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Republic of Madagascar: Selected Issues

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REPUBLIC OF MADAGASCAR

SELECTED ISSUES

March 2025

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February 11, 2025

Approved By
The African Department

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CONTENTS

BOXES

FIGURES

TABLES

THE ELECTRICITY SECTOR AND JIRAMA[1]

While only 36 percent of the population has access to electricity in Madagascar, the state-owned utility company JIRAMA is faced with three major issues: (i) insufficient and inefficient production, (ii) losses during the transmission, distribution and commercialization phases, and (iii) tariffs below costs. It results in a high fiscal cost for the government, diverting resources from much-needed social spending and investment.[2] More generally, it has a negative impact on firms' productivity, on economic growth and development, which makes the finalization of JIRAMA's recovery plan increasingly urgent. Its implementation will require strong support from the executive branch.

A. Background

1. Around 36 percent of the population has access to electricity, with most of Madagascar's energy provision coming from traditional sources (wood, charcoal).[3] According to a report financed by the African Development Bank, 83 percent of energy provision comes from wood and charcoal, which is one of the main drivers of deforestation (average forest reduction by 40,000 ha every year).[4] The remainder of energy provision (17 percent) is from other sources, with around 11 percent coming from hydrocarbons.

2. Electricity production relies mostly on fossil fuels, in spite of a strong potential for renewable energies and notably hydropower. In 2023, fossil fuels represented a total of 53 percent of installed capacity, followed by hydroelectricity (33 percent) and solar energy (14 percent), for an installed capacity totaling 718MW.[5] Hydropower was the top source of electricity for most of the last three decades, only recently eclipsed by oil-fueled generation. Economically feasible potential hydroelectric power is estimated at 7,800MW with only 3 percent currently used, and there is also unused potential with solar energy (2,800 hours of sun estimated annually) and potential wind energy, which are estimated at 2,000MW.

3. The state-owned enterprise JIRAMA is the main operator in urban areas. JIRAMA, created in 1975 with the state as the unique shareholder, is responsible for the transmission and

[1] Prepared by Constance de Soyres, Joanne Tan, and Claude Wendling. The analysis benefitted from helpful comments from the World Bank.

[2] JIRAMA is a utility company, responsible for both electricity and water activities.

[3] World Bank data, 2022. For comparison, 51 percent of the population on average has access to electricity in Sub Saharan African countries. Other data sources point to an even lower access to electricity in Madagascar, such as the International Energy Agency reporting an access at 27 percent in 2020, lower than the World Bank estimate of 32 percent in the same year.

[4] « Etude sur l'Economie Politique de la réforme du secteur de l'Energie », Dev2E, August 2022.

[5] Source: Climatescope / Bloomberg NEF

distribution of electricity in urban areas.[6] JIRAMA sells the electricity it produces or buys it from private, independent power producers (IPPs). It is under the technical supervision of the Ministry of Energy and Hydrocarbons and under the financial supervision of the Ministry of Finance. While JIRAMA is responsible for both electricity and water-related activities, the focus of this note is on electricity.

Assessment of JIRAMA Issues

4. JIRAMA's electricity service is deficient. While only a third the population has access to electricity (36 percent), there are recurrent outages affecting electricity consumption (an average of 6 hours of outage per day in Antananarivo in October 2024).[7] Additionally, JIRAMA is faced with three main issues: (i) insufficient and inefficient production, (ii) losses during the transmission, distribution, and commercialization phases, and (iii) tariffs below costs.

5. JIRAMA's production is relatively inefficient as the company produces less than what is generally acceptable, and at a higher cost. JIRAMA's electricity production is mostly based on non-renewable energy sources such as heavy fuel and diesel (54 percent), hydroelectricity (45 percent) and other renewable energy sources (1 percent).[8] In thermal power plants, the availability factor, which is the time over a specific period during which a power plant can operate, is evaluated at around 45 percent, which is well below the acceptable range of 80 to 90 percent, reflecting mostly a lack of maintenance. Operational costs tend to be high as consumption of fuel per kWh is higher than in other countries, due to a low thermal efficiency (related to lack of maintenance and investment, especially in rented power plants) and because of high imported fuel costs.[9] For hydroelectricity, the availability factor is higher, at around 75 percent. Three new hydroelectric powerplants projects (Ranomafana, Sahofika and Volobe) are under preparation and could help increase capacity while containing costs, mostly to the benefit of larger cities, but it would take several years before they can be operational.[10] Other solar projects are still under

[6] JIRAMA serves urban areas including urban, peri-urban, and rural areas that are located close to medium and low voltage networks. They consist in three interconnected networks covering the three main economic areas (Antananarivo, Toamasina, Fianarantsoa), representing 80 percent of overall power demand, and around 100 stand-alone urban networks. Rural areas include remaining areas and are served by the rural electrification development agency (ADER). In general, the system is very separated, with larger cities separated from each other and villages having their own generator.

[7] Based on the 2022 World Bank Enterprise Survey for Madagascar, for firms that report experiencing outages (around 52 percent of firms surveyed), there are 6.3 electrical outages in a typical month, which last an average of 3.1 hours.

[8] Based on 2021 production numbers. Electricity production/generation is different from installed capacity. Capacity refers to the maximum electric output a power plant or electricity generator can produce under specific conditions, while electricity production is the amount of electricity produced during a specific period of time.

[9] Lack of maintenance and investment have led to a sustained deterioration in production efficiency. Fuel consumption tends to be around 250 grams per kWh, which is above the reference values for similar types of power plants (between 200 and 215 grams per kWh). Furthermore, some of the contracts between JIRAMA and private producers force JIRAMA to pay a fixed amount to buy a declining electricity production.

[10] The two hydroelectric projects are faced with significant delays, due to COVID-19 and to other technical difficulties (e.g. infrastructure).

construction (e.g., FINEXPO) and another thermal power plant project is under way. JIRAMA's electricity production reached 1,953 GWh in 2023. It is however difficult to estimate electricity demand as only a small share of the population has access to electricity and it is reported that there is a delay of several years to connect clients to the network.

6. A large share of the electricity produced is lost during the transmission, distribution and commercialization phases.

- **Losses during the transmission phase are moderately higher than industry standards**. 8.2 percent of JIRAMA's production is lost during transmission, which is above the benchmark range of 5 to 7 percent.[11] Measures to reduce transmission losses include improving maintenance as well as constructing and extending transportation network.

- **Distribution losses amount to 22.6 percent, much higher** than the benchmark of 9 to 10 percent. They include both technical and non-technical losses. Technical losses can be related to incidents in the network (connection, rotten pillars, etc.) or to transformers (mostly due to overload), while non-technical losses are generally the result of illicit connections. Losses are mostly due to lack of maintenance, reinforcement and extension efforts, and delays in development projects. They can be reduced by improving selective power cuts, dispatching and controls. In 2016, JIRAMA had set a medium-term objective of 12 percent of distribution losses.[12]

- **Non-collection losses amount to 11 percent,** significantly above the benchmark of 5 percent.[13] They correspond to electricity sold that remains unpaid and can be linked to illicit behaviors (e.g., refusal to let JIRAMA read the meters) or exemptions.

7. Tariffs are far from cost recovery. The tariff structure for households and businesses was last revised in August 2022, but average tariffs remain far below recovery costs. The average price for electricity was 599 ariary per kWh in 2023 (or around US$13 cents per kWh), while the total cost per kWh is twice as high based on JIRAMA's estimations.[14] Costs include fuel expenses (around 56 percent of total costs of JIRAMA's electricity in 2023) as well as electricity purchases from other suppliers (30 percent). An increase in electricity tariffs for businesses was adopted by the Council of

[11] There are three main transport networks in Madagascar with a voltage higher than 35 kV for the three major cities. Other isolated centers are spread across the territory, representing around 20 percent of total consumption.

[12] PAGOSE is a project to improve governance and activities with the electricity sector over 2016–21. One of the objectives was to reduce distribution losses to 12 percent by 2030, including through the financing of distribution control centers to improve load shedding and dispatching. It was complemented by the LEAD project to develop electricity access (2019-24). See additional details in Box 1.

[13] More recent data from JIRAMA suggest that non-collection losses have increased to around 20 percent.

[14] Household electricity prices vary across countries in Africa (2023 data from Statista). If we look at other near fragile countries in Sub-Saharan Africa, the price in Madagascar is below that in Togo (US$19 cents per kWh) and Sierra Leone (US$16 cents per kWh), but above the price in Malawi (US$7 cents per kWh).

Ministers on October 23rd,2024, to be staggered over three years, 20 percent in the first year and 16 percent in the two subsequent years.

8. JIRAMA's 2023 financial accounts are not published yet. While the 2020-22 audited financial accounts were finalized in 2024 with a disclaimer opinion from the audit company, external auditors are still working on the audit of the 2023 accounts. Water and electricity activities are not separated in the statements, which complicates the analysis. Based on the Fund analysis of JIRAMA using the SOE health check tool over 2019-21, JIRAMA is faced with very elevated risks on profitability and solvency, with the net profit margin in negative territory (-40 percent in 2021) and a debt to asset ratio of 160 percent in 2021. Liquidity risks are also elevated, with a ratio of current assets over current liabilities of 85 percent in 2021. Commercial revenue covers only half of exploitation costs – subsidies plug part of the gap, with the rest being financed by debt or resulting in the accumulation of arrears.

9. JIRAMA is also crippled by significant governance issues. There are reports of widespread corruption, misappropriation issues and theft. In May 2024, JIRAMA's former CEO and interim CEO were both sentenced by the Criminal Court of Antananarivo's anti-corruption center (PAC) to ten years of forced labor, on accounts of abuse of office, misappropriation of public funds and money laundering. The governance issues that led to this conviction date back to 2021 when exceptional bonuses of MGA 40 to 180 million were awarded to the company's managers despite the company's financial difficulties.

Box 1. History of Electricity Sector and JIRAMA's Reforms

At JIRAMA's creation in 1975, the electricity sector in Madagascar was governed by law 74-002 (February 4, 1974) which gave the State the exclusive right to intervene in the sector. This right was given to JIRAMA, a state-owned utility facility created in October 1975 by law 75-024. It then controlled most of the production, transportation and distribution processes in the country.

In 1998, Madagascar passed an electricity reform law to privatize the sector and allow the entry of new operators (law 98-032). The goal was to mobilize private financing for electricity infrastructure and to promote better efficiency and service quality through more competition. In this context, the law unbundled the industry and allowed competition in electricity supply using a "concession" approach. A rural electrification agency was set up in 2002 (decree 2002-1550). While the objective was to prioritize local renewable energy sources, several private operators took the opportunity to apply for subsidies to build small mini-grids, mostly powered by diesel-fired generators.

In 2017, a new law was passed to separate the three branches (production, transmission, distribution/commercialization), facilitate reforms aimed at reducing costs and the financing of renewable energy investments to reduce reliance on fossil fuel (law 2017-020). The objective was to attract private capital to finance investments, improve service quality and efficiency and increase self-financing capacity from JIRAMA. In practice, transmission and distribution are still managed by JIRAMA while it is no longer the only electricity producer. However, JIRAMA's status, particularly regarding its public service monopoly in light of the provisions of the law that opened the sector to competition, has not been clarified yet. According to the 2017 Cour des Comptes' report, a new status has been proposed and approved by JIRAMA's Board of Directors but has not been validated by the authorities. Therefore, JIRAMA still operates under its old status.

Box 1. History of Electricity Sector and JIRAMA's Reforms (concluded)

JIRAMA's financial difficulties started in the 1980s after the costly installation of two hydroelectric power plants (Andekaleka and Namorona). As a result, lack of maintenance and subsequent investments contributed to a substantial deterioration in the power plants. The financial situation continued to deteriorate in the 1990s, with tariffs set below cost recovery and irregular adjustments. Over 2006-09, the financial situation was significantly improved, notably with tariff increases which helped improve JIRAMA's profitability. However, the situation started to worsen again in 2009 following a sudden reduction in tariffs, after which JIRAMA's profitability continued to deteriorate driven by significant losses (technical, non-technical, commercialization) and the costs associated with the increased use of thermal production to respond to high electricity demand. In this context, JIRAMA resorted to government subsidies to be able to pay for fuel and electricity purchases from private producers.

The PAGOSE program (Project to improve governance and operations in the electricity sector) was launched in 2016 with World Bank support. It aimed at (i) improving planning and financial sustainability, (ii) strengthening JIRAMA's operational performance and governance, (iii) improving electricity reliability, and (iv) improving coordination between JIRAMA and the Ministry. The LEAD project was also launched to increase electricity access for households, businesses, and health centers in Madagascar over 2019-24. The DECIM project (2023 -2028) is financing: (i) the hybridization of JIRAMA thermal power plants supplying these isolated grids with solar PV technology, battery storage, and associated equipment, (ii) the deployment of smart-grid and smart-metering technologies, (iii) strengthening, densifying and extending climate-resilient distribution grids and connecting additional customers, and (iv) feasibility, affordability and other relevant studies. These investments will improve and expand electricity access, contribute to improving JIRAMA's financial situation, increase sustainability of the systems and reduce GHG emissions.

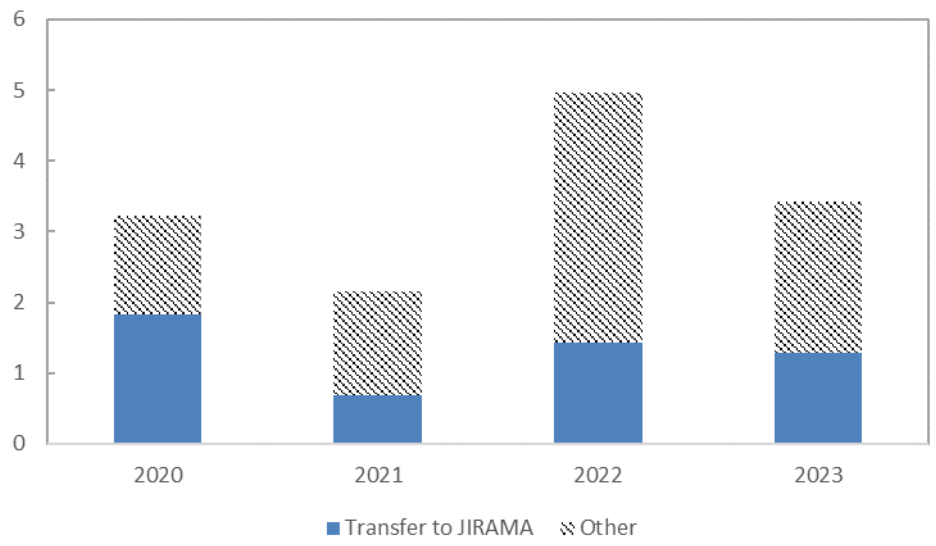
Sources : « Etude sur l'Economie Politique de la réforme du secteur de l'Energie », Dev2E, August 2022 ; 2017 Cour des Comptes report.

B. Impact on Economic Development

Fiscal Impact

10. JIRAMA represents a high fiscal cost for the government. JIRAMA incurs a deficit every year, which is partly financed by transfers from the government. In 2023, JIRAMA's net cash flow, which is calculated as total revenue inflows minus total cost outflows, amounted to MGA 1,268 billion or 1.8 percent of GDP, while the government's transfers to JIRAMA and selected suppliers reached MGA 895 billion or 1.3 percent of GDP. Other fiscal implications on the revenue side relate to the electricity tariff structure, such as the VAT tax exemption for small consumers, and to the fact that JIRAMA does not pay its taxes (e.g., JIRAMA collects the VAT but does not pay it to the government). As an example, JIRAMA has not paid its taxes due on its employees' wage incomes, which amounted to MGA 13 billion between January and August 2024.

Figure 1. Primary Fiscal Deficit
(In percent of GDP)



Source: IMF Staff Estimates.

11. JIRAMA represents a fiscal risk for the State. JIRAMA's debt to the private sector, including arrears to suppliers, amounted to MGA 1,880 billion or 2.7 percent of GDP at end-2023.[15] In 2022, the government started to issue special T-bills to pay for JIRAMA's fuel requisitions and has been treating those payments as loans from the government to JIRAMA.[16] Taking into account debt to the State, JIRAMA's debt would increase to MGA 5,316 billion or around 7.6 percent of GDP at end-2023.[17]

Impact on Business Competitiveness

12. Electricity is the second biggest constraint to competitiveness reported by businesses in Madagascar, based on the Enterprise Survey conducted by the World Bank.[18] While access to finance is considered as a constraint by 26 percent of the businesses surveyed, electricity is reported as an impediment by 17 percent of them (Figure 4). It is well above other categories such as corruption or informality.

