*); and *ajagunta*, wholesalers in the city. Some additional 200,000 workers, most often also full-time, provide transport services to the retail and wholesale trade.

Forests constitute the largest share of employment and income in terms of the energy sector's contribution. They are much more significant than oil and gas sector, which provides employment for only a fraction (some 65,000 direct jobs).

The importance of the firewood and charcoal sector cannot be overstated, as it also provides Nigeria's main energy source. Biomass accounts for around 75 per cent of total primary energy supply compared to some 15 per cent for oil and gas. Almost 70 percent of households use biomass as their primary cooking fuel. Most use three-stone open fire cookstoves (43.1 percent), self-built stoves (14.6 percent) or manufactured stoves (10.6 percent) [20]. The adoption of improved manufactured or efficient modern firewood stoves, as well as a shift from firewood and charcoal to cleaner fuel alternatives, such as LPG and solar stoves, could thus decrease the use of firewood considerably. The clean cooking solutions scenario uses estimates for the difference between the business-as-usual (baseline) scenario and the low-carbon development scenario in the Third National Communication [11]. Starting in 2021, LPG cookstoves in urban areas and efficient biomass cookstoves in rural households are estimated to increase their penetration.

Projections estimate that 35 percent of households will switch from inefficient wood cookstoves (three-stone open fire cookstoves or self-built stoves) to more efficient options over the next decade. Give the cost difference among the options, it is assumed that, of the 13 million households switching to efficient wood stoves, 50 percent would switch from three-stone/open fire to improved clay (25 percent) and metal (25 percent) cookstoves. The remaining 50 percent would switch to modern efficient cookstoves. The change from traditional/open fire to improved and modern efficient cookstoves is assumed to lower the demand for firewood for cooking by two-thirds per cookstove. Additionally, 13 percent of households would switch from kerosene to LPG, leading to an annual decrease in fossil fuel energy emissions in households of 0.3 percent. In the service sector, 10 percent of those who use firewood as cooking fuel are assumed to switch to LPG per year. Five million new LPG stoves are assumed to be purchased in Nigeria between 2020 and 2030. The prices for new cookstoves are estimated at NGN350 each for improved clay and metal cookstoves, NGN6,500 for modern efficient cookstoves ($33, using a conversion rate of NGN195/$1), and NGN19,500 per LPG cookstove ($100, using the same conversion rate) [21, 22]. Additionally, it was assumed that 6 percent of households using charcoal would switch to more efficient charcoal stoves every year, with a 30 percent reduction in the use of charcoal per stove.

Household are estimated to spend their savings from reduced expenditure on fuels (firewood and charcoal) equally on textiles, other manufactured goods, restaurants and mobile food services, wireless telecommunications, and pre-primary and primary education.

Table 4: Investment assumptions for clean cooking solutions scenario by product/service group and year

SUT PRODUCT GROUP	TOTAL (NGN MILLION)	SHARE OF TOTAL
Manufacture of clay building materials	115	1%
Manufacture of cutlery, hand tools and general hardware	4,356	30%
Manufacture of domestic appliances	9,760	69%

While the switch to clean cooking solutions has a significant impact on reducing economy-wide emissions (Figure 26), it has a very small negative effect on employment. This is driven by job losses in the firewood collection industry (Figure 27). However, this effect is artificial because the GJAM accounts for "employment" in the firewood collection industry. These jobs are mostly unpaid family work, so "losing" them would free up time to pursue education or more productive employment activities, if these options are available. The increase in female employment (blue) is driven by the additional spending on restaurants and mobile food services, as well as pre-primary and primary education.

Household emissions are reduced significantly (second bar from the right in Figure 28), as are those from services industries that also use a lot of firewood for their daily activities.

Figure 27: Clean cooking solutions scenario compared to baseline: total employment/emissions/ value added

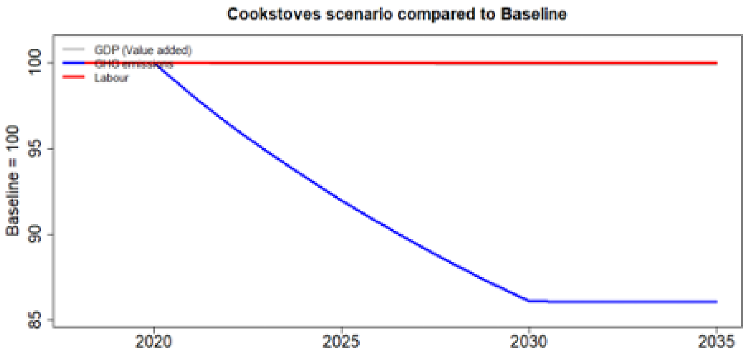


Figure 28: Clean cooking solutions scenario compared to baseline: employment by industry and gender

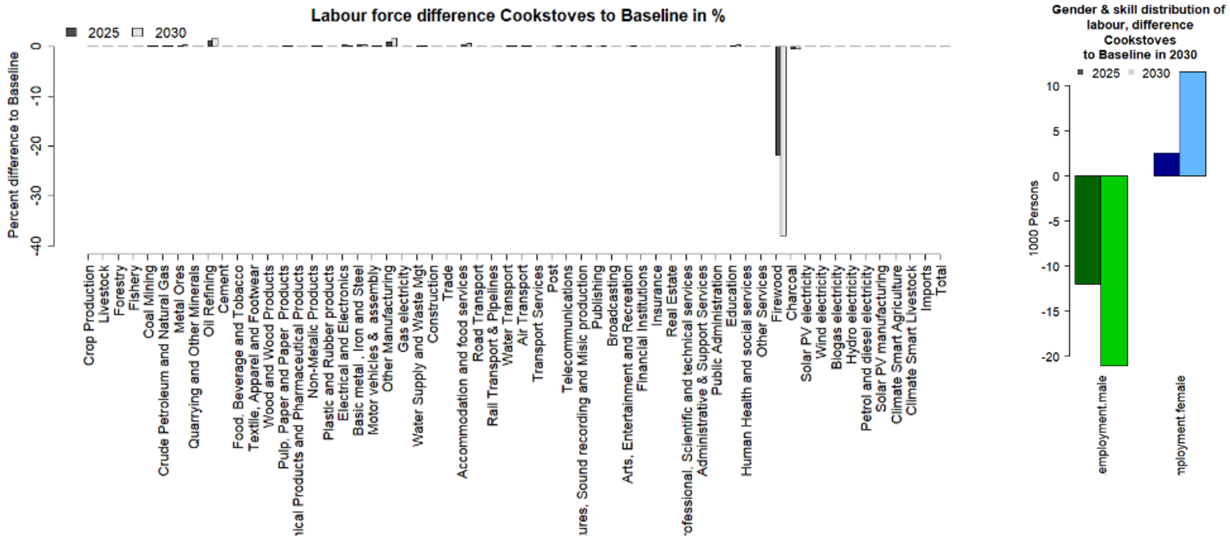
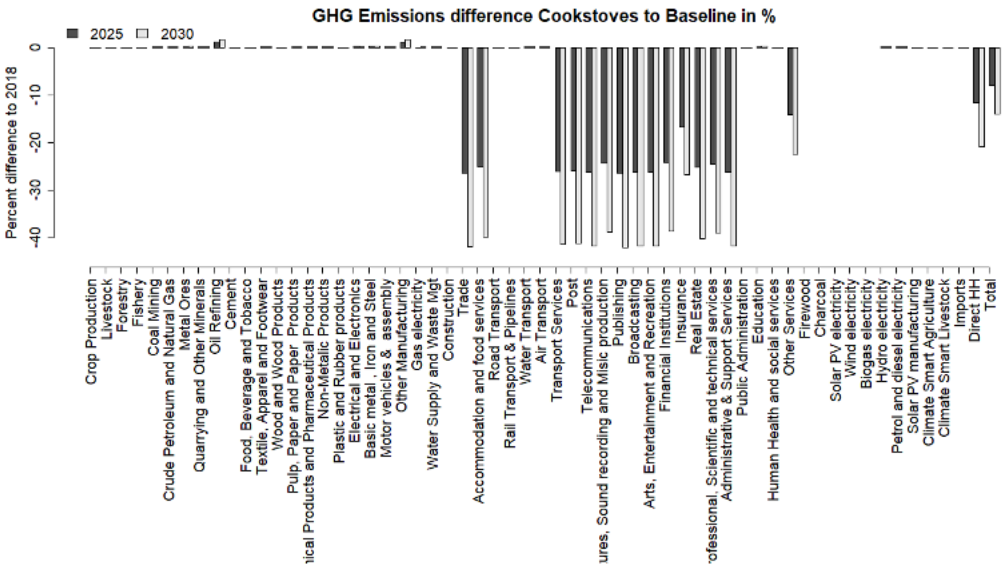


Figure 29: Clean cooking solutions scenario compared to baseline: GHG emissions by industry



5.8 Reforestation: 25 million trees (AFOLU)

In 2019, in response to the loss of 96 percent of Nigeria's forest cover, the country's president announced a massive reforestation plan that includes planting 25 million trees [23]. This will increase soil quality, decrease erosion and provide an important carbon sink, as tropical trees can sequester up to 22.6 kg carbon per year [24].

