International Labour Organization

MINISTÈRE DU TRAVAIL, DE L'EMPLOI ET DE L'INSERTION
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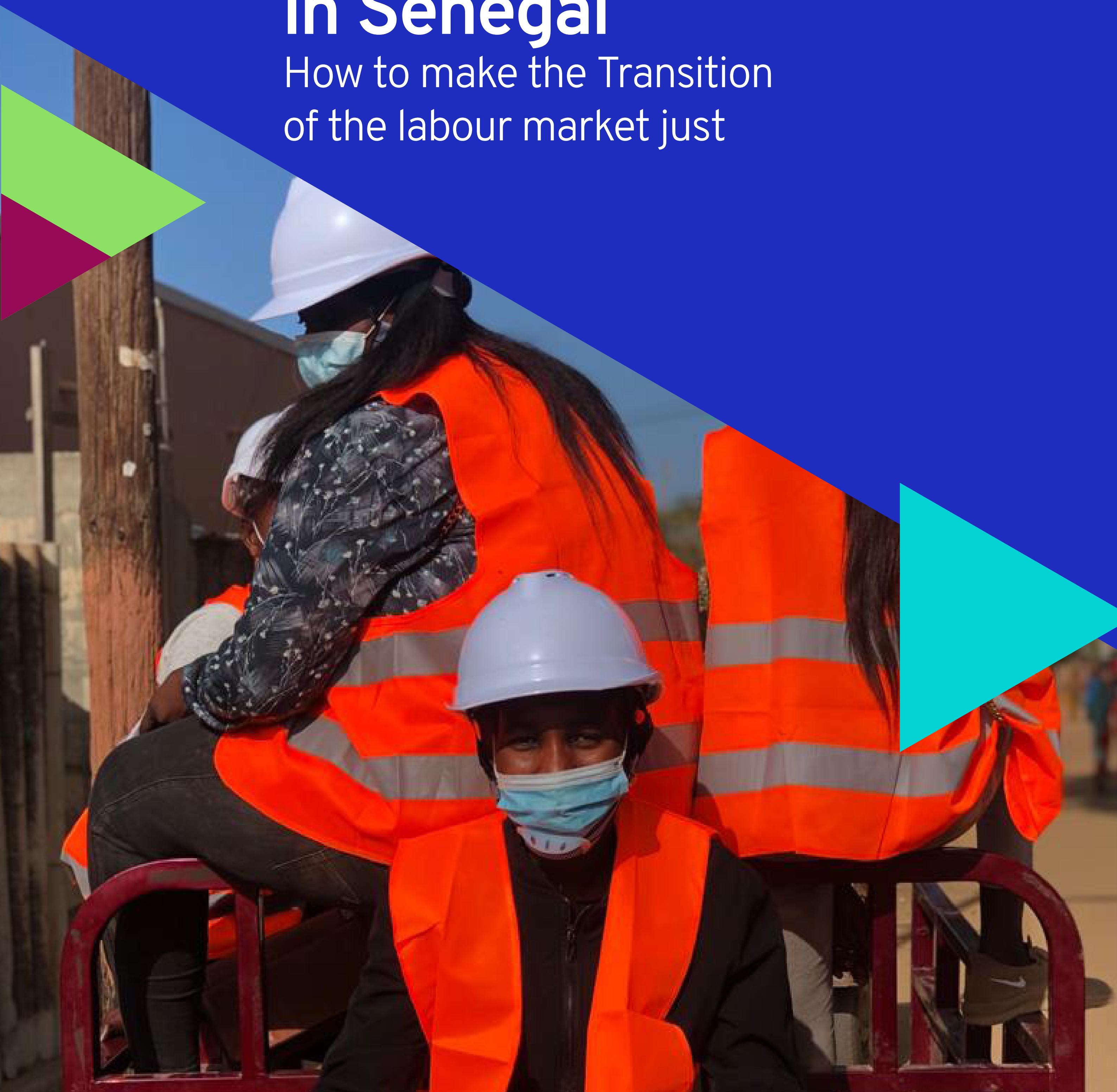
The Job impacts of Climate policies in Senegal

How to make the Transition of the labour market just



First published 2025.

ISBN: 9789220430118 (web PDF)

DOI: https://doi.org/10.54394/SAWN2326

Also available in French: *Impact des politiques climatiques sur l'emploi au Sénégal: Comment assurer une transition juste du marché du travail*, ISBN 9789220430125 (web PDF).

Acknowledgements

This just transition modelling report was produced by the ILO at the request of the Government of Senegal, on behalf of the Ministry of Labour, Employment, and Institutional Relations and the Ministry of Environment and Ecological Transition. It received invaluable financial support from, the "social dimension of the ecological transition" project funded by the French government and was the work of several stakeholders. To this end, the ILO and the Government of Senegal wish to express their recognition and sincere acknowledgements to the following people and institutions who ensured the success of this project.

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List of abbreviations

Abbreviations	Signification
AEC	African Economic Commission (United Nations)
ASH	Autorité Sanitaire Halieutique
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium
CH_4	Methane
CO_2	Carbon dioxide
CRED2	Centre for Studies and Research in Energy Economics and Sustainable Development
DGEP	Direction Générale de l'Économie et du Plan
DSGE	Dynamic Stochastic General Equilibrium
E3Analytics	Entreprise spécialisée dans l'analyse énergétique
EDGAR	Emissions Database for Global Atmospheric Research
EEZ	Exclusive Economic Zone (Zone économique exclusive)
EPM	Enquête Permanente auprès des Ménages
FAO	Food and Agriculture Organization
FTE	Full-Time Equivalent (Équivalent temps plein)
GAIN	Green Jobs Assessment Institutions Network
GDP	Gross Domestic Product (Produit Intérieur Brut)
GFCF	Gross Fixed Capital Formation (Formation brute de capital fixe)
GHG	Greenhouse Gas (Gaz à effet de serre)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GJAM	Green Jobs Assessment Model (ancien nom du JTAM)
ILO	International Labour Organization
IMF	International Monetary Fund
INFORUM	Interindustry Forecasting Project at the University of Maryland
INSTAT	Institut National de la Statistique de Madagascar
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification
JTAM	Just Transition Assessment Model
LCU	Local Currency Unit (Unité de devise locale)
LULUCF	Land Use, Land-Use Change and Forestry
MA2P	Modèle d'Analyse et de Projection de la Politique économique
MCMM	Modèle de Cadrage Macroéconomique de Madagascar
MEIO	Macro-Econometric Input-Output
MGA	Ariary malgache (devise de Madagascar)
MIDAS	Mixed-Data Sampling
MISA	Modèle d'Impact Sectoriel et d'Analyse
MPEB	Ministère de la Pêche et de l'Économie Bleue
N_2O	Protoxyde d'azote
NA	Not Applicable
NPISH	Non-Profit Institutions Serving Households
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing Power Parity (Parité de pouvoir d'achat)

Abbreviations	Signification
RGPH	Recensement Général de la Population et de l'Habitat
SINTEF	Stiftung für industrielle und technische Forschung (Foundation for Scientific and Industrial Research)
SNDAM	Stratégie Nationale de Développement de l'Aquaculture et des Pêches à Madagascar
SNEB	Stratégie Nationale de l'Économie Bleue
SUT	Supply and Use Tables (Tableaux des ressources et des emplois)
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNSTATS	United Nations Statistics Division
USD	US Dollar
WWF	World Wide Fund for Nature

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1. Executive Summary

The ambition of the Senegalese authorities, as set out in Vision 2050, is to make Senegal a sovereign, fair, prosperous country, rooted in strong values, within 25 years. This vision requires maintaining a high level of economic growth of around 6.5% in order to join the group of emerging countries. Achieving this strategic orientation and the 2024-2028 development plan involves, in particular, significantly reducing poverty while ensuring high levels of employment among young people, which presents major challenges.

Although hard economic growth factors often make the headlines, of overarching concern, but often underestimated, are the intensifying impacts of climate change. The reason why climate and the environment are not given sufficient consideration is that they are neither associated with high levels of GDP growth nor recognized as key drivers of economic growth.

In reality, natural assets and climate already shape Senegal's main economic growth sectors: tourism, agriculture, construction, and energy. Increased frequency of climate disasters, floods, and droughts hinders economic development, leading to job losses and destruction of livelihoods. Climate change disproportionately affects low-income households, reversing progress made in reducing poverty and mitigating inequality.

In addition, the global geopolitical power struggle over energy security and the future of industries is impacting Senegal's current and future growth. Severe competition between China, Asian economies, the US and EU is unfolding to dominate the future of economic growth, powered by artificial intelligence, green industries, electric vehicles, batteries, and renewable energies.

Both challenges, the climate impacts and the global race to green growth, require Senegal's economic and labour market structure to rapidly adapt. On the one hand, it must adapt to the consequences of climate impacts. On the other hand, it must ensure the growth strategy is based on future industries.

It is in this context that this study sets out to assess alternative policy options the Government has at its disposal to achieve its vision 2050. And, at the same time, face the challenges of climate change, poverty and inequality, un- and underemployment, and future economic growth.

This study proposes two major alternatives for action, which are evaluated and compared with a baseline scenario of maintaining the status quo. These projections are drawn from climate and energy policies aimed at transforming agricultural production systems.

In the agricultural scenario, several strategic changes in agricultural practices, such as resource use, energy consumption, and economic restructuring in several sectors of the economy, are simulated, with an emphasis on climate sustainability.

The energy scenario emphasizes the rapid expansion of solar, wind, and hydroelectric power, aiming to provide renewable electricity to the population and industry as a whole, thereby reducing dependence on thermal energy.

Results in both scenarios point to a significant increase in employment and economic growth by 2035. As compared to a business-as-usual scenario, an additional 350,000 new jobs could be created while economic growth could advance by some 2 percentage points.

Agriculture
Policy conclusions are drawn, pointing to the importance of addressing climate change impacts in the agricultural production system. Notably, agriculture extension services, social protection, and skills training policies are required to expand climate-smart agriculture and agroindustry, and processing. This would ensure food security and employment, notably among the rural population. This would also reduce poverty and inequality. This is because rural areas tend to be poorer, more impacted by extreme climate events, and more reliant on natural resources.

To safeguard tourism and employment in fishing, forestry and agriculture, nature-based solutions, such as mangrove planting, wetland and forest restoration and natural defences are required. This will address coastal erosion, loss of prime beach destination resorts, desertification and deforestation. In addition, the agriculture, tourism and industry policies must be matched with social protection schemes to protect jobs against climate disasters, loss of income from fisheries, tourism and forestry.

Energy
- The State should step up the integration of environmental objectives into policies related to renewable and industrial energy, incentives, investments and capital expenditure, in order to accelerate the transition to green construction and sustainable energy sectors.·
- Sustainable energy policies should also include provisions for retraining, upskilling and relocation. This will facilitate the professional transition of workers from traditional fossil fuel, charcoal and firewood businesses to emerging green energy industries.·
- Social protection must be extended and regional funds deployed to ensure that declining regions, industries and employment hubs can make the structural change.

Fiscal policies and domestic financing
The assessment outlines a fiscally neutral polluter-pays system with progressive emissions or a carbon price. A contribution could be levied on the wealthiest percentile of the population, consisting of those who can afford a slight increase in energy prices. The revenue could then be pooled into a just transition fund to finance investments in renewable energy and vocational training. It would also finance social protection for low-income households and those most affected and least able to cope with climate change. The collateral impact of such a programme, which could be modelled on the European Union's Just Transition Fund, would be to reduce poverty and inequality.

2. Background

The Senegalese economy has not escaped the adverse effects of climate change, which include rising temperatures, rising sea levels, and more fragile ecosystems. In response, the political authorities have defined a Nationally Determined Contribution (NDC) in line with the Paris Agreement and submitted to UNFCCC in 2020 (CDN 2020).

Despite periods of sustained economic growth, except during the COVID-19 pandemic and the international crisis, social deficits persist. Unemployment rose to 22.3% by 2023, with a pronounced disparity between women (35.0%) and men (12.7%). Thus, promoting the green economy appears to be an appropriate response, aiming to combine robust economic growth with improved social indicators and optimal management of environmental risks and natural resources.