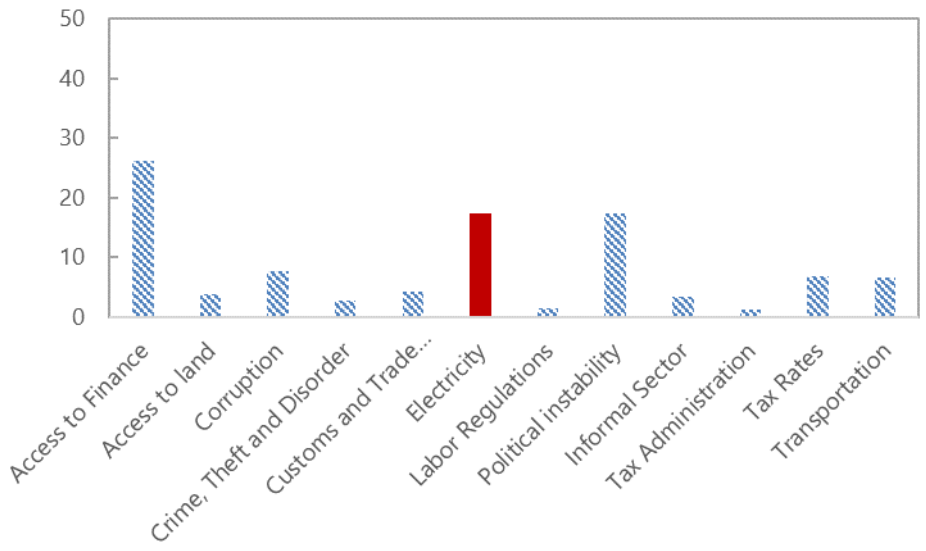
[15] This number is an estimation based on JIRAMA's 2023 non-audited financial accounts. It is derived by adding loans and financial debts from non-current liabilities to short-term debt and accounts payable from current liabilities, excluding debt to the State.

[16] While using special T-bills is an improvement by formally accounting for the contribution of the State to JIRAMA's activities, more transparency would be required, notably on the T-bills conditions and characteristics.

[17] The 2024 Cour des Comptes' report assesses that JIRAMA's debt to its suppliers (including debt to the government) amounted to MGA 2,585 billion at end-2022, with debt to suppliers being one of the components of total debt. JIRAMA's debt to its suppliers is estimated to be lower at end-2023 (MGA 2,371 billion) based on the 2023 non-audited financial statements.

[18] The World Bank conducted an Enterprise Survey for Madagascar in 2022, surveying 386 businesses.

Figure 2. Perceived Constraints to Businesses in Madagascar
(In percent of responses)

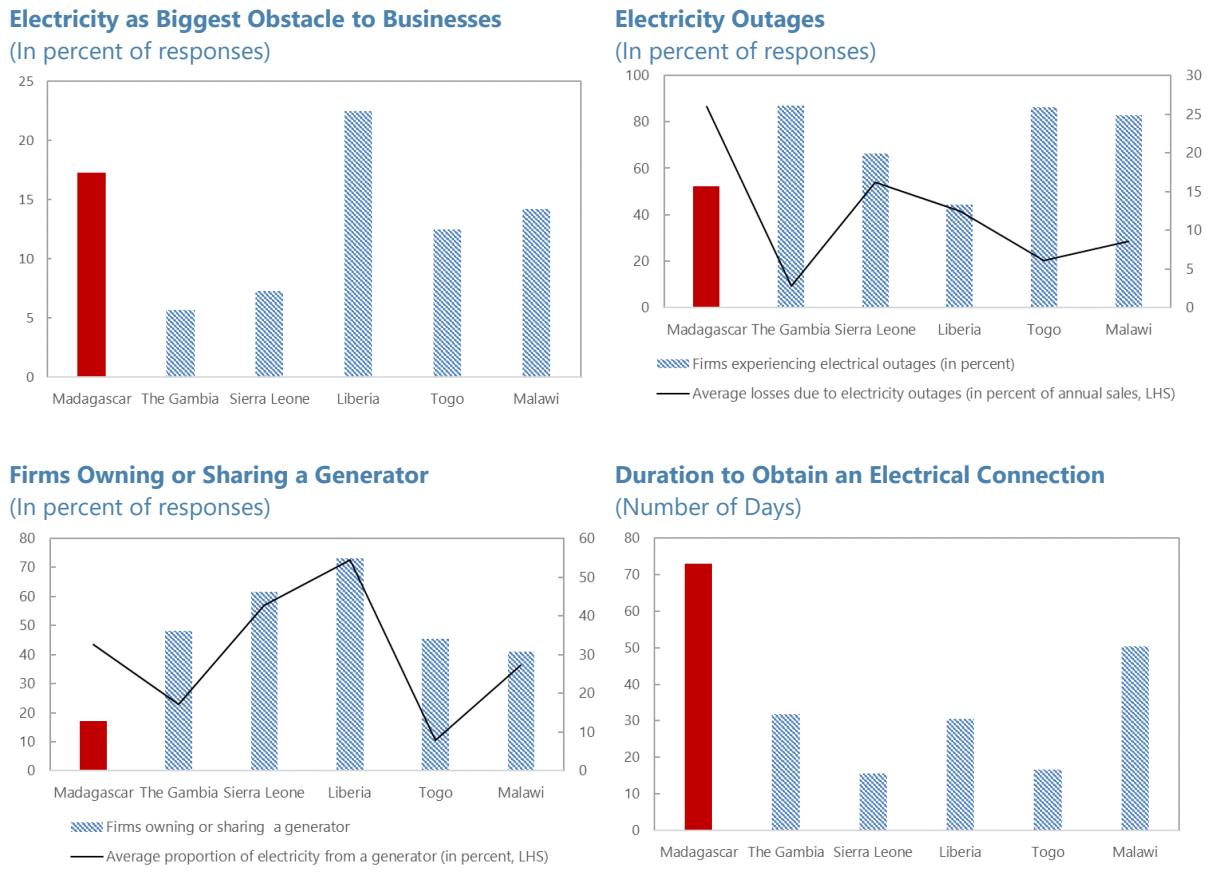


Source: World Bank Enterprise Survey on Madagascar (2022)

13. Madagascar's electricity sector performance is worse than in other similar countries in the region (Figure 5).[19] 17 percent of firms report electricity as their biggest obstacle to doing business, which is well above the average of a comparator group of near fragile countries in Sub-Saharan Africa (SSA, 12 percent). 52 percent of businesses report experiencing electrical outages, compared to an average of 73 percent in the comparator group. However, for those businesses experiencing outages, average losses due to outages represent an average of 26 percent of their annual sales, which is well above all countries in the comparator group. The number of days to obtain an electrical connection upon application is 73 days on average, which is also higher than in all countries in the comparator group. Finally, relatively fewer businesses own or share a generator (17 percent vs. an average of 54 percent in the comparator group).

[19] For the purpose of this analysis, we define a comparator group of "near fragile" countries, which are no longer "fragile" countries according to the World Bank's classification, but continue to exhibit fragilities, similar to Madagascar. Comparator countries in the region were surveyed by the World Bank in 2023 for The Gambia, Sierra Leone, and Togo, in 2017 for Liberia and in 2014 for Malawi. The average numbers reported in the text are computed by averaging over countries in the comparator group.

Figure 3. Electricity as Impediments to Businesses, Cross-Country Comparison



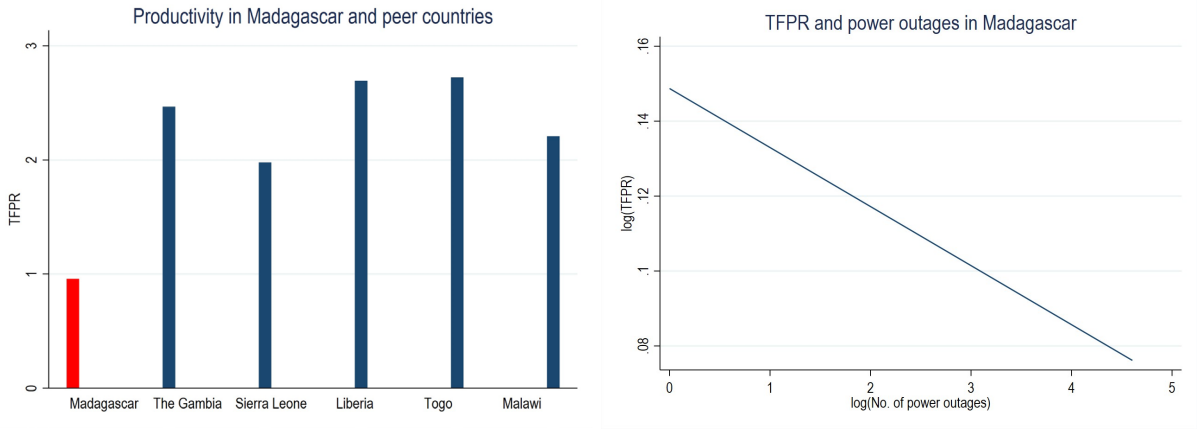
Source: World Bank Enterprise Surveys

14. Unreliable electricity supply dampens firm productivity, particularly among smaller firms without generators. Using revenue-based total factor productivity (TFPR) estimates at the firm-level derived from the World Bank Enterprise Surveys, we find that Madagascar's average TFPR is lower than that of peer countries (Figure 6).[20] In addition, descriptive evidence from the Enterprise Surveys suggests a negative relationship at the firm level between TFPR and the frequency of power outages.[21] Rigorous empirical analysis based on richer firm-level panel datasets for other developing countries corroborate our findings. For example, using manufacturing plant-level panel data and state-level information on electricity outages in India, Allcott et al. (2016) find that, for the average plant, electricity shortages lowered productivity by 1.5 percent, a statistically significant result. Similarly, using panel data on Chinese firms, Fisher-Vanden et al. (2015) find that electricity shortages raised production costs by 8 percent on average.

[20] Estimates of TFP based on the World Bank Enterprise Surveys are constructed by Francis et al. (2020). Using a translog production function with capital and labor as inputs, the authors obtain estimates of revenue-based TFP (TFPR) at the firm-level for establishments represented in the survey.

[21] Causality is difficult to establish based on cross-sectional data.

Figure 4. Total Factor Productivity and Power Outages



Source: World Bank Enterprise Surveys and IMF staff estimates.

Impact on Economic Growth

15. More broadly, lack of electricity is a constraint on economic growth. As a factor of production, electricity availability directly impacts economic growth.[22] In addition, by facilitating commercial activity at night, reducing indoor air pollution from substitute energy sources, and reducing the uncompensated time spent collecting firewood, electrification also has a positive indirect impact on growth. Yet, reliable estimates of the impact of electricity access on economic growth vary across existing studies due to endogeneity issues. Best and Burke (2018) find that the elasticity of GDP growth with respect to electricity access varies substantially by econometric specification and by choice of controls.[23] Using a panel regression of average annual GDP per capita growth on measures of electricity access and lagged GDP per capita over 2006-16, the authors find that a 10 percentage point increase in electricity capacity per capita could significantly increase GDP per capita growth by anywhere between 0.6 and 1.1 percentage points over a ten-year period.[24] Using a simple back-of-the envelope calculation, their results imply that were Madagascar's electricity capacity 10 percentage points higher, annual GDP per capita could have been 9 percent greater after a ten-year period.

16. Adopting a similar empirical strategy with more recent data, we estimate the impact of raising electricity access on GDP per capita growth.[25] As presented in Box 1, a ten-percentage

[22] Lee et al. (2020) provide a useful overview of the literature on the growth impact of reliable electricity access.

[23] The authors measure electricity access in several ways, including electricity consumption per capita in kilowatt hours, electricity capacity per capita, as well as electricity transmission and distribution losses.

[24] Electricity capacity is measured as the total electricity installed capacity in million kilowatts. Depending on the specifications, other controls include other non-electric energy consumption per capita, life expectancy, consumer price inflation, corruption, trade openness, regional fixed effects, time effects and country fixed effects.

[25] Electricity access is measured as the percentage of the population with access to electricity at the country level. Data is taken from World Development Indicators.

point rise in electricity access raises annual per capita GDP growth by between 0.4 and 0.9 percentage points. Using these estimates, our back-of-the-envelope calculations suggest that if the share of population with electricity access in Madagascar were to increase from the current 35 percent to the objective of 70 percent by 2030 targeted in the PGE, GDP per capita would be anywhere between 13 and 28 percent higher relative to the baseline after 10 years.

Box 2. Economic Growth and Electricity Access at the Country Level

Following Best and Burke (2018), we adopt the following econometric specification to measure the impact of electricity access on long-term growth at the country level:

$$\frac{log(y_{it}) - log(y_{it-10})}{10} = \rho_0 + \rho_1 Electricity_{it-10} + \rho_2 log(y_{it-10}) + X_{it-10}\beta + \psi_i + \delta_t + \epsilon_{it}$$

Where the left-hand side of the equation refers to average annual growth of GDP per capita of country i, y_{it}, over a decade and $Electricity_{it-10}$ refers to the percentage of the population with electricity access. We also control for growth convergence (y_{it-10}), other time varying country-level controls (X_{it-10}), country fixed effects and year effects. Standard errors are clustered at the country level. We run the regression with data over two decades over a set of 168 countries, from 2001 to 2010, and 2010 to 2019.[1/]

	Per capita GDP growth (annual average)		
log(GDP per capita)	-1.42***	-1.60***	-9.62***
	(0.21)	(0.19)	(0.70)
Electricity access (% of population)	0.04***	0.05***	0.09***
	(0.01)	(0.01)	(0.03)
log(life expectancy)	3.66	2.59	-5.08
	(2.72)	(2.48)	(5.35)
CPI	-0.13***	-0.04***	0.01
	(0.01)	(0.01)	(0.01)
Trade (% of GDP)	0.01***	0.01***	0.02**
	(0.00)	(0.00)	(0.01)
Country FE	No	No	Yes
Year FE	No	Yes	Yes
R^2	0.58	0.65	0.89
N	312	312	312

Country-level economic growth and electricity access

From the regression table above, a one percentage point increase in the share of population with electricity access significantly raises average annual per capita GDP growth anywhere between 0.04 and 0.09 percentage points.

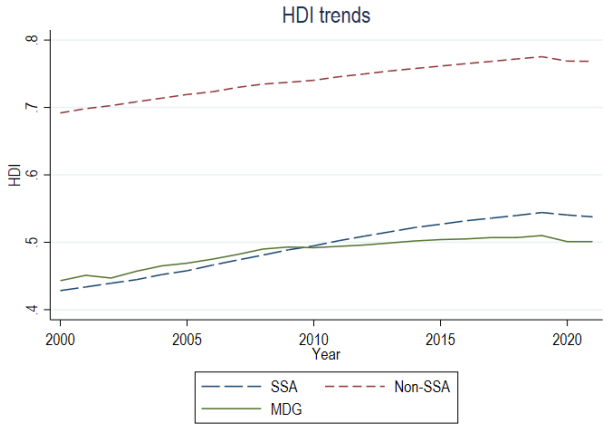
1/ Data are from the World Development Indicators. They can be accessed here.

Impact on Human Development Index (HDI)

17. Madagascar's HDI has stagnated between 0.49 and 0.50 for the last ten years, placing the country in the category of "low human development", according to the United Nations

Development Program (UNDP).[26] Madagascar has increasingly lagged behind its peers in SSA (Figure 6). Electricity access is expected to impact all facets of HDI by affecting the duration and type of economic activity, education, and health outcomes. Indeed, electricity access is deemed by the UNDP to be a necessary condition for development and is one of the Sustainable Development Goals (SDG 7).

Figure 5. HDI Trends in Madagascar and SSA[1]



1/ The figure is constructed using country-level HDI data from the Global Data Lab. Mean HDI is calculated for each of the relevant country groups by year.

18. Substantial variation in HDI is observed across districts within Madagascar (Box 2). Applying machine learning methods to satellite data, Sherman et al. (2023) estimate HDI at the district level for all countries including Madagascar. While wealthier districts around the capital and the northeast such as Toamasina I on the east coast had levels of HDI at just under 0.66 in 2019, close to the average among emerging economies (0.75), other districts in the central south, such as the district of Benenintra, face much lower levels of development of around 0.37. Moreover, there is no evidence of convergence in development across districts, with less developed districts in the southwest for instance experiencing a decline in HDI over time. Overall, the gap in HDI between the most and least developed districts in Madagascar has stagnated at around 0.34 since 2013.