Assuming that planting one tree costs $2.70 [25], the investment cost of planting 25 million trees totals $67.5 million (or NGN13,356 at the I&FF report exchange rate of NGN 198/$1). We assume that half of the costs are to produce and grow the seedlings, including fertilizer and pesticide costs, and the other half cover the forestry industry costs to plant them. The scenario is modelled based on the assumption that all trees are planted by the end of 2023.

The economy-wide increase in jobs and decrease in emissions is minimal (Figure 29), but still important. In the long run, about 20,000 jobs are created, due to the overall slightly higher level of economic activity in the forestry industry generated by the original investment impulse, divided equally between men and women (right panel in Figure 30).

The small emissions increase due to increased economic activity is more than offset by the significant carbon sequestration that the new trees provide. Once fully grown, they will sequester 565,000 tonnes carbon per year (25 million x 22.6kg).

Figure 30: Reforestation scenario compared to baseline: total employment/emissions/value added

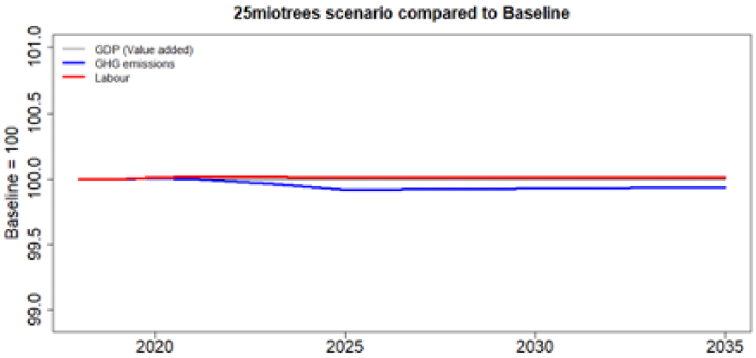
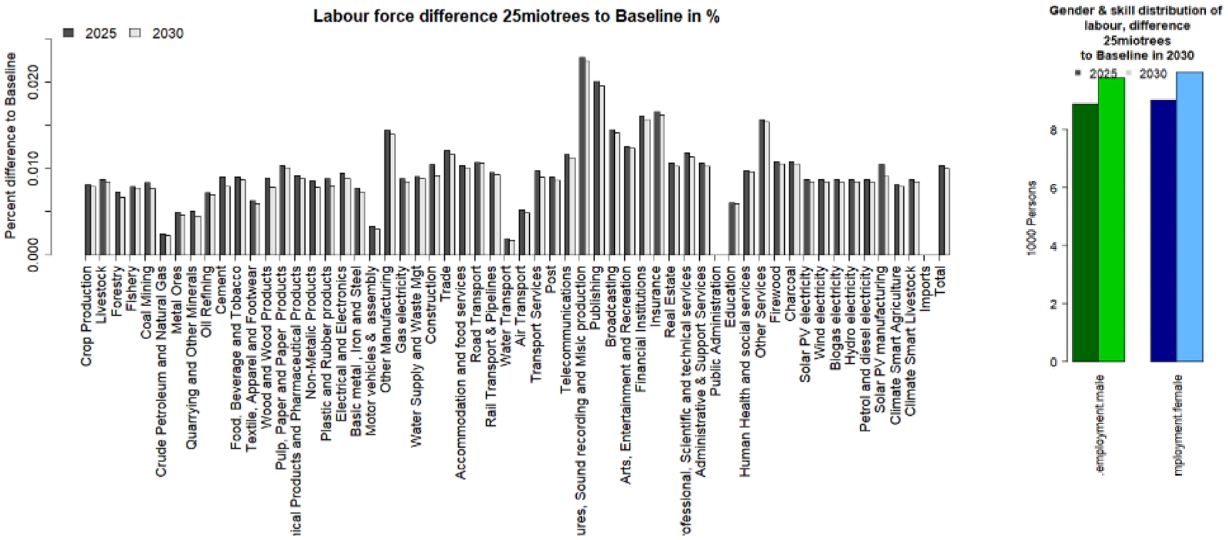


Figure 31: Reforestation scenario compared to baseline: employment by industry and gender



5.9 Efficiency in iron and steel production (industry)

Iron and steel production is one of the most emission-intensive industries in the world. Several emission reduction options exist, which should be combined to achieve the greatest possible effect. They include energy efficiency improvements, replacement of fossil carbon by bio-carbon, use of innovative and more efficient light-weight steel, and deployment of CCS technologies. The I&FF report [3] envisions investments of about $3.8 billion in this industry to reduce emissions.

We assume that 50 percent of this is spent on energy efficiency measures, 30 percent on CCS technologies, and 20 percent on R&D into innovative steels. The R&D is assumed to be completed between 2023 and 2027, but is not expected to yield significant emission reductions before 2030. Energy efficiency measures and deployment of CCS technologies are to be implemented in the first half of the 2020s and expected to yield gradual emission reductions.

Energy efficiency measures are assumed to reduce energy use per unit of production by 2 percent per year over the next decade, while CCS technologies reduce the emission intensity of production by about 10 percent following implementation.

Table 5 displays the investment assumptions for the iron and steel scenario in NGN million per year and product group (NGN198=$1). The rows highlighted in grey represent investments in energy efficiency and CCS. The remaining rows represent R&D investments in innovative steels.

Table 5: Investment assumptions for the iron & steel scenario per year and product/service groups (NGN1 million)

SUT PRODUCT GROUP	2022	2023	2024	2025	2026	2027
Manufacture of other fabricated metal products n.e.c.	50,120	50,120	50,120	50,120	0	0
Manufacture of measuring, testing, navigating and control equipment	50,120	50,120	50,120	50,120	0	0
Other construction installation	50,120	50,120	50,120	50,120	0	0
Architectural and engineering activities and related technical consultancy	0	6,014	6,014	6,014	6,014	6,014
Technical testing and analysis	0	6,014	6,014	6,014	6,014	6,014
Research and experimental development on natural sciences and engineering	0	6,014	6,014	6,014	6,014	6,014
Manufacture of clay building materials	0	6,014	6,014	6,014	6,014	6,014
Manufacture of articles of concrete, cement and plaster	0	6,014	6,014	6,014	6,014	6,014

Figure 31 shows an overall small positive effect on the economy and employment during the investment phase, which declines gradually when investments end. Emissions do decline in the long run, while they are slightly higher during the investment phase than shown in the baseline due to increased economic activity.

All industries benefit somewhat from increased employment opportunities in the short run (see Figure 32). The largest long-run employment losses are in coal mining, due to lower demand for fossil energy. Positive effects are observed for the iron & steel industry itself, due to higher demand because of lower prices resulting from reduced energy inputs. This also explains why employment for men is expected to increase (green bar). The observed reduction in women's employment (blue) in the long run is negligible and should be interpreted as having no effect.

Emissions are reduced most in percentage terms for coal mining, but most in absolute terms in iron and steel production.

Figure 32: Iron & steel scenario compared to baseline: total employment/emissions/value added

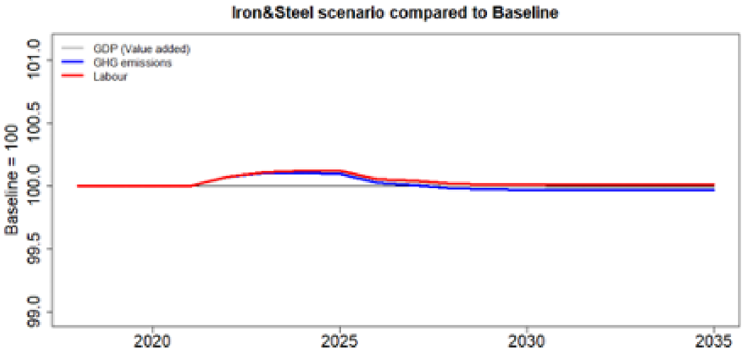


Figure 33: Iron & steel scenario compared to baseline: employment by industry and gender