Senegal's commitment to sustainable development, as expressed in its Emerging Senegal Plan (PSE), has been reaffirmed by Senegal 2050 – National Transformation Agenda, which sets out a long-term vision based on four pillars: sovereignty, social inclusion, economic competitiveness and environmental sustainability. This vision is set out in the National Development Strategy (SND) 2025-2029, which focuses on ecological transition, climate resilience and the creation of sustainable jobs.

Furthermore, Senegal has relied on the Partnership for Action on Green Economy (PAGE) to promote green recovery and the creation of green jobs. However, the effectiveness of the transition policy must be assessed by measuring its impact on social indicators and the labour market.

The International Labour Organization's (ILO) initiative to assist countries in developing a green jobs assessment tool is a welcome development. This tool will help inform climate policy decisions and facilitate dialogue among stakeholders by assessing the impact of different measures on the overall economy, different sectors and stakeholders' situation.

This report therefore aims to:
- Present the Just Transition Assessment model for Senegal;
- Analyse climate policy scenarios;
- Discuss the policy implications of the findings.

3. Current state of the Economy, Employment and Emissions

Senegal is the westernmost country on the African continent, with 700 km of coastline. It is bordered by Mauritania, Mali, Guinea Conakry, Guinea-Bissau, and Gambia. It ranks as the second-largest economy in the West African Economic and Monetary Union (WAEMU), following Côte d'Ivoire. Senegal's economic growth has accelerated sharply since the mid-1990s, and the World Bank has classified it as a lower-middle-income country in 2019, with a gross national income per capita of US$1,410 in 2018. Despite robust economic growth, Senegal has struggled to create enough decent jobs, resulting in a slow decline in poverty. Poverty rate fell from 38% in 2011 to 32.9% in 2019. However, the COVID-19 pandemic has exacerbated the situation, with the World Bank estimating that an additional 600,000 people have fallen into poverty as a result.

3.1 Economic performance

Senegal's economic situation is marked by political and social stability following a period of political tensions, culminating in a peaceful presidential election. The country's average annual growth rate of GDP[1] during the pre-COVID-19 pandemic period (2010-2019) was about 5%, which was above the average for sub-Saharan Africa and the CFA Zone. Despite the COVID-19 pandemic, Senegal avoided a recession in 2020, achieving a growth rate of 1.3%, due to favourable rainfall and counter-cyclical government support measures for businesses and households. However, economic growth slowed to 4.2% in 2023, slightly below the 4.6% rate in 2022. This deceleration is due to a sharp slowdown in the secondary sector and a contraction in the primary sector (-0.5%) caused by a less favourable agricultural year, combined with ECOWAS sanctions against Mali, Senegal's main export market.

Growth has also been hampered by persistent inflation, rising world commodity prices, unfavourable rainfall patterns and an overall economic slowdown linked to Russia's invasion of Ukraine. Inflation reached a record 9.7% in 2022, driven by soaring food prices. To contain these inflationary pressures, the BCEAO revised the minimum liquidity injection rate to 3% and the marginal lending rate to 5%, while the government increased energy subsidies to 4% of GDP and significantly reduced public investment (ANSD 2023a).

Senegal's economic growth has not sufficiently benefited the poor. Surveys carried out by the national statistics and demography agency (ANSD) show that, outside the capital, Dakar, the number of people in poverty increased in urban areas (327,620 new poor) and nationally (200,048) between 2011 and 2019. According to the World Bank, the poverty rate remained stable at around 37% in 2022, as growth is primarily driven by urban services, while the poor predominantly rely on rural agriculture.

1. Data source: Ministry of Economics, Planning and Cooperation

The continuation of the public infrastructure development programmes and food and energy subsidies has led to an increase in the budget deficit to 4.8% in 2023. However, a significant increase in government revenues (23%) reduced the budget deficit slightly to 6.1% of GDP in 2022 from 6.3% in 2021.

The accumulation of government deficits since COVID-19 has pushed public debt from 64% of GDP in 2019 to 75% in 2022. Public debt has been growing at an accelerated pace due to shock mitigation measures and additional borrowing by state-owned enterprises to finance investments in the oil and gas sector. It now exceeds the 70% of GDP ceiling, which is a convergence criterion for WAEMU countries, reaching about 80% of GDP in 2023, compared to 73.3% in 2021 and 76.6% of GDP in 2022.

Senegal's external situation has deteriorated due to sanctions imposed on Mali and rising import bill, widening the current account deficit to 15.1% of GDP in 2023.

The banking sector remains resilient, with a significant 20.2% increase in credit to the economy. In 2022, the default rate slightly decreased to 11.2% from 11.5% in 2021. However, delays in hydrocarbon production, lower private investment and exports, a contraction in industrial production and increased borrowing costs on domestic and international markets have impacted economic performance (World Bank, 2023).

The outlook is favourable, with strong economic activity expected, driven by the secondary sector, mainly industrial production. The start of hydrocarbon exports and enhanced revenue mobilization efforts are expected to help reduce the budget deficit to 3% of GDP by 2025. However, in the short term, the impact of the war in Ukraine will continue to be felt on basic food prices, although lower commodity prices mitigate it.

Senegal is also highly vulnerable to climate change and the regional security situation. The country faces considerable economic impacts due to its climate change vulnerability. Senegal's carbon footprint is significantly lower than that of developed countries. As a result, the country is expected to receive about USD 2.76 billion annually in compensation. The annual funding gap for climate resilience is estimated by the African Development Bank (ADB 2023) at USD 1.1 billion, and climate finance needs are estimated at USD 13 billion according to the Nationally Determined Contribution (CDN 2020). Thus, exploring climate finance at local and international levels is crucial to ensuring energy transition and resilience to climate change. The contribution of the private sector to climate finance in Senegal remains low. The country has implemented several measures to attract private investment by establishing a clear regulatory framework and innovative financing mechanisms. However, these sources of funding are still underutilized by the private sector. The accreditation of Crédit Agricole with the Green Climate Fund marks a significant step in mobilizing private-sector involvement in climate finance.

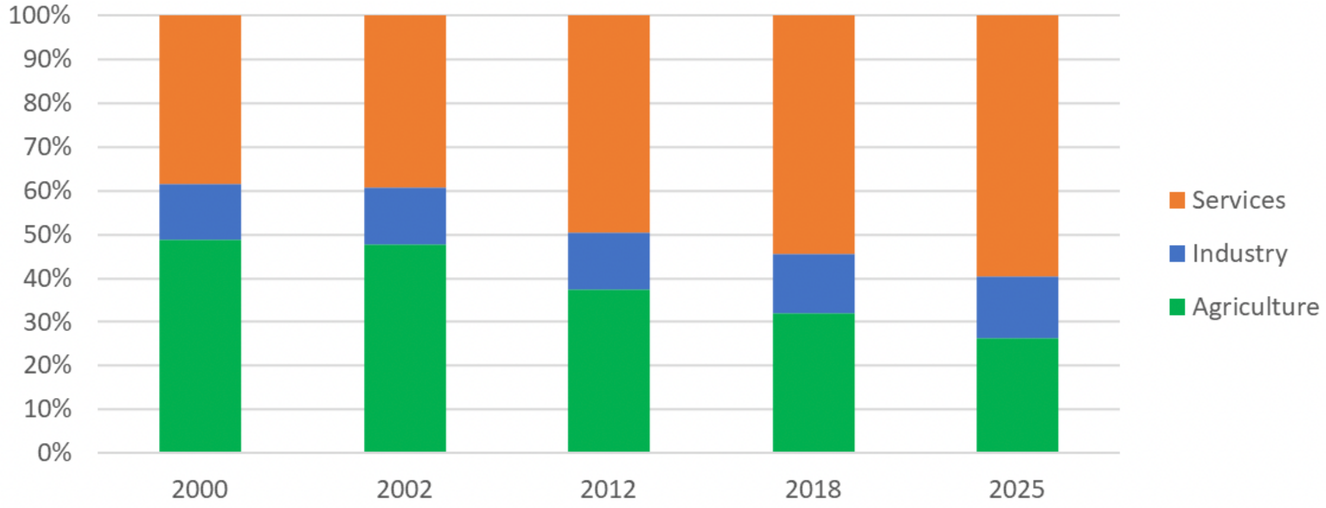
3.2 Employment by industry

The high level of unemployment in Senegal, which stood at 22.3% in 2023, disproportionately affects young people aged 15-24 and women, highlighting a significant imbalance in the labour market. Structural changes in the economy are evident in the evolving employment structure. The share of agricultural employment in total employment has steadily declined, falling by more than 16 percentage points between 2000 and 2018. In contrast, the proportion of industrial employment in has remained relatively stable, increasing by less than one point during the same period. This indicates that Senegal has not yet succeeded in reversing the phenomenon of "early deindustrialization" that many developing and African countries experienced from the 1980s due to structural adjustment programs.

Workers leaving the agricultural sector have predominantly moved to the service sector, see Figure 1. The service sector's share of has risen significantly, matching the decline in agricultural employment by 16 percentage points between 2000 and 2018. However, with the exception of sectors such as banking, insurance and the hotel industry, most industries in Senegal are dominated by informal activities, including trade, transport, catering, etc. As a result, employment in Senegal is largely informal, failing to meet the decent work criteria, and many workers remain "poor in employment".

▶ Figure 1. Distribution of jobs by sector

Source: World Development Indicators of the World Bank (World Bank 2022), authors' calculations



According to an employment survey conducted by the Agence Nationale de la Statistique et de la Démographie (ANSD) in 2018, medium-sized companies are the biggest providers of formal employment for 44% of the total (ANSD 2019). They are followed by large companies and small businesses, which employ 39.0% 17.0% of the total workforce, respectively.

Figure 2 shows that employment is concentrated in agriculture, trade, manufacturing and agri-food production. In agriculture, employment is dominated by men in both urban and rural areas. In trade, on the other hand, women occupy a dominant position in both urban and rural area