19. Improving electricity access would significantly raise HDI in Madagascar. To avoid endogeneity concerns that could arise in the relationship between HDI and electricity access, we adopt the instrumental variables strategy of Dinkelman (2011), which hinges on the assumption that the land gradient of a locality correlates with the cost of electrification but does not otherwise correlate with the unobserved factors that affect HDI.[27] Exploiting the variation in development and electricity access across districts in Madagascar, we find that a 10-percentage point increase in the

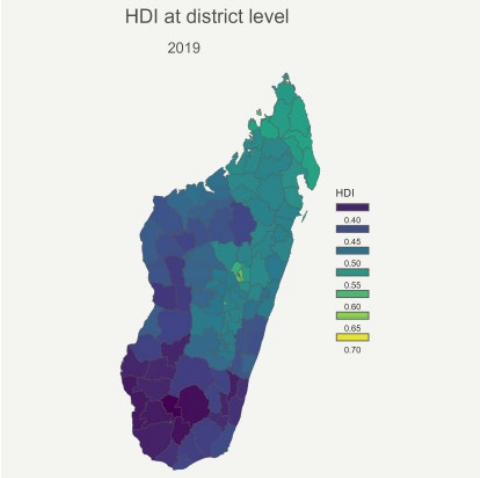
[26] The HDI is a composite measure of 3 indicators of development: (i) life expectancy at birth, (ii) expected years of schooling, and (iii) GNI per capita (PPP$). It ranges from 0 (least developed) to 1 (most developed).

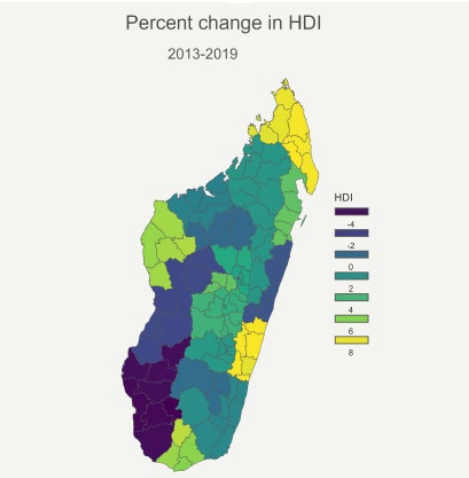
[27] The impact of electrification on development has also been explored by papers including Lipscomb et al. (2013), in which the authors exploited exogenous topographical variation to estimate the development effects of electrification in Brazil.

share of households with reliable electricity access would raise HDI at the national level significantly, by 1.3 percentage points (Box 3).

Box 3. Sub-National Data on Development and Electricity Access

Due to lack of official data, information on economic growth, development, and electricity access in Madagascar must be gleaned from other sources. Using a range of features from world-wide satellite imagery and machine learning applied to sub-national units for which official data is available, Sherman et al. (2023) estimate the Human Development Index (HDI) for all countries at the sub-national level. We use their HDI estimates at the district-level as a measure of development in Madagascar.[1/]

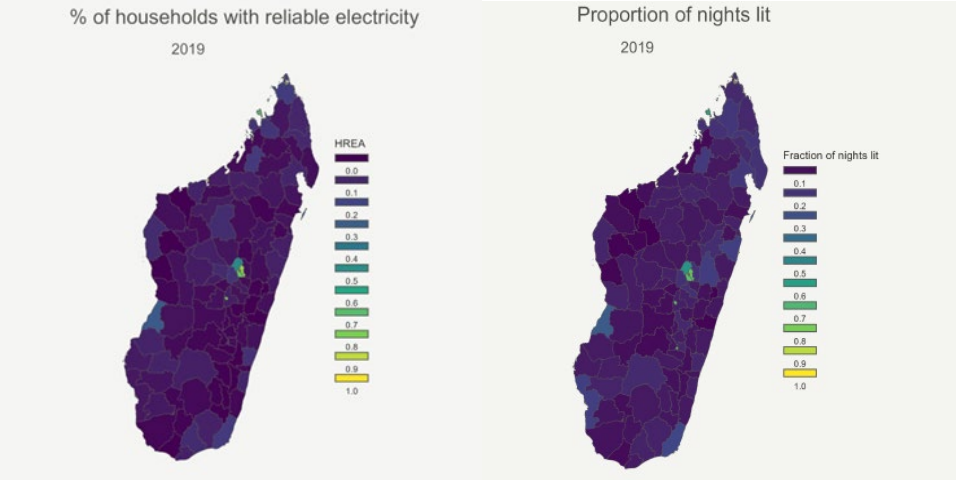




For electricity access, we rely on estimates from Min et al. (2024), based on average yearly measures of luminosity at night.[2/] We aggregate these settlement-level estimates and calculate the percentage of households with electricity access, as well as the fraction of nights lit at the district level for Madagascar.[3/]

1/ The sub-national HDI data can be found here. For our analysis, we focus on the period from 2013 to 2019, to abstract from the pandemic years.
2/ From this night light information, the authors derive estimates of the percentage of households with reliable access to electricity (HREA) in each settlement, as well as the proportion of nights a settlement is observed to be lit each year.
3/ The use of satellite data to measure electricity access or outages has also been explored in Min et al. (2017) and Shah et al. (2022).

Box 3. Sub-National Data on Development and Electricity Access (concluded)



Box 4. Estimating the Impact of Electricity Access on Development

We adopt an instrumental variable strategy to estimate the causal impact of electricity access on development, following Dinkelman (2011), with the following econometric specification:

$$HDI_{drt} = \alpha_0 + \alpha_1 Electricity_{drt} + X_{drt}\beta + \mu_{rt} + \underbrace{\psi_{drt} + \epsilon_{drt}}_{\upsilon_{drt}}$$

$$Electricity_{drt} = \delta_0 + \delta_1 Slope_{drt} + X_{drt}\Gamma + \mu_{rt} + \upsilon_{drt}$$

Where HDI_{drt} and $Electricity_{drt}$ refer to HDI and some measure of electricity access in district *d*, region *r*, at time *t* respectively. X_{drt} is a vector of observed time-varying controls, while μ_{rt} and ψ_{drt} refer to regional time-varying effects and unobserved time-varying district-level effects respectively. The coefficient of interest is α_1, which measures the impact of greater electricity access on HDI.

	OLS	OLS	IV (Mean slope)	IV (Max slope)
HREA	0.16***	0.13***	0.13***	0.13***
	(0.02)	(0.01)	(0.03)	(0.01)
Distance to road (100km) -0.02**	-0.00	0.00	-0.00	
	(0.01)	(0.00)	(0.01)	(0.00)
Annual irradiation (100kWh/m2)	-0.01	-0.01***	-0.01***	-0.01***
	(0.01)	(0.00)	(0.00)	(0.00)
Distance to grid (100km)	-0.27	4.81*	4.06	4.26*
	(5.88)	(2.59)	(2.62)	(2.39)
Population (100,000s)	0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Region FE × Year FE	No	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
R^2	0.42	0.98	0.88	0.88
N	760	760	760	760

Impact of reliable electricity access on HDI

Box 4. Estimating the Impact of Electricity Access on Development (concluded)

Since electricity access in a district is likely endogenous to HDI, such that

$$\mathrm{E}[\upsilon_{\mathrm{drt}}|\mathrm{Electricity}_{\mathrm{drt}}] \neq 0,$$

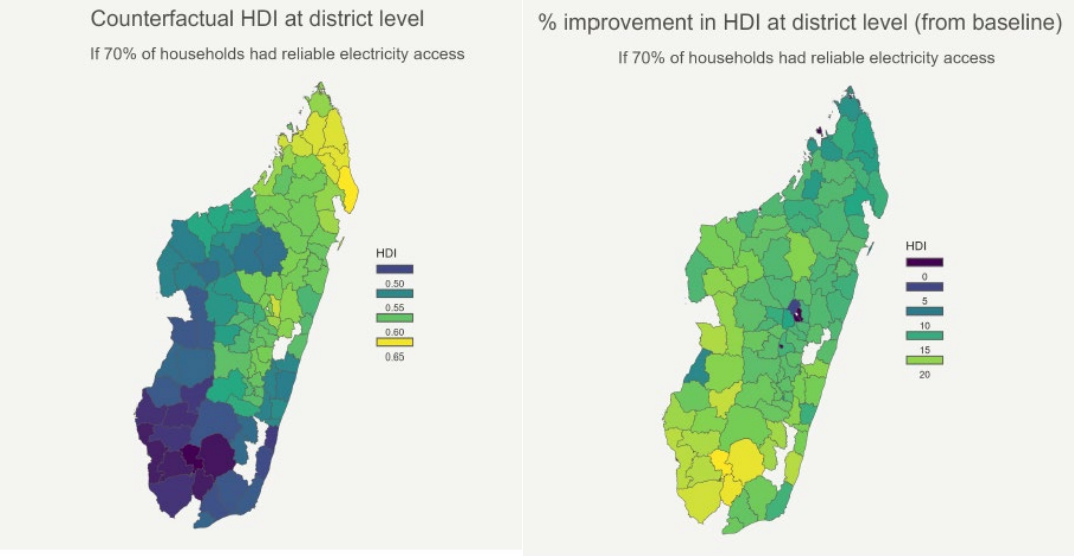
we use the land gradient of a district as an instrument for electricity access, following Dinkelman (2011).[1/] We find that a 10-percentage point increase in the share of households with reliable electricity access would raise HDI by 1.3 percentage points.

1/ The assumption is that the slope of a district affects the cost of reliable electricity access, but not other unobserved factors that also affect economic development. Since it is possible that in-migration to districts with flatter gradient is larger, which would affect HDI, we control for time-varying population at the district level. We experiment with average and maximum slope of a district and confirm that the IV results are similar for each of the two instruments. We also use both instruments jointly and conduct a Durbin-Wu-Haussman test of overidentifying restrictions to check for exogeneity. We do not reject the null hypothesis that the instruments are exogenous.

Regional Disparities

20. If the authorities' aim of 70 percent household electricity access by 2030 were achieved, Madagascar's national HDI would rise by 16 percent and the HDI gap between the most and least developed district would narrow by 29 percent.[28] Using the regression estimates in Box 3, we calculate the counterfactual HDI for all districts in Madagascar, presented in Figure 7. We find that for the least developed districts in the south, district-level HDI would rise by close to 25 percent if the electricity access objective were achieved. At the national level, this would translate into a rise in HDI to 0.58, placing Madagascar on par with countries such as Cameroon. [29]

Figure 6. Development Gains from Rise in Electricity Access



Source: IMF staff estimates

[28] The authorities' energy strategy plan can be found here.

[29] As of 2023, Madagascar's HDI stood at 0.49, ranking 177th out of 192 countries. A HDI of 0.58 would move the country up by around 25 places in the global HDI ranking, everything else constant.

C. Possible Way Forward

Comparison with Other Countries

21. In SSA, one third of electricity utilities encounter financial difficulties. Work done by the World Bank's Energy Sector Management Assistance Program (ESMAP) through its Utility Performance and Behavior in Africa Today (UPBEAT) framework illustrates the difficulties faced by electricity utilities in SSA.[30] Based on 2012-2018 data, it points to the precarious financial situation of most power companies and explains that only one in three utilities in SSA recover their operating and debt-servicing costs (one in four if subsidies are excluded). It notes that financial performance correlates with reporting on performance management, making the link between better financial performance and improved transparency and accountability. Fewer than half the utilities surveyed published their audited financial statements and fewer than one in three had unqualified audit opinions.

22. Improvements in cost recovery tend to result from reductions in non-technical losses or from sharp increases in capacity. The UPBEAT survey also points to some success story in terms of improvement of cost recovery through reduction of non-technical losses such as fraud and other unmetered consumption (Côte d'Ivoire) or in terms of improvement of reliability of electricity supply (Rwanda). In Rwanda, a drastic reduction in System Average Interruption Duration Index was linked to a vast increase in generating capacity (from 76 MW in 2009 to 225 MW in 2020) and to the rehabilitation, upgrade, and extension of the transmission and distribution infrastructure to better serve existing customers and expand electricity access (from 6 percent in 2009 to 54 percent in March 2020). Rwanda was also able to significantly reduce system losses through better monitoring of the consumption of large customers and state-of-the-art information systems.

23. Successful electricity sector reforms are correlated with the presence of an electricity law, a sector regulator, vertical unbundling, and private participation. A 2022 paper analyzes the performance of electricity sector reforms in 37 SSA countries between 2000 and 2017.[31] It indicates a positive correlation between reforms and installed generation capacity per capita, plant load factor, and reduction of technical network losses. The presence of an electricity law, a sector regulator, vertical unbundling, and private participation in the management of assets are all positively correlated with reform performance. The paper points notably to the performance of Côte d'Ivoire, with an early engagement (1994) in IPPs for power generation and a successful privatization through a concession contract of the vertically integrated Compagnie Ivoirienne d'Electricité, in charge of generation (partly), transmission and distribution of power.

[30] Balabanyan, A., Y. Semikolenova, A. Singh, and M. A. Lee. 2021. Utility Performance and Behavior in Africa Today (UPBEAT): SUMMARY REPORT. ESMAP Papers. Washington, DC: World Bank.
[31] Asantewaa, A.; Jamasb, T.; Llorca, M. Electricity Sector Reform Performance in Sub-Saharan Africa: A Parametric Distance Function Approach. Energies 2022, 15, 2047. https://doi.org/10.3390/en15062047

Recommendations

24. A recovery plan is currently under preparation by the new JIRAMA management. While a first objective is for JIRAMA to reach financial sustainability and no longer be dependent on government transfers, other important objectives relate to electricity access and a shift of the production mix towards more renewables.[32] Recommendations include:

- **Increase production capacity and efficiency and expand access to electricity**. While it is difficult to estimate the size of electricity demand, it is estimated that electricity production should be at least doubled by 2030. Improving production efficiency involves reducing the amount of fuel needed to produce electricity, including through a better monitoring of fuel stocks (geo-filling).

- **Shift the production mix**. The expansion of production capacity should take place through an increase in renewable energy to reach 85 percent of the production mix (75 percent hydroelectricity, 5 percent wind energy and 5 percent solar energy). In this context, the share of thermal production (using fossil fuel) could be decreased to 15 percent for both cost and environmental reasons. Potential hydroelectric power is estimated at 7,800MW but a large share of hydroelectric power plants has little storage capacity, which means that it cannot be a substitute to thermal energy during peak hours. There is also unused potential with solar energy (2,800 hours of sun estimated annually), but it is more expensive than hydroelectricity production and tends to supply electricity outside peak hours. Finally, potential wind energy is estimated at 2,000MW.

- **Reduce losses**. Losses could be reduced to around 20-25 percent of production (transmission, distribution, and commercialization phases). This would require a broad use of smart and prepaid meters to better control consumption and fully extend the use of prepaid meters in all administrations. Investments in maintenance to improve the quality of the network would also be crucial.

- **Review the tariff structure**. Tariffs should be in line with recovery costs, including operational, distribution, commercialization, and investment costs. A first-best approach is to have one single household tariff and compensate most vulnerable households with targeted transfers. When targeted transfers are difficult to implement, the second-best approach is a tariff structure by consumption brackets. Going forward, an automatic indexation mechanism is needed to keep prices in line with costs.

[32] The objectives are presented in the national Energy Policy 2015–2030. One goal is to increase electricity access to 70 percent of households by 2030.

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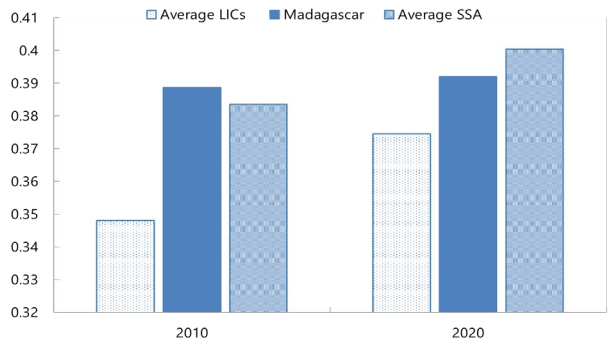
IMPROVING EDUCATION QUALITY—THE RETURNS TO TEACHER TRAINING IN MADAGASCAR[1]

The Malagasy education system is today at a critical crossroads. With a significant number of Malagasy children still outside of the education system, a poor and declining level of academic proficiency among students, as well as low primary school completion rate, urgent and bold reforms are needed. In line with the new Orientation Law for Madagascar's Education System (LOSEM)[2], the Malagasy Ministry of National Education (MEN) identified three strategic pillars as key to strengthening basic education in the country: i) availability of well-trained, motivated, and competent teachers, ii) effective learning time (in terms of hourly volume) and quality (in terms of an effective teaching approach and academic remediation), and iii) learning conditions favorable to the development and fulfillment of learners. This paper focuses on the first strategic axis. After an overview of education attainment in Madagascar, it examines the link between education and growth with an emphasis on teachers' training It finds that doubling the share of qualified primary school teachers could raise per capita real GDP growth by around 2.5 to 3.1 percentage points in Madagascar. The paper then quantifies the spending needs for recruiting and training primary school teachers, with focus on current unqualified teachers, to meet the country's projected needs over the next 6 years and finally draws some policy implications.