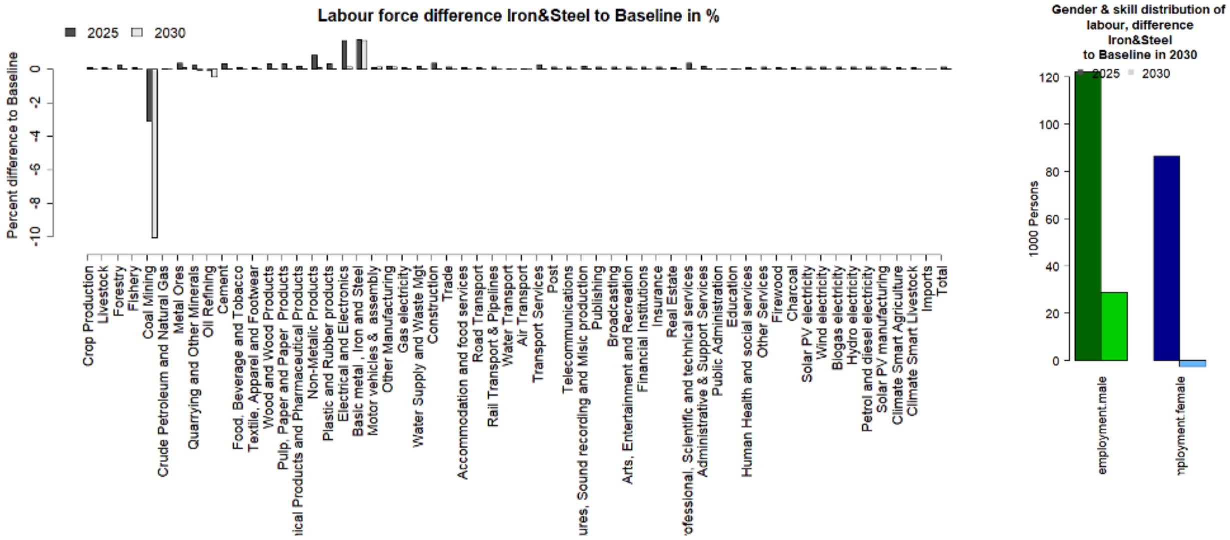
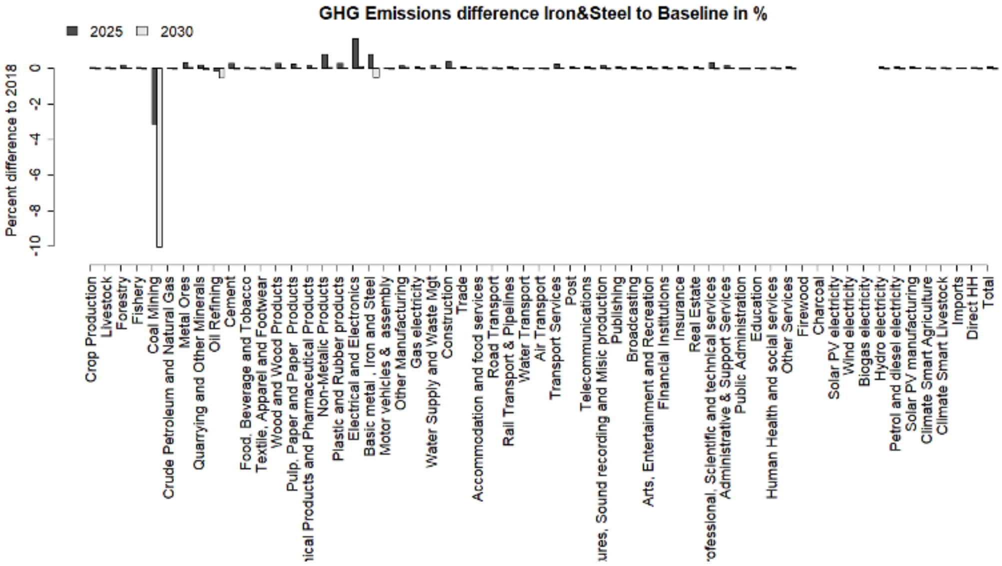


Figure 34: Iron & Steel scenario compared to baseline: GHG emissions by industry



5.10 Efficiency and material substitution in cement (industry)

As with iron & steel, producing cement is a highly emissions-intensive process. Emissions can be reduced through energy efficiency improvements, substitution of clinker with other materials, more efficient use of cement or the use of other building materials, development of alternatives to cement, and the deployment of CCS technologies. The I&FF report [3] envisions investments of about $11 billion in this industry to reduce emissions.

The first three rows highlighted in grey in Table 5 present the investment assumptions for energy efficiency and CCS technologies. Architectural and engineering activities and related technical consultancy are assumed to be needed for both the efficient use of cement and the use of other building materials and development of alternatives to cement. The last four rows in the investment table are goods and services needed to develop alternatives to cement.

To model the use of other building materials, we assume that the construction industry will use 1 percent less cement per year and replace it by clay building materials. The more efficient use of building materials is also assumed to reduce cement use in construction by 1 percent annually between 2022 and 2030. This will reduce the cost of construction activities.

CCS technologies are expected to reduce cement industry emissions by 10 percent after their deployment in 2025.

Table 6: Investment assumptions for the cement scenario per year and product/service groups (NGN1 million)

ROW (PRODUCT)	2021	2022	2023	2024	2025	2026	2027	2028	2029
Manufacture of other fabricated metal products n.e.c.	0	100241	100241	100241	100241	0	0	0	0
Manufacture of measuring, testing, navigating and control equipment	0	100241	100241	100241	100241	0	0	0	0
Other construction installation	0	100241	100241	100241	100241	0	0	0	0
Architectural and engineering activities and related technical consultancy	55683	55683	76621	76621	76621	76621	76621	55683	55683
Technical testing and analysis	0	0	20938	20938	20938	20938	20938	0	0
Research and experimental development on natural sciences and engineering	0	0	20938	20938	20938	20938	20938	0	0
Manufacture of clay building materials	0	0	20938	20938	20938	20938	20938	0	0
Manufacture of articles of concrete, cement and plaster	0	0	20938	20938	20938	20938	20938	0	0

As the cement industry is more than twice as large as the iron & steel industry, its effects on the economy and emissions are also relatively higher, but follow a similar curve. Investment activities result in higher economic activity in the short run, increasing value added, employment and emissions (see Figure 34). In the long run, emissions are lower than the baseline, while employment is higher.

The cement industry employs fewer people as the demand for the product declines as a result of more efficient use and substitution by other materials. The positive employment effects are slightly larger for men (green) than for women (blue), as the manufacturing-related increases in economic activity are higher than the service industry-related increases.

The reduction in GHG emissions is driven by significant reductions in the cement and the non-metallic mineral products industry, while emissions in all other industries increase slightly due to generally higher economic activity.

Figure 35: Cement scenario compared to baseline: total employment/emissions/value added

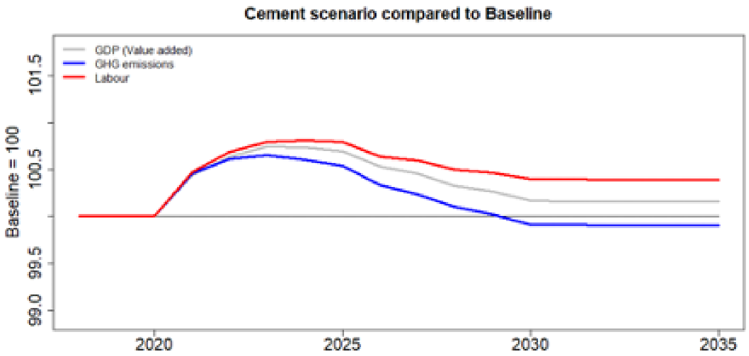


Figure 36: Cement scenario compared to baseline: employment by industry and gender

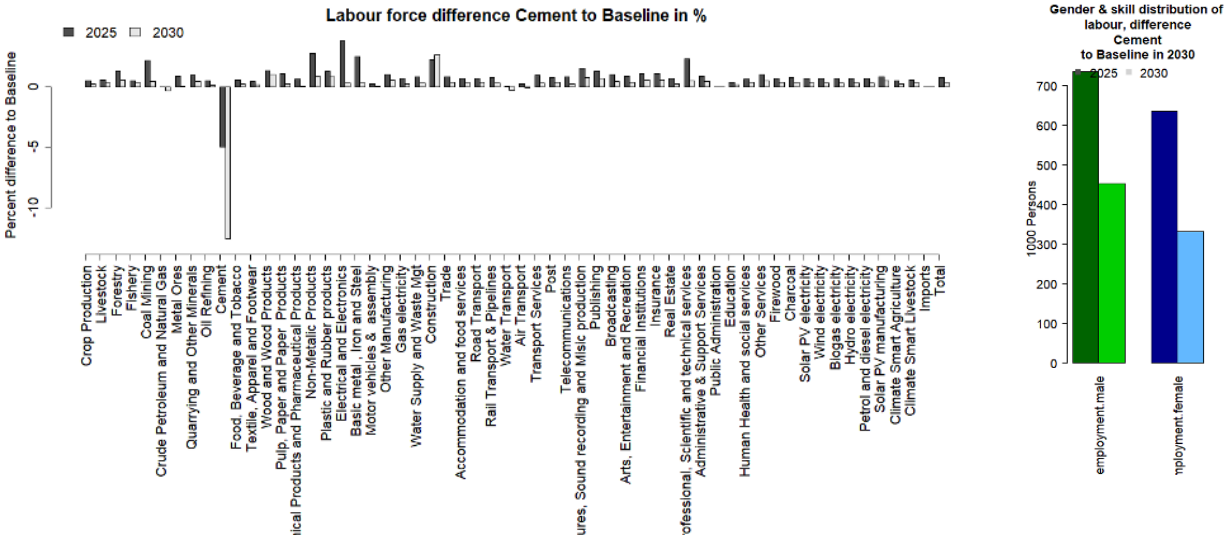
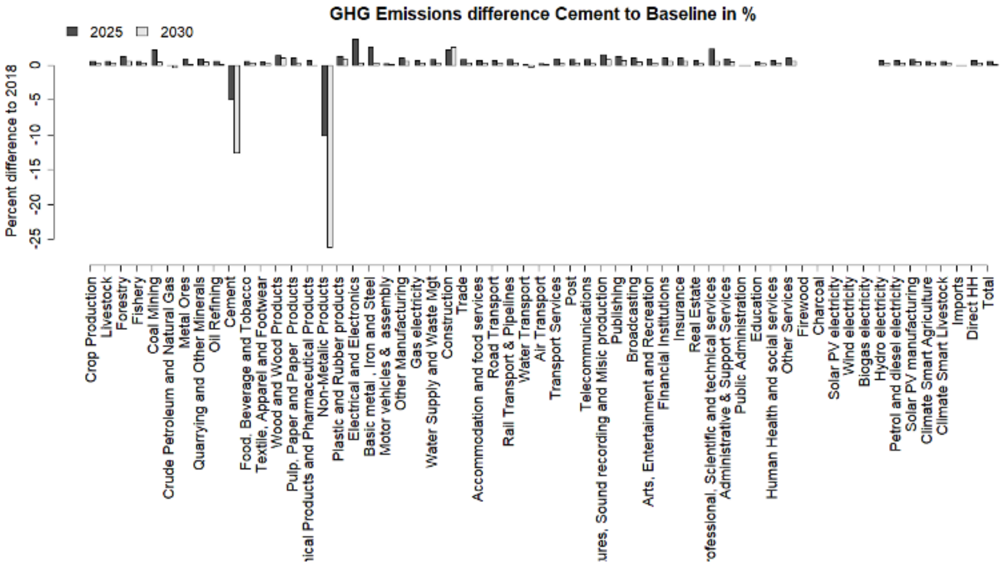