▶ Figure 2. Employment by industry, gender, and location

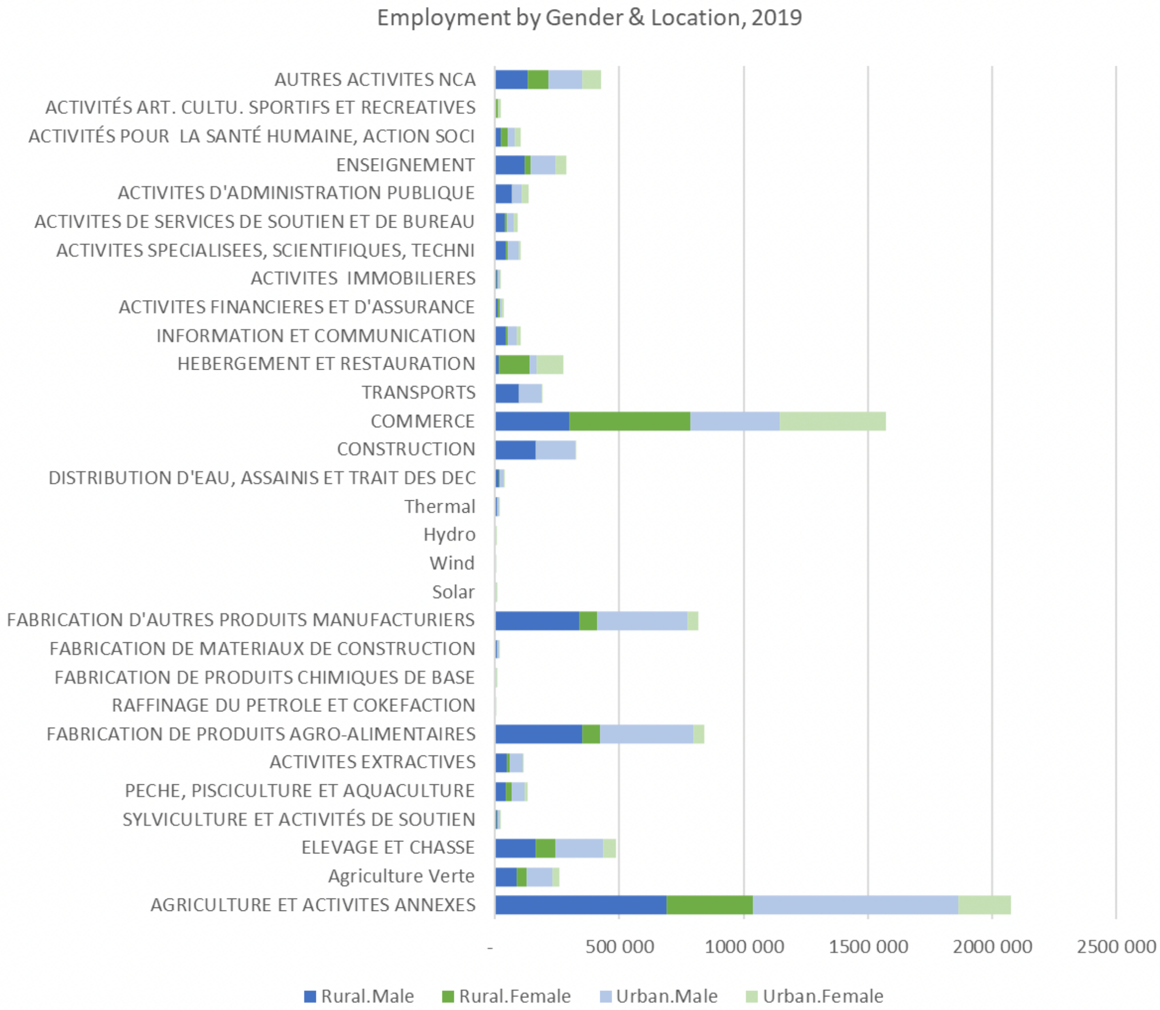


Figure 3 shows that workers mainly occupy agricultural employment with little or no primary education. However, the proportion of uneducated workers is rather low in urban agricultural areas. In urban areas, there is a significant proportion of workers with tertiary education.

Employment in commercial activities is dominated by educated workers (primary, secondary or tertiary level). In rural areas, on the other hand, commercial jobs are held mainly by uneducated workers.

The profile of employment in manufacturing activities is quite similar to that in the production of agri-food goods. In these activities, the proportion of uneducated workers is rather low. A significant proportion of workers have secondary or tertiary education.

▶ Figure 3. Employment by industry, education level, and location

3.3 GHG emissions by industry

In 2005, the greenhouse gas emissions profile of Senegal by sector was 49% for agriculture, 40% came from energy, 7% from waste and 4% from industrial processes and product use. The total of these emissions amounted to 13,084 Gg CO_2e, with an emission of 1.2 tonnes of CO_2 per inhabitant for a population of 10,817,844 inhabitants. (Source: 3rd National Communication on Climate Change - 2020).

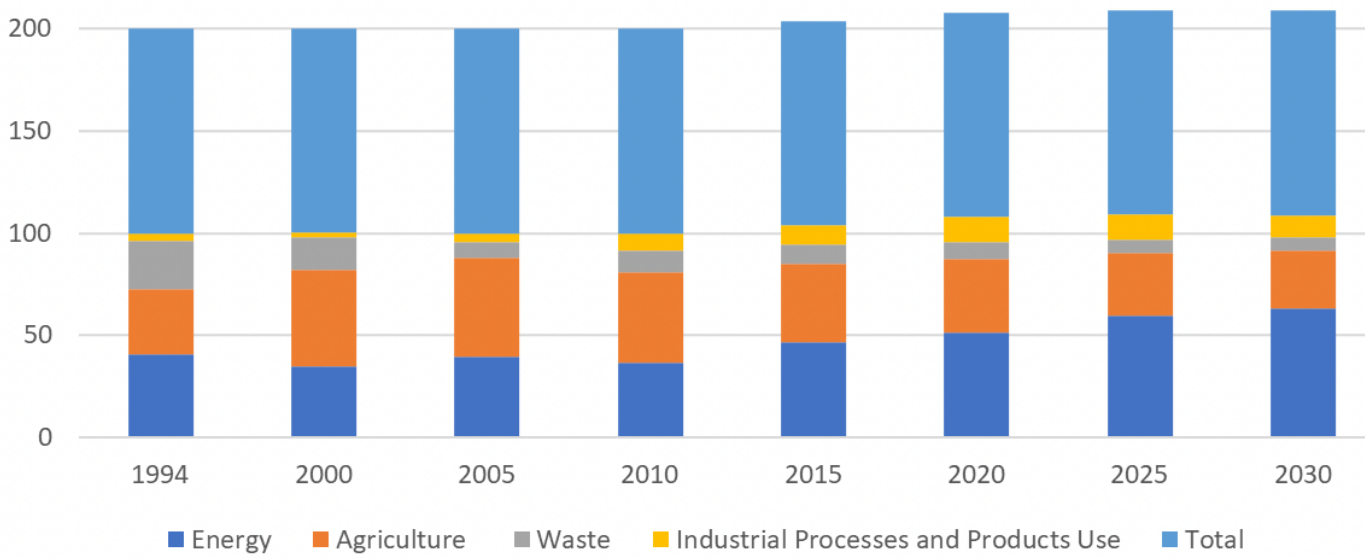
In 2010, total net emissions reached 16752 Gg CO_2 equivalent, of which 76% was carbon dioxide, 6% methane, 6% nitrous oxide and 2% fluorinated gases. These emissions are expected to more than double by 2030 to reach 37,761 Gg CO_2e.

The trend indicates that two sectors are presenting themselves as the main GHG emitters at the national level. The energy sector will experience exponential growth, contributing to about 50% of the country's total emissions by 2022, largely due to the start of oil and gas production from 2022. Emissions from the agriculture sector will also increase gradually and steadily, until 2030. Enteric fermentation will remain the major emission category in this sector.

However, Senegal commits, unconditionally and conditionally, to reduce its GHG emissions, respectively in 2025 and 2030, in each of the different sectors of the Senegalese economy, compared to the projected emissions for the same years, according to a scenario 'Business as Usual', based on a number of assumptions. These emission reductions set to achieve an unconditional target (CDN target) will represent respectively 5% and 7%, in 2025 and 2030, on the basis of domestic and controlled financing. Compared to the conditional target (CDN+ target), these reductions will reach 23.7 and 29.5% respectively, in 2025 and 2030, provided substantial support is received from the international community.

▶ **Figure 4. Emissions overview for the three national communications and projections by sector to 2030 (Gg CO_2e)**

Source: Senegal NDC, 2020



The residual capacity of forest sequestration is 5997 Gg ECO_2, offsets emissions from other sectors which amount to 9318 Gg ECO_2. This results in net emissions of 3321 Gg ECO_2;

The sectoral breakdown follows:

- Energy = 3788.6 Gg ECO_2 = 40.6%
- Agriculture = 2957.6 Gg ECO_2 = 31.7%
- Waste = 2226.2 Gg ECO_2 = 24%
- Industrial Processes = 345.5 Gg ECO_2 = 3.7%
- Forests = -5997 Gg ECO_2, approximately 64% sequestration capacity relative to emissions.

44% of emissions from energy sources are attributable to industry, 32% to transport and 24% to households and other sectors.

The net emissions in Senegal, for the year 1994, are thus estimated at: 3321 Gg ECO_2 for a population of 8.133.000 inhabitants, thus: 408.3 kg ECO_2 inhabitants/ year or 1.12 kg ECO_2/ inhabitant/ day.

It was also seen that the energy sector was responsible for 40.6% of emissions outside forests, of which almost half (44%) is linked to industrial activities.

The strategies for reducing and/or stabilizing GHG emissions will focus on energy efficiency programs on the one hand, and on the other, capacity building for forest sequestration.

Finally, Senegal's share of global emissions due to energy excluding biomass is 4 shares out of 10,000.

4. Green policy scenarios

4.1 Just Transition assessment modelling

JTAMSenegal is a macro-econometric input-output (MEIO) model, based on data from National Agency of Statistics and Demography of Senegal (Agence Nationale de la Statistique et de la Démographie, ANSD). The main data sources are the System of National Accounts, supply-and-use tables (ANSD 2022b), the GHG inventory (DEEC 2015), and household and labour force surveys (ANSD 2019, 2021). JTAMSenegal is following the same philosophy and modelling approach as taken for MEIONorway (Aponte et al. 2021; Wiebe et al. 2022) and the models in several other Green Jobs Assessment Reports[2], e.g. Nigeria, Zimbabwe, Turkey, Burkina Faso, or Ghana[3].

JTAM is structured as follows:

- Section A.1 gives a short background on the modelling philosophy,
- Section A.2 gives an overview on existing economic models in Madagascar,
- Section A.3 a description of how to use these types of models for policy analysis
- Section A.4 a detailed description of the data used.

The Just Transition Assessment Models (JTAMs) quantify the impacts of policies on:

1 The economy. Gross value added corresponds to the GDP by industry, giving insights into the effects of climate policies to national GDP growth, and on the growth or decrease of each industry's economic activity

2 Greenhouse gas emissions. Besides direct changes due to, for example, a decrease of coal electricity, it also considers the net changes in emissions, including increased emissions from infrastructure investments, and from increased or decreased economic activities in other industries.

3 Employment. The model gives insights of the potential increase or decrease of the demand for workers in different industries. By including information on the structure of workers in each industry, per gender, skill level, and formality status, it can measure how the demand for skills will change in the economy, and how it can affect workers in disadvantaged groups.

The results of the green scenarios are always assessed relative to a reference (baseline) scenario: This serves as a baseline to which the development in the green scenario can be compared. Here, we assume, for the baseline, that the economy grows (as specified in more detail in section A.5 of the appendix), but that the general structure of the economy does not change: industries continue to produce with the same production technology, and import shares of products remain stable.

It is important to note that JTAM are not economic forecasting models. Rather, these 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 show how changes in individual economic activities influence the economic structure and reflect on direct, indirect, and induced effects.

2. The Green Job Assessment Model (GJAM), now renamed the Just Transition Assessment Model (JTAM), reflects a major conceptual shift. This change in name marks the shift from an approach focused solely on assessing green jobs to a more holistic perspective, integrating them into a just transition dynamic. This encompasses the social, economic and environmental dimensions of climate change policies in a cross-cutting manner.

3. The reports are available for download at http://www.ilo.org/gain.

How Just Transition Assessment Models work?

Just Transition Assessment Models are built to answer one main question: **How do climate and other green policies affect workers?**

Here is how it works:

First, policies questions are translated into scenarios, describing these policies in values such as:

- **Which are the industries directly affected?** For example, electricity generation industries when shifting from coal to solar and wind electricity

- **How fast and by how much do green industries grow?** For example, how does the electricity mix change year by year, by increasing green electricity and decreasing in coal shares?

- **What are the investments needed for this transition?** Investments include, for example, goods, services, research, and training.

Next, these scenarios are implemented in the model:

- A baseline scenario for economic growth is built using macro-econometric parameters for economic and population growth
- New green industries are added to the supply-and-use table
- Annual changes in the market shares of green and traditional industries supplying products according to green industries' growth
- Annual investments in green industries distributed in products as additional investments to the economy or replacing investments in traditional (such as coal) industries.

Finally, the model quantifies direct impacts on the industries affected, and how these changes affect the demand for goods and services from other industries (and how increase or decrease of economic output from these other industries affect the demand from other industries, and so on).

The results of the JTAM model, then, comprise all (direct and indirect) impacts of the modelled policies on the economic output of every industry in the national economy, and how these affect workers and greenhouse gas emissions in each industry.

4.2 Green Agriculture scenario

This scenario focuses on transforming conventional agriculture into "Green Agriculture" (Agriculture Verte) by 2030 as specified in Senegal's NDC. This transition involves several strategic shifts in agricultural practices, resource use, energy consumption, and economic restructuring across multiple sectors in the economy, emphasizing sustainability and reduced environmental impact.

