MADAGASCAR'S NATIONAL ROADMAP TO SUPPORT THE TRANSFORMATION OF FOOD SYSTEMS

What Are the Priorities and How Much Will It Cost?

July 2025

FOREWORD

At a crossroad between a historic challenge and a unique opportunity, Madagascar has undertaken a critical mission: to transform its agrifood systems as part of its commitment to the Sustainable Development Goals (SDGs) by 2030. This challenge is not only a response to current food crises but also the foundation for our goal of sustainable and equitable development for all our citizens.

Today, we face challenges that directly threaten our food security and exacerbate our vulnerabilities. Our statistics highlight the need for decisive action: more than half of our population is affected by malnutrition, a vast majority has no access to nutritious food, and over 80 percent of our fellow citizens live below the poverty line. At the same time, extreme weather conditions are occurring more frequently and amplifying their devastating effects on our territory.

In this context, the Madagascar Emergence Plan, initiated by His Excellency Andry Rajoelina, and the responses we are adopting today, demonstrate our resolve and hope. Madagascar's National Roadmap to Support the Transformation

of Food Systems, enriched by the invaluable contribution from the Zero Hunger Coalition, proposes evidence-based solutions. Our three strategic pillars — strengthening climate resilience, promoting agricultural diversity, and ensuring access to healthy food for all — serve as the foundation for this transformation. They are designed to address current challenges while anticipating future requirements.

These pillars also include the strengthening of climate-resilient agricultural production, the development of innovative financial mechanisms, such as agricultural insurance, the promotion of storage and processing infrastructure to improve market access, the protection of natural resources, the strengthening of the early warning system, as well as improvements to social protection policies and the empowerment of women in the agrifood sector.

We are pleased to announce that the recommendations from this report have been integrated into the operationalization plan of our Food Systems Pathway document. This achievement is the result of unprecedented mobilisation and synergy between the government, technical partners, the private sector, NGOs, and above all, our local communities. Together, we are defining, financing and implementing the relevant activities.

The cost of this transformation, though significant, is a vital investment in our future. Investing in our human capital and natural capital is the key to Madagascar's long-term prosperity and stability. I am deeply convinced that our collective ability to imagine, plan, and act will enable us to achieve these ambitious goals - goals that are essential for building a more resilient, greener, and fairer Madagascar.

The time has come for resolute action and political courage. Together, let us convert these challenges into opportunities for our generation and those to come.

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Minister of Agriculture and Livestock

ACKNOWLEDGMENTS

Madagascar's National Roadmap to Support the Transformation of Food Systems: What Are the Priorities and How Much Will It Cost?

July 2025

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Recommended citation

Maminiaina, L., Eber-Rose, M., Laborde, D., Mamun, A., Olivetti, E., Picard, F., Pineiro, V., Scholtz, L., and Smaller, C. 2025. *Madagascar's National Roadmap to Support the Transformation of Food Systems: What Are the Priorities and How Much Will it Cost?* Shamba Centre for Food & Climate. Geneva, Switzerland.

TABLE OF CONTENTS

LIST OF FIGURES, TABLE & BOX

EXECUTIVE SUMMARY

Madagascar is way off track to achieve the United Nations Sustainable Development Goals (SDGs) by 2030. Hunger levels (40 percent of the population) are higher today than when the SDGs were adopted in 2015, and poverty levels remain stubbornly high (80 percent of the population). Severe droughts in the south of the country have driven the rise in hunger and stagnation in poverty levels.

But it does not have to be this way. To get back on track, it is critical to pursue policy pathways that favour synergies and limit the trade-offs between hunger, poverty, nutrition, and climate change. This report presents an evidence-based prioritization of effective interventions to operationalize the three axes of Madagascar's National Roadmap to Support the Transformation of Food Systems: (1) Promoting access to a diversified, healthy and nutritious diet; (2) Promoting governance that supports equitable and resilient livelihoods; and (3) Promoting resilient production in the face of climate change.

An additional USD 4.5 billion per year would help Madagascar operationalize its Roadmap and achieve its SDG 2 (Zero hunger) targets by 2030. This would largely be in the form of social protection programmes, such as cash transfers. The prioritization of cash transfers over and above more longer-term systemic interventions is due to the 5-year countdown to 2030. A longer-term view over the next 10 years would help allocate spending to longer-term development priorities in order to support resilience building. This would help mitigate against future shocks and crises as well as maintain greenhouse gas (GHG) emissions in agriculture to Madagascar's nationally determined contribution (NDC) goals.

The report recommends that Madagascar and its development partners:

|1| **Significantly increase public investment by an additional USD 4.5 billion** in annual public investment per year to 2030 to achieve the transition to sustainable food systems. Given the steep reductions on global aid budgets, Madagascar should actively seek to mobilise innovative financing mechanisms beyond traditional aid, including leveraging private sector investments and strategically directing climate finance and financial flows toward long-term, sustainable interventions.

|2| **Diversify and sustainably intensify both crop and livestock production.** Given that this is a top priority for Madagascar, the government and development partners should allocate additional resources to implement the goals and actions listed in its relevant strategies supporting growth in productivity, including those focusing on climate-smart agriculture and diversification of crops and livestock. This must be accompanied with extension services, improved crop choices, investment in machinery and small scale irrigation, and increased access to improved animal feed and breeds to protect soils and biodiversity, conserve water, and limit land-cover change.

|3| **Expand sustainable fisheries and aquaculture programmes.** This should be prioritized to provide both alternative livelihoods as well as increase the availability and affordability of nutrient-dense food. New donor-funded projects should focus on the fisheries and aquaculture sector which represents a potential area for impactful investment.

|4| **Invest in roads, electricity, and storage infrastructure**, to simultaneously contribute towards the accessibility of nutritious and affordable food, help small- and medium-sized enterprises (SMEs) access markets, and reduce the high levels of food loss and waste. Investment in renewable energy infrastructure in particular would benefit farmers and SMEs directly by enabling them to charge phones, access weather and market information online, and use digital services.

|5| **Improve water infrastructure and water management,** particularly in the south of the country, given the vulnerability to recurring droughts. Madagascar can draw from best practices elsewhere that do not require specialised equipment and can be implemented after the harvest, when the opportunity costs of family labour and wages for paid labour is low. These include training on farm rainwater-harvesting techniques such as mini-catchments that can increase yields, reverse soil degradation and combat desertification.

|6| **Expand climate responsive social protection programmes and early warning systems.** Madagascar has made expanding its existing early warning system a priority. It should now invest in new technologies to provide more accurate, current weather forecasts—crucial given increased weather variability. The government should also expand its social protection programmes to target more people. Efforts should concentrate in particular on those living in the south of the country which is highly prone and vulnerable to droughts. Equally, donors need to maintain their support for social protection and safety nets to address the immediate hunger and poverty crisis in Madagascar.

|7| **Expand nutrition interventions, such as biofortification and food fortification, accompanied by nutrition education.** Build on the success of the iodine enrichment of table salt or the moringa-based bio-fortified food supplements. Accompany these efforts with nutrition education to improve the consumption of nutritious and diverse foods and support the transition to healthier diets. Key in this respect would be to address the relatively high prevalence of rice in the diets of both urban and rural households.

|8| **Prioritise cross cutting policies and programmes that address insecure tenure rights and combat high levels of deforestation** such as improving renewable energy access, promoting agroforestry and providing title to land to stem outward migration from the south of Madagascar.

|9| **Address existing gender inequalities in agriculture by ensuring women participate in decision-making at all levels,** reducing their work burden, providing them with access to and supporting their use of resources, such as land, agro-climatic information, technology, livelihood incomes and credit, and supporting collective action by women's groups.

|10| **Accelerate cross-sectoral coordination among local, regional, and national government departments to drive food systems transformation effectively.** This includes improving their capacity to monitor, analyse, and inform on progress and achievements. This will help institutions support the transformation of sustainable food systems, including by collecting disaggregated data to account for subnational and gender differences.

These recommendations support Madagascar's National Roadmap for Food Systems Transformation, which was written in light of the United Nations Food Systems Summit in 2021 and to support the 2030 Agenda. In this way, the results, findings, and recommendations of our study offer an evidence base and costing on which to support the implementation of the key priority action areas identified in Madagascar 's National Roadmap for Food Systems Transformation.
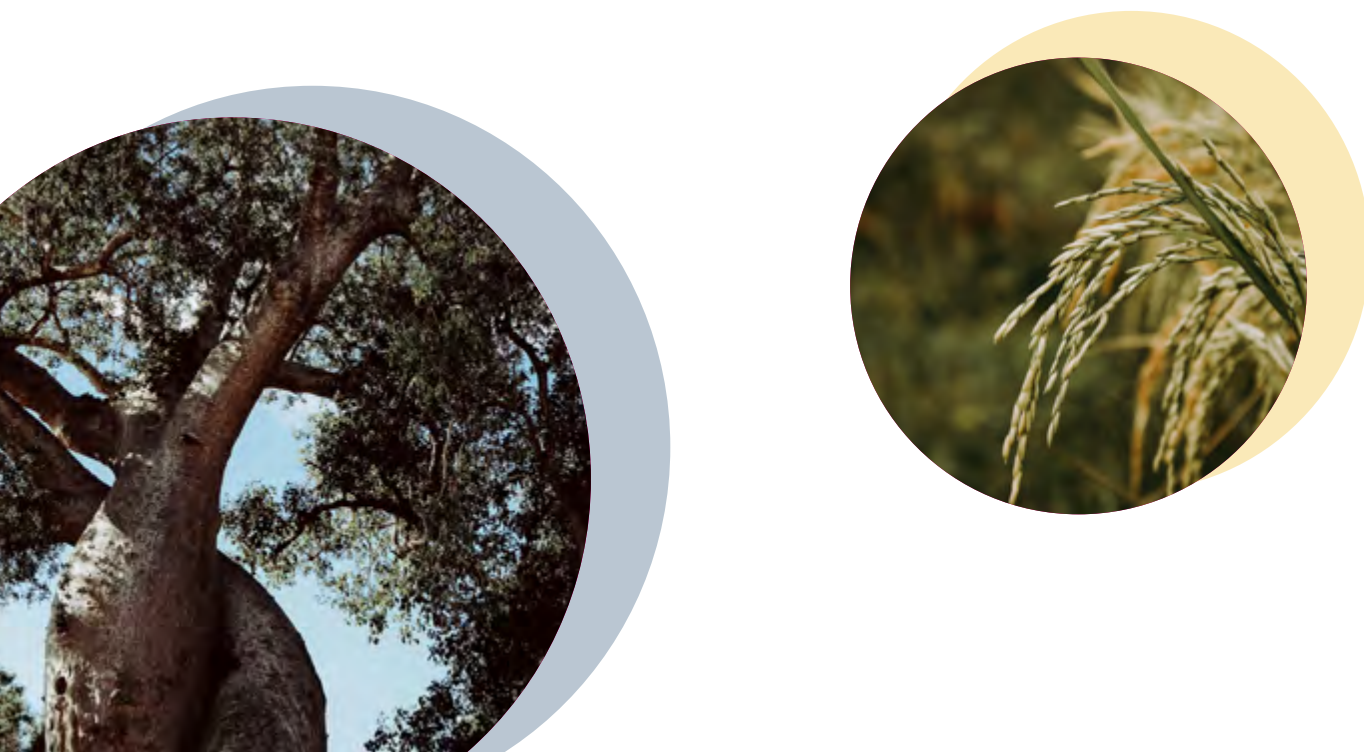
INTRODUCTION

Madagascar's food system is at the intersection of profound social, economic, and environmental crises, creating a unique case for studying the multifaceted challenges of food security, nutrition, and climate resilience in low-income, climate-vulnerable contexts. Just over 80 percent of the population lives below the extreme poverty line (World Bank, 2023c), and 98 percent cannot afford a healthy diet (FAO, 2023a). This crisis has worsened due to economic shocks, rising food and oil prices, and persistent droughts. In the past decade, the number of people affected by hunger has risen sharply to 40 percent of the population (see Figure 1). However, hunger is not merely a matter of caloric deficiency; it is intricately tied to malnutrition, with the affordability of nutritionally adequate diets emerging as a critical barrier to human development.

Madagascar's acute vulnerability to climate change exacerbates these challenges. Despite contributing less than one percent of global greenhouse gas (GHG) emissions, the country ranks as the fifth most exposed to the risks of climate change and the most vulnerable country in Africa (FAO, 2016). Prolonged droughts, extreme weather events, and other climate-induced shocks have deepened food insecurity and poverty, disproportionately affecting rural communities that rely on subsistence farming. Without additional efforts and targeted interventions, hunger and poverty will continue to rise (World Bank, 2024b).