Figure 37: Cement scenario compared to Baseline: GHG emissions by industry



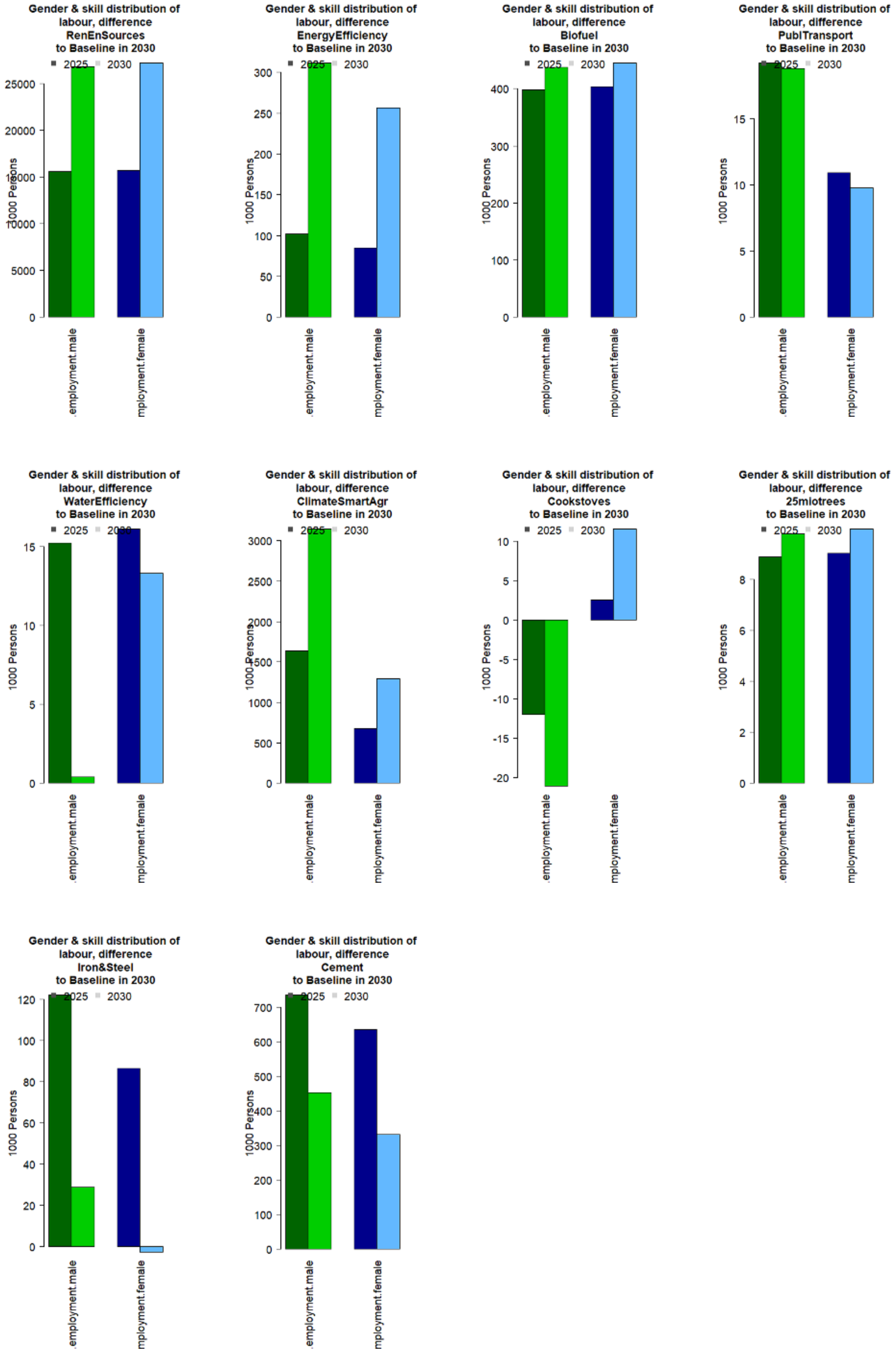
6 Summary and policy recommendations

Figure 37 summarizes employment effects by gender for all scenarios (green for male, blue for female). Note that the vertical axis differs for all scenarios. For many scenarios, the increase in jobs typically held by women and men is distributed equally, with some exceptions: relatively more jobs typically held by men are created (for example, drivers in the public transport scenario) in the public transport, agriculture, cement, and iron and steel scenarios. In the water efficiency scenario, the short-run effects (dark bars representing the year 2025) are equal, while in the long run (the light bars representing 2030), there are more jobs typically held by women. In the clean cookstoves scenario, the increase in women's employment is driven by additional spending on restaurants, mobile food services, and pre-primary and primary education.

It is thus important to emphasize that this potential positive contribution of the NDC climate policies to economic growth, employment creation and emission reduction depends on accompanying economic, social and labour market policies. Indeed, if climate policies are to be effective and contribute positively to development at the same time, they must be accompanied by just transition policies. Five key aspects of just transition policymaking require detailed attention.

First, failing to address social consequences may lead to protest and the non-implementation and failure of the climate policies. Second, the type of climate policy has significant and very different effects on social and labour market outcomes. Integrating just transition policies at the design phase can maximize social inclusion , pro-poor growth and job creation. Third, well-intended climate policies and capital investments in the low-carbon economy require managers, workers, enterprises, and entrepreneurs with the skills to finance, manage, construct, operate and maintain the capital asset or implement the structural production changes (such as those required by climate-smart agriculture), and make productive use of the asset in the long term. Fourth, social protection measures and social dialogue mechanisms are needed to address and signal the concerned population that the government will buffer potential negative impacts. And fifth, accompanying fiscal, macroeconomic, sectoral and industry policies have the potential to support structural economic change and enhance economic growth and social development.

Figure 38: Overview of employment effects by gender



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Annex: Technical description of the model and data

The model documentation provides details on its technical aspects. Understanding the data underlying the model is crucial for understanding and interpreting the results. Their quality depends directly on the quality of the underlying data. If the data present major uncertainties, the model cannot correct them and the outcomes will be equally uncertain.

A.1 General limitations and strengths of the modelling approach*

** Excerpt from general documentation of economic core model (SUT_core).*

Supply-and-use table-based macro-econom(etr)ic input-output models-/GAIN-type GJAM are not economic forecasting models. Rather, they models are a tool to inform about possible effects of "what-if" scenarios on emissions and labour demand by industries, given that the remaining structure of the economy remains as is.

The results should be assessed relative to the baseline scenario. They indicate the direction and possible size of the effects but should not be taken exact estimates.

The results show how changes in individual economic activities influence the economic structure. Direct, indirect, and induced effects of technological change and changes in household, government and investment structure are reflected.

A(n imperfect) list of limitations to the modelling approach

- The model is based on historic relation between economic activity, income and consumption and the production structure of the base year (currently 2018), which in turn might be estimated based on older supply-and-use tables. For some countries, the most recent available supply-and-use table might be from 2010 or 2012. To extrapolate data based on this until over the next decade will not necessarily give a complete picture, but it is a valuable starting point for assessing effects of climate change mitigation and adaptation and other sustainability policies through "what-if" analyses.
- While the option for price changes is given, there is no adjustment of production structure or investment based on price changes. Household demand for different product groups, however, is modelled using own- and cross-price elasticities.
- Investments grow with the previous year's growth rate, and the structure of the investment remains the same, with one exception: the exogenously given investment for individual scenarios, which comes in addition to the general investments. That means that additional investments in the scenarios are not crowding out other investments but come as an additional economic stimulus.
- The results show which industries are likely to have an increased demand for labour, and which industries might contract. The actual labour market outcomes of course also depend on other factors as well as dynamic labour market adjustments such as wage adjustments, labour availability, labour productivity changes etc, that are not considered here.
- The current modelling of international trade is very simplified. Import shares by product are based on the supply table from the base year. Exports grow with global GDP projections from the IMF or OECD.

Once these limitations are well understood, they contribute to the **main strength of the model: simplicity and transparency**. These are reinforced by the other strengths:

- The model depends on very few types of data, which can be combined into one consistent framework with few equations.
- The model is data driven and reflects country-specific characteristics very well.

- Scenarios are implemented using one Excel sheet and the model runs only a few seconds, so that a large number of scenarios can be calculated for assessing the validity of different scenario assumptions.
- For every single result, we can find an explanation that is in the data or one of the very few assumptions underlying the model.