To implement this transformation into our model, we applied three changes. Firstly, we shifted market share from conventional agriculture to green agriculture. We assumed that this aligns with one of the objectives of the NDC, which is to achieve a soil regeneration rate (RSR) of 28% by 2030 (CDN 2020), up from the current 11% (DAPSA 2021), thus necessitating an annual increase of 9.8%. Accordingly, the market share for the current agricultural product, "Produits de l'Agriculture et Activites Annexe," is set to decrease annually, reaching a reduction of up to 2.5% by 2029, transitioning to the new green agriculture products.

Secondly, we have integrated changes into our model to reflect the strategic shifts toward sustainable practices in the use of agricultural inputs such as fertilizer, water and energy uses, as outlined by the NDC. Specifically, the NDC targets a significant reduction in the use of chemical products, such as reducing the area from 45,000 hectares treated with chemical fertilizers in 2020 to 14,400 hectares by 2030. This reduction translates to an average annual decrease of 12.33% until 2030, which we have implemented as an annual reduction in the use of chemical products in our model. This change signifies a transition from reliance on chemical fertilizers to the utilization of compost and organic materials within the agriculture sector.

Additionally, we anticipate that shifts in water and energy usage within green agriculture will positively impact employee compensation by reallocating financial resources saved through more efficient energy use. In particular, our model includes reductions in refining and coking products starting in 2025 and continuing through 2030, with an annual decrease of 1.66%. This adjustment corresponds to the planned "replacement of fuel oil by natural gas in dual thermal power plants and the transformation of the 320 MW Jindal coal-fired power plant into a combined-cycle gas-fired power plant" over the same period (CDN 2020). We assume a fixed replacement rate annually to achieve the cumulative 320 MW by 2030. This fixed rate represents the average over the 2025-2030 period, and the savings from this replacement are reallocated each year to enhance employee remuneration.

Furthermore, the electricity and gas sector, "Electricité, Gaz Et Supports Energétiques" is set to an annual reduction of 1.44%, with each year's savings in energy costs similarly redirected towards increasing employee compensation. We derived this figure utilizing the projected increase in the renewable energy penetration rate to 18% by 2022, up from 13.7% in 2019, as stipulated in the (CDN 2020). To achieve this target, we have calculated a constant average annual increase based on the share of inputs from green agriculture in the electricity and gas sector being reallocated to employee compensation.

When it comes to water use, we set a reduction of 1% by 2030. The strategy for adjusting inputs into the products of the "Water production and distribution, sanitation, waste treatment and depollution" branch is based on the average of waste emissions reduction percentages from the CDN and CDN+ initiatives, adjusted according to their respective quantities of emissions from the waste sector. Consequently, this rate is adopted as the reduced share of inputs from green agriculture in products from the "Waste management and remediation" sub-branch. These adjustments are then redirected to enhance employee remuneration, aligning financial savings with improvements in worker benefits within this sector (estimated from Senegal's CDN 2020).

Thirdly, the table below illustrates the distribution of investments we have inputted in our model corresponding to sectors such as construction, manufacturing, and information and communication technology (ICT) from 2020 to 2030, to support the Green Agriculture. This investment distribution highlights that manufacturing and construction account for 99% of the total investment directed towards supporting infrastructure and capabilities essential for green agricultural practices.

Table 1
Distribution of Investment on Green Agriculture

Product	Share (%)
Autres Produits Manufactures nca	51%
Constructions et Travaux Construction	48%
Services d'Information et de Communication	1%

Source: Own calculation based on data from Senegal's CDN 2020 and SUT

Figure 5 depicts the annual changes in GDP (Value Added), employment (Labor), and GHG emissions under the Green Agriculture scenario compared to a baseline from 2020 to 2035. From this figure, we observe that GDP, labor, and GHG emissions show growth until around 2030, where they peak before slightly declining thereafter. The labor curve closely follows the GDP curve, indicating that the economic growth in this scenario is likely accompanied by increased employment opportunities. Overall, the results from this scenario show positive outcomes in terms of economic gains, employment, and reduced GHG emissions, highlighting the benefits of transitioning to Green Agriculture practices.

▶ Figure 5 . Annual changes in Value Added, Employment, and GHG emissions in Green Agriculture scenario compared to the baseline.

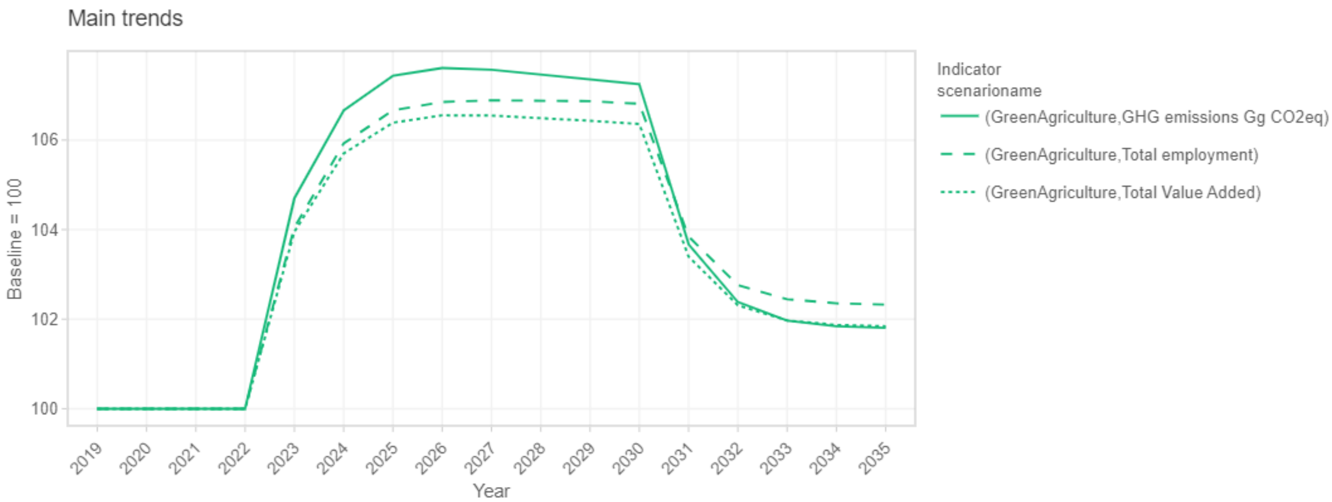


Figure 5 illustrates a shift in employment within the agricultural sector from 2025 to 2035, marked by a decline in the conventional “Agriculture et Activités Annexes” sector and a corresponding rise in “Agriculture Verti” (Green Agriculture). This trend underscores the reallocation of labor to more sustainable agricultural practices, aligning with broader NDC objectives. Employment trends in other sectors such as construction, manufacturing, and ICT remain positive, suggesting these sectors are benefiting from the agricultural transition. The stability in green agriculture employment, combined with some positive impact on other sectors, indicates that the transition to sustainable practices can be achieved with overall improvement in employment.

▶ Figure 6. Relative difference in employment to the baseline by industry

Figure 6 further shows the absolute amount of difference in employment for “Agriculture et Activités Annexes” and “Agriculture Verte” from 2025 to 2035, distinguishing between rural and urban areas. As expected, both urban and rural employment in the “Agriculture et Activités Annexes,” sector declines significantly by 2030 and 2035, indicating a reduction in traditional agricultural jobs. In contrast, “Agriculture Verte” shows substantial job growth in both rural and urban areas, with rural areas experiencing more significant increases. This suggests a shift from traditional agricultural employment to green agriculture jobs, reflecting the positive impact of sustainable practices on rural employment.

Figure 7. Relative difference in employment to the baseline by industry

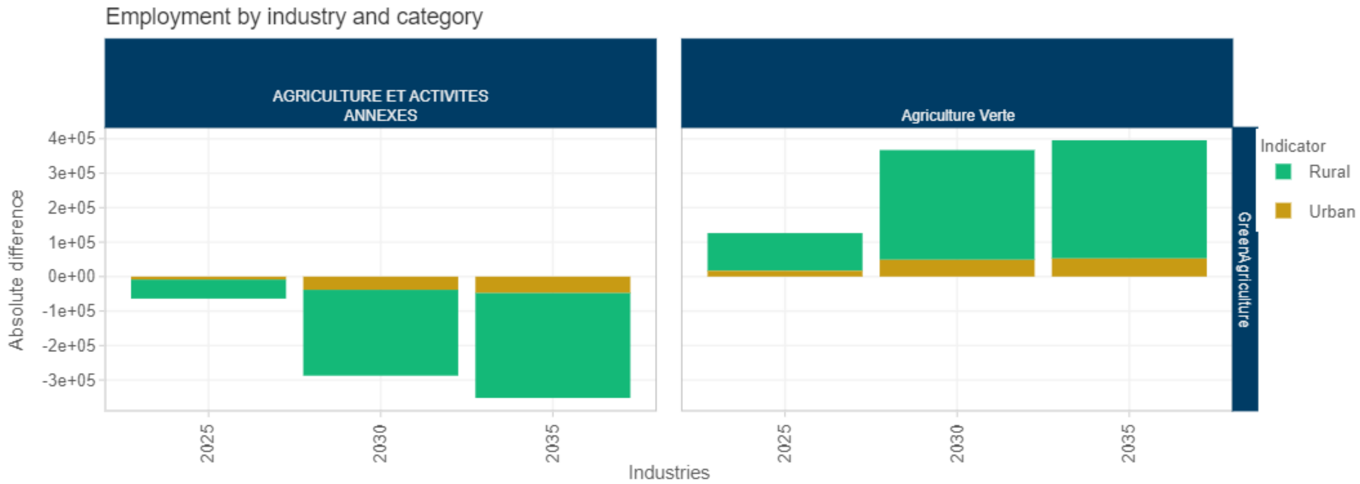


Figure 7 illustrates the absolute difference in employment by industry and education level for "Agriculture et Activités Annexes" and "Agriculture Verte" from 2025 to 2035. As expected, "Agriculture et Activités Annexes," employment shows significant declines by 2030 and 2035, predominantly impacting those with no schooling. In contrast, "Agriculture Verte" exhibits substantial employment growth throughout the period, especially among individuals with no schooling, but also benefiting those with primary, secondary, and tertiary education levels. This indicates a shift from traditional agriculture, which is experiencing job losses, to green agriculture, which is generating jobs across all education levels, particularly among the less educated.

Figure 8. Relative difference in employment to the baseline by industry

4.3 Green Electricity scenario

As emissions from energy are expected to increase significantly in the near future (see Section 2.3), it is important to analyse the impacts of a switch towards more renewable electricity. In this scenario, the contribution of renewable energies (solar, wind, and hydro) to electricity production increases, thereby reducing the reliance on thermal energy.

We model both the short-term investment effects and the long-term structural change effects. Firstly, regarding the latter, the contribution of thermal power to electricity generation decreases, favouring renewable energies: solar power increases by 0.8% in 2023 and 2024, and 1.1% annually from 2025 to 2030; wind power by 0.3% in 2023 and 2024, and 0.5% annually from 2025 to 2030; and hydro power by 0.9% in 2023 and 2024, and 1.4% annually from 2025 to 2030 (cf. Table 2). Secondly, investments, gross fixed capital formation (GFCF), on sectors such as “Other manufactured products not included elsewhere,” “Construction and building work,” “Information and communication services,” and “Transport Services” are increased in alignment with the growth of green energy investments. The values of these investments are projected based on the growth rate of GFCF in the “electricity” sector between 2018 and 2019 for the first three sectors, and the trend forecast in the NDC for transport.