Beyond its socioeconomic challenges, Madagascar is a biodiversity hotspot and a steward of critical environmental assets. Its rainforests, mangroves, and other ecosystems pro-

vide vital global public goods, from carbon sequestration to biodiversity conservation (FAPBM, 2023). However, these natural resources are under threat due to unsustainable agricultural practices, land degradation, and deforestation driven by poverty and hunger. The sustainable transformation of Madagascar's food systems thus necessitates a dual focus: addressing the immediate needs of poverty and hunger while safeguarding the country's critical ecosystems.

Recognizing these interlinked challenges, the government of Madagascar has committed to ambitious global and national frameworks, including the 2030 Agenda for Sustainable Development Goals (SDGs), and the Paris Climate Agreement. Its National Pathways to Support the Transformation of Food Systems Towards Achieving the SDGs of Agenda 2030 (Roadmap)[1], aims to create an efficient, inclusive, resilient, and sustainable food system that can nourish a healthy population. This Roadmap aligns with existing policies, including food security, nutrition, agriculture, climate, environment, and gender. The government has simultaneously committed to provide sufficient food for all, improve the productivity of the agricultural sector, increase the incomes of small-scale producers, make diets healthier and more affordable, contain greenhouse gas (GHG) emissions, and build capacities to adapt to climate change and halt environmental degradation. Despite these efforts, Madagascar faces substantial barriers, including financial constraints, limited institutional capacity, and competing development priorities.

Importantly, the donor community has responded to the worsening situation in Madagascar, and aid has more than tripled in the past decade, from an annual average of USD 80 million in 2012-13 to USD 273 million in 2020-21 (OECD, 2024). But this report finds that Madagascar needs an additional USD 4.5 billion in public investment between 2025 and 2030 to transform food systems and achieve the SDGs. Given the steep cuts to global aid, and constraints on budgets, Madagascar must adopt innovative financing strategies to attract commercial investment alongside increased public and private funding. Transforming Madagascar's food systems will require not only additional resources but also innovative mechanisms to leverage development finance.

This report examines Madagascar's food system challenges and explores pathways for sustainable transformation. It provides the evidence and costs for the most effective interventions that the government and its development partners should prioritize between now and 2030 to fulfil the objectives in the Roadmap and achieve SDG 2. The report centres around the operationalization of the Roadmap employing an integrated methodology that includes a machine-learning assisted scoping review of country-level policy documents and peer-reviewed literature, a microeconomic analysis of changing dietary and food consumption habits, engagement and consultations with in-country stakeholders, and macro-economic modelling using a computable general equilibrium (CGE) model integrated with data from household surveys.

The report is part of the Hesat2030 project that explores the interaction between achieving healthy diets, reducing hunger and poverty, and addressing climate change within the evolving food systems in nine countries – Bangladesh, Benin, Democratic Republic of Congo, Cambodia, Ethiopia, Malawi, Nigeria, Madagascar, and Zambia. It was coordinated through the Zero Hunger Coalition.

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1 / Feuille de Route nationale pour soutenir la transformation des systèmes alimentaires vers la réalisation des objectifs de développement durable (ODD) de l'agenda 2030 (RM, 2022c)

Chapter 1:
MADAGASCAR'S MULTIPLE FOOD SYSTEM CHALLENGES

Madagascar is grappling with a severe food system crisis, marked by escalating hunger, entrenched poverty, and vulnerability to climate change. Hunger affects 40 percent of the population, poverty affects 80 percent of the population, and a staggering 98 percent of people cannot afford a healthy diet (FAO, 2023a). Three consecutive years of drought in southern Madagascar and rising international oil prices have intensified these problems (Fayad, 2023).

Though Madagascar contributes less than one percent of global greenhouse gas emissions, it ranks as Africa's most climate-vulnerable country and the fifth worldwide for climate-risk exposure (FAO, 2016). Cyclones, floods, and droughts are frequent, devastating livelihoods and infrastructure. Agricultural productivity remains low, except for limited areas producing high-value cash crops. This section analyses the challenges facing the food system.

1.1 Rising hunger and persistently high poverty

Madagascar is facing one of the most severe hunger crises in Africa. The prevalence of undernourishment rose sharply over the past decade, from 26 percent in 2012 to 40 percent in 2022 (FAO et al., 2024) (see Figure 1). This is double the sub-Saharan African average of 20 percent in 2023 (FAO et al., 2024). This alarming trend reflects the deepening food insecurity in the country, with multiple factors exacerbating the situation. Poverty has remained entrenched for decades, with 80 percent of the population living below the extreme poverty line (World Bank, 2023c). This figure is more than double the sub-Saharan Africa average of 35 percent (World Bank 2023c). Poverty is especially pervasive in the southern and southeastern regions, where it exceeds 90 percent due to recurrent climate shocks, including droughts, cyclones, and floods (World Bank, 2024). The persistent vulnerability of these regions underscores the fragility of the country's socio-economic fabric.

Income inequality is also a critical issue in Madagascar; with a Gini coefficient of 0.36 in 2022 (World Bank, 2024), there are clear significant disparities in wealth distribution. These structural inequalities limit access to opportunities, essential services and resources, including nutritious food, further perpetuating cycles of hunger and poverty.

In 2021, nearly 98 percent of Madagascar's population could not afford a healthy diet (FAO, 2023a). The country's inability to provide affordable nutrition for its citizens is largely driven by a combination of multiple crises — three years of droughts in the southern regions, the global impact of the COVID-19 pandemic, and the economic disruptions caused by the Ukraine conflict. These crises have driven up food prices, fuel costs, and transportation expenses, severely affecting the purchasing power of the most vulnerable populations. The 2019 drought alone pushed an additional one million people into food insecurity, with 250,000 facing famine-like conditions (Fayad, 2023). Despite the immediate emergency, the underlying challenges of access to food remain persistent.

Poverty remains high but stagnant while hunger doubles in a decade

Figure 1. Poverty and food security in Madagascar, 2012-2022
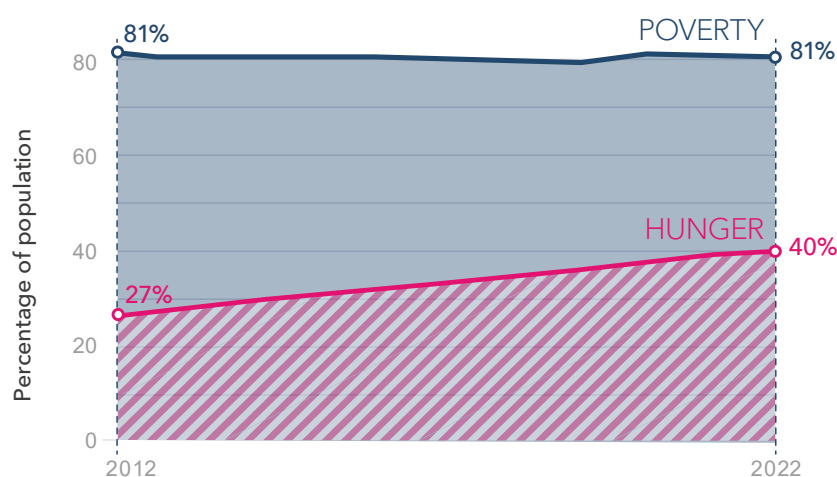
Note: Poverty is poverty headcount ratio at USD2.15 per day (2017 PPP) (% of population), from World Bank, Poverty and Inequality Platform (nowcasts for 2013-2022) (World Bank, 2023c). Undernourishment is the prevalence of undernourishment (percent) from FAOSTAT using 3 year averages (FAO, 2023b).

1.2 Triple burden: climate change, economic decline, and population growth

Madagascar faces a complex interplay of challenges, exacerbated by economic decline, a rapidly growing population, and the intensifying impacts of climate change. These interconnected issues create a "triple burden" that threatens the country's development and its efforts to combat food insecurity, poverty, and environmental degradation.

Economic decline

Madagascar's real gross domestic product (GDP) per capita has steadily declined since independence, leaving the average Malagasy today 41 percent poorer than in 1961 (Sharma, 2020). At the time of writing, projections suggest improvement: real GDP should grow by 4.2 percent in 2023 (World Bank, 2023a) and at 2.6 percent for the period 2024-2026 (World Bank, 2024a). Growth is expected to be driven by agriculture, telecommunications and mining (particularly graphite, nickel, and cobalt). The global demand for these minerals has led to an increase in exports supporting the country's economic recovery.

Although GDP growth is a positive sign, it does not necessarily translate into widespread prosperity. Between 2015 and 2019, Madagascar's economy grew at an average annual rate of 3.7 percent. (AfDB, 2021). However, the country experienced a severe economic downturn in 2020, with a 7.1 percent contraction in real GDP due to the impacts of the COVID-19 pandemic, reversing progress in poverty reduction. Despite the growth achieved over the past decade, it has not been sufficient to reduce the poverty rate, which remains extremely high. More importantly, the economic benefits have not reached the poorest segments of the population, particularly those in rural areas dependent on agriculture. This highlights the challenge of ensuring that growth is inclusive and addresses structural inequalities.

Population growth

The projected growth in GDP is unlikely to keep pace with the demands of a rapidly growing population. Madagascar's population is growing at an annual rate of 2.7 percent, significantly higher than the global average of 1.1 percent (World Bank, 2023b.). With a median age of 19, the population is expected to reach nearly 36 million by 2030 (UNDESA, 2022; World Bank, 2023b). This will increase demand for food, infrastructure, and public services. Unemployment is a major challenge, particularly among youth, with 70 percent of the unemployed population being aged 15-30 (ILO, 2023). This demographic is particularly vulnerable to the impacts of food insecurity, as a large portion of the young population struggles to find stable and decent work (AfDB, 2021). The lack of employment opportunities, coupled with the high cost of living and inadequate access to resources, leaves many youth without the means to change their situation or contribute to food system solutions.

Climate change

Tropical cyclones hit Madagascar every 11 months on average, while droughts and floods occur every three years. Although the future frequency of these events is uncertain, their impacts are projected to intensify. For instance, tropical cyclones are expected to become 18 percent more damaging by 2050 (Fayad, 2023). Between 2012 and 2022, the frequency of droughts increased significantly, a trend likely to persist (see Figure 2). The effect of climate change varies by region. The southern regions face rising temperatures, reduced rainfall, and prolonged drought while the northern, central eastern, and western coastal areas experience more intense cyclones, tropical storms, and floodings. These changes reduce crop yields and are expected to decrease productivity because of extreme heat and increase damage inflicted by drought-induced pests such as locusts (Fayad, 2023).

The frequency of drought has increased significantly since 2012

Figure 2. Drought in Madagascar, 2012-2022

Drought Hotspot Categories

- 0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1
- 1. High
- 2. Medium
- 3. Low
- 4. None
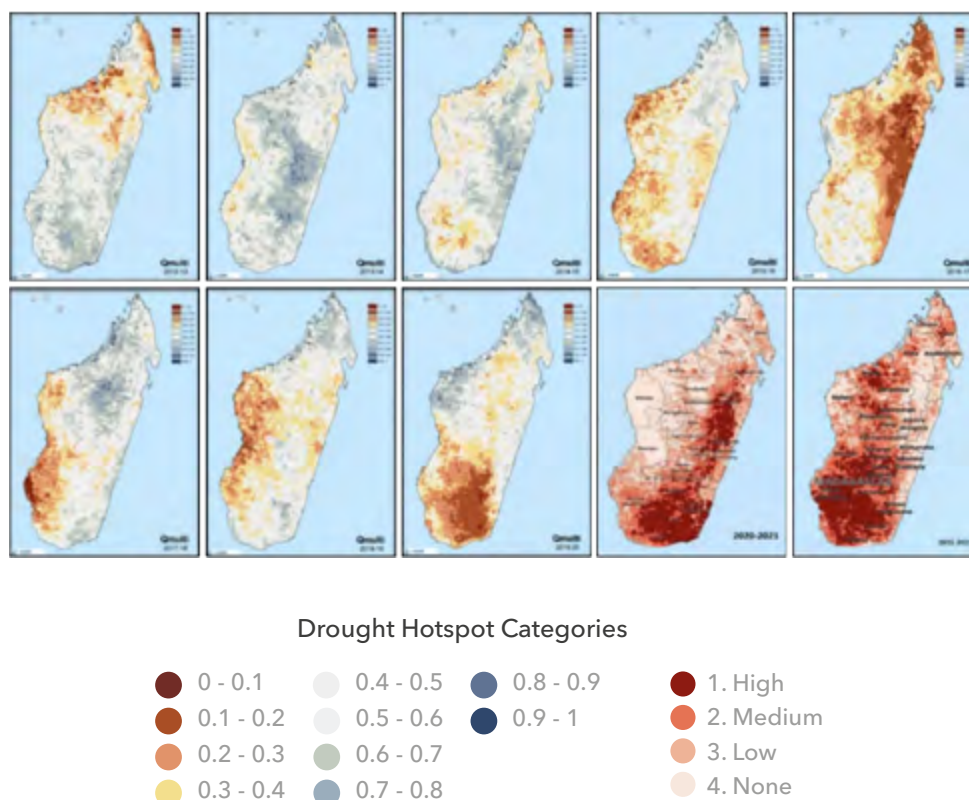
Source: Malagasy Meteorological Institute, WFP

Climate change also threatens Madagascar's marine and freshwater ecosystems. Coral bleaching, seagrass loss, fisheries loss, and ocean acidification damage the fisheries sector (Fayad, 2023). Overfishing, destructive fishing practices, and habitat destruction further harm coastal fisheries (World Bank, 2020). Freshwater fishery resources in Madagascar have also been impacted by unplanned land use conversion driven by increasing demand for food. This has resulted in increasing sedimentation that often fills-in and shrinks lakes (Konoshima et al., 2021).