A.2 Data requirements and available data

The absolute minimum data requirements for the GJAM are:

- Input-output table (IOT) or supply-and-use table (SUT) for a recent year;
- Time series of system of national accounts (SNA) data, with as much detail by industry as possible’
- Data on employment by industry, e.g., a labour force survey for the same industry classification as the IOT or SUT;
- Data on emissions by industry, e.g., from the GHG inventories, for the same industry classification as the IOT or SUT; and,
- Data on changes in consumption and production structure for the green scenarios.

The GJAM Nigeria used the following data:

- Population 2018 – 2050: UNDESA World population forecast;
- Global economic development: OECD Longview;
- Supply-and-use table 2010: National Bureau of Statistics NBS (~340 products, ~45 industries),own estimates of green industries;
- System of National Accounts 2016-2019: NBS;
- Energy data from 2018 IRENA Energy Balance;
- Employment (by gender) by industry: NBS Labour Force Survey; and,
- GHG emissions by industry: Third 3rd National Communication, 2016

A.2.1 Supply-and-use table (SUT)

Several steps are involved in updating the original 2012 SUT table data (in basic and purchaser's prices) to reflect the 2018 data in basic prices with additional green industries and products.

1. Original 2010 SUT: Data/RASupdateSUT/original sut/2010 SUT Nigeria.xls (2010 data)
    - conversion of USE from purchasers to basic prices in Excel 2010 SUT Nigeria_basicprices.xls
    - manual update of structure of final demand to ensure consistency: Moving 500,000 PP exports to oil extrac exports, at the same time allocating 500,000 k pp exports to HHE; reducing oil extrac CIES by 550,000; moving 50,000 oil extrac CIES to HHE; balancing by moving 550,000 HHE wholesale to CIES wholesale; moving additional 67,000 CIES electr to HHE and from wholesale HHE to CIES.
2. Update SUT to 2018: Data/RASupdateSUT/2018 SUT Nigeria.xlsx
    - Updated to 2018 using a simple iterative RAS procedure, using aggregate demand side and gross value-added components by industry for 2018 from NBS Nigeria_GDPTimeSeries.xlsx
3. Include employment and GHG extension data elect /2018 SUT Nigeria.xlsx
    - added sheets for extension data and concordance matrices for emission extensions and Household demand model
    - more information on extension data in Section

4. Update SUT to consider unaccounted firewood industry (2018_SUT_Nigeria_CharcoalFirewood.xlsx)
    - introducing the new industry/product
    - using SUT price model to update the entire table for including the cost of firewood
5. Update SUT to include green industries (SectorSplit/2018_SUT_Nigeria_SplitSectors.xlsx)
    - See Section A.2.4.1

A.2.2 Macro-economic drivers

The model is driven by the macro-economic demand-side variables as shown in Figure 1.

A.2.2.1 Household demand model

Given that a supply-and-use based model includes household consumption by products, their possible development can be determined using a **demand system**. Household consumption by product prod depends on total income (GDP) and income, own-price, and cross-price elasticities el, eop, with grX denoting the %growth in variable X

HHEprod[t] = HHEprod[t-1] + el*grGDP + eop*grOwnPrice + ecp*grOtherPrices

Here, we take income, own-price and cross-price elasticities from the USDA international food comparison programme [6,7].

Income elasticities for broad consumption categories, 144 countries, 2005: Nigeria

Food, beverages & tobacco	Clothing & footwear	Housing	House furnishing	Medical & health	Transport & communication	Recreation	Education	Other
0.79	0.967	1.075	1.054	1.68	1.211	2.413	0.93	1.696

A.2.2.2 Government expenditures

Government expenditures are assumed to grow proportionally with population. We thus estimated government expenditure as a function of population using a simple OLD model. While population was indeed significant, the explanatory power of the regression was not very high. The equation implemented in the model is

GOVR[t] = 563803.74 + 0.0295* POPU[t]

The error term in the last year was 3183.4, so we need to correct for that. While this may not be the best way to model this, it is a simple, elegant solution that ensures model transparency, as it avoids too many complicated details. Population development is based on the medium fertility scenario from UNDESA's population prospects. For a different development, simply exchange the data in the Excel input file.

A.2.2.3 Gross-fixed capital formation

General gross fixed capital formation/investments are assumed to grow in line with the previous year's growth rate. General investments are thus exogenous to the model in the current year, contributing to stabilizing the model. However, this makes it possible to capture the effect of increased economic activity on investments; that is, investments are higher if last year's GDP growth is higher. This also enforces some path dependency for investments.

The investment structure - the shares of investment spending on different product groups in the SUT in total investments - is assumed to be constant.

Scenario-specific investments are modelled as additional to the general investments. Here, the product structure is flexible; that is, given as a model input. This modelling may overestimate the effect of investments in general, as investments from a scenario may sometimes crowd out general investments.

A.2.2.4 Exports

Exports grow with the global long-term GDP growth rate from the OECD Longview from 2022. Estimates for prior years are drawn from the IMF. While 2021 growth is expected to be higher, we adjusted it down to 2 percent. For a different development, simply exchange the data in the Excel input file.

	2018	2019	2020	2021	2022-2030	2030-
Global GDP growth rate	3.0%	2.5%	-4.9%	2.0%	3.4%	2.4%

Export product shares are assumed constant; that is, the type of products that are exported changes. This assumption can be modified for future model versions.

A.2.3 Modelling the economic impulse from additional availability of electricity

A significant portion of the NDC plans include additions of renewable electricity generation capacity. In most high- and middle-income countries, these are meant to replace existing fossil power plants. In many developing countries however, the capacity addition constitutes additional electricity supply. In the GJAM model, these capacity additions and their effects are gradually introduced into the economic system.

1. The additional capacity needs to be deployed.
   - Investment goods must be purchased: technology components, water or wind turbines, solar PV panels, and the components connecting the electricity generating technology to the (mini-)grid.
   - The hydropower plant needs to be built and/or solar and wind power capacity needs to be installed.

While domestic workers would do most of the construction/installation work, thereby generating additional income and demand, most technology components would be imported. Thus, it is important to know the approximate share of the technology component imported and the construction/installation work and related services, such as project planning.

2. When the new electricity generation is online, it will influence a country's overall economic activity in two key ways.
   - Employment and value creation related to the additional electricity production, i.e., all workers at the hydro-power dam and the workers responsible for repair and maintenance of wind and solar installations. This will generate income and related additional demand by households and for investments.
   - If significant electricity supply shortages and frequent outages occurred previously, then additional electricity supply will generate additional production possibilities. Additional employment will be generated for those economic activities that were previously constrained by electricity supply. Again, additional income will influence final demand.

Two questions related to the second aspect remain: First, which economic activities will benefit most from the additional electricity supply? And second, by how much will economic activity increase?

A.2.3.1 Which economic activities will benefit most from the additional electricity supply?

In keeping with the demand-driven economic perspective inherent to input-output models, production of goods and services and related economic activity are determined by demand, both final and intermediate. These are determined, in turn, by household behaviour, investment demand and foreign trade. Regarding the latter, political industrial strategies may play a major role, whether by promoting the export of selected goods and services (for example, specific agricultural products, raw materials - or better, processed versions of both - or tourism) or by aiming at import substitution. Nigeria’s NDC does not articulate such plans, except for solar PV panel production.

Final demand is dominated by household consumption expenditures, followed by demand for investment goods. The household demand system is based on income and price elasticities from Muhammad and Meade [6,7]. Analysing these in detail shows that with increasing income, consumption of goods and services that are more electricity-intensive increases. More specifically, the "Food, beverages and tobacco" and "Education" categories are the least elastic. We therefore assume that the additional goods and services that will be consumed when they can be produced are consistent with the changes in consumption patterns of the demand system implemented. For investment goods, one could assume that relatively more will be invested in machinery and equipment that rely on electricity availability. With the exception of "Manufacture of computers and peripheral equipment", electrical machinery and equipment and similar products already represent large shares of the investment goods. The low share of computers and related equipment is due to fact that the SUT is based on the year 2010. However, given that no better information is available, we assume that the structure of investment goods remains the same. That is, investment will increase as more electricity is available and will be directed to those goods and services that already receive a higher share.

A.2.3.2 By how much will economic activity increase?

For most European countries, as well as OECD countries, economic activity is unlikely to increase due to capacity additions of renewable energy generation technologies. Rather than generating additional economic activity, the market share of renewables will increase accordingly.

In the context of countries with geographic areas or population segments that still lack access to reliable electricity supply, electricity shortages could hamper economic development [26,27].

The approach described below assumes that the extra electricity that will be available from the capacity additions will be absorbed by extra economic activity, rather than replace existing electricity generation.