A. Education in Madagascar: Background and Recent Developments

1. Madagascar is among the countries with low human capital development. Its Human Capital Index (HCI) was estimated at 0.39 in 2020[3], implying that a child born at that time will reach only 39 percent of her/his potential productivity as she/he grows into adulthood based on the quantity and quality of health care and education received during her/his childhood. According to this metric, the level of human capital has stagnated over the last decade, and it was in 2020 slightly below the

Figure 1. Human Capital Index
(2010, 2020)



Source: Human Capital Index DataBank, world Bank

[1] Prepared by Kodjovi Eklou, Ialy Rasoamanana and Joanne Tan (IMF), Mamy Andrianarilala, Rolland Andrianjaka and Chrystelle Tsafack (UNICEF), and Almedina Music (World Bank). The analysis benefitted from helpful comments from staff from the Ministry of Education.

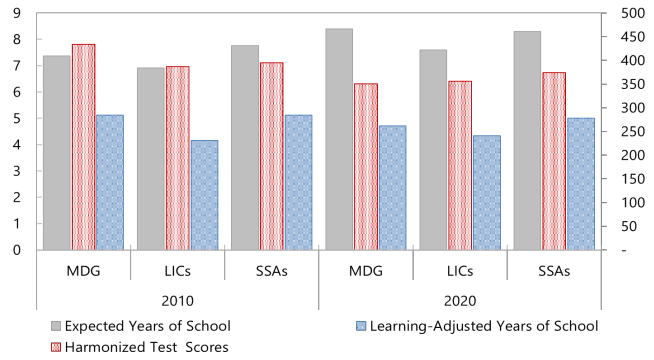
[2] LOI n°2022 - 018 portant orientation générale du système éducatif à Madagascar.

[3] The Human Capital Index (HCI) is measured at the country-level by the World Bank and ranges from 0 (lowest) to 1 (highest).

average in Sub-Saharan Africa (SSA) region (0.40), although moderately above those of low-income countries (0.37) (Figure 1).

2. The education component of the HCI deteriorated notably between 2010 and 2020. Indeed, HCI sub-indicators aimed at measuring the quality of education, such as standardized tests scores or learning adjusted years of schooling (LAYS), have significantly decreased in the past decade.[4] The number of expected years of schooling[5] has however improved and remained above the performance of the two groups of countries mentioned earlier (Figure 2). In contrast, standardized test scores have declined by about 19 percent between 2010 to 2020 and are barely above the minimum score of 300[6].

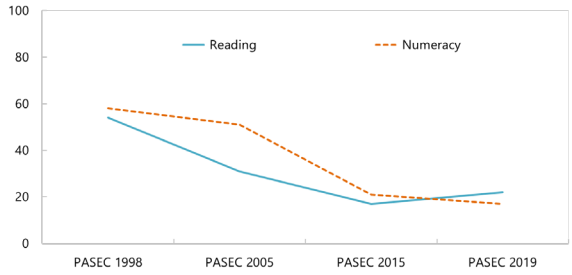
Figure 2. Human Capital Index – Education Components
(2010, 2020)



Source: Human Capital Index DataBank, world Bank

3. Many students finish primary school without acquiring basic numeracy and reading skills. The "learning poverty" indicator, jointly developed by the World Bank and UNESCO, reveals an alarming situation. Indeed, 24 percent of children of primary school age are out of school; and 97 percent of the Malagasy children aged ten are classified as "learning poor", meaning that they could not read and understand a simple text. Compared to peer countries in the region (SSA) or of the same income level (LIC), learning poverty is respectively 10 points and

Figure 3. Students with the Minimum Skills at the End of Primary School
(In percent)



Source: PASEC Reports

[4] The LAYS combines quantity and quality of schooling into a single metric of progress that is it accounts for how much students learn for each year they are in school. LAYS is an index obtained as the product of the average years of schooling for a relevant cohort of students and a measure of learning relative to a benchmark (top performer based on test scores).

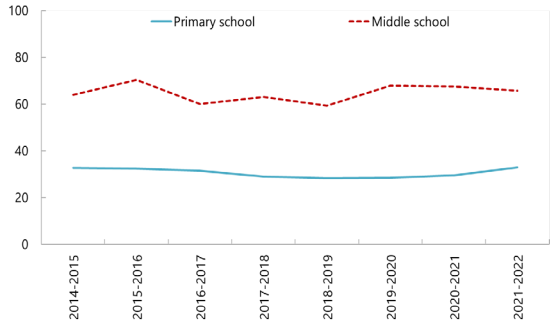
[5] Expected years of schooling is the number of years a child of school entrance age is expected to spend at school, or university, including years spent on repetition. It is the sum of the age-specific enrolment ratios for primary, secondary, post-secondary non-tertiary and tertiary education.

[6] The standardized score ranges between 300 (minimum level) to 625 (advanced level). The Covid-19 pandemic and the related lockdown has led to learning losses in many emerging and developing countries.

6.8 percentage points higher in Madagascar[7]. Likewise, according to PASEC2019, 83 percent and 78 percent of students reached the end of primary school without basic numeracy and reading skills respectively, compared to 42 percent and 46 percent in 1998, suggesting a significant deterioration of academic competencies (Figure 3).[8]

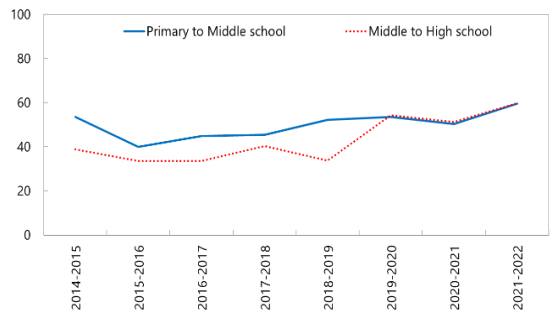
4. The internal efficacy of the education system has stagnated. The retention and transition rates at the primary and lower secondary levels have showed no substantial improvement over the past ten years. Only 1 in 3 students completes primary school, and only 60 percent of these students then continue to middle school. Furthermore, only 60 percent of students entering middle school eventually complete it, and of these graduating students, just under 60 percent go on to start high school. Taken together, these retention and transition rates (Figures 4 and 5) imply that out of every 100 children entering primary school, only 7 eventually reach high school).

Figure 4. Retention Profile
(2014–2022, in percent)



Source: Ministère de l'Education Nationale (MEN)

Figure 5. Transition Profile
(2014–2022, in percent)



Source: Ministère de l'Education Nationale (MEN)

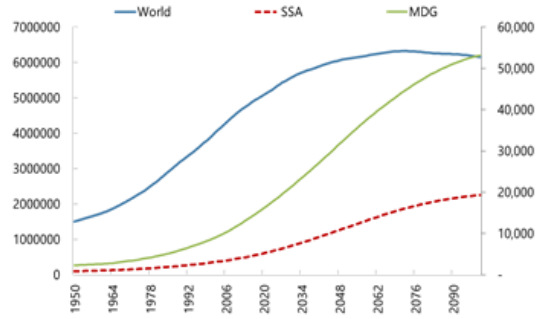
5. Access to quality education remains a major challenge. Madagascar continues to face challenges e to provide both quantity and quality education. Indeed, apart from the net primary school enrollment rate (97.9 percent in 2022) and the literacy rate (80 percent in 2021), other indicators of education quality remain below the levels required to achieve the Sustainable Development Goals (SDGs). For instance, the completion rates of the first cycle of secondary education and the rate of participation in pre-primary learning remained respectively at 30.2 percent and 39.5 percent in 2023.

[7] Fighting poverty with education: Why school reforms are urgently needed in Madagascar, World Bank, February 2024.

[8] The Program for the Analysis of Educational Systems of the Conference of Ministers of Education of French-speaking States and Governments (PASEC) evaluates the performance of the education systems of 24 member Francophone countries.

6. Investing in education could allow Madagascar to benefit from its demographic dividend. In 2050, the world population is projected to reach 9.7 billion individuals including 2 billion from Sub-Saharan Africa[9]. According to these estimates, SSA countries will account for more than 20 percent of the global workforce at this time. Madagascar is projected to almost double its population over the same period from 27 to 52 million between 2018 and 2050. The demographic dividend in Madagascar will more than double the number of its working-age population, which will go from 15 to 33 million (Figure 6).

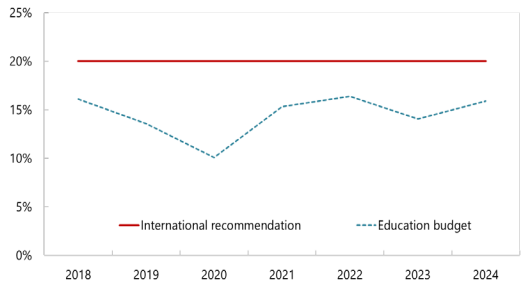
Figure 6. Evolution of Working Age Population in Madagascar (LHS), SSA and the World (RHS)
(In thousands)



Source: UN population projections

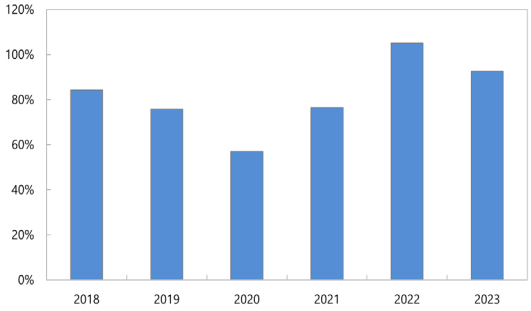
7. Yet public spending on education remains low. In Madagascar, public spending on education remains well below both the LIC and SSA average (Figure 7). Over the period 2010-2022, the government of Madagascar devoted about 2.7 percent of GDP on average to education while over the same period, this ratio stood at 4.1 percent and 13.4 percent for SSA countries and LICs respectively. The country's spending on education is also far below the level required to reach the SDG on education by 2030, with a gap of about 8 percentage points between the current and the needed level of spending (4.4 percent in 2020 against 12.3 percent in 2030).[10] Similarly, spending

Figure 7. Budget Allocation to the Education Sector in Madagascar
(As a percent of total budget)



Source: Lois de règlements (2018-2020); Budget. execution report (2021-2022) ; Loi des finances (2023-2024). UNICEF staff estimates.

Figure 8. Budget Execution Rate in Madagascar
(In percent)



Source: Ministry of Economy and Finance

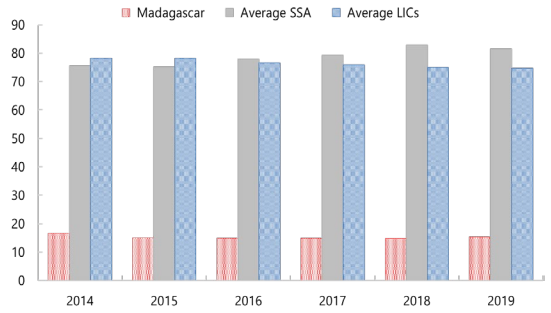
[9] Source: UN World Population Projections.

[10] These estimates are based on the 3rd edition of the IMF SDG Costing tool (2022). The tool assesses the additional spending needed to achieve a strong performance in selected SDGs, including education (SDG4). Specifically, the 8-percentage point of GDP increase in education spending is estimated to cover full access to two years of pre-primary education, five years of primary education, six years of secondary education, and two years of tertiary education.

per student shows a gap of about US$123 (US$79.3 in 2020 versus US$ 201.9 in 2030) (Figure 8).[11] Even as a share of total government budget, the budget allocated to education is low. In addition, that budget is not always fully executed (Figure 10). As a result, the share of the executed government budget to education has barely increased since 2018 and remains below the 20 percent recommended by UNICEF (Figure 9).

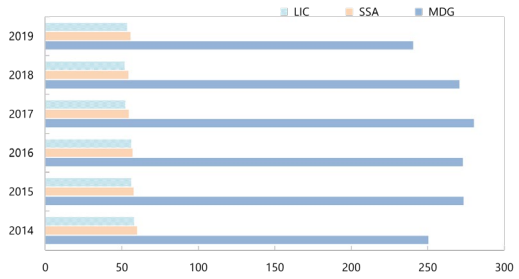
8. The number of qualified teachers is severely inadequate. A quick comparison with peer countries at the same level of development shows an alarming situation. Indeed, the proportion of teachers with the minimum required qualifications at the primary school level remains low and has stagnated over the years.[12] Over the period 2014-2019, it stood at around 15.2 percent on average, well below the average in SSA countries (79.4 percent) and in LIC countries (76.1 percent) (Figure 11). Little improvement was also observed in the ratio of students to qualified teachers (Figure 12), which stood at 240:1 in Madagascar, far above the LIC and SSA average, in 2019.

Figure 9. Proportion of Teachers with the Minimum Qualifications Teaching in Primary School
(In percent)



Source: UNESCO Institute for Statistics (UIS)

Figure 10. Ratio of Pupils to Qualified Teachers
(Headcount basis)



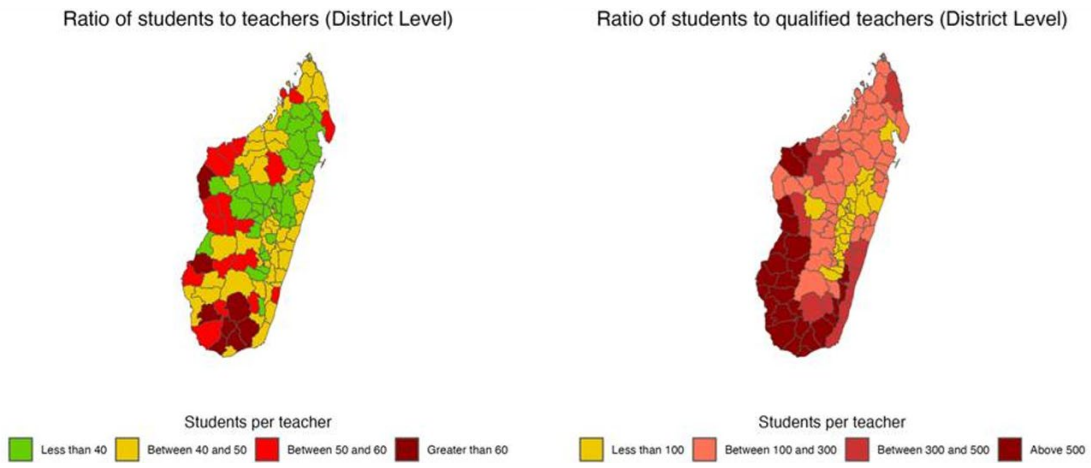
Source: UNESCO Institute for Statistics (UIS)

9. Large regional disparities exist in terms of both the quantity and quality of teachers. As shown in Figure 13, there is significant heterogeneity across districts in student-teacher ratios, notably with poorer districts in south-west of Madagascar having substantially higher student to teacher ratios than wealthier districts around the capital and in the north-east. The gap between districts widens when considering the ratio of students to qualified teachers. The student to qualified teacher ratio falls below 100 in only 28 districts around the capital and exceeds 500 in 24 districts in the south and western parts of the country.

[11] Here, spending per student refers to average public spending per student, including students from the last two years of pre-primary to the first two years of tertiary education.

[12] The share of teachers meeting the minimum required qualifications is estimated by UNESCO Institute for Statistics (UIS). This refers to the share of teachers who have received at least the minimum organized pedagogical teacher training required for teaching at the relevant level, out of all teachers at that given level, for a given country. To improve comparability between differing minimum training requirements across countries, the UIS developed an international classification of teacher training programs as a basis for the construction of this indicator.

Figure 11. Student-to-Teacher (LHS) and Student-to-Qualified Teacher Ratios (RHS) at the District Level in Madagascar



Source: World Bank based on data from the *Institut National de Formation Pédagogique* (INFP) and Annuaire Statistique Nationale. Qualified teachers are defined as teachers who hold a teacher training certificate.

B. Education and Economic Growth: Potential Gains for Madagascar

10. As an input to production, a more educated workforce is expected to boost economic growth. Descriptive evidence suggests that among LICs, real GDP per capita growth is positively correlated with the share of the working-age population with at least primary school education (Figure 14). With under 20 percent of the working-age population having completed primary school, Madagascar (in red) has a working age population with one of the lowest primary school completions in the sample.