In 2020, Madagascar generated 40 millions tons of greenhouse gas emissions. The agriculture sector was the largest contributor, accounting for 57 percent of total emissions, followed by land use change and forestry (LUCF) at 24 percent (see Figure 3). On farms, four main sources each contributed about one-quarter of emissions: nitrous oxide from soil management (25 percent), methane from flooded rice fields (24 percent), livestock manure management (24 percent), and enteric fermentation (23 percent) (Bockel et al., 2010; Rakotovao et al., 2017; WRI, 2023).

Agriculture accounts for more than half of Madagascar's greenhouse gas emissions

Figure 3. Greenhouse gas emissions (GHG) sources in Madagascar (MtCO2eq)

Fruits

Land-Use Change and Forestry 24%

Industrial Processes

Energy 14%

Agriculture 57%

25% — Nitrous oxide from soil management

24% — Methane from flooded rice fields

24% — Livestock manure management

23% — Enteric fermentation
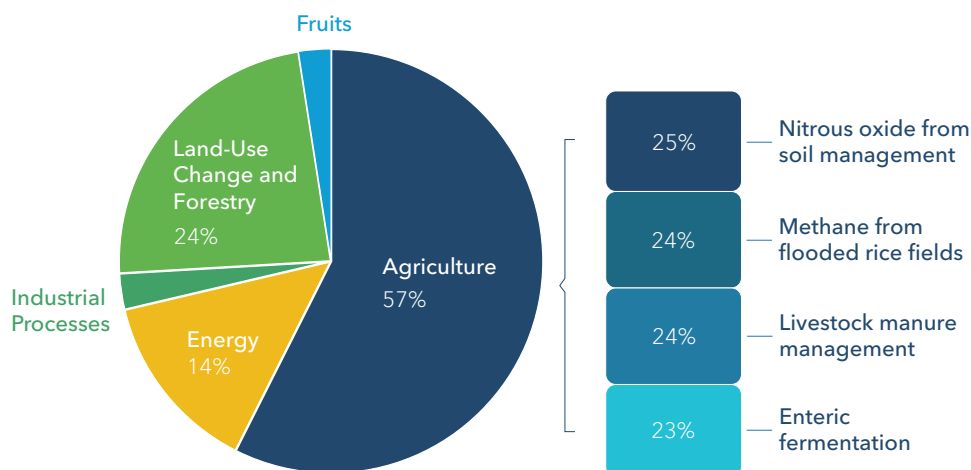
Source: Climate Watch Historical GHG Emissions (1990-2020), WRI, 2023.

Climate change is also driving migration in Madagascar. People from the south are moving north to the Menabe and Boeny regions. In these areas, they burn vegetation and clear land for agriculture (Fayad, 2023).

Without action and resources to address hunger, poverty, and deforestation, current projections indicate that Madagascar will shift from absorbing carbon to emitting carbon by 2030. The country's total emissions will increase 87 million metric tons of carbon dioxide (MtCO2) in 2000 to 214 MtCO2 in 2030. Simultaneously, its carbon absorption capacity is expected to decline from 290 MtCO2 in 2000 to just 92 MtCO2 by 2030, shifting Madagascar's net carbon balance from a sink of 203 MtCO2 to a net emitter of 22 MtCO2 (RM, 2022f).

1.3 Weak agricultural productivity: dualistic and underperforming

Madagascar's agricultural sector lies at the heart of the country's economy and livelihoods, yet it remains fraught with challenges that undermine its potential. Although the sector encompasses farming, fishing, and forestry and employs the majority of the labor force, its contribution to the national economy is disproportionately low.

An underperforming agriculture sector

Madagascar's agricultural sector, which includes farming, fishing, and forestry, remains

highly unproductive despite its importance to the economy. It is bedevilled by several factors: limited access to agricultural productive assets, credit and markets; gender inequality that limits women's and girls' access to land; poor post-harvest techniques; inadequate natural resource management; poor infrastructure, including electricity supply; and lack of adequate markets for smallholder farmers (WFP, 2019 and 2023, World Bank, 2022a).

Consequently, despite employing 74 percent of the labour force in 2021, the sector only accounted for 22 percent of the country's GDP in 2022 (see Figure 4) (ILO, 2024; World Bank 2023b). On average, each agricultural worker generated an output of only USD 370 in 2019—far below the sub-Saharan African average of USD 1,427 and just 10 percent of the global average of USD 4,005 (World Bank 2023b). Rice yields perfectly illustrate this gap: Madagascar's farmers harvest 2.45 metric tons per hectare, while farmers worldwide produce 6 to 11 metric tons per hectare worldwide.

Agricultural productivity and GDP per capita are both declining

Figure 4. Agricultural trends in Madagascar, 2008-2022
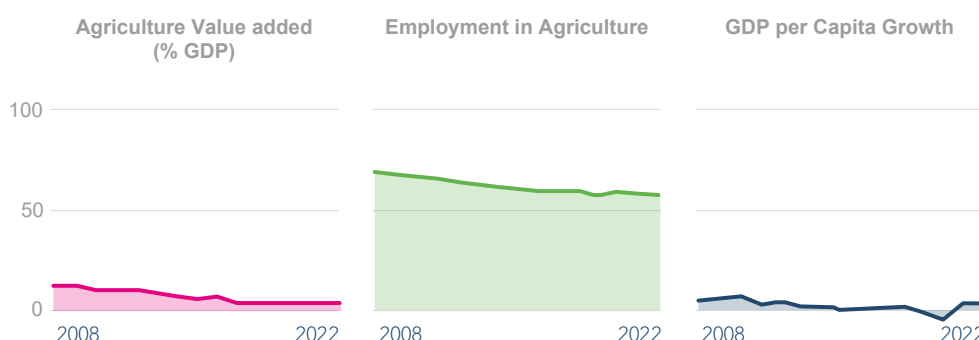
Source: GDP per Capita Growth is GDP per capita growth (annual %) from World Bank, 2023b. Employment in Agriculture is the Employment in agriculture (% of total employment) (modelled ILO estimate) from International Labour Organization modelled estimates database ILOSTAT (accessed January 2023). Agriculture Value Added is the Agriculture, forestry, and fishing value added (% of GDP) from World Bank, 2023b.

The lack of rural infrastructure and poor electricity coverage remains a major constraint across Madagascar, as emphasized during the stakeholder consultation process[2]. Although approximately 1.1 million hectares in the country are equipped with irrigation infrastructure, much of the agricultural production operates at a semi-subsistence level with limited access to essential inputs. Poor road networks make it difficult for farmers to transport their produce to markets. Consequently, many farmers produce primarily for self-consumption, selling surpluses only to meet immediate needs. Moreover, the absence of adequate transport, storage facilities, and post-harvest conservation treatments contributes to significant post-harvest losses (World Bank, 2022a; Fayad, 2023).

2 / Consultations for the report were held on 19 April 2023, 11 September 2023, and 16 April 2024 in hybrid format.

Electricity coverage is equally problematic, with national connectivity at just 15 percent at national level: 14 percent in urban areas and a mere 5 percent in rural areas (RM, 2020). This severely limits small-scale farmers' ability to adopt technology, access market information, and attract investments in critical infrastructure, such as cold storage. Additionally, the low electrification rate, particularly in rural areas, forces nearly 90 percent of the population to rely on biomass for daily energy needs, placing immense pressure on Madagascar's indigenous forests (Suzzi-Simmons, 2023).

In Madagascar's southern region, agricultural challenges are particularly severe. A significant proportion of households operate on small plots: 45 percent cultivate less than 50 acres, 34 percent manage between 50 and 100 acres, and only 21 percent have more than 100 acres. Recurrent droughts, combined with the high costs and limited accessibility of quality seeds, hinder effective planting and crop management. Seed provision constitutes merely 3.5 percent of all assistance received by households, benefiting only 34.5 percent of households. Other essential agricultural inputs—such as organic and chemical fertilizers, phytosanitary products, and farming equipment—are available but often remain unaffordable for most farmers (Fayad, 2023).

A dualistic agricultural system

Madagascar therefore presents a dual agricultural system characterized by a stark contrast: the vast majority of small-scale producers engaged in subsistence farming coexist alongside concentrated pockets of high-value cash crop production. The type and geographic concentration of crop production also varies significantly across the country. For instance, horticultural products are predominantly grown near large urban centres, emphasizing the importance of short value chains in ensuring access to markets. Similarly, agribusinesses are concentrated in areas with reliable market access and infrastructure (IFC, 2021).

Staple crop production is also regionally concentrated. Cassava, the second most cultivated crop after rice, is largely produced in the southern regions of Matsiatra Ambony, Androy, Atsimo Andrefana, and Anosy, which together account for half of the country's total cassava production (IFC, 2021). Alternatively, maize originates primarily from four regions: Vakinankaratra, Itasy, Atsimo Andrefana, and Boeny.

Rice dominates Madagascar's agriculture. Seven out of ten of Madagascar's 2.5 million small scale farmers grow rice on plots smaller than 1.2 hectares. Half of the production comes from southern Madagascar, which has been badly affected by recurring droughts. Deforestation exacerbates the challenges of rice farming: eroded soil silts up reservoir dams and irrigation canals, reducing water storage capacity (Fayad, 2023). Production has been unable to keep up with local demand, forcing Madagascar to import rice (IFC, 2021; World Bank, 2022a). The country imports about 80 percent of non-basmati white rice from India, which makes it vulnerable to price fluctuations and export restrictions, such as the export ban imposed by India in July 2023 (Laborde & Mamun, 2024). These vulnerabilities have raised concerns among stakeholders, who, during consultations, emphasized the need to increase local food production and reduce post-harvest losses to decrease the country's dependence on rice imports.

Most Malagasy households raise livestock, mostly poultry, with 95 percent of households engaged in poultry farming (Sendramampionona et al., 2020). Livestock plays a critical role in household income: in the commune of Soalara-Sud, goat sales contribute over 50 percent of annual household cash income and account for 15–29 percent of net food expenditures across the Mahafaly Plateau—far exceeding the contribution of food crops at just 6 percent (Feldt et al., 2016; Sendramampionona, 2020). However, diseases, poor livestock management, and limited market information constrain household incomes (Hänke et al., 2017; Sendramampionona et al., 2020). Similarly, the fishery sector, which supports coastal livelihoods, suffers from environmental degradation and inadequate investment in storage and transport infrastructure. Production does not meet national demand, and as a result the availability and consumption of beef, milk, and fish have declined since the early 1990s (IFC, 2021).

Regional differences in agricultural production and accessibility to a variety of food create stark variations in the nutritional quality of diets and calorie consumption between regions, as Section 1.4 discusses.

Finally, women face systemic barriers that limit their productivity, despite contributing 45 percent of agricultural labour and being primarily responsible for family nutrition and food security. Compared to men, women have less access to essential resources such as land, finance, and modern seed varieties. They also face limited access to mobile phones, technical assistance, and credit, which restricts their ability to obtain crucial information on weather forecasts, early warning systems, and market trends needed to guide crop choices, planting schedules, and marketing strategies (WFP, 2019). Their productivity is further constrained by the burden of domestic responsibilities, such as collecting water and firewood, alongside cultural norms that often discourage women from working outside their homes. These structural challenges perpetuate inequalities and hinder women's full participation in agricultural activities, ultimately affecting overall productivity and food security (WFP, 2019).