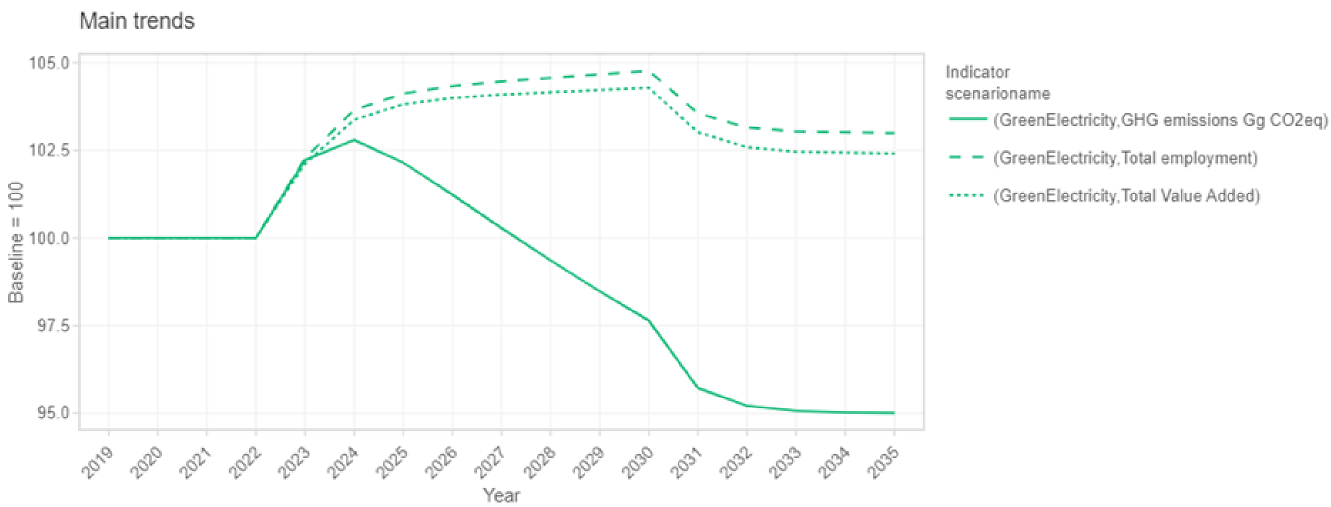
▶ **Table 2**
Substitution between thermal power generation and renewable energy production

Source of energy	2023 - 2024	2025 - 2030
Solar	0,80%	1,10%
Wind	0,30%	0,50%
Hydro	0,90%	1,40%

Source: Own calculation based on data from Senegal’s NCD 2020 and SUT

Figure 8 below shows the comparative evolution of value added (GDP), employment and CO_2 emissions between the renewable energy scenario and the business-as-usual scenario over the period 2020-2035. GDP and employment increase, peaking in 2030. The employment growth rate surpasses that of GDP, indicating the growth rate differential with the trend scenario is higher for employment (around 5%) than for GDP (around 4%). This suggests that the renewable energies scenario enhances job creation alongside economic growth, showing that this scenario is particularly effective in generating employment. Regarding CO_2 emissions, they initially rise due to the investment effect, then steadily decline, resulting in a reduction of around 5% lower in 2030 compared to the baseline scenario.

▶ **Figure 9. Annual changes in Value Added, Employment, and GHG emissions in Green Electricity scenario compared to baseline.**



As it is shown in Figure 9, the industries benefiting most from additional job creation are trade, agriculture, manufacturing, food processing and hotels and restaurants. By 2030, the number of additional jobs is expected to rise to 70,000 in trade, 40,000 in agriculture, 30,000 in manufacturing and 20,000 in food processing and hotels and restaurants.

▶ Figure 10. Relative difference in employment to the baseline by industry

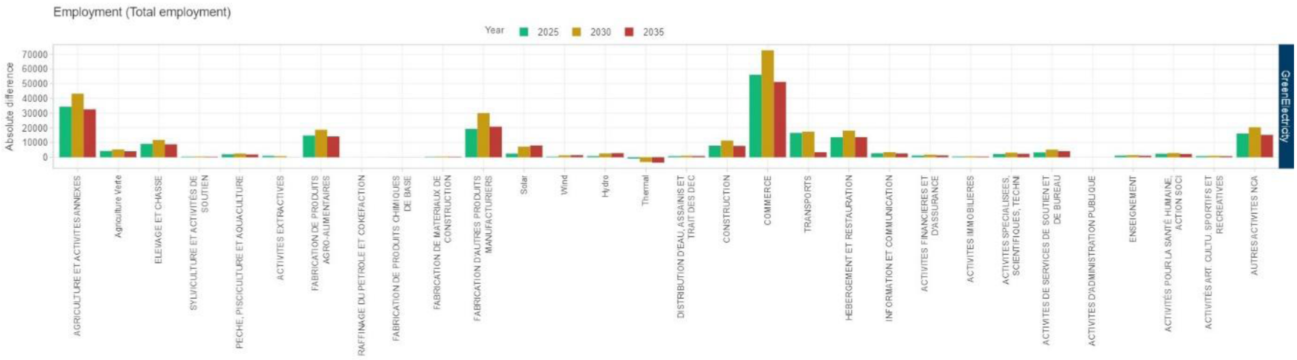
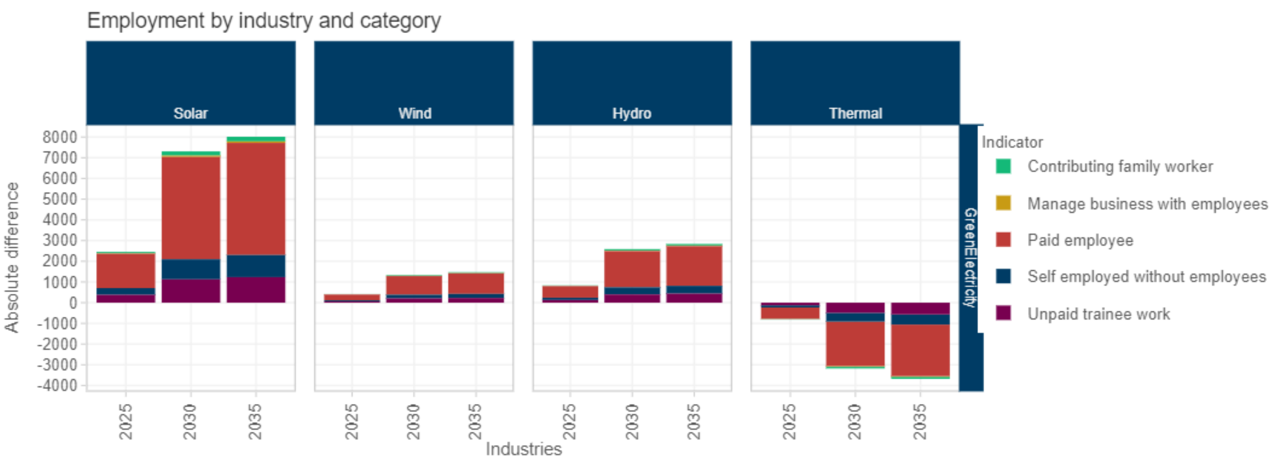


Figure 10 further reveals that among the renewable energies considered, solar power leads in job creation, generating 7,000 salaried jobs and 2,000 additional individual jobs by 2030. Hydropower follows closely, with nearly 3,000 jobs, while wind power contributes around 1,000 jobs by 2030. Overall, the renewable energy scenario is characterized by a considerable gain in growth, significant job creation -primarily driven by solar energy activity-and a reduction in CO_2 emissions.

▶ Figure 11. Relative difference in employment to the baseline by industry



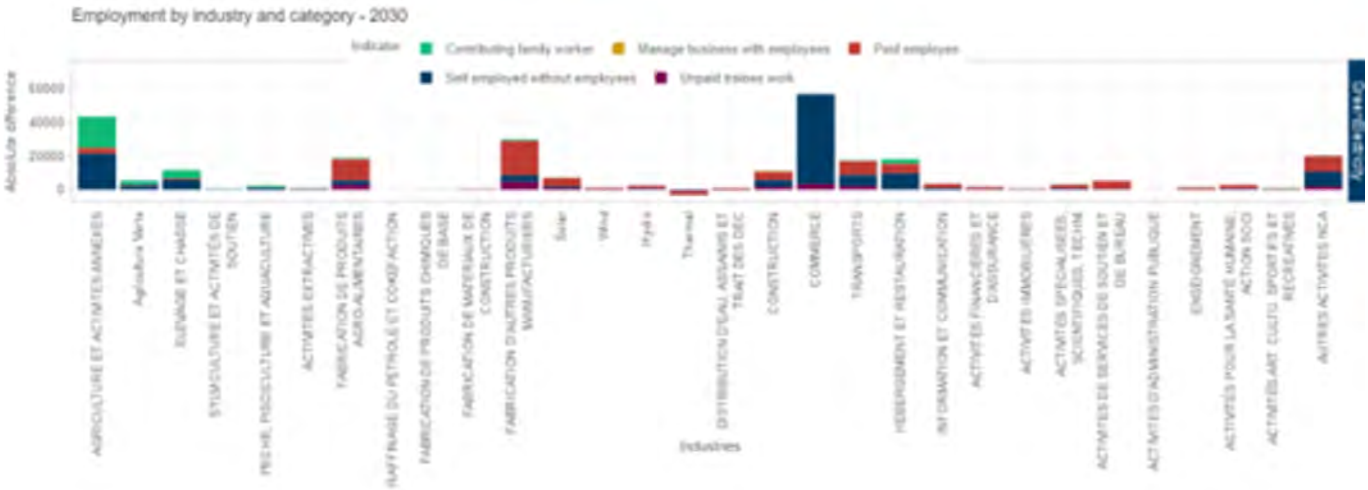
5. Policy implications

For Senegal to realize its development vision and become an emerging market economy by 2035, green industrial growth and climate policy are central. Implementing an integrated Just Transition strategy – to combine fiscal and industrial policies with social and employment policies - would simultaneously accelerate economic growth, employment creation, and social justice, preserve the environment, and exploit natural resources with long-term profits.

In the two scenarios analysed, transition policies have a significant positive impact on GDP growth, job creation and CO_2 emissions. Compared with the reference scenario, growth gains range from 2-2.5% and additional job creation from 2-3% in 2035. **As far as CO_2 emissions are concerned, in deviation from the reference scenario, emissions decrease 2% in the climate-smart agriculture scenario. In the renewable energy scenario, the level of CO_2 emissions is below that of the reference scenario, falling by up to 5% in 2035.**

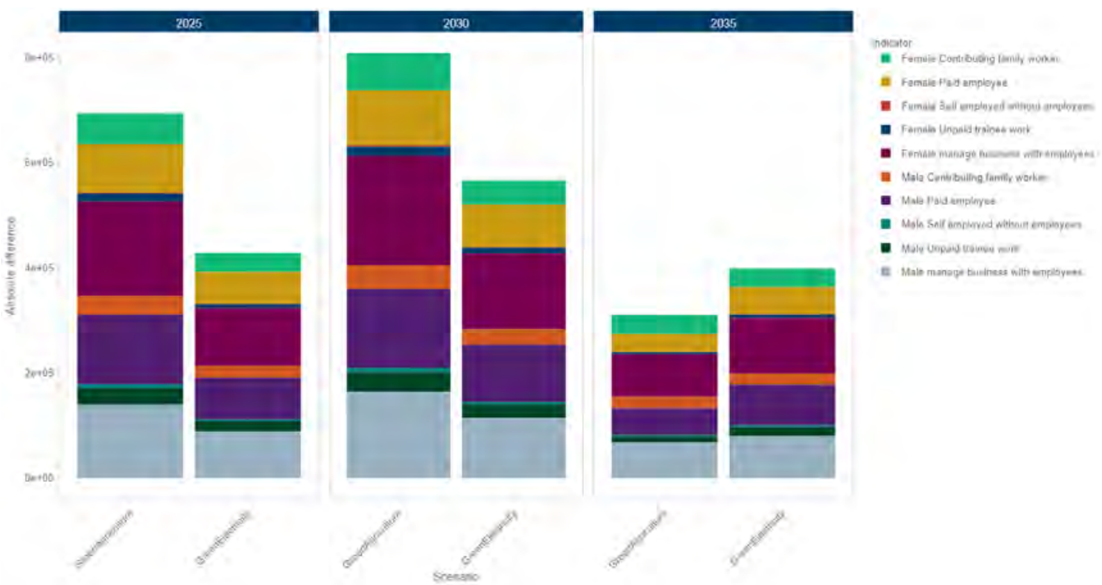
In terms of employment composition in the labour market, individual jobs and family-type jobs benefit most from job creation as they constitute the largest share of today's labour market. The creation of self-employment will amount to 60,000 in the retail sector and increase by 40,000 in agriculture. As for salaried jobs, they will increase by 30,000 in manufacturing and by 20,000 in food processing (see graph).