11. A large body of literature has provided evidence of the impact of both the quantity and the quality of education on economic growth. For instance, Barro (2000) argues that higher human capital, through education (especially at the secondary and higher levels), generates higher economic growth by facilitating the absorption of technology from more advanced economies. Consistently, Hanushek and Kimko (2000) show that the quality of the labor force, that is the quality of education measured by test scores is a stronger determinant of economic growth compared to the quantity of education (years of schooling).[13] More recently, Glewwe, Maiga, and Zheng (2014) presents a review of the evidence on the contribution of education to economic growth with a specific focus on implications for sub-Saharan Africa. They argue that the lack of education progress in Sub-Saharan Africa compared to East Asia, explains at least partly the difference in the average economic growth performance between these regions from 1980 to 2000 (real GDP per capita declined by 0.6 percent in the former region while it grew by 4.9 percent in the latter region over the

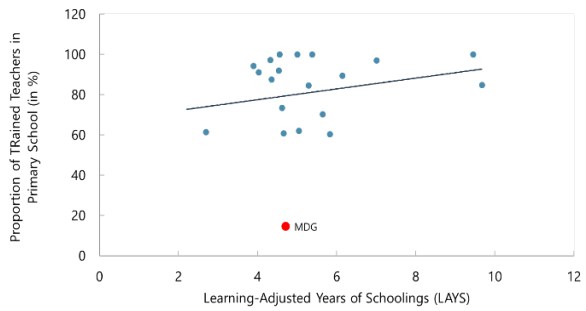
[13] See also Hanushek and Woessmann (2008).

same period).[14] Glewwe et al. (2014) find that the low education quality in Sub-Saharan African countries may have a sizeable negative effect on economic growth in these countries.

12. Training teachers could be critical to improve education quality in Madagascar. Glewwe et al. (2014) claim that the rapid increase in school enrollment since 2000 may have reduced school quality as schools became over-crowded and existing resources are under pressure (e.g. higher teacher-to-student ratio). Teacher quality is widely recognized as an important input in the production of education (see for instance Hanushek, 1986). A recent study by Bietenbeck et al. (2023) shows that teacher subject knowledge has a large positive impact on student achievements in francophone Sub-Saharan Africa, including in Madagascar. They find that 37 percent of the variation in the average student achievement across countries is due to teacher subject knowledge, suggesting an important role for training teachers. This finding is particularly concerning given that in 2023, only 3.6 percent of teachers in Madagascar mastered their subject content, according to World Bank.[15] Other studies on the positive impact of teacher quality on student performance in Africa include for instance Buhl-Wiggers et al (2017) using data from a randomized control trial in Uganda.[16] More recently, using data from over 200 impact evaluations spanning 52 countries, Angrist et al. (2024) find that interventions targeting the productivity of schooling, including training, monitoring and raising pedagogical standards among teachers are the most cost effective ways of raising a country's LAYS.

13. Education quality is positively correlated with the share of qualified teachers in SSA countries. Consistent with the fact that the quality of teachers is an important input in enhancing education quality, the data depicts a positive correlation between the proportion of qualified teachers in primary school and the learning adjusted years of schooling in sub-Saharan Africa (Figure 15). Further, as discussed previously, Figure 15 shows Madagascar as an outlier with both relatively low education quality and teacher qualification.

Figure 12. Learning-Adjusted Years of Schooling vs. Proportion of Trained Teachers in Primary School Among SSA Countries
(2018)



[14] From 1980 to 2000 the primary school gross enrollment rate in Sub-Saharan Africa declined, from 80 percent to 77 percent while the primary gross enrollment rate increased, or held steady at a high level, in East Asia at 111 percent in both years (Glewwe et al, 2014).

[15] Estimates from World Bank (2023). Education Service Delivery Indicator – Round II and Global Education Policy Dashboard -Round II 2021.

[16] Other studies include for instance Angrist and Lavy (2001) who find that training teachers provided a cost-effective means to improve test scores in Jerusalem public schools and, Metzler and Woessmann (2012) in Peru with a focus on the impact of teacher subject knowledge on student achievement.

14. In addition, increasing primary education attainment among the working-age population could amplify the impact of the demographic dividend on economic growth. Following Kotschy et al. (2020) and IMF (2024), our estimates show that greater primary school education attainment raises economic growth mainly via its positive interaction with the share of working-age population (see Text Box 1 for more details). This complementarity between primary school attainment and the share of working-age population can be viewed in two ways. First, countries with a greater share of working-age population enjoy larger economic gains from improvements in primary education attainment. Second, countries with a higher share of primary education reap a larger demographic dividend. From Text Box 1, this complementarity between primary school attainment and the share of working age population is statistically significant only for LICs, and not for higher-income countries.

15. Despite a relatively low share of working-age population, the returns to economic growth of improving primary school attainment in Madagascar could be sizeable. Text Box 1 presents the estimates of the effect of primary school attainment on growth in real GDP per capita. The impact of educational attainment on growth is expected to mediate through two channels. First, a greater share of primary school attainment may raise economic growth directly, via its impact on worker productivity. Second, educational attainment may have an indirect impact on growth, by increasing the returns from a larger working age population. The regression table in Text Box 1 displays the estimates for all countries, non-LIC countries and LIC countries. In line with the findings from IMF (2024), primary school attainment has a significant impact on growth among LIC countries, notably by boosting the demographic dividend. From the regression estimates, the expected gains to raising primary school attainment can be calculated for Madagascar. Given that the share of working-age population as share of the total population in Madagascar is expected to increase from 53 percent in 2023 to 63 percent in 2050, the regression estimates imply that a 1 percentage point increase in primary education attainment would yield an additional 0.6 percentage point rise in real GDP per capita by 2050. Otherwise put, our estimates show that, at current levels of primary school completion among the working age population (around 20 percent), the rise in share of working-age population in the next two decades would have no significant impact on growth. However, if primary school attainment among the working age population were to meet the SSA average (around 60 percent), the projected 5 percentage points increase in working age population in Madagascar would raise annual real GDP per capita growth by 4 percentage points.

Box 1. Primary Education Attainment and Economic Growth

The empirical specification follows Kotschy (2020) and IMF (2024) as follows:

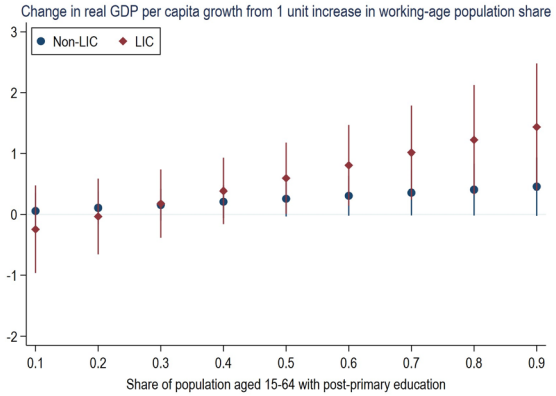
$$\Delta log(y_{it}) = \alpha_0 + \alpha_1 \Delta log(k_{it}) + \alpha_2 \Delta log(working\_age_{it}) + \alpha_3 share\_educ_{it} + \alpha_4 log(working\_age_{it-1}) + \alpha_5 log(y_{it-1}) + \alpha_6 share\_educ_{it} \times log(working\_age_{it-1}) + \psi_i + \rho_t + \epsilon_{it}$$

Where y_{it} refers to real GDP per capita of country i *at time* t, k_{it} to per capita capital stock, $working\_age_{it}$ to the share of working age population, $share\_educ_{it}$ refers to the share of the working age population with at least primary school education. ψ_i refers to country fixed effects, ρ_t to time effects and ϵ_{it} is the error term. The marginal impact of raising the share of primary education is given by $\alpha_3 + \alpha_6 \log(\text{working\_age}_{it-1})$. We run the above regression using data from Kotschy et al. (2020), which spans from 1950 to 2015.
The regression results, for all countries, non-LICs and LICs separately, are presented below.

Box 1. Primary Education Attainment and Economic Growth (concluded)

	(1) All	(2) Non-LIC	(3) LIC
Growth of capital per worker	0.54***	0.62***	0.37***
	(0.05)	(0.07)	(0.06)
Growth of share of working age population	0.22	0.27	-0.04
	(0.23)	(0.26)	(0.47)
Primary education share	0.25	0.22	0.99
	(0.15)	(0.17)	(0.62)
L. share of working age population	0.06	0.02	-0.47
	(0.16)	(0.17)	(0.42)
L. log income per capita	-0.20***	-0.21***	-0.19***
	(0.02)	(0.03)	(0.06)
Primary education share × L. share of working age population	0.56*	0.49	2.14**
	(0.29)	(0.33)	(0.87)
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
R^2	0.50	0.55	0.43
N	1510	1051	459

α_6 is postive and statistically significant, particulary for the sample of LICs, implying that LICs with larger share of working-age population benefit more from being educated.



Using the regression estimates for non-LICs and LICs, the figure above plots the marginal impact on growth of the share of working-age population, at different levels of primary school attainment. While the marginal return from a larger share of working age population in non-LICs is not statistically different from 0, regardless of the level of primary school attainment, one can observe that, for LICs, the marginal gain from a higher share of working age population increases with the level of primary school attainment.

Source: IMF Staff Estimates, Kotschy et al (2020), IMF (2024).

16. Consistent with the literature, we find that the quality of education has a positive impact on economic growth in LICs and in SSA. Independent of the demographic dividend, we find that improvements in the quality of education, measured via LAYS and HCI, have a positive and statistically significant effect on real GDP per capita growth, particularly in lower income countries. From the estimates in Text Box 2, a 1-year increase in LAYS, for instance, raises economic growth by 7 percentage points among LICs and countries in SSA. Likewise, among LICs, a 0.1 unit increase in HCI raises economic growth by about 0.2 percentage point. At 4.7 years in 2018, Madagascar's LAYS lies below that average among countries in SSA (5.1 years) and LICs (5.5 years). Raising the country's

LAYS to the SSA average would imply a 2.8 percentage points increase in real GDP per capita growth relative to the baseline.

Box 2. Quality-Adjusted Education Attainment and Economic Growth

To estimate the impact of quality-adjusted educational attainment on economic growth, the empirical specification below is used.

$$\Delta log(y_{it}) = \alpha_0 + \alpha_1 quality\_educ_{it-1} + \alpha_2 log(y_{it-1}) + \psi_i + \rho_t + \epsilon_{it}$$

Where y_{it} refers to real GDP per capita of country i *at time* t, $quality\_educ_{it-1}$ refers to the quality-adjusted education in country i at time t. ψ_i refers to country fixed effects, ρ_t to time effects and ϵ_{it} is the error term.[1] We focus on a sample of LICs and countries in SSA including Madagascar.Two measures of quality-adjusted education are used LAYS and HCI. The estimation results are presented below.

	LAYS		HCI	
	LIC	SSA	LIC	SSA
L. log income per capita	-0.23***	-0.23***	-0.21***	-0.20**
	(0.06)	(0.06)	(0.07)	(0.09)
L.LAYS	0.07***	0.07***		
	(0.03)	(0.03)		
L.HCI			1.51**	0.87*
			(0.73)	(0.49)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
R^2	0.23	0.23	0.17	0.12
N	105	105	105	97

1/ The regression is based on data from UNESCO. We kept a parsimonious specification, to inform on the correlation between

17. We show that raising the share of qualified teachers would significantly increase quality-adjusted educational attainment and thus real GDP per capita growth in Madagascar. We estimate that a 10-percentage point increase in the share of qualified teachers in primary school level would significantly raise LAYS by about 0.3 years (Text Box 3) among both LICs and countries in SSA. Combining the estimates from Text Boxes 2 and 3, a simple back-of-the-envelope calculation ($\frac{\partial GDP}{\partial Teacher} = \frac{\partial GDP}{\partial educ} \times \frac{\partial educ}{\partial Teacher}$), suggests that doubling the share of trained teachers in primary school (from current level at 15.2 percent to reach about half of the levels seen in SSA and LICs) would raise the LAYS by about 0.4 year and thus boost growth by between 2.5 to 3.1 percentage points in Madagascar.

Box 3. Teacher Training, Quality-Adjusted Educational Attainment, and Economic Growth

The following regression specification is adopted to measure the impact of primary school teacher training on quality-adjusted educational attainment.

$$quality\_educ_{it} = \beta_0 + \beta_1 quality\_educ_{it-1} + \beta_2 share\_qualified_{it-1} + \psi_i + \rho_t + \epsilon_{it}$$

Where $quality\_educ_{it}$ refers to quality-adjusted educational attainment at time t and $share\_qualified_{it-1}$ refers to the share of primary school teachers who have a minimum level of qualifications at year $t-1$. ψ_i refers to country fixed effects, ρ_t to time effects and ϵ_{it} is the error term.[1] We focus on a sample of LICs and

Box 3. Teacher Training, Quality-Adjusted Educational Attainment, and Economic Growth
(concluded)

countries in SSA including Madagascar. Two measures of quality-adjusted education are used - LAYS and HCI. The estimation results are presented below.

	LAYS		HCI	
	LIC	SSA	LIC	SSA
L.LAYS	0.037	-0.019		
	(0.082)	(0.078)		
L.HCI			0.096	0.058
			(0.083)	(0.045)
L.Share of qualified primary school teachers	0.028***	0.026***	0.001***	0.001***
	(0.004)	(0.005)	(0.000)	(0.000)
R^2	0.47	0.40	0.59	0.50
N	32	28	32	28

Interpreting the estimates from column 1 in the table above, a 10-percentage point increase in the share of qualified primary school teachers would raise LAYS by about 0.3 years. Together with the finding in Text Box 2 that a 1-year increase in LAYS would raise growth by 7 percentage points, the estimation results suggest that increasing the share of qualified teachers by 10-percentage points would boost per capita real growth by 2.1 percentage points.

1/ The regression is based on data from UNESCO. We kept a parsimonious specification, to inform on the correlation between the quality of education and growth, given the limited number of observations owing to the availability of data on LAYS and HCI.
Source: Staff estimates using data from UNESCO and the World Bank.

C. Improving Teaching Quality in Madagascar

18. Multiple bottlenecks constrain the quality of teaching in Madagascar. These include the insufficient number of qualified teachers (as discussed earlier) given lack of resources dedicated to training, a non-transparent and non-competitive recruitment process of teachers, and poor support and supervision of teachers. 41 percent of civil servant teachers and 64 percent of FRAM[17] teachers surveyed in a World Bank study reported that they did not participate in a competitive recruitment process. Moreover, both entry-level and continuous training fail to remedy the low level of academic and pedagogical competence among teachers. The quality of initial training is weakened by insufficient and ill-adapted training structures while continuous training and qualification opportunities are irregular due to lack of resources and has little impact on improving teachers'

[17] Fikambanan'ny ray amandrenin'ny mpianatra (parents association). FRAM teachers are therefore teachers hired by the parents association.

pedagogical practices. [18] Moreover, just over half of teachers are adequately supervised, according to the PASEC2019 survey, and teacher job satisfaction is low, particularly among FRAM teachers.[19]

19. Teacher training in Madagascar is inadequate, partly due to the increasing reliance on largely unqualified FRAM teachers. This category of teachers emerged in 1975, with the wave of public primary school construction and a subsequent shortage of teachers. FRAM teachers are hired and remunerated by local parent associations, with only some being subsidized by government. From 2004 to 2024, their numbers rose from 13,000 to 90,180, and they now represent more than 50 percent of teachers in the public education.[20] Figure 16 shows the breakdown of teachers by status and teaching level. At the primary school level for instance, FRAM teachers (subsidized and unsubsidized) make up 51 percent of teachers, while contractual and civil servant teachers hired and paid by the state form only 41 percent of the teaching force.[21] According to the INFP database, over 85 percent of FRAM teachers are not qualified i.e., lack a pedagogical diploma (Figure 17). More generally, recent data shows that the skill level of Malagasy teachers is extremely low. Indeed, according to the PASEC2019 survey, only 11 percent of Malagasy teachers reach the highest level of the skills scale in reading comprehension and 24 percent do so in mathematics. Further, according to the results of the 2021 SDI survey, the proportion of teachers with minimum knowledge and skills is only 3 percent in French and 8 percent in mathematics[22]. The inadequate level of teacher competence is a significant constraint of education quality.

[18] Findings are drawn from the report APPRENDRE (2022). APPRENDRE is a joint program from the French Development Agency (AFD) and Francophony University Agency (AUF) which stands for: Support for the professionalization of teaching practices and resources development (Appui à la professionalisation des pratiques enseignantes et au développement des ressources).