1.4 Poor and undiverse diets

Madagascar faces a persistent challenge of poor nutrition and limited dietary diversity, shaped by high poverty levels, unaffordability of healthy food, and structural inefficiencies in the agricultural sector. These issues are further compounded by regional disparities and the increasing frequency of climate-induced crises.

An analysis of household-level food and nutrition patterns, using data from the National Survey on the Monitoring of the Millennium Development Goals 2012-2013 (AfDB et al., n.d.), conducted by Madagascar's National Statistical Agency (INSTAT), reveals stark insights. High poverty rates, the unaffordability of healthy food, and structural problems in the agriculture sector contribute to Malagasy diets being both limited in diversity and poor in nutrients. Rice dominates Malagasy diets, providing 56 percent of calorie intake. Both poor and wealthy households rely heavily on starches and consume few vegetables, fruits, or animal-source foods.

Between 2012 and 2021, average caloric intake in Madagascar dropped by over 25 percent, from 2,315 to 1,700 kilocalories per day (see Figure 5). This sharp decline primarily

reflects reduced consumption of cereals and starches, which fell from 637.1 grams per day in 2012 to 463.2 grams per day. Despite this, cereals and starches still constitute 80 percent of calorie intake. Over the same period, average daily food consumption decreased from 855 grams to 818 grams.

Importantly, as hunger and poverty rose, fruit and vegetable consumption increased substantially. Fruit consumption nearly tripled from 52 to 154 grams per day, while vegetable consumption almost doubled from 65 to 115 grams per day. By 2021, these foods became the second and third most consumed food group by weight, increasing from 14 percent to 33 percent of total food intake—a shift offset by a similar decline in the consumption of starches and cereals as a share of the diet. While this is beneficial from a diversity and nutrition perspective, the implication on caloric intake is significant: fruits and vegetables added just 69 kilocalories to daily diets, whereas reduced cereal and starch consumption led to a loss of 600 kilocalories. Meat, fish, and dairy consumption collectively accounted for slightly more than five percent of the total daily consumption, with little consumption of legumes, nuts, and seeds (two percent) or vegetable oils (one percent).

Significant decline in calories consumed from 2012 to 2021, with diets still dominated by cereals and starches

Figure 5. Average dietary composition in Madagascar, 2012 and 2021
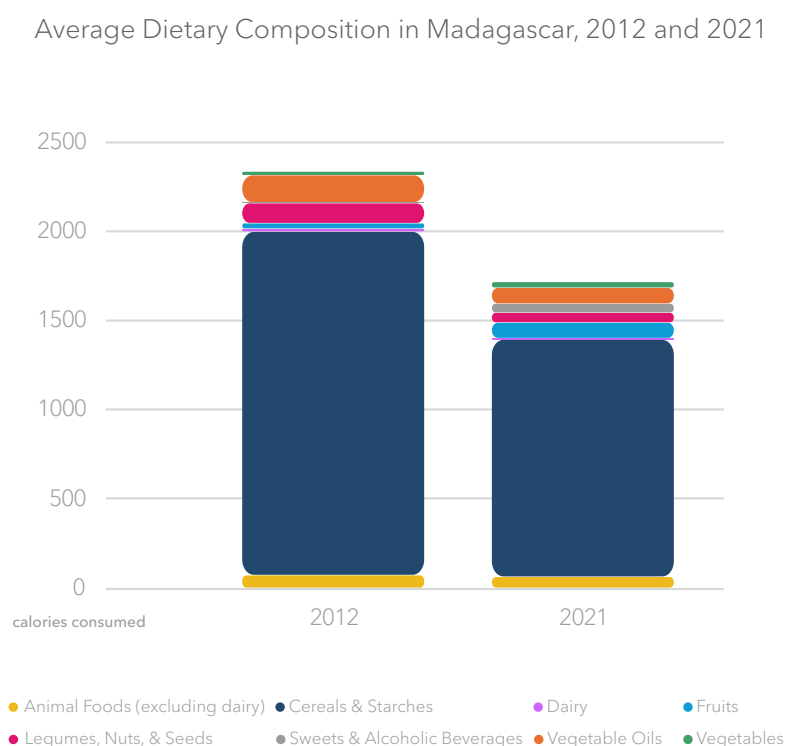
Source: Author's own using data from the National Survey on the Monitoring of the Millennium Development Goals 2012-2013 and Madagascar Demographic and Health Survey 2021.

Understanding Madagascar's current hunger and poverty crisis is complicated by the lack of up-to-date and disaggregated data. The most recently available statistics are still being verified and are only available at the national level. These aggregate statistics likely mask differences among regions—for instance, between the drought-prone south and other parts of the country.

To understand some of these regional differences, we can—with some reservations—make use of the 2012-2013 surveys. One important caveat is that in 2012, undernourishment was half the current level, therefore the data's applicability to explaining the current hunger and poverty crisis facing Madagascar is limited. Nonetheless, data from 2012-2013 can provide insights into the variation in consumption patterns across Madagascar. Figure 6 highlights stark disparities.

Geographical and economic differences in food consumption patterns are clearly visible in southern Madagascar. Here, 95 percent of people facing acute food insecurity rely on agriculture, livestock and fishing, but are unable to cultivate enough food for their own consumption. As a result, they resort to desperate survival measures. These include eating locusts, raw red cactus fruits, and wild leaves (Makoni, 2021).

People in the south of Madagascar, the poorest and most drought-prone regions, are consuming almost half of the calories of those in the capital

Figure 6. Average calorie intake by region in Madagascar, 2012-2013

Source: Author's own using data from the National Survey on the Monitoring of the Millennium Development Goals 2012-2013.
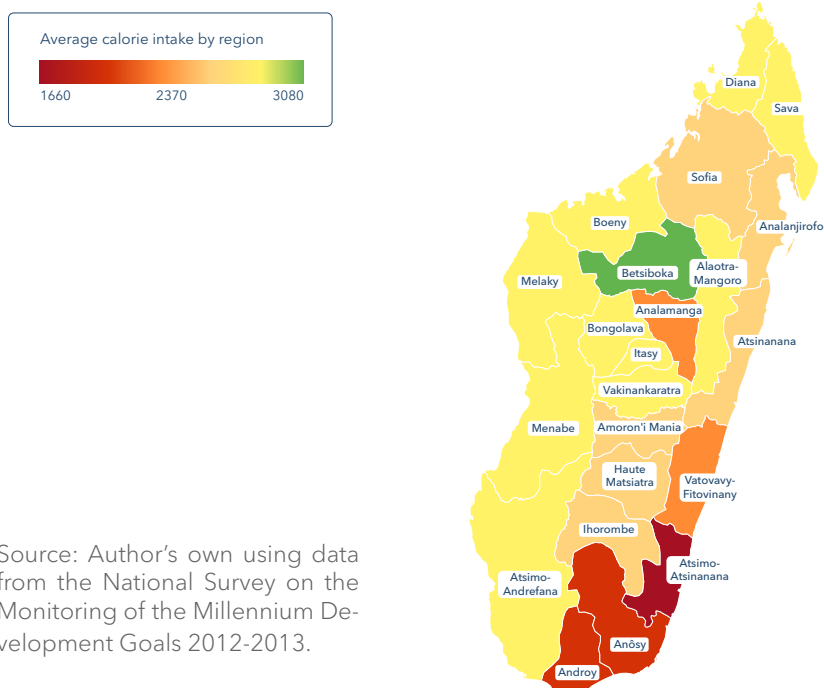
Data from the 2012-2013 surveys shows how income affects diet quality and quantity in Madagascar. Figure 7 shows calorie consumption by food group, comparing the highest and lowest income deciles. Households in the highest decile consume an average of 3,131 kilocalories per day, compared to just 1,671 kilocalories per day in the lowest decile—barely more than 50 percent of the caloric intake of their wealthier counterparts. While cereals and starches dominate the diets of both groups, wealthier households benefit from more diverse diets, including significantly higher amounts of animal protein and dairy. Additionally, households in the highest income decile consume more of every food group, with the exception of sweets and alcoholic beverages, compared to those in the lowest income decile.

The lowest-income households consume half the calories of the highest-income households, whilst all diets are dominated by cereals and starches

Figure 7. Average daily calories by food group for the lowest and highest income deciles in Madagascar, 2012-2013
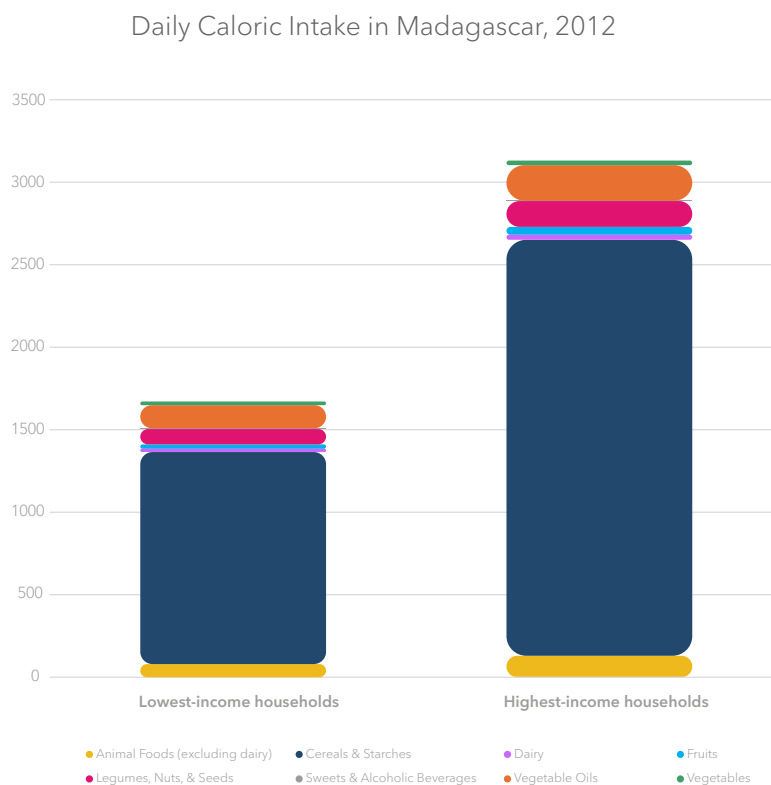
Source: Author's own using data from the National Survey on the Monitoring of the Millennium Development Goals 2012-2013. Note: Lowest-income households are the lowest decile of the Malagasy population, whilst highest-income households are the highest decile.

Many households adopt coping mechanisms during the lean season between harvests, such as selling productive livestock or changing their patterns of consumption. In south-western Madagascar, farmers use a range of non-farm income sources, including wage labour, charcoal production, trade, and handicrafts to cope with food and cash shortages. More than 80 percent of households

collect wild food, particularly the fruit of the prickly pear cactus and yam roots. More than 70 percent of households also receive food aid from non-governmental organizations, mainly through food-for-work programmes. Almost half of the households report reducing food intake for adults; 36 percent also reduce food intake for children (Hänke et al., 2017). In the Amoron'i Mania region in central Madagascar, people significantly reduce their consumption of green vegetables, peanuts, fish, and eggs, replacing these with fruit, legumes, and non-leafy green vegetables. These dietary changes increase maternal undernutrition from 19.6 percent in the post-harvest period to 27.1 percent in the lean period (Ravaoarisoa et al., 2019).

The widespread prevalence of nutrient-poor and calorie-deficient diets in Madagascar is a major driver of the country's persistent malnutrition crisis and associated health challenges. These include alarmingly high rates of child stunting, anemia, and an emerging double burden of malnutrition characterized by rising obesity rates (see Figure 8).

Madagascar ranks tenth globally in child stunting, with 38.6 percent of children under age five experiencing stunted growth in 2022—despite a notable 17 percent reduction since 2013 (see Figure 8). Acute malnutrition, or wasting, remains a significant concern, affecting 7.2 percent of children under age five (World Bank, 2023b).

In 2019, anemia continued to impact one in three women of reproductive age in Madagascar, a figure better than the sub-Saharan Africa average of one in two (World Bank, 2023b). The prevalence of obesity rose from 3.5 percent in 2008 to 7.1 percent in 2022, most likely because of increased urbanisation. The prevalence of diabetes has remained stable over the past decade, while hypertension rates have decreased from 40.6 percent in 2008 to 35.6 percent in 2022 (WHO, 2023).