Figure 12. Employment by industry and job status in the Green Electricity scenario



The impact of the transition policy on employment is strongest in the case of the green farming scenario in the years from 2025 to 2030. However, the situation reverses in 2035, and the impact of renewable energy promotion on employment becomes dominant. This suggests that the renewable energy transition policy has a more lasting effect on employment, while the agriculture sector requires high levels of upfront capital investments and in irrigation and processing, creating a significant amount of jobs in construction in the earlier phases of the policy.

Figure 13. Total employment by gender and job status, Green Agriculture and Green Electricity compared to the Baseline scenario

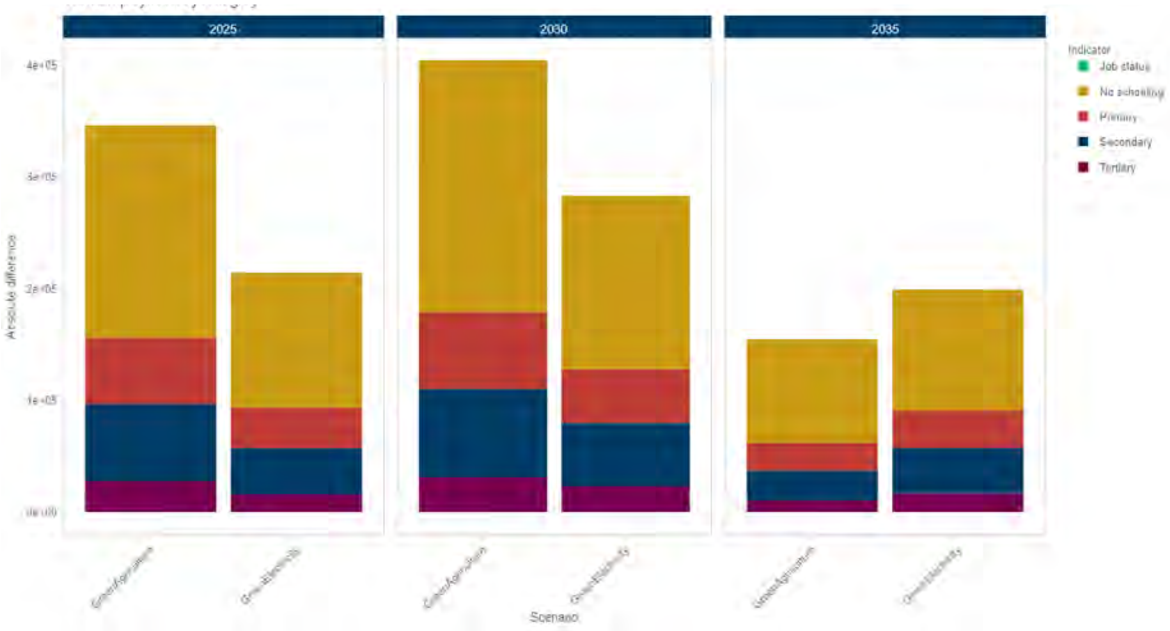


In both scenarios, the dominant type of employment is family or self-employment. This type of employment outweighs that of salaried employment or employment in a company with employees. To counter the informalization and increase in precarious employment, a key focus must be set on transition policies which focus on formalization, social security and enterprise development.

In terms of employment profile, unskilled (no education) or low-skilled (primary school level) jobs clearly dominate in both scenarios, compared to skilled (secondary school level) or high-skilled (tertiary level) jobs. This pattern is also the result of the current labour market composition. However, jobs created seem to benefit more women, who work predominantly in service and agriculture, despite the fact that most often they are unskilled. Dedicated gendered technical and vocational training, agricultural extension and skills upgrading systems must be put in place to ensure higher levels of labour market participation and productivity among women.

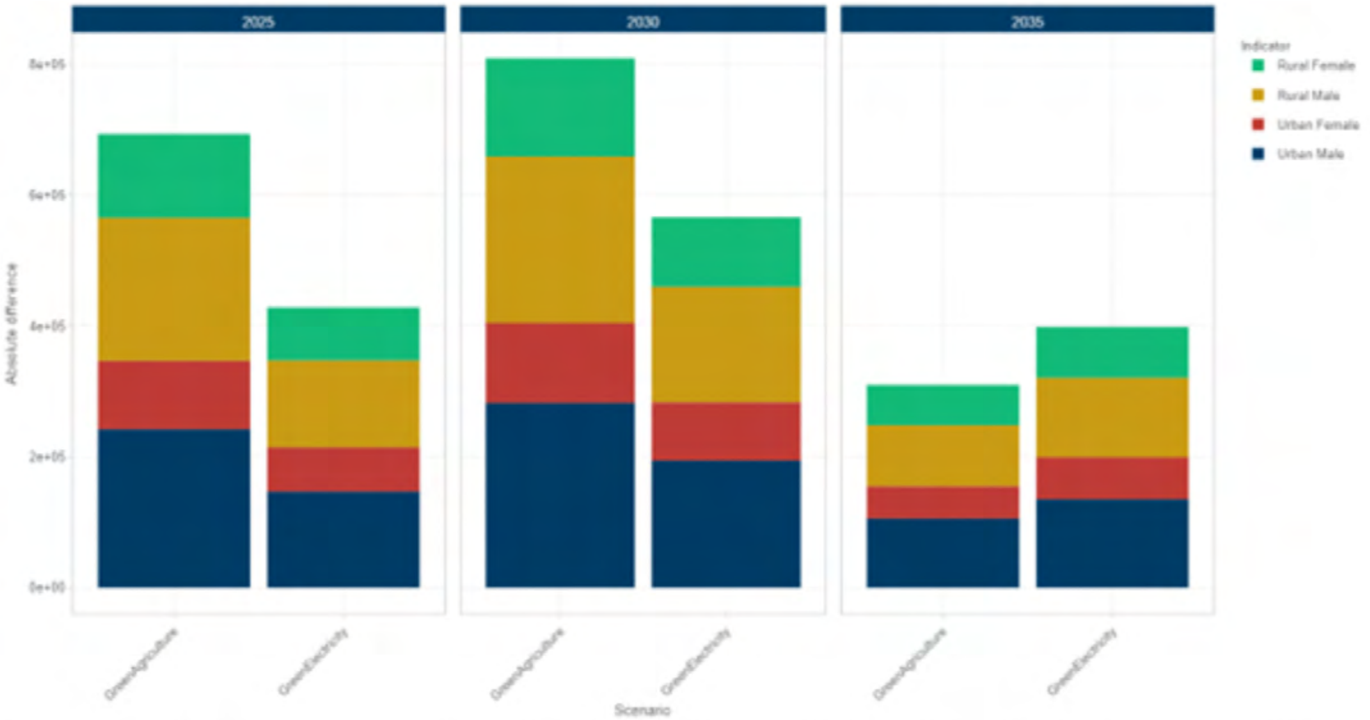
In conclusion, the two climate and clean energy transition policies point to a positive quantitative impact on employment overall. However, the decency and job quality aspects in the transition do not improve from the current situation and are perpetuated into the future. This suggests that the climate and green energy policies should go further than simply focusing on industrial and growth policies by investing in physical capital and infrastructure. First and foremost, skills policies, up- and reskilling, technical and vocational training, and extension services are required at the same time as support for small and very small businesses.

▶ **Figure 14. Total employment by education level, Green Agriculture and Green Electricity compared to the Baseline scenario**



In terms of rural employment, the structure of employment is favourable. In 2025 and 2030, rural male and female employment grow faster than employment in urban areas. This is driven by the highlighted agriculture and energy investments in irrigation, agro industries and processing facilities. However, by 2035, there is a rebalancing as construction jobs become less important while the productive use, operation and maintenance of energy and industrial capacity in the case of the renewable energy scenario picks up. The urban job growth, however, depends on equally important investments into skills, training and education policies to ensure the right skills of workers in the emerging green industries. Social protection is required for urban workers in potentially declining fossil fuel-based industries, notably charcoal trading and firewood selling.

Figure 15. Total employment by gender and location, Green Agriculture and Green Electricity compared to Baseline



In terms of fiscal policies and domestic financing, the assessment points to the possibility of a fiscal neutral scheme that sets a progressive emission or carbon price. This could be levied among the richest percentile of the population, those who can afford a minor increase in energy prices. The revenues could then be channelled through a Just Transition fund to finance renewable investments, skills training and social protection among low-income households, most impacted and less capable of addressing climate change. Such a scheme as the further benefit of reducing poverty and inequality, and could be modelled on the European Union Just Transition Fund.

Such Just Transition Fund would ensure the institutionalization of accompanying just transition policies which are required to enable the structural change. Notably, social protection, skills and human capital development, micro and small enterprises and farmers support, regional development and relocation policies must be funded and part of any climate and energy transition..In conclusion, policies focused on promoting green climate smart agriculture and renewable energies have a positive effect on economic growth, job creation and the decarbonization of the Senegalese economy. However, significant investments must be made in a systematic way to match the renewable energy and agricultural infrastructure, industry and capital investments with human capital investments. Skilled and formal workers with decent work contracts are required to install, operate and maintain and manage the renewable energy industries. Skills training, up and reskilling, technical and vocational training, notably among women and youth, is needed to build the necessary labour force to enable the energy system change and ensure decent work and jobs are effectively created. Combining industrial and financial with social and employment policies in an integrated just transition framework has a triple beneficial effect: growth gains, decent work creation and lower CO_2 emissions.

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Emplois
Verts Delta

A. Annex: Method and data

A.1 Background and modelling philosophy

The Just Transition Assessment Model developed for Senegal is based on the model suggested in the International Labour Organization's GAIN Training Guidebook (ILO 2017), adapted to the use of supply-and-use tables. We have further introduced endogeneity of some macro-economic key variables to capture dynamic development paths over time. To this end, we follow ideas put forward by INFORUM, the Interindustry Forecasting Project at the University of Maryland (Clopper 2012). We embed the supply-use model into a set of linear macroeconomic equations. Population and exports are exogenous drivers of the model, while investments (gross capital formation), household demand and GDP (and value added) are endogenous. The model is path-dependent and can be classified as a simple macro-econometric input-output (MEIO) model (Lewney, Pollitt, and Mercure 2018; West 1995). While similar to computable general equilibrium (CGE) models, the most important differences are that MEIO models are more empirically based (estimation of behavioural parameters), assume myopic foresight of all agents, and have a Leontief production function (Pollitt, Lewney, and Mercure 2018) in contrast to e.g. a constant elasticity of substitution (CES) production function. Although some price effects are considered in the JTAM model family, these models are to date simpler than other MEIO models, such as E3MG (Mercure et al. 2018) and related models or models from the INFORUM family, such as INFORGE (Maier, Mönnig, and Zika 2015; Mönnig, Maier, and Zika 2019) for Germany.

The methodology has also been used for GJAMNigeria (ILO and UNDP, Wiebe, Simas, et al. 2021), GJAMZimbabwe (ILO and UNDP, Wiebe, Andersen, et al. 2021), GJAMTurkey (UNDP and ILO et al. 2022), GJAMBurkinaFaso (ILO, Wiebe, Simas, et al. 2023), and GJAMGhana (ILO, Wiebe, Aponte, et al. 2023).

A.2 Existing economic scenario models in Madagascar

Simulation models are invaluable decision-support tools, facilitating the formulation of development policies and informing the choices made by public decision-makers. In Senegal, the simulation model used by the economic administration is a national version of the T21 model developed by the Millennium Institute, based in Washington D.C. The T21 model, which is based on the system dynamics method, is a medium- and long-term planning tool that integrates economic (blue sphere), social (red sphere), and environmental (green sphere) sectors. The model's database is fed from a plurality of national and international sources, and the model contains indicators for the 17 Sustainable Development Goals (SDGs). The Senegalese T21 model has been used in various exercises such as the 2030 Agenda, the greening of the Senegalese economy and Senegal's Nationally Determined Contribution (Direction de la Planification 2017).