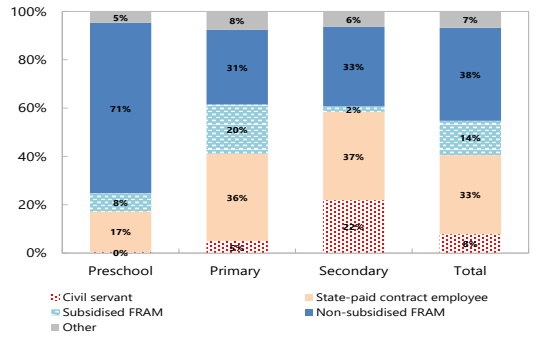
[19] From the PASEC2019, 55 percent of teachers are not satisfied with their salary level, 37 percent of them complain about the irregularity of their pay and 24 percent find that professional training opportunities are lacking. A representative survey conducted by UNICEF in 2023 showed that compared to their civil servant counterparts, contractual and subsidized FRAM teachers are 14 percentage points less likely to be satisfied and unsubsidized FRAM teachers 24 percentage points less likely to be satisfied with their job.

[20] These numbers are obtained from the 2024 INFP data. In 2003, a category of "subsidized FRAM teachers" was created, partly paid by the state for 9 months in a year, for a wage 60 percent lower on average compared to their civil servant counterparts. FRAM teachers that are unsubsidized are compensated according to the financial capacity of the families and the parents' association. Many suffer up to 8 months of late salary payments.

[21] Private sector teachers make up the remaining 8 percent of the primary school teaching force.

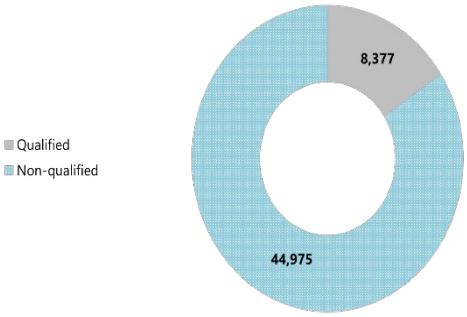
[22] The Service Delivery Indicators (SDI) are indicators developed by the World Bank to measure the quality of social sector services (health and education). SDI data help to identify gaps, track change over time, benchmark progress, stimulate evidence-based debate, and ultimately, influence policies design and interventions to accelerate progress in human capital areas.

Figure 13. Breakdown of Teachers by Level and Status in Madagascar
(2023)



Source: Ministère de l'Education Nationale (MEN)

Figure 14. Share of FRAM Teachers with Qualifications
(2023)



Source: Institut National de Formation Pédagogique (INFP)

20. Education spending, including on teachers, remains low, poorly executed, and subject to leakages (Text Box 4). According to the 2021 PETS survey, the budget execution rate on resources allocated to the decentralized technical, coaching and supervision support to teachers in schools stood at a mere 47 percent (2019) [23]. The lack of resources, coupled with a difficulty in executing the allocated resources, hinder the implementation and monitoring of teacher work plans as well as the support and control of school facilities.

21. Infrastructure and basic classroom inputs remain a major challenge for quality learning in Madagascar. According to a 2021 World Bank Service Delivery Indicators (SDI) report on education, an average school has access to only 34 percent of the infrastructure essential for learning. Only 0.4 percent of schools have access to electricity, 2 percent have internet and 8 percent have access to functional and clean toilets. Only 50 percent of schools have potable water sources, which greatly impacts the health and well-being of students. Furthermore, the availability of crucial learning tools in classrooms is insufficient. While 83 percent of schools have blackboards, only 4 percent have enough textbooks, only 23 percent have access to educational technologies, 16 percent to stationery and 23 percent to furniture.[24]

[23] The Public Expenditure Tracking Survey (PETS) survey allows to track the financial flows going to both the health and education sectors. It helps government to assess if the funds allocated to a specific sector reach their intended recipients or if there are leakages along the way.

[24] There is considerable variation from region to region in terms of infrastructure availability.

Box 4. Education Spending in Madagascar – A Strained and Leaky Pipeline

Weak financial governance, characterized by numerous inefficiencies and leaks, further compromises the already stretched financial resources of the public education sector. The Public Expenditure Monitoring Survey of National Education (UNICEF 2021) identified issues in terms of financial governance in three areas of expenditure flows in the public education sector: (i) compensation for civil servant teachers and community teachers; (ii) school funds; and (iii) school kits. The survey employed a rigorous methodology of monitoring flows, supported by maps of the financial information system of National Education and its decentralized structures including regional directorates, colleges, and schools.

The survey found that resource leakages between the central government, schools and colleges were significant. Regarding compensation for civil servant teachers, the loss rates were estimated at about 11.8 percent (2018) and 8. 8 percent (2019), while they were respectively assessed at 28.5 percent (2018) and 23.7 percent (2019) for community teachers. The same is true for school funds with loss rates respectively valued at 19.1 percent (2018) and 18.4 percent (2019). In addition to flow losses, teacher absenteeism represents an additional indirect loss. The survey estimated that 46.4 percent of civil servant teachers in 2018 and only 13.4 percent in 2019 have provided teaching services in line with their paid teaching hours. Among community teachers, the proportion was respectively estimated at 47.8 percent (2018) and 54.3 percent in 2019.

Source: UNICEF.

22. Raising the number of qualified teachers would require increased spending on education. According to UNICEF calculations (Text Box 5), the number of primary school students tripled between 1998 and 2023 and is projected to increase at an annual rate of 3 percent thereafter. At this rate, the number of pupils at primary level is expected to increase from about 4.2 million in 2023 to about 5.4 million in 2031. To reach the standard of 40 students per qualified teacher, UNICEF staff estimate that a total of about MGA 181.7 billion (US$ 40.4 million) is needed per year until 2031. This estimate includes the total cost of primary school teacher training at MGA 15.7 million (US$ 3.5 million) per year and cumulative additional salaries at about MGA 71.8 billion (about US$ 16 million). Text box 5 further details the methodology used to project teacher training costs, including the assumptions. While estimates may vary depending on assumptions, the above can be interpreted as a lower bound of actual cost.[25]

Box 5. Projecting the Cost of Teacher Training in Madagascar

The following assumptions were adopted to project the cost of teacher training in Madagascar. The estimates include the continuous as well as initial entry-level training of teachers and the assumptions include:

- Primary school enrollment increasing at an annual rate of 3.02 percent, in line with demographic projections.
- A target of student to qualified teacher ratio of 40:1, implying that 14,500 teachers require continuous training annually and 2000 require initial training at the INFP annually.

[25] World Bank estimates for instance that the initial cost of qualifying a teacher with a high-school certificate would be at least 900 US dollars and even higher for a teacher without a high-school certificate. This estimate of initial training cost is far above the UNICEF estimate of 133 US dollars used in Text Box 5.

Box 5. Projecting the Cost of Teacher Training in Madagascar (concluded)

- The number of civil servants and contract teachers currently in post remains constant, i.e. if there are civil servant/contractual teachers who retire or otherwise, they will be numerically replaced in the state budget.
- The INFP continues the production of 2,000 teachers every two years (in line with current practice), who are then absorbed into the public sector over the next 12 months after graduation.
- All qualified teachers from continuing education will be recruited as contractual teachers.
- The unit cost of initial training is estimated at MGA 600,000 (US $ 133) per teacher-student without teacher salary.
- The unit cost of continuous training is estimated at MGA1,000,000 (US$222) per teacher.
- Given the unit training cost and the number of teachers to be trained annually, the total annual cost of training is estimated at around US$3.5 million. Further, using the average gross monthly salary of civil servant and contract teachers, estimated at MGA 932,000 (US$ 207) and MGA 651,000 (US$ 145) respectively and the additional number of qualified teachers needed to attain the 40:1 student to qualified teacher ratio, the annual additional salary cost of the reform can be calculated, as shown in the table below.
- Summing the training and salary costs, an estimate of the total additional annual cost of the reform can be obtained.

(In US$)

	2025	2026	2027	2028	2029	2030
Total cost of training	3,488,889	3,488,889	3,488,889	3,488,889	3,488,889	3,488,889
Total additional salary cost	2,551,889	4,609,556	6,996,556	9,094,222	11,481,222	13,578,889
Total additional cost of reform	6,040,778	8,098,445	10,485,445	12,583,111	14,970,111	17,067,778

- Given that the above simulation only takes into account the additional training and salary costs of the reform, the estimates can be interpreted as a lower bound of the total cost of attaining the 40:1 student to qualified teacher ratio.

Source: UNICEF staff estimates

D. Conclusion and Policy Recommendations

23. Educational outcomes are declining in Madagascar. Most indicators of the education efficiency indicate that the country is undergoing a learning crisis with students lacking the minimum skills needed at the required age, especially in reading and mathematics. The low quality of education, and thus the decline in skill acquisition, reflect the lack of qualified teachers.

24. Consequently, the country is losing out on its growth potential from a more qualified labor force. Empirical evidence has shown that both the quantity and quality of education have sizeable positive effects on growth and may explain the difference in growth performance across countries. In the case of Madagascar, our empirical investigations suggest that, based on the projected growth in working age population, improving primary education could add 0.6 percentage point to economic growth by 2050.

25. Increasing the number of qualified teachers will be critical to improve the quality of education and maximize Madagascar's growth potential. We find that increasing the number of qualified teachers to the average level among its peers, could raise per capita real GDP growth by around 2.5 to 3.1 percentage points in Madagascar.

26. In the longer term, boosting the attractiveness of the teaching profession is key to raising the number of qualified teachers in Madagascar. As emphasized in a 2023 World Bank report, "Making Teacher Policy Work", the professional development of teachers extends beyond teacher training and includes the alignment of career incentives with professional development goals and follow-up support even after teachers are initially qualified. This could be achieved with effective human resource policies including increasing the competitiveness of teacher compensation, improving career progression structures, and alleviating job precarity and improving medical benefits. Such measures could raise the recruitment, retention, and job satisfaction among teachers.[26] In addition, promoting the meritocratic selection and effective deployment of teachers would lift teaching standards.

27. Apart from measures targeting teacher quality, a broader program on education reform is needed. Indeed, teacher's qualification is only one input of the education system. However, other elements such as adequate infrastructure, availability of teaching materials, or a school feeding program (in the case of Madagascar) are also important and all contribute to a good learning environment. For the country to reap the economic gains from its youthful population, addressing the various bottlenecks to quality education in Madagascar is key.

[26] In its report released in 2023, the UNICEF finds that job satisfaction partly determines teachers' behaviors, the efforts invested in teaching, commitment within the school and the probability of continuing to teach. These elements influence the learning process of students either directly, for example with activities adapted for each student, which require sustained investment from the teacher, or indirectly by facilitating the functioning of the school.

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RICE PRODUCTION IN MADAGASCAR—CHALLENGES TO SELF-SUFFICIENCY[1]

The Malagasy government aims to achieve self-sufficiency in rice production by 2027. In line with the national strategy on the development of rice cultivation (SNDRIII), adopted in 2023, Madagascar seeks to produce 6 million tons of rice in 2024 and to eventually reach an annual rice production of 11 million tons by 2030. To meet its goal, however, the country faces numerous challenges, including stiff competition from cheaper rice imports, chronic low productivity, and climate change. In this paper, we examine current issues faced by the rice sector in Madagascar, notably with regards to productivity. We estimate the impact of competition from rice imports on the local rice market, by exploiting historical changes to import tariffs and value-added taxes (VAT). Using data from the Food and Agriculture Organization (FAO), we study the maximum potential rice output, under different climate and input scenarios. Lastly, we examine possible supply-side strategies to sustainably raise future rice productivity in Madagascar, taking into consideration relevant environmental concerns, the impact of climate change as well as climate-smart agricultural practices.

A. Rice Production in Madagascar: Background and Recent Developments

1. In Madagascar, rice is the most widely consumed and produced crop, accounting for a substantial portion of total agricultural production. The average Malagasy individual consumes 153.5 kilograms of rice annually, which represents more than half of their total daily caloric intake (Table 1).[2] According to the 2021 National Household Survey, 27.2 percent of households reported engaging in agricultural activity within the previous week, with 49.5 percent of such households cultivating rice paddies primarily for subsistence. Since 2002, annual rice production has increased by 76 percent, reaching 4.6 million tons in 2022. However, despite local cultivation efforts by small rural farmers, rapid population growth since 1960s has intensified Madagascar's reliance on rice imports to meet demand. While the population grows at an annual average rate of 3 percent, rice production has only increased by an average of 2 percent per year, resulting in a persistent production gap.

Table 1. Madagascar: Annual per Capita Consumption of Rice

(kg/capita/year)

Gambia	256.4
Bangaldesh	246.9
Vietnam	228.1
Thailand	178.9
Madagascar	153.5
China	132.3
India	99.0
Nigeria	33.1
Pakistan	17.7

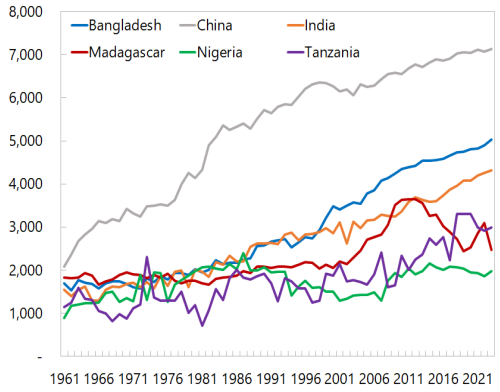
Source: FAO Food Balances Database

[1] Prepared by Vaishali Ashtakala, Timila Dhakhwa, Joanne Tan, Yipei Zhang. The team gratefully acknowledges the helpful inputs and feedback from experts of the Food and Agriculture Organization and the World Bank Group, as well as fruitful discussions with staff from the Ministry of Agriculture.

[2] FAOSTAT Food Balances database 2022 estimate.

2. Despite growing levels of rice production, Madagascar's ability to meet local rice demand has dwindled since the 1960s, due to stagnating productivity. After a severe rice crisis in the 1960s, the government implemented policies to stabilize producer and consumer prices and promoted the use of fertilizers. However, from the 1970s, government policies vacillated between intervention and market liberalization. In the 1970s, Madagascar's rice yields were comparable to or even exceeded those of other rice-producing countries (Figure 1). However, yields in countries like Bangladesh, began to outpace Madagascar's in the 1970s, largely due to government investments in irrigation and developing infrastructure.

Figure 1. Selected Economies: Top Rice Producing Countries Yields
(In kg/hectare)

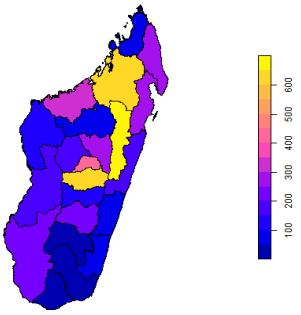


Source: FAOSTAT

Figure 2. Rice Production and Consumption

Production varies significantly based on regional climate differences.

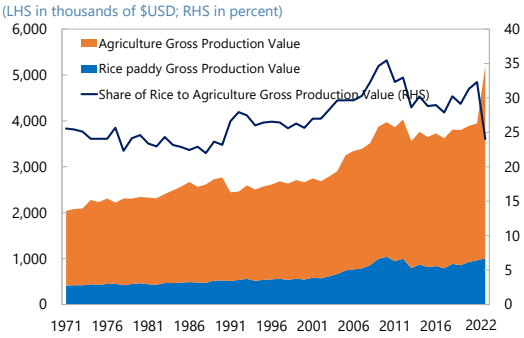
MDG: Regional Rice Production, 2023
(in thousands of tonnes)



Source: MINAE.

Rice paddy accounts for 24 percent of total agricultural gross production value, totaling $1,006,030 in 2022.

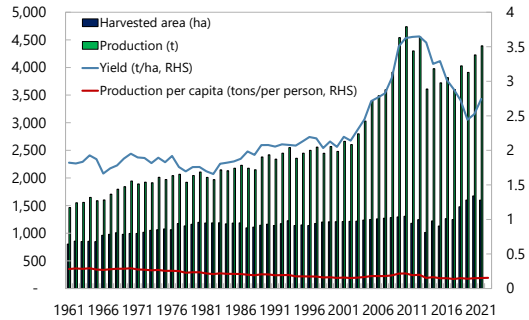
MDG: Gross Production Value
(LHS in thousands of $USD; RHS in percent)



Sources: Rice Observatory; FAO STAT; USDA; and IMF staff calculations.
Note: Agricultural production includes forestry and fishing.

Rice production per capita has been dwindling with large population increases and falling yield since the early 2000's.