The evidence for the direction of the relationship between economic growth (in terms of GDP per capita) and energy use, specifically electricity consumption, is mixed across both countries and estimation methods used. Comprehensive literature reviews on the bidirectional relation are given in Omri [28] and Chen [29]. In the demand-driven GJAM model, electricity production does depend on demand. However, we need to account for the possibility of an expansion due to the availability of additional electricity. We therefore estimate the bi-directional relationship between electricity consumption and GDP per capita based on historic data from 1971 to 2018, for Zimbabwe, Nigeria, and all of Africa. Data sources are the UNDESA population data; the UNSNA main aggregates database for value added per capita in constant prices (this, rather than GDP per capita, that GJAM uses), and two different electricity data series (electric power consumption (kWh per capita) from the World Development Indicators (WDI Indicator code: EG.USE.ELEC.KH.PC) for 1971-2014 and electricity production (kWh) from the World Bank's Africa Development Indicators[2] (ADI Indicator code EG.ELC.PROD.KH) for 1971-2010). For Zimbabwe, data on electricity production was available for 2009 – 2019 from the Zimbabwe Electricity Supply Authority. Using the growth rates from the Africa Development Indicators Electricity production (kWh) data, we extrapolated Zimbabwe's electricity production back to 1971. This ensured that we used the country-specific data available for the most recent years. Such data was not available for Nigeria. Electricity consumption data is available for the most recent years from the IEA country profiles. We applied those growth rates to generate estimates for the years after 2014. The econometric

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[2] https://databank.worldbank.org/source/africa-development-indicators

models were estimated including and excluding the years after 2010/2014, respectively. We could not find a significant difference between the coefficients.

We test the system of equations[3] as specified by [30]:

$$GDPpc_t = \alpha_G + \beta_G\ ECpct + \varepsilon_{Gt} \qquad (A.2.1)$$

$$ECpc_t = \alpha_E + \beta_E GDPpc_t + \varepsilon_{Et} \qquad (A.2.2)$$

where $GDPpc_t$ is real GDP per capita and $ECpc_t$ is electricity consumption per capita in year t. The simple OLS estimation shows a strong relationship between development in GDP and electricity consumption per capita, as shown in Table 6.

The causal relationship between GDP per capita and electricity production is provided through the household demand system integrated into the supply-and-use framework. However, the effect of the increase in electricity supply on GDP per capita is missing. To incorporate this into GJAM, we use the results from Equation A.2.1 and include them in order to provide additional growth impulses when initializing GDP per capita at the start of each year. That is, rather than initializing value added per capita for the first iteration by last year's value, value added per capita grows by what is expected from the estimated Equation A.2.1 based on the increase in electricity supply per capita available that year due to capacity additions.

Table 7: OLS estimation results Equation 1 & 2 for Nigeria

	EQUATION (1) GDPpc ~ ECpc(ADI)	EQUATION (1) GDPpc ~ ECpc(WDI)	EQUATION (2) ECpc(ADI) ~ GDPpc	EQUATION (2) ECpc(WDI) ~ GDPpc
Coef	3318.969	4822.788	0.00027	0.00019
SE	194.9388	244.8914	2.00E-05	1.00E-05
t-stat	17.0257	19.69358	17.0257	19.69358
p-val	0	0	0	0
Adj. Rsq	0.87837	0.90629	0.87837	0.90629

A.2.4 Addition of new industries and products to the SUT tables

The original industry and product classification in the SUT tables were supplemented by the additional industries and products needed to implement the GJAM. The following industries and products were included:

- *"Firewood"* industry, which supplies the new product *"Firewood"*;
- *"Charcoal"* industry, which supplies the new product *"Charcoal"*;
- *"Hydropower"*, "*Solar Photovoltaics"*, *"Wind"*, and *"Biomass Electricity"* renewable electricity industries, which supply the existing product *"Electric power generation, transmission and distribution"*;
- *"Petrol/Diesel Electricity"* industry, which supplies the existing product "Electric power generation, transmission and distribution";
- "Gas Electricity" industry, which supplies the existing products *"Electric power generation, transmission and distribution"* and *"Manufacture of gas; distribution of gaseous fuels through mains"*;
- *"Photovoltaic Panels"* new manufacturing industry, producing new products *"Photovoltaic panels"*; and,
- New *"Climate Smart Agriculture"* and *"Climate Smart Livestock"* industries, producing all existing agriculture and livestock products.

These new industries were central to implementation of many of the scenarios. Below, we provide details on the assumptions and data used to add these new industries and products to the SUT.

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[3] We also tested for unit roots and possible cointegration using the dLagM package in R 52, which allows for the PSS cointegration test 53 that avoids the possible bias that can occur to the pre-tests for unit roots. Wolde-Rufael [54] suggested its use in this context. Results are available upon request.

A.2.4.1 Firewood and charcoal

Although it is an oil-rich country, Nigeria still depends on traditional biomass. Biofuels – mainly fuel wood and charcoal – are the largest source of energy used, accounting for 54 percent of all primary energy supply in Nigeria and 60 percent of all final energy consumption [12]. The largest segment of biomass use is as household cooking fuel. An earlier assessment of biomass use by sector estimated that in 2012, households used 92 percent of all biomass, primarily as fuelwood [12]. While some households, especially in urban areas, have a choice of fuel depending on the nature of the event and price (kerosene, LPG, firewood or charcoal), poor households rely primarily on firewood for cooking and heating [31].

The model needs to include the production and consumption of firewood because it is a large share of the energy economy, particularly for households. In addition, it plays a major role in GHG emissions from biomass burning and deforestation. Furthermore, the effects of transitioning to clean, affordable energy and clean and efficient cooking and heating sources in households should be assessed.

However, there are significant uncertainties associated with estimates of this industry. The first challenge is allocating a monetary value to a non-monetary activity, as most users of firewood collect their own. In fact, fuelwood is, to a large extent, obtained free of charge by industries (e.g., agriculture) and households. The non-monetary nature of this activity is related to the second challenge: the employment created by this industry consists, largely but not exclusively, of unpaid household activities. In 2018, nearly 50 percent of the population reported gathering wood for their own consumption [20]. The use of firewood that is gathered instead of purchased is higher in rural areas than urban ones. On average, households collect approximately 75 percent of the fuelwood they use; this share exceeds 80 percent in rural areas [32]. These activities might be performed either by people whose main activity is caring for the farm or household, or by individuals who fetch water and firewood before going to their main jobs. However, people involved in each of the activities for their own use cannot be added in the model as additional employment. Employment in the firewood industry was thus re-estimated based on generation of value added, as detailed in section A.2.5.1.

Estimating firewood production and consumption

While there are many statistics on the total production and consumption of firewood by households, some are contradictory. The problem arises from the use of international estimates that are modelled using national information, combined with global/regional variables. For this model, we use firewood consumption that is consistent with the CO_2 emissions from biomass burning in the Third National Communication's GHG emissions inventory [11]. The following assumptions were used:

- Total CO_2 emissions from burning of biomass are taken as a starting point to estimate the amount of biomass used in Nigeria: 256 090 Gg CO_2 from solid biomass combustion in 2016. These emissions are consistent with the estimated firewood and charcoal use in the 2015 energy SUT [33]. The total amount of firewood and charcoal used and the distribution between industries and households is based on the energy SUT. Energy content was translated into mass of charcoal and firewood, in kilogrammes, using energy content consistent with emissions from cookstoves [34]
- Monetary values for the total consumption of wood and charcoal are estimated by multiplying the amount of fuel, in kilogrammes, with average prices of NGN3/kg and NGN5/kg for firewood and charcoal, respectively, purchased by households [35]. It is assumed that all consumption of firewood (purchased or collected) is valued based on average final consumer prices.
- It is assumed that there are no intermediate inputs for firewood and all sales of firewood are translated into wages.
- Intermediate inputs for the charcoal industry are based on Oluwasola, et al [36]. Most sales (90 percent) of charcoal to final users is assumed to be translated into wages for workers.
- The use of firewood and charcoal by industries and households is distributed based on the use of each fuel in the energy SUT. For both firewood and charcoal, the distribution is as follows: 75 percent of use by households, 20 percent by services and 5 percent by agriculture.

- Within the broad industries (services, agriculture), the use of firewood and charcoal is divided into the SUT industries (e.g., from the general agriculture and forestry into the four specific SUT industries - agriculture, livestock, fishing, and forestry) based on the distribution of value added in these industries.

A.2.4.2 Climate-smart agriculture (CSA)

CSA involves practices that aim to optimize agricultural production, while minimizing GHG emissions. It includes measures to improve productivity and income, increase resilience of agricultural production and rural livelihoods (adaptation to climate change), and reduce emission intensity from agricultural products. There is no blueprint for climate-smart agriculture that fits all countries and implementation depends on the country and community context [37]. In Nigeria, CSA opportunities are based on the following characteristics [38,39]:

- Improved soils and nutrient management through tillage and grassland systems, leading to lower direct and indirect emissions from soil management, and lower use of fertilizers;
- Agro-forestry systems, crop rotation, and crops and livestock diversification;
- Reduction of post-harvest losses, with better use of storage facilities;
- Use of drought resistant crops and livestock feeds;
- Better use of irrigation systems; and,
- Fuel switching in rural areas, with gradual reduction of firewood use and elimination of charcoal use.