The Just Transition assessment model (JTAM) has many specific features. It is based on a disaggregated input-output table that distinguishes between green and conventional activities. It provides a detailed description of the national economy by branch of activity. It provides information on employment and CO_2 emissions at both branch and national level, and enables analysis of the impact of transition policies on economic growth, green and non-green jobs, CO_2 emissions, and social indicators. It is also less data-intensive than the T21 model.

A.3 Using supply-and-use tables for policy analysis[4]

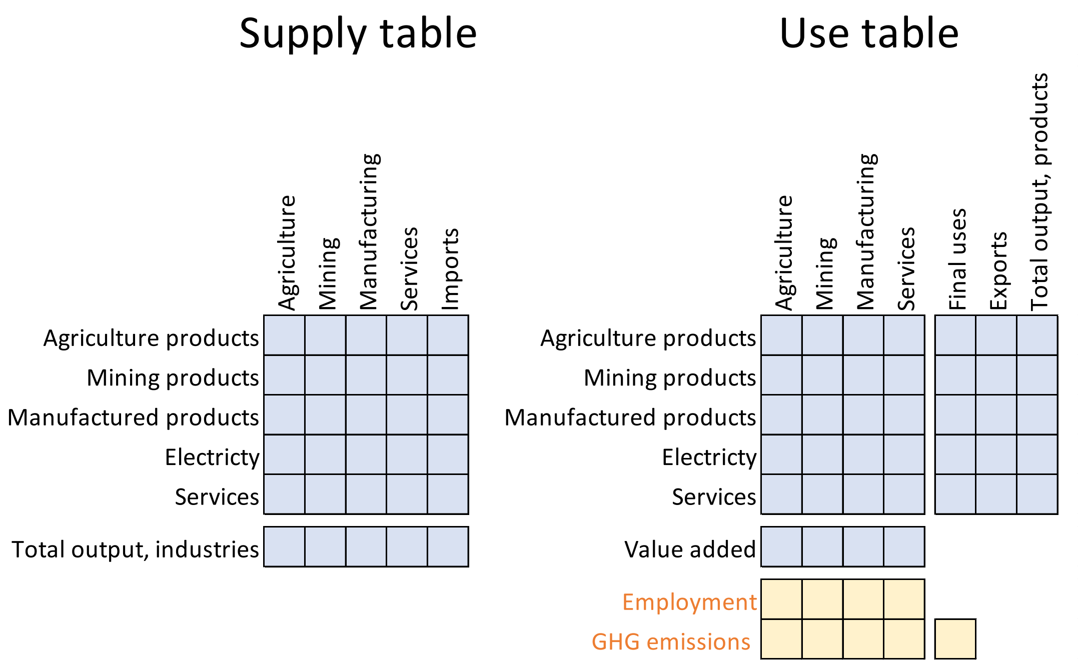
Policies have effects throughout the economy. A climate or energy policy that affects one industry directly – for example, coal power plants – causes ripple effects throughout the economy. The decrease in the demand for coal will impact the demand for products from the coal mining industry. The decrease in the demand for coal will also affect the demand for machinery and financial services related to coal mining. The reduced demand for machinery will, in turn, affect the demand for metals and components, which will affect the demand for iron ore. The substitution of coal power plants for solar energy for the production of electricity will lead to an increase in the demand for photovoltaic panels and for electric inverters. Those will then increase the demand for electronic components, for products from copper mining and refining, and other industries that provide goods and services for these new products. The direct effects of the policies – decrease of coal electricity, increase of solar electricity – will therefore have indirect economic effects on different industries due to the changes in the demand of goods and services from the industries directly affected, which will also impact their suppliers, and the suppliers of their suppliers, and so on.

The increase or decrease of economic activity will impact jobs. With any policy, there will be industries that will increase their economic output and therefore increase the demand for workers, but there will also be industries that will have a decrease in their economic output, leading to job losses. Assessing the positive and negative impacts of policies is, therefore, necessary to maximise the potential benefits and minimise potential negative economic, social, and environmental implications.

JTAMs are built to quantify these ripple effects of climate policies and green structural change. JTAMs are macro-economic models based on IOTs or SUTs that integrate economic data with data on jobs and GHG emissions. The starting point is the economic SUTs, compiled by statistical offices. These tables give a picture of the total supply and the total use of goods and services in the economy, quantifying the transactions in products between industries, purchases by final consumers, and to and from international trade. Supply tables describe what industries produce and how much of each product is imported. It also includes the trade and transport margins and taxes, less subsidies on products, which represent the difference between the production (basic) prices and the final consumer (purchase) prices. Use tables to describe all products used by industries in the country, as well as products purchased by final consumers and exported, and gross value added (VA) generated by industries.

4. This section in based on the GJAM report for Turkey (UNDP and ILO et al. 2022)

Figure 16. Simplified illustration of a supply table (left) and a use table (right), extended with employment and GHG emissions data per industry.



Models based on SUT can simulate the direct and indirect effects of different policies on the economic output of the different industries. Not only that, but supply-and-use and input-output tables can be linked with social and environmental indicators (called extensions) that describe direct impacts of each industry on workers and on the environment. A simplified supply-and-use table is illustrated in Figure 16.

Note that we do not model inflation. The only price changes that can be modelled are those due to changing technology of production in the scenarios, which are reported in constant prices.

The model iterates in every year until the change in final household demand from one iteration to the next is below a given threshold. The next year is then initialised with endogenous variables being set to the current year solution and exogenous variables as well as scenario inputs taking the next year's value.

For the scenarios it is possible to model

- additional investment by product
- changes in the structure of household and government demand
- changes in the use coefficient matrix, i.e. the technology with which an industry produces
- changes in the market share matrix, i.e. which industries produce which share of a product
- changes in the import shares by products
- changes in emission intensities of industries

Production and value added are always endogenous. From this we can estimate changes in employment by using a constant labour intensity (that is, a fixed number of workers by skill and gender per unit of value added by industry) multiplied with the new value added by industry.

General limitations and strengths of the modelling approach
Excerpt from general documentation of the software for the economic core model (SUT_core)

SUT based macro-econom(etr)ic IO models / GAIN type Just Transition Assessment Models are not economic forecasting models. Rather, these 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 reference scenario. They indicate the direction and possible size of the effects but should be taken as indicative 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, which in turn might be estimated based on older supply-and-use tables. For some countries, the most recent available SUT might be from 2010 or 2012, while other countries might have tables as recent as 2019. Extrapolating data over the next decade based on such data will not necessarily give a complete picture, but it constitutes 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 investments 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. This entails that the 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 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 in only a few seconds, which allows to calculate a large number of scenarios and thereby 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.4. Data for the Just Transition Assessment Model

A.4.1 Overview of data sources for the Just Transition Assessment Model

The main sources of data for this analysis are derived from the national accounts and the supply and use table (Tableau des Ressources et des Emplois With the results of the national accounts, the TES has been extended to include a stock of employment and CO_2 equivalent emissions. The emissions data are estimated on the basis of Senegal's third communication to UNFCCC (DEEC 2015) and the Nationally Determined Contribution (CDN 2020).

For disaggregating employment stock by place of residence, gender, and branch of activity, the 2019 edition of the national employment survey in Senegal was used. For the purposes of splitting greenhouse gas emissions by industry, the intermediate consumption matrix was used. Lastly, the annual agricultural survey was used to determine the structure for breaking down the agricultural sector into green and conventional categories.

The scenarios are developed based on Senegal's commitments in the 2022 NDC (CDN 2020) for the agriculture and energy sectors.

Supply-and-use table

In this report, we used **the SUT available** from The National Agency of Statistics and Demography of Senegal(ANSD 2022b), which describes the economy in the year 2019 for 26 products and 26 industries (see Table 3 for the full industry and product details). The base year for the analysis in this report is the same year as the updated SUT, that is, 2019, and all economic growth is estimated based on 2019 constant prices.

Macro-economic time series data

The model considers the past and current state of the economy as described by data from the System of National Accounts (UNSD 2022), that is the macro-economic values for final household and government consumption expenditure, gross fixed capital formation, imports, and exports, as well as value added with as much industry and component (e.g., net taxes on production, compensation of employees, net operating surplus) as possible. The SUT should adhere to these macro-economic key indicator values.

For the econometric estimations, we use a historical time series of data from the UN System of National Accounts (UNSD 2022). The estimated parameters together with exogenous information on the development of investments and exports from the IMF (IMF 2022), and global economic (Guillemette and Turner 2018) and population growth (UN 2019), are the main parameters defining the baseline scenario pathway, which is described in more detail in Section A.5

Labour data

The **labour data** used comprises full-time equivalent employment stock data from the UTS and labour force survey data for breakdown by sector and by characteristic (gender, urban/rural area, etc.) (ANSD 2019, 2021). It is available in the same industry classification and year as the SUT. It contains details of indicators of labour force composition, describing employment per gender, level, location, education level, and job status. The employment indicators available are presented in Table 3 below.

Greenhouse gas emissions data

The **GHG emissions data** used come from the national GHG inventory conducted by the Ministry in charge of Environment between 1994 and 2005 and an estimate to 2030, with 2010 as the base year (DEEC 2015). The GHG inventory provides information on emissions of CO_2, CH4 and N2O (HFCs, PGCs and SF6 if available) according to broad and detailed activities described in the IPCC guidelines4 for GHG inventories. However, the IPCC sector classification does not match the SUT ISIC classification so that reallocate emissions to the SUT industries.

A.4.2 Senegal's supply-and-use table

▶ Table 3
List of SUT 26 products and 26 industries

Product Name	Industry Name
Produits De L'agriculture Et Activités Annexe	Agriculture et Activités Annexes
Produits De L'élevage, De La Chasse Et Activi	Elevage et Chasse
Produits De La Sylviculture, De L'exploitation	Sylviculture et Activités De Soutien
Produits De La Pèche, De L'Aquaculture Et De	Peche, Pisciculture et Aqua-culture
Produits Des Industries Extractives	Activités Extractives
Produits Agro - Alimentaires	Fabrication De Produits Agro-Alimentaires
Produits Du Raffinage Et De La Cokéfaction	Raffinage Du Pétrole et Cokéfaction
Produits Chimiques De Base	Fabrication De Produits Chimiques De Base
Ciment Et Autres Matériaux De Construction	Fabrication De Matériaux De Construction
Autres Produits Manufactures Nca	Fabrication D'autres Produits Manufacturiers
Electricité, Gaz Et Supports Energétiques	Production Et Distribution D'électricité Et D
Production Et Distribution D'eau, Assainissem	Distribution D'eau, Assainis et Trait Des Dec
Constructions Et Travaux Construction	Construction
Vente	Commerce
Services De Transports	Transports
Services D'hébergement et De Restauration	Hébergement et Restauration
Services D'information et De Communication	Information et Communication
Services Financiers et D'assu-rance	Activités Financières et D'assurance
Services Immobiliers	Activités Immobilieres
Services Spécialises, Scientifiques Et Techni	Activités Spécialisées, Scienti-fiques, Techni
Services De Soutien et De Bureau	Activités De Services De Soutien et De Bureau
Activités D'administration Publique	Activités D'administration Publique
Enseignement	Enseignement
Services Pour La Santé Humaine Et L'action S	Activités Pour La Santé Humaine, Action Soci
Services Artistiques, Culturelles, Sportives	Activités Art. Cultura. Sportifs Et Récréatives
Autres Services NCA	Autres Activités NCA

A.4.3 Measuring impacts: employment and GHG indicators

▶ Table A3
List of Employment Indicators

1 -Single Dimension	2 - Combined Dimensions	
Gender	**Gender & Location**	**Gender & Job Status**
Male	Male	Male-Paid employee
Female	Male-urban	Male-Self-employed without employees
	Female-rural	Male-Contributing family worker
Residential Location	Female-urban	Male-Manage business with employees
Rural		Male-Unpaid trainee work
Urban	**Gender & Educa-tion level**	Female-Paid employee
	Male-no education	Female-Self-em-ployed without employees
Level of Education	Male-primary	Female-Contribu-ting family worker
No schooling	Male-secondary	Female-Manage business with employees
Primary	Male-tertiary	Female-Unpaid trainee work
Secondary	Female-no education	
Tertiary	Female-primary	**Location & Education Level**
	Female-secondary	Rural-o education
Job Status	Female-tertiary	Rural-primary
Paid employee		Rural-secondary
Self-employed without employees		Rural-tertiary
Contributing family worker		Urban-no education
Manage business with employees		Urban-primary
Unpaid trainee work		Urban-secondary
		Urban-tertiary

▶ Table A4
List of GHG emissions Indicators

CO_2 emissions from biomass in Gg
CO_2 emissions from AFOLU in Gg
Energy CO_2 emissions by industry in Gg
Agricultural CO_2 emissions by industry in Gg
Waste emissions in Gg
Industrial Process emissions by industry in Gg
Total N2O emissions by industry in Gg CO_2eq

A.4.4 Splitting Green Agriculture Industries

The agricultural sector is divided into green and conventional based on the natural regeneration rate of agricultural land, which was estimated at 11% in 2019 according to the national agricultural survey. This rate is used as a proxy to distinguish between the green and conventional agricultural practices. Consequently, the structure of the agricultural industry (by product is used to split into green and conventional agriculture, ensuring that the value of the agricultural branch is equal to the sum of the values of its sub-branches for each product. To achieve this, the following assumptions have been added:

To achieve this, certain assumptions have been applied. Intermediate consumption by green agriculture is considered zero for thermal energy products, refining and coking products, and basic chemical products. On the other hand, intermediate consumption by conventional agriculture is considered zero for renewable energy products as well as forestry, logging, and support activities.