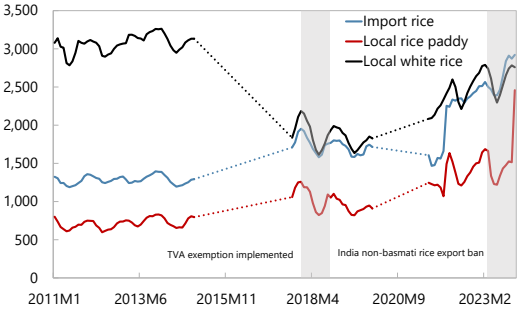
MDG: Harvested Area, Yield and Production
(LHS in thousands)



Sources: FAO STAT; and IMF staff calculations.

Imported rice prices have remained lower than local white rice varieties since 2011.

MDG: Average Local and Import Rice Price
(In ariary/kilogram)



Sources: Authorities' data; and IMF staff calculations.
Note: Data contains breaks due to inavailability, data has been interpolated.

3. Madagascar's rice sector has faced numerous longstanding challenges, resulting in sluggish production. Across the country, various planting methods are employed in different regions to address specific agricultural challenges and improve productivity. In the central highlands, where population density is the highest, cultivation methods such as agroforestry systems are common. In regions along the east coast, these systems integrate crops like clove, vanilla, coffee, and cocoa with fruit trees or livestock, enhancing biodiversity and soil fertility. The System of Rice Intensification (SRI) is also employed in the central highlands to increase rice yields while reducing water usage and input costs.[3] In contrast, the eastern coast of Madagascar, which experiences abundant rainfall, often relies on traditional methods like slash-and-burn agriculture (*tavy*) and permaculture gardens. These methods are adapted to the region's climatic conditions and are a means of subsistence farming among rural communities.

4. The local rice market is sensitive to changes in import prices and quantity. Domestically produced rice often incurs higher production costs due to limited mechanization and input usage, making it less competitive in price compared to imported rice. In 2023, the export ban on rice imposed by the Indian government significantly impacted imports, as Madagascar sources a substantial portion of its rice imports from India and Pakistan. Trade from India and Pakistan accounted for 98 percent of total imported rice to Madagascar in 2022, leaving the country vulnerable to policies enacted by its trading partners.[4]

5. While some reforms have targeted local production, other policies have sought to keep prices affordable for the local populace. One notable policy is a value added tax exemption (previously at 18 percent) on both imported and locally produced rice, in place since July 2008, in response to soaring international food prices and cyclone damage to local production (David-Benz et al., 2014). While VAT exemptions on rice have been credited with maintaining affordable rice prices for domestic consumers, they also exact a high fiscal cost, diverting government resources away from other public spending needs. By some estimates (Wen et al., 2021), VAT exemptions on local and imported rice amount to around 1.3 percent of GDP (1.1 percent from the former and 0.2 percent from the latter). In addition, the exemption of customs duties on imported rice since 2005 is estimated to cost another 0.2 percent of GDP annually.

6. In the wake of supply chain disruptions following the Covid pandemic and Russia's invasion of Ukraine, the Malagasy authorities elaborated a national strategy to attain rice

[3] SRI is method of rice cultivation that includes the planting of young seedlings, the adequate spacing between rice plants, the application of organic fertilizer and the maintenance of optimal soil moisture via controlled irrigation. Despite originating in Madagascar in the 1980s, SRI adoption across the country remains limited. A study among rice farmers in Manombo by Moore et al. (2024) cites factors including perceptions of SRI as being more time and labor intensive than traditional methods, lack of farming tools and organic fertilizer, inadequate access to fast-growing rice seeds suitable for SRI, as well as lack of technical knowhow as reasons for the low adoption among Malagasy rice farmers. More broadly, Moser and Barrett (2006) find that financial liquidity constraints prevent small scale farmers in Madagascar from adopting higher yield rice production methods like SRI.

[4] WITS data (2023) HS 6 Digit Code 100630 for semi-milled or wholly milled rice.

self-sufficiency by 2027.[5] The guiding principles of the national strategy revolve around i) raising productivity and local rice production, ii) promoting competitiveness, and iii) reinforcing agricultural R&D. Implementation challenges continue to hamper Madagascar's efforts to boost rice production and reduce its reliance on imports. Although comprehensive policy frameworks are developed, translating these into effective action on the ground remains difficult. Issues such as inadequate infrastructure, limited irrigation investment, and insufficient access to quality seeds, fertilizers, and machinery hinder progress. Compounding these issues are a lack of coordination among government agencies and bureaucratic delays, which weaken the impact of reforms. The persistence of traditional farming practices and limited agricultural extension services further slow the adoption of modern techniques. Additionally, climate shocks, including droughts, cyclones, and erratic rainfall, frequently devastate rice crops, discouraging investment in rice farming and making non-subsistence production financially precarious for smallholders.

7. In the following sections, we examine the impact of import competition on local rice production as well as possible reform measures that could boost local production. Import competition has been a significant factor affecting local rice production. The influx of cheaper and tax-free imported rice has led to a decline in local production, as farmers find it difficult to compete with the lower prices of imported rice. This has resulted in a reliance on imports to meet domestic demand, which can be problematic in times of global supply disruptions. On the other hand, measures targeting local production have focused on improving agricultural practices, providing subsidies, and investing in infrastructure to support rice farmers. These measures aim to increase productivity, ensure food security, and reduce the country's dependence on imported rice. Potential reform measures to boost local production include promoting sustainable agricultural practices, such as SRI and permaculture techniques, which can lead to higher yields and more resilient crops. Additionally, improving access to quality seeds, fertilizers, and irrigation systems, as well as providing training and support to smallholder farmers, could enhance local rice production.

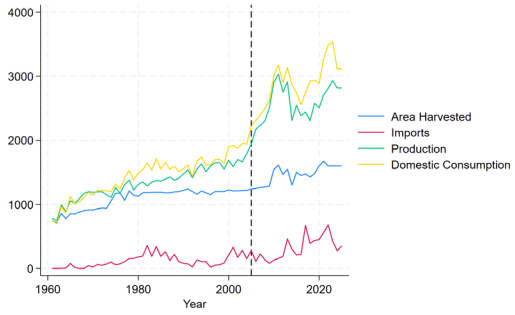
B. Levelling the Playing Field - Measuring Price Elasticities of Rice Demand and Supply in Madagascar

8. Levelling the playing field and removing custom duty exemptions may incentivize local rice production, by raising the price of rice in local markets, thereby encouraging local farmers to increase production beyond their subsistence level. In this section, we exploit two events, namely the one-off imposition of tariffs in 2005 and the VAT exemption on imported rice from 2008, to estimate the price elasticities of rice demand and supply in Madagascar. Knowing these price elasticities would provide a sense of whether the removal of tariff or tax exemptions would raise local production and the extent to which Malagasy households would be affected by an increase in rice prices.

[5] The Ministry of Agriculture and Livestock's rice self-sufficiency strategy for 2022-2030 is detailed in the National Strategy for Rice Production (SNDR III). Since then, the issue has become a key presidential priority, with 2027 as the target year for full rice self-sufficiency.

9. Local rice production increased following a one-off tariff increase on imported rice in 2005. The dashed line in Figure 3 marks a temporary increase in the average tariff rate applied on imported rice from 0 to 17.5 percent in year 2005[6]. As shown in Table 2, we observe a cumulative increase in local rice production from the level in 2005, suggesting that local rice production gradually picked up as imported rice became more expensive. Indeed, by 2010, local rice production was nearly 40 percent greater than in 2005.

Figure 3. Rice Production, Imports and Consumption in Madagascar, 1961–2025



Source: USDA Foreign Agricultural Service

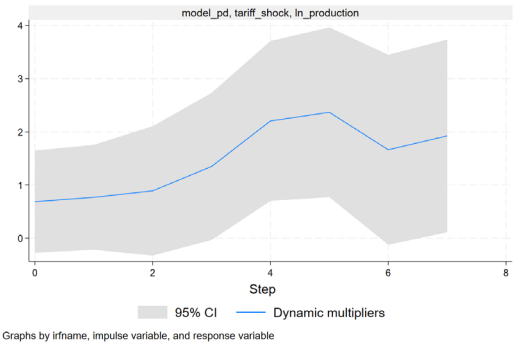
Table 2. Madagascar: Response of Local Rice Production in Madagascar to the 2005 Tariff Increase

Year	Percent change in local production from 2005
2005	0
2006	2.8%
2007	5.9%
2008	15.4%
2009	33.9%
2010	39.7%

Source: USDA Foreign Agricultural Service

10. The price elasticity of supply (PES) is estimated around 2 percent at a 4-to-5-year horizon. We estimate the price elasticity of supply (PES) based on the 2005 event, using the time series of local rice production in Madagascar. The shock to rice price is indexed by the tariff shock, which is considered a quasi-natural experiment. By running a simple local projections (LP) model, we find that local production is relatively inelastic in the short-term following the price shock but is estimated at around 2 at 4-5 years following the price shock, that is, a 1 percent increase in rice price would lead to an increase in local rice production of around 2 percent (Figure 4). Further details on the estimation strategy are presented in Text Box 1.

Figure 4. Impulse Response of Local Rice Production



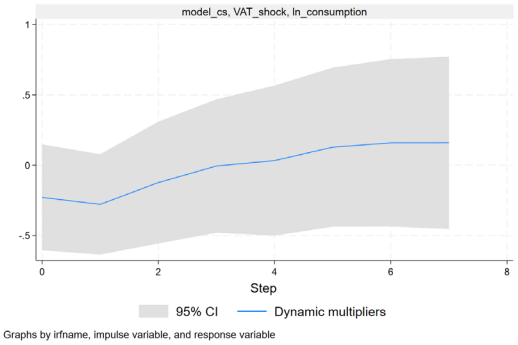
Source: IMF staff estimates and USDA Foreign Agricultural Service

[6] This is the average of effectively applied rates weighted by the product import shares corresponding to each partner country.

11. The price elasticity of demand (PED) is close to zero. We then estimate the demand elasticity following a price shock i.e. change in local rice consumption in response to change of rice price. In this exercise, we use the introduction of a VAT exemption in 2008. In contrast to a tariff shock which only directly affects the price of imported rice, a VAT exemption affects the price of both imported and domestically produced rice. Hence it provides a better indicator of the overall price change faced by consumers. Our estimates show that local rice consumption is inelastic to rice price (Figure 5). Given that rice is the main staple in Madagascar, this finding is expected. Further details on the estimation of PED can also be found in Text Box 1.

12. A balanced approach is therefore warranted when considering policies related to removing tariffs or VAT exemptions on imported rice. While higher tariffs may raise local rice supply with some lag, the immediate impact on rice prices would lower the welfare of households in Madagascar, whose demand for the essential staple is inelastic. Yet, as mentioned in the previous section, the fiscal cost of VAT exemptions on imported rice is high, diverting government spending from other pressing needs. One possible middle ground would be to remove VAT exemptions on high-quality, specialty rice consumed by affluent households while maintaining the exemptions for low-quality broken rice consumed by poorer households. Such a policy could raise the competitiveness of locally produced non-broken rice, thereby spurring local rice production while shielding modest households from higher prices. However, enforcing the tax regime distinction between high- and low-quality rice could be challenging in practice, and would require strengthening controls to limit the risk of tax evasion and misclassification.

Figure 5. Impulse Response of Local Rice Consumption



Source: IMF staff estimates and USDA Foreign Agricultural

13. More generally, a comprehensive VAT reform on agriculture-related products could incentivize investments in the rice sector. Apart from the VAT exemption on imported rice which depresses local rice prices and hampers local production, current VAT exemptions on agricultural inputs do not sufficiently target and incentivize productivity-boosting investments and mechanization. Reconsidering the VAT exemption on imported rice would not only have a direct positive impact on local rice production, as discussed above, but also leave greater room for targeted VAT exemptions on agriculture inputs that are crucial to productivity. Furthermore, since low rates of mechanization and fertilizer use are mainly prevalent among smaller-scale rice plantations, such VAT exemptions on farming inputs could be targeted at farmers with revenues below a given threshold (Rota-Graziosi et al., 2015).

Box 1. Estimating PES and PED using Local Projections (LP)

In our estimation of PES and PED, we estimate dynamic multipliers using LP, where we treat local rice production or consumption as the response variable and the tariff or VAT shocks as the exogenous variable. Specifically, we estimate the effect of the exogenous variable x_t on the response variable h steps ahead by estimating the following local projection for horizon $h = 0, 1, 2, \dots, H-1$:

$$y_{t+h} = \emptyset_h x_t + \boldsymbol{z}_t \boldsymbol{\delta} + u_{t+h}$$

where the coefficient of interest is the dynamic multiplier coefficient $\emptyset_h$. Additional controls $\boldsymbol{z}_t$ are included i.e. further lags of the endogenous variables. The estimation tables below give the dynamic multipliers at each horizon following the event.

```
Local-projection impulse-responses

Sample: 1962 thru 2018                              Number of obs       = 57
                                                    Number of impulses  =  2
                                                    Number of responses =  1
                                                    Number of controls  =  0
```

	IRF coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ln_production						
ln_production						
F1.	.9397081	.0319629	29.40	0.000	.8770619	1.002354
F2.	.9111327	.0327957	27.78	0.000	.8468543	.9754112
F3.	.8908726	.0404335	22.03	0.000	.8116244	.9701207
F4.	.8608419	.04599	18.72	0.000	.7707033	.9509806
F5.	.8431713	.0500131	16.86	0.000	.7451475	.941195
F6.	.8355437	.0530929	15.74	0.000	.7314836	.9396038
F7.	.8280103	.0594024	13.94	0.000	.7115837	.9444369
F8.	.828073	.0602838	13.74	0.000	.7099189	.9462271
tariff_shock						
ln_production						
--.	.6865813	.4899061	1.40	0.161	-.273617	1.64678
F1.	.7687383	.5026705	1.53	0.126	-.2164778	1.753954
F2.	.8900548	.6197365	1.44	0.151	-.3246064	2.104716
F3.	1.349463	.7049024	1.91	0.056	-.0321206	2.731046
F4.	2.205686	.7665657	2.88	0.004	.7032448	3.708127
F5.	2.368127	.8137712	2.91	0.004	.7731647	3.963089
F6.	1.662993	.9104794	1.83	0.068	-.1215142	3.4475
F7.	1.924584	.9239889	2.08	0.037	.1135988	3.735569

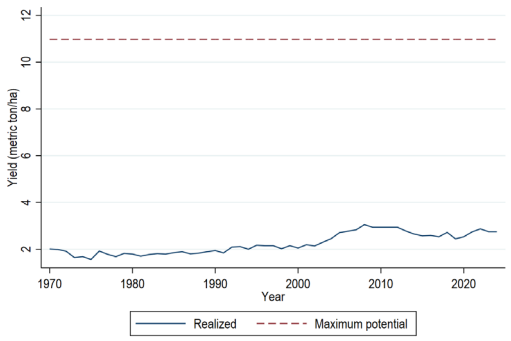
```
Note: IRF coefficients for exogenous variables are dynamic multipliers.
Impulses:  ln_production tariff_shock
Responses: ln_production
```

Source: IMF staff estimates using USDA IPAD data, WITS

C. Raising Local Rice Production – Potential and Pitfalls

14. Despite recent improvements in productivity, Madagascar's rice yield remains far below potential (Figure 6). While the rice yield improved gradually over 1980-2010, it has stagnated since the late 2000s at around 2.75 tons per hectare, far below FAO country-level estimates of maximum potential yield of 11 tons per hectare.[7] As mentioned, the chronically low yield in Madagascar can be attributed to several factors, including weak agricultural inputs such as mechanization, irrigation and fertilizer use, natural disasters including drought, flooding, cyclones and locusts, land degradation as well as inadequate land rights management.[8]

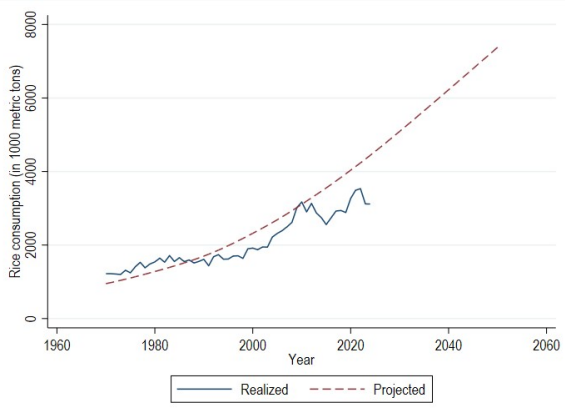
Figure 6. Rice Yield in Madagascar
(Realized vs potential in metric ton/hectare)



Sources: Authorities' and IMF staff estimates. FAO

15. In tandem with the rise of the Malagasy population from 31 million in 2023 to nearly 52 million by 2050, local rice consumption is expected to rise to 7.4 million metric tons in 2050, far above current local production levels (Figure 7).[9] To meet local demand, raising the productivity of existing rice fields should be prioritized. Indeed, according to FAO and USDA projections, if rice yields in Madagascar were at their maximum potential of 11 tons per hectare, rice production in 2023 would have been at around 17.5 million metric tons, 3.4 times its realized 2023 production level of 5.3 million metric tons and comfortably above

Figure 7. Projected Annual Rice Consumption in Madagascar
(In 1000 metric tons)



Sources: USDA and FAO projections.