The new climate-smart agriculture industry is based on the original crop production industry, with modification to its intermediate inputs based on the following assumptions:

- Soil and nutrient management using low-tillage systems, allied with efficient fertilizer applications, would require lower use of synthetic fertilizers. However, low-tillage systems also require higher use of pesticides [40]. A survey of farmers in five sub-Saharan African countries on their adoption of conservation agriculture practices (intercropping, residue retention and minimum tillage) found that they used 33 percent less fertilizers per hectare, but more pesticides [19]. As inorganic fertilizer use in Nigeria is among the lowest in the world [41], this reduction was assumed to be around half that, or 15 percent.
- Measures to improve mitigation of and adaptation to climate change would require that smallholder farmers have greater access to financing services [42]. We assume 10 percent greater access to financing services than under conventional agriculture.
- Reduced use of firewood through more efficient cookstoves and fuel switching for cooking and heating would reduce wood consumption by 30 percent, assuming a switch to efficient cookstoves as described in the clean cooking solutions scenario. Furthermore, we assume no use of charcoal as fuel to reflect the INDC goal of eliminating the use of charcoal [10].
- Although reduced tillage practices usually reduce labour requirements in developed countries, they can be more labour intensive in developing countries. In sub-Saharan Africa, soil and nutrient management practices are estimated to require more labour [19], especially during harvesting and threshing. Labour input in value added (employee compensation and net operating surplus) was assumed to be 10 percent higher than under conventional agriculture due to the adoption of practices such as low tillage, crop rotation and agro-forestry. This is lower than the 18 percent additional labour requirements for full adoption of conservation agriculture practices in maize farming in five sub-Saharan African countries [19]. However, the increased labour inputs under conservation agriculture (intercropping, residue retention and minimum tillage) are provided primarily by household labour - especially women - and do not necessarily result in increased paid farm labour.
- Lower direct emissions of nitrogen from managed soils (assumed to be 15 percent) [37].

The new climate-smart livestock industry is based on the original livestock industry, with its intermediate inputs modified based on the following assumptions:

- Measures to improve mitigation of and adaptation to climate change would require that smallholder farmers have greater access to financing services [42]. We assume 10 percent greater access to financing services than under conventional agriculture.
- Better control of animal disease and health, as well as higher herd vaccination rates, leading to higher inputs from veterinary services[43]. Due to lack of data on how these inputs would differ from conventional livestock production, they were assumed to be 15 percent higher.
- Reduced use of firewood through more efficient cookstoves and fuel switching for cooking and heating would reduce wood consumption by 30 percent, assuming a switch to efficient cookstoves, as described in the clean cooking solutions scenario. Furthermore, we assume no use of charcoal as fuel to reflect the INDC goal to eliminate the use of charcoal [10].
- Climate-smart practices, such as general improvements in animal husbandry, manure management and grassland management, would require more labour. However, due to lack of data with which to estimate the difference in labour inputs compared to conventional livestock, those additional inputs were assumed to be the same as under climate-smart agriculture.
- Changes in livestock diets, health control, genetics and reproduction, and grassland management practices would increase animal productivity and decrease direct methane emissions [37] by 18 percent (based on estimates for Zimbabwe [15]).

It was assumed that there would be no significant production from climate-smart agriculture and climate-smart livestock in 2018. Total base-year production year is assumed to be NGN1.

A.2.4.3 Electricity industries

The electricity industry overall is divided into six specific industries: hydropower, gas electricity, petrol/diesel electricity, solar photovoltaics, wind electricity and biomass electricity. The original electricity industry was divided among hydropower, gas and petrol/diesel electricity. The other renewable electricity industries (solar PV, wind and biomass) were added as new (that is, non-existing industry structures in the original table for 2010) industries. It is important to note that these new industries correspond to the operation and maintenance of these electricity industries. They do not include the construction of new electricity infrastructure or the production of energy equipment (for example, photovoltaic panels or wind turbines).

Hydropower and the split from original electricity industry

Hydropower electricity provided 12 percent of electricity supply in 2018 [12]. This division into hydropower and the remaining fossil electricity was carried out based on the following assumptions:

- 12 percent of monetary production from the product "Electric power generation, transmission and distribution," (total industry output) of the original electricity industry was allocated to hydropower. The remaining (88 percent) was allocated to the remaining fossil electricity.
- The input structure (intermediate inputs from other industries and value-added inputs, such as labour compensation and gross operating surplus) of the hydropower industry was based on monetary coefficients for hydropower industries from the input-output database EXIOBASE [44], adjusted to match the products used by the original electricity industry.
- The products used to produce hydropower were subtracted from the original electricity sector, resulting in a new industry structure for the (remaining) fossil electricity industry.
- The entire distribution of outputs from the hydropower industry was allocated the "Electric power generation, transmission and distribution" product, subtracted from the fossil electricity industry. It was estimated that the product "Manufacture of gas; distribution of gaseous fuels through mains" was produced exclusively by the fossil electricity industry.

Division of fossil electricity into gas electricity and petrol/diesel electricity

Grid electricity generation is comprised of gas and corresponds to 39.5 percent of all electricity generated in Nigeria in 2018 [12]. Self-generation (i.e., off-grid electricity) is provided by gas (9.4 percent), petrol (22.6 percent) and diesel (16.6 percent). Self-generators are those producers (households or businesses) who produce electricity for own consumption and whose main activity is not electricity generation. This model distinguishes electricity from gas (grid and off-grid) from electricity generation from petrol and diesel. The remaining fossil electricity, which corresponds to the original electricity industry without the inputs for the production of hydropower, was further divided between gas electricity and petrol/diesel electricity.

The production structure of the two fossil electricity types is assumed to be identical (aside from using either gas or petrol/diesel), and the original industry was divided using the energy carrier's respective share in electricity generation. However, the gas and diesel/petrol electricity industries differ in terms of GHG emissions, as detailed in section A.2.5.2.

The electricity output supply was divided between the two industries based on their share of electricity generation, while the entire supply of the product "Manufacture of gas; distribution of gaseous fuels through mains" was allocated to gas electricity.

Solar photovoltaic, wind, and biomass electricity

The three new renewable electricity industries were added as new industries that did not exist in 2018. The input structure (intermediate inputs from other industries and value0added inputs, such as labour compensation and gross operating surplus) for these industries were estimated based on input coefficients to different electricity generation industries from the input-output database EXIOBASE [44]. As they are new industries, they have not been split off (or allocated) from the electricity and gas industry. Instead, their structure was described in the base-year SUT tables with virtually no output (NGN1). Although a small fraction of Nigeria's 2018 electricity production (around 0.1 percent [12]) derived from biomass – off-grid electricity production from bagasse and palm oil waste – it was assumed that the original industry structure used as the basis for this analysis (2010 economic table) did not include this industry. The same applies to small-scale off-grid solar PV in operation in Nigeria today.

A.2.4.4 Production of photovoltaic panels

The production of solar photovoltaic panels was also added as its own industry, so that for the scenarios we can assume different shares of imports versus local production of equipment. The input structure for the "Production of solar photovoltaic panels" was based on Lehr et al [45]. The industry was assumed to have had no production in 2018 and its structure is described in the base-year SUT tables with virtually no output (NGN1). It is important to note that the import shares of inputs to these industries are the same as the product import share in the model described currently. That is, the intermediate inputs that are imported now (for example, manufacture of batteries and accumulators) will still be imported if solar photovoltaic panels are produced in Nigeria. They can be changed exogenously.

A.2.5 Labour and environmental extensions

The inclusion of labour and emissions effects require that labour and emissions be classified in a way that is fully consistent with the economic data in the SUT regarding same industry classification and base year. This section details the data needs in these extensions and the steps used to build them for the GJAM Nigeria.

A.2.5.1 Labour extensions

Labour extensions refer to the employment statistics found in labour force surveys (LFS). At a minimum, they include the total number of persons employed by gender (male/female) and, ideally, by skill level (skilled/

unskilled). Additional indicators can be included to provide additional analysis of which jobs will be affected by the structural economic changes. These additional indicators may refer, for example, to job location (rural/urban) or employment status (employee/self-employed/unpaid family worker).

The indicators included in GJAM Nigeria are total employment, divided between male and female workers. All indicators are quantified in number of persons. Each indicator corresponds to a row describing persons employed in each of the 46 industries in the SUT. Data for employment originates from the 2010 LFS [46] and is scaled to 2018 using growth in value added for each industry between 2010 and 2018. It was assumed that labour productivity did not grow during the period and that the distribution of male and female workers remained unchanged in each industry. Although more recent data on employment exist, the data in the 2017 LFS [47] are more highly aggregated and reveal major inconsistencies for this model. For example, while the 2010 survey reported 152,610 workers in electricity, gas steam and air condition supply, the 2017 LFS reported only 7,129 workers employed in this sector. Therefore, the level of detail and more comprehensive nature of the 2010 key industry data for the 2010 data was preferred over the updated LFS.

Labour extensions for the new industries

The labour data was divided further into the new industries based on the assumptions below.

Firewood and charcoal industries: The number of workers estimated in the firewood and charcoal industries was calculated assuming that the average wages of firewood collectors and producers of charcoal would be the same as the wages for agricultural (crops) workers. Workers in the firewood industry are additional in the economy. They are not included in any of the SUT industries in the LFS because this activity is reported as subsistence (i.e., production of goods and services for own use). The gender distribution of workers in the firewood industry would follow those as reported in the General Household Survey-Panel [48] and, for the charcoal industry, those described in Oluwasola et al [36].

CSA and livestock industries: The estimated employment for the CSA and livestock industries was assumed to follow the same number of persons employed per value added in the original crop production and livestock industries. It also assumed the same employment structure (workers by gender).

Energy industries: For solar PV, wind, biomass electricity and hydropower, employment extensions were assumed to follow the same number of persons employed per value added in the original electricity industry. Employment in hydropower was subtracted from the original electricity industry. The remaining employment in fossil electricity (after subtracting hydropower) was then divided between gas electricity and petrol/diesel electricity proportional to their compensation of employees. The employment structure (employment by gender) was assumed to be the same across all electricity and gas and other electricity industries.