Despite progress, there is an alarmingly high rate of child stunting in Madagascar

Figure 8. Nutrition indicators in selected population groups in Madagascar
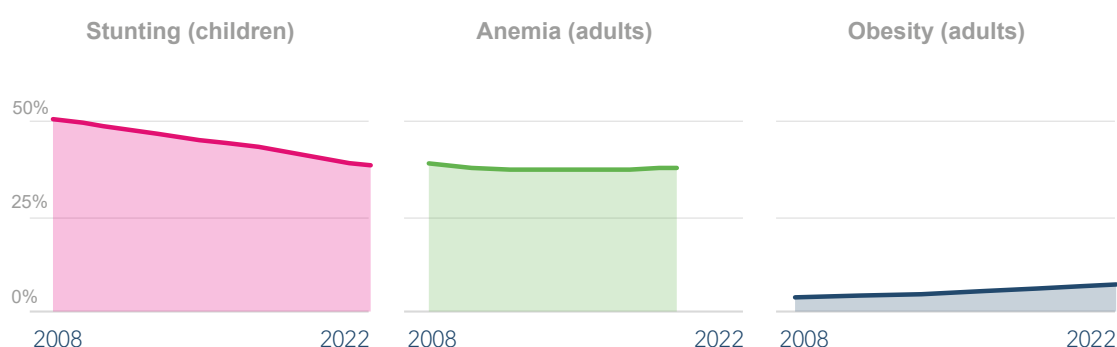
Sources: Stunting is the percentage of children under 5 years of age who are stunted (percent; Joint child malnutrition estimates (JME) (World Bank, 2023b). Anemia is the prevalence of anemia among women of reproductive age (15-49 years) (percent), from World Health Organization, Global Health Observatory Data Repository/World Health Statistics (World Bank, 2023b). Obesity is the Prevalence of obesity among adults (age-standardized estimate after 2016) (%) from the World Health Organization's Department of Non communicable Diseases (NCDs) (WHO, 2023).

Chapter 2:
EFFECTIVE INTERVENTIONS TO OPERATIONALIZE MADAGASCAR'S ROADMAP & OTHER POLICIES

Madagascar's 2022 National Roadmap for Food Systems Transformation lays a foundation for addressing the country's persistent challenges of malnutrition, food insecurity, and climate vulnerability. This section reviews the Roadmap's three main axes: (1) Promoting access to a diversified, healthy and nutritious diet; (2) Promoting governance that supports equitable and resilient livelihoods, and (3) Promoting resilient production in the face of climate change. It also identifies gaps in the Roadmap.

Using evidence from Madagascar and other comparable contexts, we propose interventions to strengthen the Roadmap's implementation and accelerate progress toward sustainable food systems and the United Nations SDGs by 2030. The government and its development partners should prioritize production, consumption, and market-related interventions, targeted to the right regions and households to achieve the goals in the Roadmap and SDG 2 by 2030. Focus should be given to the need to increase the availability and affordability of diverse and nutritious foods, while recognizing that Madagascar must become more resilient to climate change stresses and shocks and align with its nationally determined contributions (NDC) commitments for GHG emissions from agriculture.

2.1 Madagascar's National Roadmap to Support the Transformation of Food Systems Towards Achieving the SDGs of Agenda 2030

In response to the global call to action at the United Nations Food Summit in 2021, Madagascar conducted a national assessment of its food systems, consulting extensively with stakeholders. The assessment revealed numerous challenges, particularly in the south and the highlands regions: shortcomings in the design and implementation of national programmes; limited investment in institutional capacity, coordination issues among agencies; low nutritional value in diets; deficient health, water supply, sanitation, and hygiene infrastructure; low agricultural productivity; local food insecurity; low rural infrastructure investment; lack of support for smallholder farmers to adapt to climate change; poor early warning and response systems; and gender, age, or disability-based discrimination.

To tackle these challenges and achieve the SDGs, Madagascar launched its Roadmap in 2022. The Roadmap's aim is to build an efficient, inclusive, resilient, and sustainable food system while improving nutrition and health nationwide. The Roadmap builds on key agricultural policies, including the Emerging Madagascar Plan (PEM) 2019-2023 (RM, 2019). Although Madagascar is pursuing overall food self-sufficiency, it has introduced rice-specific policies such as the National Rice Development Strategy to address domestic demand by improving rice cultivation (RM, 2022a). The Roadmap also aligns with climate-responsive agriculture policies, most importantly the National Adaptation Plan (RM, 2021c), which focuses on strengthening the adaptation of the agricultural sector and enhancing the resilience of rural populations in the Great South. The Roadmap also strongly aligns with the National Nutrition Policy (PNN) and the National Multisectoral Action Plan for Nutrition (NAPMN) for the period 2022-2026 which was developed subsequent to the Roadmap and includes targets and indicators. Both reflect the interventions highlighted in the Roadmap, namely, the scaling up of school canteens and food banks, improving nutrition through the implementation of large-scale food fortification, outreach and communication on healthy diets, developing appropriate food standards for the country, strengthening multi-sector coordination and developing nutrition related platforms at local level. Importantly, they also make provision for targets and indicators (RM, 2022c).

The Roadmap is structured around three axes (see Figure 9 for details):

- **Axis 1:** Promoting access to a diversified, healthy and nutritious diet

- **Axis 2:** Promoting governance that supports equitable and resilient livelihoods

- **Axis 3:** Promoting resilient production in the face of climate change

Although the Roadmap divides its interventions into three axes for clarity, the goals often overlap. For example, nutrition-sensitive agriculture under Axis 1 depends on governance mechanisms (Axis 2) and climate-smart agricultural practices (Axis 3). Similarly, infrastructure investments in Axis 2 require climate-resilient design from Axis 3, while food banks, categorized under Axis 1, depend on improved infrastructure and governance from Axis 2. These interdependencies underscore the importance of coordinated action across all three axes to achieve the Roadmap's objectives, rather than treating them as isolated domains.

Figure 9. Three axes and related priority interventions from Madagascar's National Roadmap to Support the Transformation of Food Systems Towards Achieving the SDGs of Agenda 2030

Axis 1
Promoting access to a diverse, healthy and nutritious diet

- Promote and scale up nutrition-sensitive agriculture according to the agroecological specializations of each region or subterritory
- Diversify crops (agriculture/small-scale livestock farming) and disseminate improved agricultural production techniques, including peri-urban and urban agriculture
- Implement large-scale actions for food enrichment and fortification for all age groups
- Establish food banks
- Scale up school canteens
- Strengthen national programs for agricultural and food intensification and diversification
- Strengthen multisectoral coordination and develop various platforms related to nutrition at the local communities' level
- Develop a specific strategy for food diversification in the Grand Sud
- Develop food guidelines adapted to a low-income country and scale up a communication for social and behaviour change program on Healthy diets and Nutrition
- Complete the map of regional production specializations
- Promote entrepreneurship among youth and women focused on sustainable food systems
- Create a conductive environment for the private sector and civil society to engage in Initiatives supporting sustainable food systems
- Create local factories to improve the preservation and processing of agricultural products in order to reduce post-harvest losses and create added value
- Expand the regular organization of Creativity Fairs for producers in every region

Axis 2
Promote governance that support suitable and resilient livelihoods

- Strengthen good governance of funds allocated for food systems in Decentralized Territorial Communities
- Strengthen the legal framework to the availability of sufficient resources in the regions to ensure food safety and adherence to food and nutritional standards
- Develop simplified and secure local land use plans .
- Inventory, on both a quantitative and qualitative basis, the existing infrastructures and improve the participative management of agricultural and transportation infrastructures
- Prioritize construction and rehabilitation of roads, tracks, and access routes to productive and remote areas
- Revitalize local agricultural services through tailored service packages and conduct agricultural extension programs sensitive to nutrition for rural communities
- Promote practices aligned with Climate-Smart Agriculture and establish a knowledge-sharing system at the regional level

Axis 3
Promoting resilient production in the face of climate change ensuring the sustainability of natural resources (soil - water)

- Promote practices aligned with Climate-Smart Agriculture and establish a knowledge-sharing system on practices at the regional level.
- Restore degraded landscapes.
- Enhance actions in favour of sustainable soil management and restoration.
- Support the construction and rehabilitation of improved water, sanitation, and hygiene infrastructure, and promote rational water management for irrigation, drinking water, sanitation, and hygiene through effective technologies and context-appropriate approaches

2.2 Effective interventions to support the operationalization of the Roadmap

The government and its development partners should prioritize a portfolio of production, consumption, and market-related interventions, targeting the highest need regions and households, to achieve the goals in the Roadmap and SDG 2 by 2030. The Roadmap also has significant gaps. These include insufficient attention to gender equity, lack of support for small- and medium-scale enterprises serving small-scale producers, an absence of interventions for sustainable aquaculture, and missing investments in renewable energy infrastructure. These gaps are particularly significant given Madagascar's context.

Axis #1
Promoting access to diverse, healthy and nutritious food

Axis 1 is about promoting access to diversified, healthy and nutritious food. As Figure 9 shows, it includes 14 priority actions in this axis. Some focus on consumption-related interventions, such as large-scale food fortification, school canteens, food banks, and scaling up nutrition education programmes. Other actions target production and markets to increase the availability of nutritious and diverse food, including the promotion and scaling-up of nutrition-sensitive agriculture according to the agro-ecological specializations of each region, diversification of agriculture and small livestock especially in the Great South, popularization of improved agricultural production techniques, strengthening of national agricultural intensification and food diversification programmes, and reduction of food waste and loss.

Given that 74 percent of the labour force is engaged in farming, fisheries and forestry sectors, there are many entry points to incorporate diet and nutrition objectives in agricultural activities across Madagascar. To effectively promote and scale up nutrition sensitive interventions, promising approaches that are tested in and tailored to the conditions and context of each agro-ecological zone, which vary greatly, should be considered. Critically, though Axis 1, with its focus on diet, is sweeping in its scope, it does not ensure gender-sensitive targeting of interventions. Gender needs to be systematically integrated into all intervention design and implementation.

Agricultural diversification

Because 95 percent of Madagascar's food-insecure population in the south depends on agriculture, livestock, and fishing (Makoni, 2021), agricultural intensification, diversification and food security are essential to ensure more diverse and nutritious diets and to improve farmer income (Fayad, 2023).

The **diversification of crops and appropriate livestock production** is critical to ensure more diverse and nutritious diets, as well as improve the income of farmers. All potential interventions should be context specific and incentivise the uptake and subsequent consumption of the nutritious crops. For example, when implementing interventions recommended for nutrition-sensitive production, preference should be given to selecting and producing locally grown crops that are nutrient dense, such as moringa, or staple

crops that can be nutritionally enhanced like cassava, or using agrobiodiverse cropping systems and low-cost inputs that are easily accessible to farmers, to improve affordability and yields. These can be combined with agricultural extension programmes and infrastructure aimed at education and supporting farmers to grow and market these crops, generating income for farmers and increasing consumption of these crops by producers households (Rakotosamimanana, 2015; Hawkes et al., 2020).

Madagascar can also benefit from best practices from elsewhere. Innovative examples include seasonal loans for the pre-harvest hungry season and after the harvest (Innovation Commission, 2023b). In Zambia, these loans reduced paid hours working on other farms by 25 percent and facilitated on-farm labour investment, increasing paid labour use by 67 percent and increasing family labour by 11 percent. This resulted in a nine percent increase in agriculture output and improvements in food security, with larger effects for poorer households facing the highest seasonal liquidity constraints.

Given the lack of animal protein in Malagasy diets, a focus on livestock production is a critical intervention. Evidence from case studies show that regions with large herds of livestock are less affected by stunting, whilst more nutrient-dense food is eaten in areas with large herds of sheep and goats which rely less on staple grains (Fayad, 2023). Data gathered from 344 households in rural Madagascar indicated significant linkages between livestock ownership and improved household food security and children's dietary diversity. Further, where this was accompanied with mothers receiving information on childcare and nutrition, food security and dietary diversity increased. This highlights the importance of linking livestock ownership with strengthened nutrition-sensitive messages to improve household food security and nutrition for children (Raholirarimanana et al., 2023).

Given existing concerns related to the climate impacts of enteric fermentation and manure emissions, as well as the ecological fragility of certain regions such as the dry Mahafaly region, the emphasis on small ruminants, such as goats, sheep, and poultry, will help contribute simultaneously to nutrition and climate objectives. Beyond the dietary and nutritional benefits, goats, sheep, and chicken are also important in decreasing food expenditures. Given this context, existing policies that promote livestock diversification and poultry, and systematic fodder forestation, diversification of crops, and extension services to support improved local agricultural skill sets to increase the productivity of smallholder farming should be prioritized (Feldt et al., 2016; Hanke et al., 2017; Sendramampionona et al., 2020; Konzack et al., 2020).