A.4.5 Splitting Renewable Electricity (Solar, Hydro, and Wind) Industries

The disaggregation of intermediate consumption in the "electricity and gas production and distribution" branch by energy sources-solar, wind, hydro and thermal-for each product is determined based on different energy production technologies and their corresponding input coefficients.

This disaggregation is based on the information that refining and coking products and transport services are only used for thermal energy, and the structure of intermediate consumptions by energy source follows the pattern of energy production, with the information provided by the Société Nationale d'Electricité du Sénégal (SENELEC).

The approach consisted of the following steps:

- allocation of the intermediate consumptions for refining and coking products to the "thermal" sub-branch,
- allocation of the intermediate consumption for transport services to the "thermal" sub-branch,
- allocation of the branch's total intermediate consumption of "electricity and gas production and distribution" to the sub-branches (solar, wind, hydro, and thermal) in proportion to their weight in energy production. Thus, the totals for the sub-branches (solar, wind, hydro, and thermal) are given, and the intermediate consumptions for the products allocated to the thermal energy sub-branch, and
- using the sub-branch totals as a basis (calibration method) for distributing the intermediate consumptions of each product according to the sub-branch, ensuring it aligns with the structure of national energy production by source.

The distribution of emissions by energy source was based on the average quantity of CO_2 eq emissions and the quantity of energy produced by type of energy. As for employment, for each modality, under the assumption of constant marginal productivity of the labour factor, the workforce was distributed according to the structure of energy production by source.

Baseline development[5]

The purpose of establishing this reference scenario is to create a baseline for economic development against which the green scenarios can be compared. In this scenario, we assume that the economy grows (as specified in the following paragraphs), but that the structure of the economy remains unchanged. That is, industries continue to produce with the same production technology and the import shares of products remain stable.

In the reference scenario, we calibrate the model to follow the macro-economic trends from the OECD Economic Outlook for the years up to 2022 for the demand side variables, changes in inventories, government consumption and gross fixed capital formation, as displayed in Table 4 (OECD Statistics 2021). Additionally, we also set the exogenous export growth rate to follow the trends from IMF WEO data (IMF 2022) and we use the development of global GDP as described in the OECD Long View (Guillemette and Turner 2018) but correct for the difference in these years (Table 4).

Table 4
Values for exogenous variables 2019-2022 from the OECD Economic Outlook

Selected variables (in Percentage)	2019	2020	2021	2022
Change in inventories, contributions to changes in real GDP	-38%	2%	4%	4%
Exports of goods and services, volume (national accounts basis)	9.2%	-11.9%	5.8%	-10.3%
Government final consumption expenditure, volume	8%	2%	4%	4%
Gross fixed capital formation, total, volume	10%	2%	4%	4%
World real GDP pc growth (OEC-Dlongview)	5%	1%	5%	5%

5. Based on the description of the baseline scenario used for JTAM Turkey and other JTAM models, but adapted to the model for Senegal.

The other macro-economic demand side components are modelled as follows:

- Government consumption grows (exogenous to the model) as a function of population growth rate (estimated using econometric techniques),
- Gross fixed capital formation (exogenous to the model for the current year) grows with the previous year's GDP growth rate
- Exports (exogenous to the model) grow with the global GDP growth rate.
- Changes in inventories (exogenous to the model) decrease by 1% annually.

The product shares for these variables in the total are constant.

Household consumption is endogenous to the model, as is GDP (the sum over all industries' value added). The household consumption model utilises income elasticities from USDA International Food Comparison Programme (Meade et al. 2014; Muhammad et al. 2015) for nine consumption categories, see Table 5. The change in household income for the consumption model is approximated by the change in GDP.

Table 5
Income elasticities for broad consumption categories for Senegal from the USDA international food comparison programme

Food, beverages & tobacco	Clothing & footwear	Housing	House furnishing	Medical & health	Transport & communication	Recreation	Education	Other
0.79	0.967	1.075	1.054	1.675	1.211	2.405	0.93	1.694

The economic structure (described by the market share matrix *D*, calculated from the 2019 supply table) and the technology coefficient matrix *B* (calculated from the 2019 use table) are kept constant for the years 2020-2035. This entails that the economy is assumed to have a static Leontief production function without technological change or any economies of scale or price effects. Import shares per product are constant. As there is no technological change or changes in the structure of primary inputs (value-added components), prices are constant.

Production by industry *g* is calculated using the industry-by-commodity commodity-demand-driven SUT model (Miller and Blair 2009) $g = D\ (I - BD)\text{-}1\ y$. In this demand-driven model, this results in, for example, electricity production growing with electricity demand in monetary terms.

Since the technology coefficient matrix *B* is constant, the share of value added in total industry output is also constant. Value added per industry is then determined endogenously by multiplying the value added in output shares by output per industry. Total GDP equals the sum of all industries' value added and is then used to determine the development of household consumption expenditures. Since both total value-added/GDP and household consumption expenditures are endogenous to the model, they are not completely equal to the forecast.

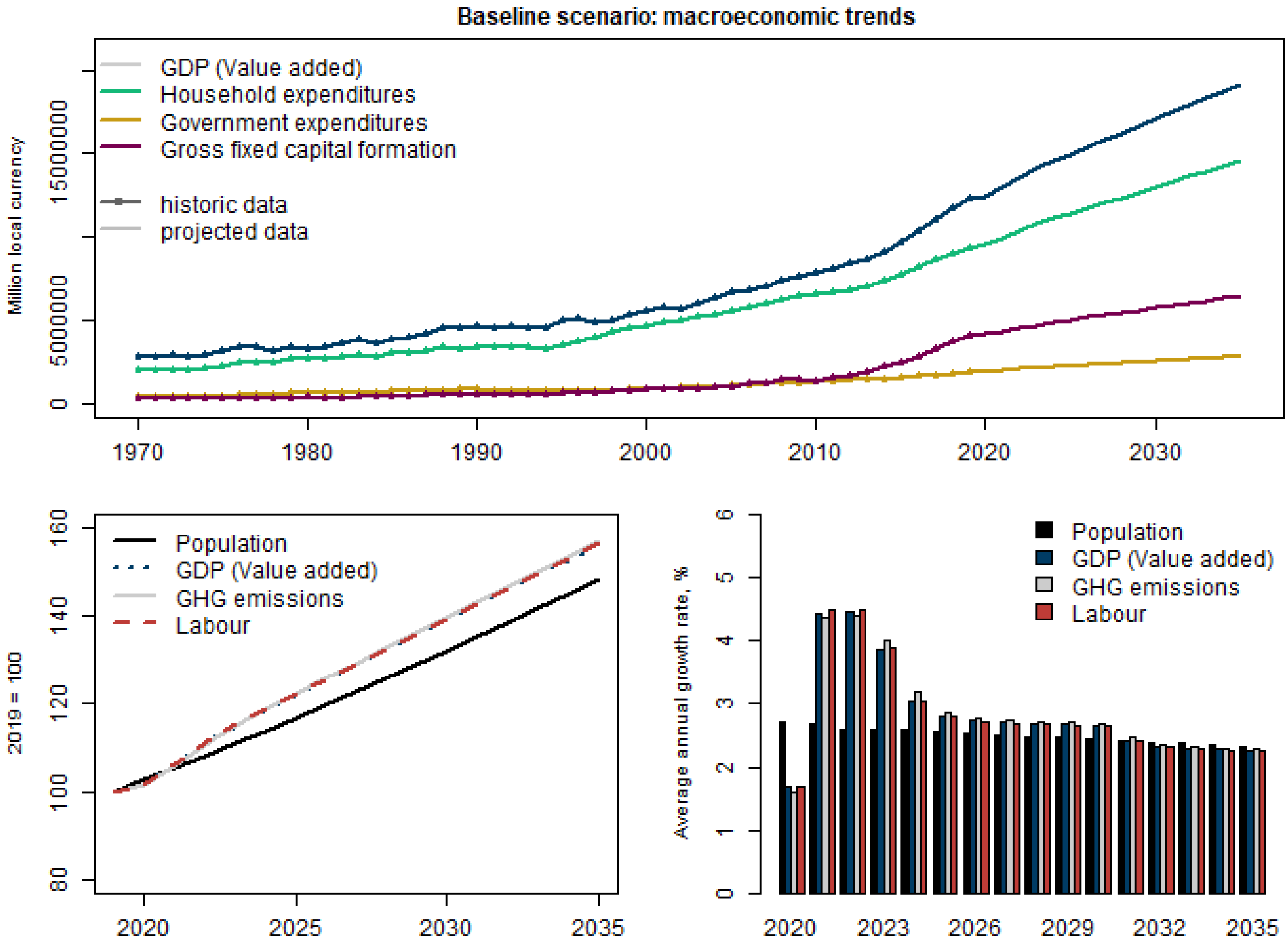
The purpose of having this reference scenario is to have an economic development that can serve as a baseline to which the development in the green scenario can be compared. When interpreting the results, we will not look at the absolute values of the growth rates of GDP, emissions, and employment, but we will analyse the difference between the green scenarios and the baseline scenario. It is therefore not vital that national or international IMF forecasts are met for the model.

In this reference scenario, we assume constant labour productivity (persons employed per unit industry output). To estimate the employment requirements, we thus multiply the (constant) number of persons per unit of industry output by the projected output of the industry in monetary terms. The same procedure is used for GHG emissions. Note that the model, akin to other macro-economic models (Rosendahl et al. 2021) does not include land use, land use change, and forestry (LULUCF) emissions.

Figure 17 displays the macroeconomic trends of the model in the baseline scenario, covering various economic indicators from 1970 to 2035. The fluctuations in the growth rate of GDP, emissions, and employment (lower right panel of the figure) up to 2019 are introduced into the model through the calibration with the exogenous variables exports and investments (gross fixed capital formation).

The top graph traces the historical and projected values of GDP (value added), household expenditures, government expenditures, and gross fixed capital formation from 1970 to 2035, with a noticeable increase in GDP over the years compared to the others. Below, the left graph indexes the projected growth of population, GDP, GHG emissions, and labour force from 2020 to 2035, all starting from a base value of 100 in 2019, showing similar growth trajectories. On the right, the bar chart depicts the average annual growth rates of population, GDP, GHG emissions, and labour force from 2020 to 2035, highlighting a general trend of declining growth rates over time.

▶ Figure 17. Macroeconomic trends as per JTAM Senegal for the baseline scenario



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