[7] FAO estimates of maximum potential yield are based on geo-spatial data on historical climate attributes, soil and terrain conditions, land cover and protected area. Estimates of maximum potential yield also assume that there are ideal input conditions, including 200mm/m of water available under irrigation, fertilizer use, and mechanization.

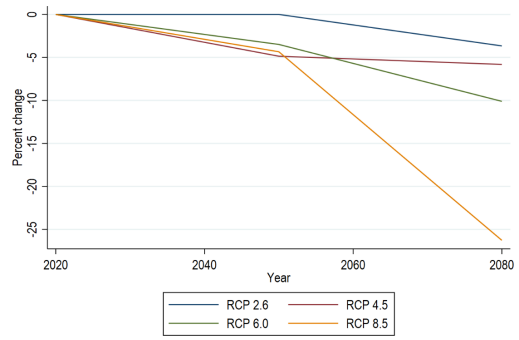
[8] According to a 2020 report on the irrigation sub-sector in Madagascar, World Bank experts found that only half of cultivated areas with irrigation infrastructure did actually benefit from irrigation, due to the deterioration of existing infrastructure. They estimate that modernizing the existing irrigation infrastructure would reap greater production benefits compared to constructing new irrigation infrastructure and would be less costly.

[9] Projections assume an average annual consumption of 143 kg of rice per person.

local population needs, even if the current size of rice cultivation plots were unchanged. Yet, while maximum potential yields under optimal conditions would be sufficiently high for self-sufficiency, such ideal conditions may not be achievable. According to World Bank experts, rice yields in Madagascar could realistically reach 6 to 8 tons per hectare at best, even with improvements to rice farming systems. [10]

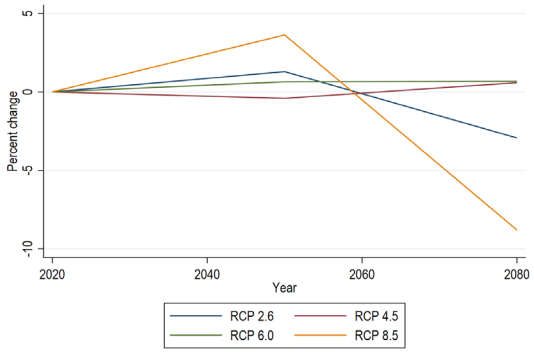
16. At current input levels, the worsening of climate conditions is expected to adversely affect future rice production, hampering self-sufficiency and exacerbating food insecurity. Using FAO projections of potential rice yield under different climate scenarios, we calculate the projected rice production losses from 2020 (Figure 8). Under Representative Concentration Pathway (RCP) 4.5, where greenhouse gas emissions peak in 2040 and decline thereafter, annual potential rice yield in Madagascar would be 5 percent lower by 2050 and continue to fall over time.[11] Should greenhouse gas emissions continue to rise after 2040, the projected losses in potential rice yield would be even larger. For instance, under RCP 8.5, a business-as-usual scenario under which greenhouse emissions continue to rise unabated, annual rice production in Madagascar would decline by 25 percent by 2080. Given that FAO projections are based on agro-climatic conditions and exclude natural disaster shocks including cyclones, droughts, and floods, which would intensify with the climate crisis, these projections likely underestimate the adverse impact of climate change on rice production in Madagascar.

Figure 8. Decline in Madagascar's Rice Production Under Different RCP Scenarios
(Current input conditions)



Sources: IMF staff estimates and FAO projections.

Figure 9. Decline in Madagascar's Rice Production Under Different RCP Scenarios
(Ideal input conditions)



Sources: IMF staff estimates and FAO projections.

17. However, access to irrigation and sustainable fertilizer use could mitigate the threat of climate change on Madagascar's rice production. In their study of the impact of climate change on rice production in Africa, Van Oort and Zwart (2017) find that by adopting more

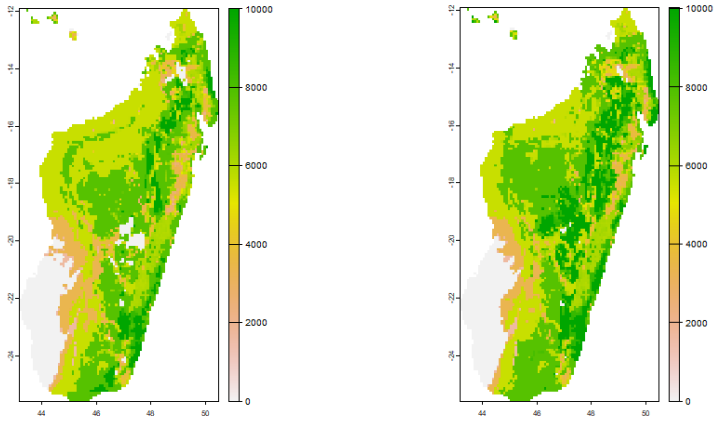
[10] The system of improved rice farming, or the *Système du Riz Amelioré (SRA)*, is a less input demanding rice cultivation method compared to the SRI and adopts only selected features of the SRI, such as the planting of young rice seedlings and leaving adequate spacing between individual rice plants (World Bank Background Report, 2022).

[11] RCP 4.5 corresponds to a future global mean temperature rise of around 2-3 degrees Celsius and is regarded by the IPCC as a stabilization scenario, under which all countries impose emission prices that rise over time.

heat resistant rice varieties and irrigation, rice production in East Africa could rise by as much as 25 percent, due to CO_2 fertilization and, to a lesser extent, lower rates of cold sterility.[12] Likewise, FAO projections show that, with ideal input levels, including irrigation and fertilizer access, rice production in Madagascar could be more resilient to climate change (Figure 9). Under RCP 4.5 and ideal input conditions, for instance, rice production would remain close to its 2020 baseline in 2050, even rising slightly in 2080. Once again, it should be noted that these results assume adequate water availability for irrigation and abstract from natural disaster shocks and should therefore be regarded as a highly optimistic projection of future rice production in Madagascar. Indeed, should climate change disrupt the water cycle and hence water availability in Madagascar, adequate water access for rice cultivation would be jeopardized. Moreover, higher CO_2 concentration, while promoting rice growth, could lower the protein content of rice, thereby diminishing its nutritional value (Ujiie et al., 2019).

18. Intra-country changes in agricultural suitability in the face of climate change may further complicate the achievement of Madagascar's self-sufficiency goal. As shown in Figure 10, under RCP 4.5, the projected suitability index for wetland rice cultivation is expected to shift in the coming decades, increasing in the north and east of the country, while declining in the south west over the coming decades. With population growth and competing land use needs including biodiversity conservation, adapting to shifting rice cultivation suitability while accomodating other land needs would be a challenge and would require an adequate legal framework for land use management.

Figure 10. Projected Suitability Index for Wetland Rice Cultivation in Madagascar under RCP 4.5



a) 2011-2040 **b) 2041-2070**

Source: IMF staff estimates and FAO projections.

[12] Assuming heat resistant rice species and adequate irrigation, higher CO_2 concentration raises the rate of photosynthesis, thereby promoting rice plant growth. The authors note that cold-induced sterility in rice plants in East Africa typically occurs in the highlands when temperatures fall below 22 degrees Celsius.

D. Climate-Smart Agriculture (CSA) Practices for Rice Cultivation

19. Policies to boost local rice productivity need to be sustainably implemented. Madagascar's second Nationally Determined Contribution (NDC) identifies rice farming and cultivated soils as contributors towards agricultural GHG. The NDC recommends a wide range of agricultural initiatives such as climate-smart agriculture, organic agriculture, Integrated Resilient Rice Models (MIRRs), conservation agriculture as well as setting up monitoring and technological capacity-building mechanisms. While the Ministry of Agriculture and Livestock has identified several measures to boost local rice production, including the adoption of high-yield hybrid rice seeds from China, an improved access to fertilizer and an increase in the allotted land for rice cultivation, careful consideration of their secondary socio-economic and environmental impacts is needed (Text Box 2). Rice cultivation practices should encourage prudent water and fertilizer use without sacrificing yield given the methane and nitrous oxide emissions associated with flooded rice paddy fields and the long-term adverse impacts of chemical fertilizers on soil fertility and the environment.

Box 2. Hybrid Rice – A Panacea for Madagascar's Self-Sufficiency Goals?

Developed in 1974 by Chinese agronomist Yuan Longping, hybrid rice involves crossbreeding two distinct parent rice species. Such crossbreeding leads to heterosis, or "hybrid vigor", which significantly increases the yield of the offspring plant compared to their purebred counterparts, with yields of some strains of hybrid rice reaching more than 15 tons per hectare in studies conducted in the Hunan province of China. Furthermore, hybrid rice varieties are generally palatable and easily substitutable with non-hybrid rice varieties among consumers.

Since the enactment of a south-south cooperation agreement between China and Madagascar in 2018, the adoption of hybrid rice has been incorporated into Madagascar's national rice strategy. Pilot studies conducted with Chinese hybrid rice seeds in Madagascar have attained yields of around 11 tons per hectare. To date however, data on the inputs used to obtain these results are not available. Furthermore, no study has been conducted comparing the yields of local and hybrid rice varieties under the same conditions. Since pilot studies of hybrid rice yields have typically been conducted under ideal input conditions, while the yield of local rice varieties is often measured using realized rice yields under non-controlled settings, it is hitherto unclear if the yield gains from using hybrid rice have been accurately established.

In addition, other factors should be considered before the adoption of hybrid rice is scaled up. Unlike purebred rice varieties, hybrid rice seeds cannot be saved and replanted from the current crop, which means that these seeds must be newly procured with each planting season. Furthermore, compared to other local rice varieties, hybrid rice seeds are around ten times more expensive than local rice seeds and require greater inputs including chemical fertilizers and water, which would have environmental implications. Because of these factors, hybrid rice cultivation is likely to be unaffordable for small-scale farmers in the absence of generous government subsidies, which could in turn weigh heavily on the government budget. Moreover, the widespread adoption of hybrid rice may lead to the crowding out of local rice varieties and a loss of crop diversity, thereby lowering the resilience of Madagascar's rice production to diseases and pests. Indeed, some of these local varieties may be more resistant to extreme climatic shocks such as cyclones and floods.

Source: FAO staff, Ma and Yuan (2015)

20. Rice production contributes to the release of Green House Gas (GHG), particularly methane (CH_4) as well as nitrous oxide (N_2O). The Intergovernmental Panel on Climate Change (IPCC) has indicated a Global Warming Potential (GWP) for methane between 84-87 when considering its impact over a 20-year timeframe (GWP20) and between 28-36 when considering its impact over a 100-year timeframe (GWP100). Nitrous oxide on the other hand has a GWP of 289 over a 20-year period and 298 over a 100-year time span. Rice grown in flooded fields has been found to be the main reason for the release of both methane as well as nitrous oxide, which is also impacted by over-application of fertilizers.

21. Flooded fields create an anaerobic condition ideal for bacteria called methanogens that release methane as they decompose organic matter. Nitrous oxide is produced primarily due to microbial processes in the soil called nitrification and denitrification. Nitrification is an aerobic process where soil bacteria convert ammonia to nitrate which produces nitrous oxide as a byproduct. Denitrification occurs under anaerobic conditions when the soil is waterlogged, such as in rice paddies during which soil bacteria convert nitrate into nitrogen gas releasing nitrous oxide as a byproduct. Estimates suggest that paddy rice production is responsible, on average, for 16 percent of agricultural methane emissions or 4.3 percent of total agrifood system emissions.

22. Climate-Smart Agricultural (CSA) practices that include sustainable water management practices and careful application of fertilizers are key strategies in mitigating methane and nitrous oxide production. CSA is an integrated approach to managing agricultural production that can achieve the "triple win" of the following: (1) economic gains, (2) climate resilience, and (3) lower GHG emissions (Sutton et al., 2024). There are several on-farm practices available to reduce rice paddy emission such as direct seeding, midseason drainage, residue management, improved fertilization, alternate wetting and drying (AWD), and integrated rice and fish farming (Searchinger and Adhya, 2015). In fact, System of Rice Intensification (SRI), originated in Madagascar in the 1980s and has been considered as one of the most promising management techniques that also reduce agricultural water use in addition to reducing GHG emissions. In terms of yields, the practice has maintained, and sometimes even increased, rice yields. While most of the data on methane emission from rice production is from Asian countries, these practices may hold promise in terms of water and fertilizer use efficiency for Madagascar as well.[13] Policy and financing incentives that reward adoption of low-emission practices could open the door to new sources of climate finance including carbon finance. The bilateral agreement between Ghana and Switzerland on Internationally Transferred Mitigation Outcome (ITMO)[14] to purchase carbon credits from emission reductions from rice cultivation is an example (UNDP 2022).

[13] Some CSA practices may be more suited to certain types of rice cultivation than others. For instance, in lowland stepped rice fields in Madagascar, the supply of irrigation water to the rice fields is cascading, meaning that a rice field receives the excess water from the one above. Given the added difficulty of controlling water supply to individual rice plots, such practices may be less suitable.

[14] An ITMO is a unit of emission reduction that can be traded between countries under the framework of the Paris Agreement. ITMOs are part of the cooperative approaches outlined in Article 6.2 of the Paris Agreement, which allow countries to work together to achieve their Nationally Determined Contributions (NDCs) through the transfer of mitigation outcomes.

E. Conclusion

23. While rice production in Madagascar has lagged its population needs over the past decades, there is potential for the country to meet its rice needs. This paper has shown that local rice supply displays positive price elasticity, rising significantly when rice price increases, albeit with several years lag. However, policies resulting in higher rice prices, including import tariffs or VAT increases, may erode consumer welfare in Madagascar, given the inelasticity of rice demand. As such, those policies must carefully weigh their impact on local production and local food prices. In contrast, supply-side policies aimed at increasing the productivity of local rice farmers could raise local rice production without a spike in rice prices. As this paper has shown, rice yields in Madagascar are far below their potential and under the right input conditions, could be substantially improved and allow the country to meet its self-sufficiency goals.

24. Even with improvements in local rice production, Madagascar's rice self-sufficiency goal may be hampered by other factors including poor market access and storage, as well as natural disasters. While measures to raise the productivity of local rice production should be undertaken, there are other non-productivity related constraints that require attention. Of particular concern is poor transport infrastructure, which severely limits the market access of rice producers, hence disincentivizing investments to raise productivity and preventing rice producers from meeting rice demand. Moreover, while agricultural best practices could raise local rice production despite climate change, idiosyncratic natural disaster shocks including cyclones, drought, and locust infestations, would still pose significant risks. Improvements to the transport and storage of rice buffer stocks (procured locally or abroad) would help Madagascar to tackle these challenges.

25. While the country aims to reach rice self-sufficiency by 2027, the environmental and socio-economic impacts of proposed measures should be carefully studied. Where possible, CSA practices that concurrently improve rice yields, climate resilience and limit the negative environmental impact of rice cultivation should be adopted. In addition, while the planting of hybrid rice seeds is a key prong of the authorities' rice self-sufficiency strategy, further studies on the efficacy and unintended effects of hybrid rice adoption are needed.[15] Given the elevated cost of procuring hybrid rice seeds, their greater need for chemical fertilizers, and the lack of studies comparing the performance of hybrid rice seeds to local rice varieties under comparable input conditions, more research should be conducted before the use of hybrid rice seeds is scaled up. Attention should also be paid to the emergence of a rice monoculture, which could erode the resilience of Madagascar's rice production. Lastly, the goal of rice self-sufficiency should not be viewed in silos but instead be balanced against other considerations, including macro-economic, fiscal, and environmental sustainability.

[15] At the start of 2025, the World Bank, in collaboration with the FAO, the Rice+ Project will install field schools in the Alaotra Mangoro Region to compare the performance of the hybrid rice with that of high-yielding local varieties, at various levels of organic and chemical fertilizations. Farmers in the region will then be invited to these field schools to choose the rice variety and the cultivation method best suited to their farms.

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