Complementing these strategies, projects like Amélioration de la Sécurité Alimentaire et des Revenus Agricoles[3] in the southern districts of Bekily, Betroka and Amboasary Atsimo help farmers build resilience and develop entrepreneurial skills. These initiatives promote activity and income diversification through poultry and small ruminant farming, increase crop variety for market sales, and improve access to finance and financial management (EU, 2022).

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3 / Amélioration de la Sécurité Alimentaire et des Revenus Agricoles translates to Improvement of Food Security and Agricultural Income.

Fortification and biofortification

Madagascar needs targeted interventions like **biofortification**[4] and **food fortification**[5] to address micronutrient deficiencies and high levels of undernourishment. To date, national food fortification has been implemented in Madagascar by governmental, non-governmental, and civil society organizations, as well as through multi-stakeholder partnerships (Konzack et al., 2020). Public–private cooperation has achieved progress on food fortification, such as the now widespread iodine enrichment of table salt with a target of 90 percent enrichment and consumption by the population (RM, 2022d) or the moringa-based bio-fortified food supplements (Lazaniriana et al., 2020).

Yet if food fortification programmes have scored important successes, they also reveal the costs of insufficient attention to gender equity in the Roadmap. For instance, research in the Amoron'i Mania region revealed that pregnant and breastfeeding women did not know about the benefits of iodized salt and so were not likely to use it. These findings highlight the importance of campaigns and other communication channels to create awareness of the benefits of fortified foods to ensure uptake and the realization of better nutritional outcomes (Ravaoarisoa et al., 2019).

Similar issues exist with biofortification. While these programmes can increase micronutrient levels in staple crops like rice and reduce micronutrients deficiencies in people with limited access to diverse foods or markets, their success depends heavily on seed availability and awareness of the health benefits (Das et al., 2023).

Nutrition education

Healthy and nutritious foods like fruit, legumes, and leafy vegetables are plentiful and relatively cheap in Madagascar. However, many people, particularly in low-income households, know little about nutrition. The challenge is to develop effective approaches to teach people about nutrition (Rakotosamimanana et al., 2014; Farris et al., 2019).

Complementary projects under Axis 1 that focus on **improving knowledge, attitudes, and practices related to healthy eating habits and care practices** are essential for fostering better nutrition outcomes. Additionally, upstream projects aimed at sensitizing and training small-scale producers on cultivating nutrition-sensitive products are crucial. These initiatives can play a key role in enhancing the desirability and availability of diversified and nutritious foods, helping to create a sustainable and resilient food system that addresses both immediate nutritional needs and long-term health goals.

Through these efforts, small producers can gain the necessary skills and knowledge to grow food that meets diverse dietary needs while also improving the overall nutritional quality of the food supply. For example, TALAKY BE, a project funded by the French Development Agency (AFD), raises awareness of rice, orange-fleshed sweet potatoes, veg-

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4 / Biofortification is the process by which the nutrient density of food crops is increased through conventional plant breeding, and/or improved agronomic practices and/or modern biotechnology. See https://www.who.int/tools/elena/bbc/biofortification.
5 / Fortification is the practice of deliberately increasing the content of one or more micronutrients (i.e., vitamins and minerals) in a food or condiment to improve the nutritional quality of the food supply and provide a public health benefit with minimal health risk. As well as increasing the nutritional content of staple foods, the addition of micronutrients helps restore micronutrient content lost during processing. See https://www.who.int/health-topics/food-fortification#tab=tab_1.

etables, and market garden crops for household consumption (Andry Randriantsoa and Danielle Rabenirina, personal communications, 25 May 2023). Another project, Projet de Sécurité Alimentaire, Nutrition et Renforcement de la Résilience (ProSAR), funded by GIZ, has trained 11,000 women and 2,000 men in nutrition-sensitive agriculture taking into account agro-ecological techniques, adaptation response to climate change, as well as methods of storage and preservation (GIZ, 2022a).

Reducing food loss and waste

Infrastructure remains vital to any effort to meet social development goals. Madagascar lacks transport, processing, and storage infrastructure. This means that even when harvests are good, losses can be high. Produce is often sold without any specific post-harvest conservation treatment, which makes it susceptible to spoiling (World Bank, 2022a; Fayad, 2023). The lack of adequate transport and storage facilities further compounds the problem. In 2021, 11.9 percent of rice production and 18.4 percent of corn was lost (AfDB, 2023). To put this in perspective: in 2022, Madagascar imported 800,000 metric tons of rice, an amount equivalent to its losses after the harvest (World Bank, 2022a).

Reducing post-harvest losses is essential to address Madagascar's food crisis. A multidimensional approach that combines **education, infrastructure improvements, and economic development** could significantly improve outcomes. Education will be important: small producers need training in preservation techniques and support to set storage units. Education alone, however, is not enough. As Axis 1 recognizes, establishing local factories and improving rural infrastructure are also vital. These measures will conserve agricultural produce, reduce post-harvest losses, and boost the food supply. Moreover, local processing will add value to produce, creating opportunities for livelihood diversification and higher incomes.

The Inclusive Agriculture Value Chain Development Programme (DEFIS), funded by IFAD, illustrates this multidimensional approach. The programme focuses on enhancing the resilience of small-scale farmers through a variety of interventions: strengthening water and supply chain infrastructure, training farmers in preservation techniques to reduce post-harvest food losses, building capacity in agroecology practices, promoting the use of quality fertilizers, seeds, and equipment and conducting research on climate-resilient crops and livestock (IFAD, 2022). During consultations, stakeholders emphasized the need to better integrate industry into these efforts. For example, establishing product processing units and reducing post-harvest losses require improved coordination across sectors to avoid inefficiencies in implementation.

Advancing gender equality and women's empowerment

Considering gender and **gender-specific approaches** is crucial to achieve transformative policy improvements. While the Roadmap recognises that undernourishment disproportionately affects women and children, and that investment in agricultural intensification and diversification can alleviate inadequate food quantity and quality, it lacks specific programmes and interventions to ensure that women and children benefit from these investments.

The Roadmap also highlights that women face unemployment rates significantly higher than men, representing 60 percent of the unemployed population. To address this, Axis

1's emphasis on fostering entrepreneurship is essential to empowering women economically and creating opportunities for Madagascar's rapidly growing youth population.

More can be done to build on donor-led programmes that are gender and youth focused to capture best practice and identify opportunities for scalability. For example, the DEFIS trained women and young people in the processing and preservation of foods, including turning cassava into gari. In addition, it also trained 435 community nutrition agents, including 63 young people, to build nutrition awareness and capacity, as well as establish vegetable gardens and linkages to culinary demonstrations as part of the awareness raising campaign (IFAD 2022).

Gender is also prioritized in the Madagascar Safety Nets and Resilience project supported by the World Bank. Whilst the project targets extremely poor households throughout the country, women's empowerment is a major focus and the project prioritized women as the main recipients of cash transfers in order to address existing gaps in economic exclusion (ReliefWeb, 2023).

Social protection programmes

In addition to addressing gender inequities, **Madagascar must increase its spending on social protection programmes such as food banks and school canteens**, which are prioritized under Axis 1 of the Roadmap. These safety nets play a crucial role in reducing extreme poverty and boosting human capital by improving education and nutrition outcomes for children in beneficiary households. However, Madagascar's social protection system, initiated in 2015, falls critically short. It covers only six percent of the extremely poor and spends just 0.3 percent of GDP on support—far below the sub-Saharan African average of 1.2 percent (ReliefWeb, 2022).

The donor community has recognized this gap and made social protection a major focus. Foreign aid for social protection initiatives in Madagascar has tripled in the past decade (OECD, 2024). For example, the World Bank funded the Madagascar Safety Nets and Resilience project, which aims to increase coverage of non-emergency safety net programmes while enabling temporary expansion of these safety nets in response to crises (ReliefWeb, 2023).

Relief efforts, in the form of cash and in-kind humanitarian assistance for food and subsistence, have neither met nutritional needs nor sustainably addressed household consumption (Fayad, 2023). Linking emergency aid with longer-term nutrition and food security is crucial to avoid the fragmentation of efforts—where short-term aid projects operate in isolation from broader, sustained development goals. A more integrated approach will help ensure that emergency relief supports lasting improvements in food security and ultimately leads to more sustainable outcomes.

Several donor-funded projects are testing approaches to improve the capacity of households to withstand shocks and stresses and build long-term resilience. These use a combination of cash transfers and capacity-building which can potentially be replicated and expanded (see the discussion under Axis 3). To tackle food insecurity, the government, led by the Ministry of Agriculture and Livestock, pairs 'Green Titles' with cash and in-kind transfers. This approach aims to mitigate the impact of droughts on vulnerable households and reduce land conflicts in the south caused by outward migration (Vyawahare, 2023).

Innovative donor-led approaches also exist. This includes Aron'ny Fambolena Voatse, an insurance programme for farmers launched by the World Food Program in 2020 in the districts of Amboasary and Ambovombe in the south of Madagascar, a region severely affected by the impacts of climate variability and known for its dry conditions. The agricultural insurance scheme protects smallholder farmers from the effects of drought and insect pests that reduce farmers' yields as well as to builds farmers' capacity to cope with and recover from shocks.

As a result of the agricultural insurance policies purchased for 3,500 farmers by WFP during the 2020-2021 agricultural season, covering both the rainy (November to April) and the dry (May to October) seasons, the index triggered USD 350,000 in insurance payouts for all the insured farmers following severe drought conditions that negatively affected southern Madagascar. Households also received compensation for crop losses incurred during the long-rain season (WFP, 2021).

Clustering interventions could be another approach to target vulnerable households in Madagascar. This package of interventions could combine enterprise training in livestock and agriculture (and other livelihoods), financial support through grants and interest-free loans, coaching, and matching finance (Innovation Commission, 2023a).

Axis #2
Promoting governance for equitable and resilient livelihoods

Axis 2 promotes governance for equitable and resilient livelihoods by implementing seven priority actions (see Figure 9). These actions address policies, institutions, and market-related interventions. Specifically, they focus on strengthening participatory management of agricultural and transport infrastructure, prioritizing road construction and rehabilitation in production and landlocked areas and facilitating access to land titles and land certificates for agricultural producers and young rural entrepreneurs.

However, there are also significant gaps in Axis 2. Notably, there is no provision for investments in renewable energy infrastructure to address rural energy poverty, despite its transformative potential for agricultural productivity and resilience. Addressing omissions and adopting a more integrated governance framework is essential to ensure that the Roadmap effectively tackles the interconnected challenges of food security, infrastructure development, and climate resilience.

Securing land rights for smallholder farmers

The issue of insecure land tenure for smallholder farmers, particularly affecting women and youth, is a central theme of Axis 2. The absence of clear and legally recognized land titles hampers long-term agricultural investment, limiting resilience-building efforts. To address this, the Ministry of Agriculture and Livestock has made the delivery of land certificates a priority through the Madagascar Agriculture Rural Growth and Land Management Project (RM, 2022c). Because Axis 2 clearly identifies women and youth as key target groups, securing land certificates for them is crucial for encouraging investment in sustainable agricultural practices. With legally recognized land rights, smallholder farmers are empowered to adopt climate-resilient farming techniques, improve productivity, and withstand economic and environmental shocks (Bizikova, 2020; FAO, 2023c).

However, securing land tenure alone will not lead to transformative change. A broader governance framework that integrates agriculture, infrastructure, and social services is essential for addressing interconnected challenges effectively.

Strengthening cross-sectoral governance for holistic solutions

The Roadmap currently defines governance in narrow terms, focusing mainly on equity and resilience through improvements in fund disbursement mechanisms, strengthening legal frameworks, and creating regional and communal development plans. However, it pays limited attention to the essential need for cross-sectoral coordination among national departments to drive food systems transformation effectively.

While cross-sectoral collaboration is critical for addressing complex challenges, sectors such as agriculture and nutrition often operate in silos, leading to fragmented policies that fail to fully tackle the multifaceted issues of food security, nutrition, and rural development. A clear example of this lack of coordination is seen with the National Nutritional Council, which oversees the National Nutritional Policy. Despite its authority over various ministries and stakeholders, the Council struggles to coordinate efforts related to agricultural production or infrastructure investments that would improve food availability. This disconnect hinders the overall effectiveness of the national food security strategy.

To bridge this gap, **cross-sectoral groups should bring together relevant ministries, private sector actors, and civil society organizations**. This will ensure that all policies and programmes related to food systems transformation are aligned, promoting coherence and efficiency across all sectors. Coordination between ministries such as agriculture, health, nutrition, and infrastructure will create a unified approach to addressing food insecurity and resilience challenges. Furthermore, it will ensure that marginalized groups, particularly women and youth, are included in decision-making processes, thereby benefiting from the transformation.