Production of solar photovoltaic panels: The estimated employment for the production of solar photovoltaic panels was assumed to be the same as the number of persons employed by labour compensation in the electrical and electronics industry. It also assumed the same employment structure (workers by gender).

A.2.5.2 Greenhouse gas emissions extensions

The extensions for GHG emissions are based on the emission reporting in keeping with IPCC guidelines. The emission reporting follows four main activities: energy; IPPU; AFOLU; and waste management. In addition, CO_2 emissions from biomass burning are also reported and included in GJAM Nigeria.

The GJAM Nigeria emissions are divided by the three main GHG emissions (CO_2, CH_4 and N_2O; other gases were not included) and were categorized into activities (such as CO_2 emissions from biomass burning, CO_2 emissions from fuel combustion, and CH_4 from agricultural activities) so that changes in emissions related to these different activities can be modelled individually under the different scenarios. Table 7 presents those categories, which are explained in detail below.

Table 8: GHG indicators in GJAM Nigeria and correspondence to emission inventory categories (in Gg CO_2-eq)

	CO_2					CH_4				N_2O			
	Energy	IPPU	AFOLU	Waste	Biomass	Energy	IPPU	AFOLU	Waste	Energy	IPPU	AFOLU	Waste
CO_2 emissions from combustion of solid biomass fuels					●								
CO_2 emissions from prescribed burning			(*)										
CO_2 emissions from fuel combustion (fossil fuels)	●												
CO_2 emissions from industrial processes and waste treatment		●		●									
CH_4 emissions from fuel combustion (fossil fuels) and industrial processes						●	●						
CH_4 emissions from agriculture activities and waste treatment								●	●				
N_2O emissions from all activities										●	●	●	●

(*) Not included in this assessment because the Third National Communication does not report CO_2 emissions from prescribed crop burning, but only non-CO_2 emissions.

Energy emissions

Following the 2006 IPCC guidelines [49], energy emissions are reported for the three GHG and are divided into main energy activities and use of fuels. The categories in the original data are:

- **Emissions from fuel combustion activities:** all emissions from fuel combustion, divided by:
  - *Energy industries:* emissions that are directly allocated to the **energy transformation sector** for production of electricity and fuels. This does not include the burning of these energy products. In the IPCC guidelines, those emissions are detailed for three key activities: main activity electricity and heat production; petroleum refining; and manufacture of solid fuels and other energy industries.
  - *Manufacturing industries and construction:* emissions generated by the **use of energy products** in industries and construction activities. The industries include: iron and steel; non-ferrous metals; chemicals; pulp, paper, and print; food processing, beverages and tobacco; non-metallic minerals; transport equipment; machinery; mining (excluding fuels) and quarrying; wood and wood products; construction; textile and leather; and other non-specified industries.
  - *Transport:* emissions from the use of fuels by civil aviation, road transportation, railways and water-borne navigation. It may include other transport, such as by pipeline.
  - *Other sectors:* direct emissions by fuel combustion in agriculture (fuels used in agricultural machinery), commercial and institutional sectors, and residential emissions. Residential emissions include emissions from burning of fuel for heating and cooking, but not for passenger cars.
  - *Non-specified:* stationary and mobile emissions from non-specified industries.

- **Fugitive emissions from fuels:** emissions allocated to **fossil fuel mining**. This includes fugitive emissions from solid fuels (coal mining and handling), extraction of oil and natural gas (including venting and flaring of oil and natural gas), and other emissions from energy production (such as fugitive emissions from charcoal production, biochar production, coke production and gasification transformation processes such as coal to liquids).

GHG emissions data are drawn from the Third National Communication [11]. Table 8 presents details on how emissions are allocated to the SUT industries. The main emissions categories are in grey and the details under each category are in white. The sum of the detailed categories in white corresponds to the main categories. This shows that 90 percent of energy emissions have a direct corresponding industry, while the remaining 10 percent are allocated among different industries based on energy consumption in the energy SUT (for broad sectors) and value added (for detailed industries inside broad sectors).

Table 9: Allocation of energy emissions from original activity reported in the national inventory to the industry classification in GJAM Nigeria

ACTIVITY IN THE INVENTORY	SHARE OF ENERGY EMISSIONS	ALLOCATION TO SUT INDUSTRIES
Energy Industries	**42.6%**	
Electricity generation	35.3%	Electricity, gas, steam and air conditioning supply
Petroleum refining	0.8%	Oil refining
Manufacture of solid fuels	0.01%	Oil refining
Other energy industries	6.6%	Electricity, gas, steam and air conditioning supply
Manufacturing Industries and Construction	**9.0%**	
Non-specified	9.0%	Allocated to all mining and quarrying, manufacturing, water supply and waste management, and construction based on the use of energy in the energy SUT and value added
Transport	**29.6%**	
Domestic aviation	0.1%	Air transport
Road transportation	28.3%	Road transport
Railways	0.1%	Rail Transport & Pipelines
Domestic water-borne navigation	1.1%	Water Transport
Other Sectors	**12.7%**	
Commercial/ Institutional	1.8%	Allocated to all service industries, except construction and the four transport industries detailed above transport, based on the use of energy in the energy SUT and value added
Residential	10.8%	Allocated directly to households
Agriculture/ Forestry/ Fishing/ Fish farms	0.04%	Allocated between crops production, livestock, forestry, and fishing, based on value added in each industry
Fugitive emissions from fuels	**6.1%**	
Oil and natural gas	6.1%	Crude Petroleum and Natural Gas

IPPU emissions from IPPU

Following the 2006 IPCC guidelines [49], IPPU emissions are reported for the three gases and divided into main industrial processes. This covers non-energy industrial emissions; for example, those produced by chemical and physical reactions in industrial processes. The IPCC guidelines require that inventories for IPPU emissions cover the mineral industry, chemical industry, metal industry, non-energy products from fuels and solvent uses, electronics industry, product uses as substitutes for ozone depleting substances, and other product manufacture use.

The IPPU emissions for GJAM Nigeria include CO_2 emissions from cement production, CO_2 emissions from ammonia production, and CO_2 and CH_4 emissions from iron and steel production.

AFOLU emissions

AFOLU emissions cover emissions and removal processes, including from livestock (enteric fermentation and manure management), land use (managed soils, rice cultivation, liming, urea application), prescribed burning of forest land and crops residues, and deforestation.

AFOLU emissions for Nigeria include CH_4 emissions from livestock, CH_4 and N_2O emissions from burning croplands and grasslands, N_2O emissions from managed soils and manure management, and CH_4 emissions from rice cultivation. This model allocates emissions that can be allocated to economic activities. Thus, emissions from deforestation are not included, as deforestation is a "one-time event" in order to access land. Changes in deforestation emissions cannot be estimated using an economic model.

Emissions from managed soils are allocated to agriculture, livestock and forestry, based on value added in these three industries.

Waste emissions

Waste emissions include those from open burning of waste and wastewater treatment. All waste emissions are allocated to the industry, "Water supply, sewerage, waste management and remediation."

Emissions from burning of solid biomass

Emissions from biomass burning estimated for 2016 provide the basis for accounting for firewood and charcoal consumption in the Nigerian economy. Total emissions (and physical and monetary amounts) were distributed as described in section A.2.4.1. Emissions from solid biomass are assumed to be all from firewood and charcoal, which are mostly from unmanaged production [32,50]. We assume that all emissions from firewood are additional to emissions from other sources, as the collection of firewood from unmanaged forests would contribute to deforestation and depletion of carbon sinks in Nigeria. We do not add emissions from modern biofuels (e.g., biodiesel and ethanol) as emissions from biomass, as they would likely come from managed biomass sources, with a net-zero effect on carbon emissions.

Emissions extensions for new industries

To estimate emissions extensions for new industries, we assume that they are proportional to the use of products responsible for direct emissions. Those are detailed in Table 9. For example, hydropower electricity uses 0.02 percent of fossil fuels in the original electricity industry. Therefore, 0.02 percent of CO_2 emissions from fuel combustion (fossil fuels) is allocated from the electricity industry to hydropower and the remaining is allocated to fossil electricity.

Table 10: Products used to estimate GHG emissions from new industries

EMISSION INDICATOR	PRODUCTS USED AS REFERENCE FOR SCALING EMISSIONS
CO_2 emissions from combustion of solid biomass fuels	Firewood and charcoal
CO_2 emissions from fuel combustion (fossil fuels)	Fossil fuels extraction; coke oven products; refined petroleum products
CO_2 emissions from industrial processes and waste treatment	Mining and quarrying; basic chemicals; cement, lime and plaster; sewerage; waste collection
CH_4 emissions from fuel combustion (fossil fuels) and industrial processes	Fossil fuels extraction; mining and quarrying; coke over products; refined petroleum products; production and distribution of gas
CH_4 emissions from agriculture activities and waste treatment	Crops and livestock products; sewerage; waste collection
N_2O emissions from all activities	Crops and livestock products; forestry products; fossil fuels extraction; coke over products; refined petroleum products; fertilizers and pesticides; production and distribution of gas; sewerage; waste collection

The exception to this approach was to divide gas electricity and petrol/diesel electricity. The distribution of emissions from fuel combustion was based on the share of electricity production and differences in emission factors of CO_2 emissions by energy use for different fuels [51].

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