The **National Taskforce for Food Systems Transformation** has emerged as a vital mechanism for overcoming governance challenges and driving broader transformation efforts. Inspired by the global call to action from the UN Food Systems Summit in 2021, the Taskforce unites a diverse group of stakeholders, including government agencies, UN organizations, technical and financial partners, and NGOs. Operating under the Ministry of Agriculture and Livestock, the Taskforce serves as an informal, but effective, platform for fostering collaboration and coordination among stakeholders. By aligning efforts around clear priorities, the Taskforce has enhanced the operationalization of the Roadmap through refined strategies and more coherent, effective interventions. To further bolster these efforts, specialized sub-task forces have been created to address key areas, such as agriculture and nutrition, ensuring that priorities are executed with rigor and precision.

Infrastructure investment for sustainable livelihoods

Beyond the need for more equitable governance, Axis 2 includes interventions related to the broader development of Madagascar's infrastructure. The identified interventions focus on **improving road infrastructure**, both through construction and the rehabilitation of roads, tracks, and feeder roads in productive areas, as well as the **setting up of local processing facilities**. This is critical to increase the accessibility and affordability of nutritious foods, provide market access for farmers, and reduce food loss and waste. Research

among smallholder cassava farmers in central Madagascar showed a significant correlation between the decision to sell their produce and the distance to markets. This highlights the need for improved rural infrastructure to lower transaction costs and enhance market connectivity, enabling smallholder farmers to participate more effectively in local and regional food systems (Okoye et al., 2016).

Transportation costs and accessibility significantly influence farmers' decisions to sell or consume their produce. The cost of transporting produce to market emphasizes the need for additional market outlets and aggregation centres –elements not currently included in the Roadmap (Okoye et al., 2016).

As noted in the discussion of Axis 3 below, ensuring that new infrastructure is designed to withstand climate shocks, such as flooding and storms, is crucial to reduce reconstruction costs and minimize the damage or disruption to the movement of goods and people (Fyad, 2023).

Integrating renewable energy for resilient livelihoods

Despite the clear need for **investment in renewable energy**, the Roadmap overlooks these technologies. Madagascar faces pervasive rural energy poverty, and geospatial analysis shows that about 50 percent of new electricity connections would be best served by off-grid solar technologies (Sanguen & Bienven, 2023). These technologies would benefit farmers directly by enabling them to charge phones, access weather information online, and use digital extension services. The technologies would also strengthen agricultural value chains by providing energy for processing and conservation equipment (Fayad, 2023; Robotti, 2023).

Beyond its direct agricultural benefits, supplying households and farmers with renewable energy would address multiple challenges. It would, among other things, reduce deforestation caused by the use of biomass for energy, lighten the unfair labour burden on women who are responsible for the collection of firewood, and, by making cold storage and processing facilities feasible, prevent food losses.

Furthermore, renewable energy projects create opportunities for private-sector investment in mobile broadband, services for the digital sector, and in renewable energy infrastructure such as mini-grids (Sanguen & Bienven, 2023). One example is the World Bank supported Digital and Energy Connectivity for Inclusion in Madagascar Project (DECIM) which focuses on the deployment of infrastructure and the mobilisation of private capital to improve and expand access to energy and digital services in underserved areas. This is achieved by providing incentives to encourage the private sector to invest in mobile broadband infrastructure, services for the digital sector, and in energy infrastructure, such as mini grids (Sanguen & Bienven, 2023). Another example is the WeLight project, funded by the European Investment Bank, which will develop and construct solar mini-grids in 120 rural villages in Madagascar to provide more than 45,000 households and businesses first access to sustainable, affordable and productive energy that can be channelled to storage and processing facilities and reduce food loss and waste (EIB, 2023).

Improve monitoring and evaluation systems

Finally, climate change makes it more important than ever to **invest in monitoring and early warning systems** to anticipate extreme weather and floods, and to develop emergency

response plans for evacuation and relief support for vulnerable populations when disaster strikes. Madagascar has made expanding its existing early warning system a priority. It should now invest in new technologies to provide more accurate and current weather forecasts—crucial given increased weather variability. The benefit of such investment far outweighs the cost, as the analysis of projects in India and Colombia demonstrates (Innovation Commission, 2023a). However, poor connectivity is an obstacle. In 2020, only 12.59 percent of Madagascar's population had internet access and only 46.38 percent had cell phones. These connectivity gaps must be addressed before digital agricultural extension services can be effective (Kassouwi, 2023).

Another critical component of good governance is a robust monitoring and evaluation (M&E) system to track the progress of food systems transformation. The National Taskforce for Food Systems Transformation is committed to strengthening its monitoring mechanisms through the development of a digital tool under the AgSys framework. This tool aims to provide accurate and timely information to partners, implementers, and stakeholders across sectors. A well-coordinated M&E system will not only accelerate the transformation of food systems but also foster accountability by ensuring alignment among all actors toward shared objectives.

Moreover, it will enable stakeholders, including government agencies, donors, civil society, and private sector partners, to make informed decisions based on reliable data. The need for such a system, along with the Roadmap's lack of specific indicators, was highlighted during consultations, where stakeholders emphasized the importance of developing these indicators as part of the Action Plan to ensure measurable progress and alignment with intended outcomes.

Axis #3

Promoting resilient production in the face of climate change

Axis 3 has two main goals: promoting climate-resilient agricultural production and managing natural resources sustainably, particularly soil and water. It contains four priority actions (see Figure 9): production-related interventions including climate-smart agriculture, restoration of degraded landscapes and soils, support for the construction and rehabilitation of improved water, sanitation, and hygiene infrastructure and sustainable water management for irrigation, drinking water, sanitation, and hygiene through technologies.

Climate-resilient agricultural production

Given the vulnerability of Madagascar to increasing climate shocks, the **strong focus on climate smart agriculture and water management** is critical. Existing research has shown that climate resilient crop varieties can dramatically improve climate resilience whether it is rice that is tolerant to flooding or drought resistant maize (Innovation Commission, 2023b). Similarly, on-farm rainwater harvesting techniques can increase yields, reverse degradation and combat desertification (Innovation Commission, 2023a). Better and different practices such as intermittent flooding of rice paddy fields (FAO, 2016) and switching from cattle to smaller ruminants such as sheep and goats, or poultry, can in turn reduce the rise in GHG emissions from agriculture. Given the significant contribution of rice production to Madagascar's GHG emissions, an important focus should be to support

farmers in switching to improved cropping and irrigation practices, such as shifting from permanently flooded or pre-season flooding of rice fields, to intermittent flooding and a longer non-flooded pre-season. Implementing these actions can result in significant GHG emissions reduction (Bockel et al., 2010). Successful implementation will require investment in targeted extension services as well as increased investment in R&D for climate resilient crop varieties.

Other existing policy interventions that should be prioritized to improve the long-term resilience of extensive livestock farming include farming of local breeds that will be more resilient to climatic stress and disease, prioritizing mixed production systems that integrate crops and livestock, and the large-scale application of Integrated Resilient Farming Models for extensive livestock farming areas, such as implementing measures against bushfire practices (RM, 2015c; Fayad, 2023).

Managing natural resources sustainably

Given the southern region's vulnerability to recurring droughts and insufficient water infrastructure, emphasis on **improved water infrastructure and water management** is an important policy intervention in this region. In this regard, the country can draw from best practices elsewhere that do not require specialised equipment and can be implemented after the harvest, when the opportunity costs of family labour and wages for paid labour are low. These include training on-farm rainwater-harvesting techniques such as mini-catchments that can increase yields, reverse soil degradation and combat desertification. The adoption of demi-lunes in Niger increased agricultural revenue by USD 40 per year and improved soil quality and land usage over multiple years. In Malawi, the adoption of similar pit planting techniques also increased yields by 19 percent (Innovation Commission, 2023a).

Donor projects are increasingly responding to the need to improve the resilience of drought affected households in the south, as affirmed by interviews with representatives of donors and development banks during stakeholder consultations. Given the precarity of small-scale producers in the Great South, the majority of donor-funded projects are implemented in the south and southeast of Madagascar. Of the identified donor-funded projects, 22 of the 37 projects were implemented in the south, in some instances combined with activities in other regions (see Figure 10). Responding to the challenges faced by small-scale producers, the projects focus on increasing their resilience to climate change through the implementation of climate smart agriculture. One example is the USAID/BHA project implemented by FAO, in the Atsimo-Atsinanana, Fitovinany, and Vatovavy regions that provides farming tools, small livestock production support, vegetable seeds and drought-tolerant crop seeds, as well as the installation of solar irrigations systems (USAID, 2023).

Madagascar's extreme vulnerability to climate change calls for integrating key policy interventions under Axis 3. These include building security stocks of basic inputs, adapting agricultural infrastructure to enhance farmers' resilience, establishing emergency funds for timely support, and gradually introducing agricultural insurance to address farmers' growing exposure to climate risks (RM, 2015c; Fayad, 2023).

Box 1: Donor-funded projects in Madagascar

Analysis of the existing donor funded projects identified 37 projects that contribute to the transformation of food systems in Madagascar, spread across 23 regions. Of these, 18 projects addressed the food security, nutrition and climate change nexus, 14 projects addressed the nexus between food security and climate change, and five projects addressed the food security and nutrition nexus.

Figure 10. Overview of the spread and focus areas of relevant donor-funded projects in Madagascar

Number of projects

1-2   3-4   4+

● Food security, nutrition and resilience to climate change
● Food security and resilience to climate change
● Food security and nutrition

PURPA HGD PLAE

PURPA

PURPA PLAE

Diana

Sava

PURPA

PACPA PROSOL PURPA PLAE

Sofia

PACPA AFAFI CENTRE DINAAMICC TCP/MAG/3808 PADM PURPA

Boeny

Analanjirofo

PURPA PLAE

AD2M PURPA

Melaky

Betsiboka

Alaotra-Mangoro

PURPA

PURPA

Analamanga

Bongolava

Atsinanana

PACPA FOLUR PURPA

Itasy

DINAAMICC PADM PURPA

Vakinankaratra

AFAFI CENTRE DINAAMICC PADM PURPA

AD2M PURPA

Menabe

Amoron'i Mania

PACPA FOLUR FEM7 PADM PURPA PLAE

Haute Matsiatra

Vatovavy-Fitovinany

NORAD FOLUR PADM PURPA HGD PLAE

FEM7 PURPA PLAE

Ihorombe

FOLUR FIOVANA

PA2R FEM 7 OSRO/MAG/205/USA PURPA MAHARO PTASO

Atsimo-Andrefana

Atsimo-Atsinanana

PRADA 2 PROSAR HGD FIOVANA

NORAD PA2R OSRO/MAG/208/GER PRADA 2 PURPA MAHARO

Anôsy

NORAD PA2R OSRO/MAG/208/GER PRADA 2 PURPA TALAKY BE

Androy

REGIONAL PROGRAMMES

IFAD
68 352 185 USD

European Union
32 215 000 €

FAO
22 824 289 Euros

GIZ
60 873 000 €

BAD
15 980 000 UC

AFD
65 000 000 Euros

USAID
110 500 000 USD

KFW

AD2M: PROJET D'APPUI AU DÉVELOPPEMENT DU MENABE ET DU MELAKY
PACPA: PROJET D'APPUI À LA COMMERCIALISATION DES PRODUITS AGRICOLES
NORAD: NOURRIR LES POPULATIONS ET LA TERRE GRACE A UNE AGRICULTURE INCLUSIVE ET DURABLE
PA2R: PROJET D'APPUI AU RELEVEMENT ET A LA RESILIENCE DANS LES REGIONS DU SUD
AFAFI CENTRE: PROGRAMME D'APPUI AU FINANCEMENT DE L'AGRICULTURE ET AUX FILIÈRES INCLUSIVES DANS LE CENTRE DE MADAGASCAR
DINAAMICC: DÉMARCHES INTÉGRÉES ET ACCOMPAGNEMENT POUR UNE AGRICULTURE FAMILIALE À MADAGASCAR INNOVANTE ET RÉSILIENTE AUX CHANGEMENTS CLIMATIQUES
FOLUR: GESTION INTÉGRÉE DES PAYSAGES POUR DES CHAÎNES DE VALEUR DE CAFÉ ET DE RIZ À ZÉRO-DÉFORESTATION DANS LE CENTRE SUD ET SUR LA CÔTE EST DE MADAGASCAR
TCP/MAG/3808: APPUI À LA STRATÉGIE DE DÉVELOPPEMENT AGRICOLE DE MADAGASCAR
FEM 7: CONSERVATION DE LA BIODIVERSITE, RESTAURATION ET GESTION INTEGREE ET DURABLE DES BASSINS VERSANTS DU BAS MANGOKY ET MANANARA SUD
OSRO/MAG/208/GER : ACTIONS D'ANTICIPATION POUR FAIRE FACE À LA SÈCHERESSE PRÉVUE DANS LES DISTRICTS DE BEKILY (ANDROY), BETROKA ET AMBOASARY ATSIMO (ANOSY), MADAGASCAR
OSRO/MAG/205/USA : APPUI D'URGENCE POUR RÉHABILITER LES MOYENS DE SUBSISTANCE DES MÉNAGES VULNÉRABLES TOUCHÉS PAR LA GRAVE SÉCHERESSE ET L'IMPACT DU COVID-19 À MADAGASCAR GRAND SUD
PRADA 2 : PROJET ADAPTATION DES CHAÎNES DE VALEUR AGRICOLES AU CHANGEMENT CLIMATIQUE
PROSOL : PROJET DE PROTECTION ET REHABILITATION DES SOLS POUR AMÉLIORER LA SÉCURITÉ ALIMENTAIRE
PROSAR : SÉCURITÉ ALIMENTAIRE, NUTRITION ET RENFORCEMENT DE RÉSILIENCE
PADM : PROJET D'AQUACULTURE DURABLE A MADAGASCAR
PURPA : PROJET D'URGENCE DE RENFORCEMENT DE LA PRODUCTION ALIMENTAIRE
PTASO : PROJET DE DEVELOPPEMENT DE LA ZONE DE TRANSFORMATION AGRO-INDUSTRIELLE DANS LA REGION DU SUD-OUEST DE MADAGASCAR
TALAKY BE: ADAPTATION DE L'AGRICULTURE AUX CHANGEMENTS CLIMATIQUES ET RENFORCEMENT DE LA RÉSILIENCE DES COMMUNAUTÉS RURALES DU SUD-EST DE MADAGASCAR
MAHARO
HGD : HEART GLOBAL DEVELOPPEMENT
FIOVANA
PLAE : PROGRAMME DE LUTTE ANTIÉROSIVE

NATIONAL PROGRAMMES

European Union

FAO

PROGRAMME RÉGIONAL D'APPUI À LA SÉCURITÉ ALIMENTAIRE ET NUTRITIONNELLE DANS L'OCÉAN INDIEN
STOSAR: APPUI À LA MISE EN ŒUVRE DE LA POLITIQUE AGRICOLE RÉGIONALE (PAR) DE LA SADC
PRESAN: PROGRAMME RÉGIONAL DE SÉCURITÉ ALIMENTAIRE ET NUTRITIONNELLE
TCP/MAG/3810: APPUI À L'INNOVATION ET LA DIGITALISATION DES SYSTÈMES AGROALIMENTAIRES A MADAGASCAR

Source: Author's own based on interviews with stakeholders and online information

2.3 Additional interventions to include in the Roadmap

Support for small-and-medium-scale enterprises

In addition to gender, one of the crucial omissions of the Roadmap is **support for small-and medium-scale (SMEs)** enterprises to provide services to small-scale producers. Although Axis 1 promotes youth and women's entrepreneurship in sustainable food systems, it focuses narrowly on unemployment and building resilience to external shocks through local production and processing.

SMEs can do much more. Studies show that when SMEs collaborate with small-scale producers in the informal sector in low- and middle-income countries, they successfully connect those producers to market opportunities along the supply chain (Laborde et al., 2020).

SMEs provide vital services to small-scale producers: credit, training, crop purchasing, connections to processors, and market information. These services help small-scale producers increase their productivity and adopt new technology (Liverpool-Tasie et al., 2020). As SMEs offer services that are more accessible to small farmers than those of larger enterprises, they are particularly suitable in Madagascar where small-scale producers struggle to reach markets. Therefore, Madagascar should invest in SMEs and develop the infrastructure, regulations, and technical assistance to help small-scale producers reach local, regional, and national food markets.

Sustainable fisheries and aquaculture

The Roadmap also omits interventions to promote sustainable aquaculture consumption and production. Including **sustainable fisheries and aquaculture** in axes 1 and 3 would better align the Roadmap with Madagascar's existing policies, such as the Blue Policy Letter (2015–2025), the National Nutrition Policy (PNN), the Madagascar Emerging Plan (PEM) (2019–2023), and the National Development Plan (2019–2023). These policies support coordinated, complementary interventions, including improving nutrition (e.g., doubling fish consumption for one million Malagasy from 2.2 kg to 4.5 kg per person per year) and increasing production, with a 10 percent growth target for households engaged in aquaculture and fishing. These policies support both continental subsistence fishing and small-scale pond aquaculture through several measures: support to young fishers or fish farmers in priority areas (RM, 2015b) through input support such as one-off grants, start-up packages, financing support, initiatives aimed at livelihood diversification and post-harvest beneficiation and the development of marine aquaculture (RM, 2015a; 2015b; 2019; 2022d).

In particular, there is untapped potential to expand inland aquaculture. This includes pond farming of carp and tilapia and integrating fish farming into rice paddies. Only 20 percent of suitable rice fields now practice fish farming. Expanding this practice could boost rice yields and allow farmers to harvest 200–300 kg of fish per hectare annually. The ecological synergy between rice and fish would increase farmers' income and supply fresh fish to surrounding communities (GIZ, 2022b). Expansion efforts should draw on lessons from ongoing initiatives like the Sustainable Aquaculture Project in Madagascar (PADM) which is part of the Global Programme for Sustainable Fisheries and Aquaculture, led by GIZ.

The PADM project helps smallholders in Madagascar's highlands, Antananarivo area, and eastern coast to sustainably increase fish production to diversify income and improve access to fish in food-insecure regions. The project also contributed to the establishment of the Development Plan for Continental Aquaculture in Madagascar (PDACM) by the Ministry of Fisheries and Blue Economy in 2022 (GIZ, 2022b).

In coastal areas, restoring and protecting mangroves and coral reefs as the de facto nurseries are cross-cutting interventions to ensure thriving fish populations, secure livelihoods, and increase access to fresh fish by the surrounding communities. Moreover, intact ecosystems such as mangroves and coral reefs, also provide protection to future climate impacts such as increased storm surges, sea water rise, and erosion (GIZ, 2022b). Investment into reef and coral restoration could also be attractive funding opportunities from the Global Climate Fund and/or the Global Environmental Facility. This will require addressing the existing bottlenecks relating to the lack of investment in value chains, potentially by crowding in private sector investment to develop cold storage, processing, landing sites and roads.

Setting strong targets in the Roadmap will facilitate better alignment of these policies to support effective implementation and track progress.

Preventing deforestation

Lastly, missing from the Roadmap are **interventions to prevent deforestation**. Critical to ensure future climate resilient agriculture is the need to address the current high rates of deforestation. This is a major driver of environmental degradation and GHG emissions and is not specifically addressed in the Roadmap. In this regard, Desbureaux and Damania (2018) point out that '[w]here deforestation is an agricultural problem, agricultural solutions must be combined with conservation policies to decrease deforestation.' Agroecology shows some opportunities to address both deforestation and climate change impacts. Controlled studies on small-scale farms in central Madagascar demonstrated that agroecological practices reduced carbon footprint by up to 364 percent in terms of land surface and up to 578 percent in terms of food production. This suggests an important GHG sequestration at farm scale of the main source of GHG emissions, namely nitrous oxide from soil management (25 percent), methane from rice cultivation (24 percent), livestock manure management (24 percent), and enteric fermentation (23 percent) (Rakotovao et al., 2017).

In this context policy interventions and donor programmes that build **capacity in agroecology, agroforestry, crop diversification and alternative livelihoods** should be part of the portfolio of interventions. Agroforestry and region specific agro-ecological specializations are already acknowledged in existing policy documents, not only for their mitigation potential but also their important contribution to farm level resilience. New technologies also open room for innovation and scalability.

A new joint programme supported by the World Bank and AFD to increase productivity and strengthen the resilience of rural livelihoods in Alaotra-Mangoro and Sofia, two regions that are critical to national food production, is a good example of how integrated approaches can create support and impact at scale. Through an integrated landscape ap-

proach, the project will support community-led restoration of watersheds, rehabilitation, and improved management of irrigation infrastructure and services, sustainable intensification of agriculture production, and strengthening of priority agrifood value chains. Overall, the project will reach 150,000 households, including 165,000 farmers who will benefit from the deployment of blockchain-boosted input vouchers and training on climate-smart agriculture and agroecological practices. The project will finance the rehabilitation of 30,000 hectares of irrigated perimeters, 30,000 hectares of watersheds, and 150 kilometers of rural roads for enhanced market access. It will also facilitate farmer-level investments in micro-irrigation and community-driven sustainable landscape management of 61,000 hectares (World Bank, 2023d).

2.4 Trade-offs and synergies in the context of sustainable food system transformation

Addressing the compound challenges of food systems in Madagascar will not happen without trade-offs. For example, achieving healthier diets will require people to consume more diverse foods, including animal source foods, which will lead to higher GHG emissions, land-use impacts such as soil degradation and overuse of water resources. Improvements to diets delivered using existing technologies alone will exacerbate GHG emissions in agriculture and make it challenging to achieve climate change mitigation commitments. Solutions need to build on the capacities of small-scale producers to simultaneously improve agricultural productivity while making production techniques that are GHG efficient more commercially viable alternatives.

Those affected by hunger often have no choice but to depend on staple foods rather than consume more nutrient-rich foods like meat, fish, fruits and vegetables. These tensions are very real for people in Madagascar, especially in the past ten years. Interventions that promote nutrition education, access to healthier, affordable foods, school feeding schemes and food banks can help reduce these tensions to some extent (RM, 2022c; 2022d). However, these solutions require careful integration into Madagascar's policies and strategies to ensure sustainable impacts.

Madagascar's existing policies prioritise improving agricultural productivity and promoting sustainable, climate-resilient intensification at the farm level. These efforts aim to address persistent issues of food quality and availability while aligning with broader national goals of food security and climate resilience. Policies also stress reducing the emphasis of climate shocks by enhancing access to healthier foods through targeted measures like school feeding schemes and food banks (RM, 2015c; 2016d; 2022c; 2022d).

Tensions will be created not only at the level of actual measures but also during policy development, coordination, and review. Thus, as emphasised in Axis 2 of the Roadmap, there is a need to strengthen multi-sectoral coordination across platforms to scale and strengthen implementation, particularly relating to improving knowledge on the importance of nutrition (RM, 2022c).

Maximizing synergies

Madagascar will need to decide what trade-offs it is willing to make based on the best available evidence while maximising synergies at the same time. To some extent, new policies and interventions can help manage and mitigate some of the tensions. For example, Madagascar's strong focus on improving productivity and addressing GHG emissions from agriculture, particularly rice cultivation, together with efforts to improve value chains, including by reducing food loss and waste, can contribute to increasing food availability.

In this context, the production of animal protein would need to become more GHG efficient to balance the trade-offs between the required significant increase in animal-source foods for healthier diets and the need to minimise agricultural GHG emissions. These efforts should go hand-in-hand with addressing the immense productivity gap in agriculture, particularly in the livestock sector. This is typically achieved through more and better feed and improved animal health— which are included in Madagascar's agricultural development strategies.

Finally, as mentioned earlier, indicators for farm-level, individual, household, system-wide, and aggregate outcomes need to be designed in a way that would account for possible trade-offs so that policy-makers and other stakeholders are able to track progress in managing these trade-offs and adjust policies along the way.

Chapter 3:
COSTS OF ACHIEVING A SUSTAINABLE FOOD SYSTEMS TRANSFORMATION IN MADAGASCAR

Achieving sustainable food systems requires a holistic approach to support the desired change within the food system, including both poverty reduction and the creation of a secure, diverse and safe food supply. Such change in food supply and demand will lead to a nutrition transition, creating environmental and land-use impacts that range from changing production patterns, that currently include soil degradation, overuse of water resources, and increased GHG emissions, as well as health challenges associated with obesity and diet-related diseases.

These linkages demonstrate that market-based solutions alone will not produce outcomes that simultaneously address environmental and climate constraints while meeting nutritional targets. Thus, the core focus is to identify policy interventions and related public costs to influence production and consumption patterns that lead to better environmental and nutritional outcomes.

3.1 Portfolio of interventions

The complexity of the interrelationships among the key food system challenges requires a balanced mix of interventions. For example, the necessary changes in consumption patterns to progress toward healthier diet targets will require, and trigger, changes in production patterns. Those changes will have to be compatible with the shift toward a more resilient agriculture and food system, in particular in the context of climate change mitigation (reduction of GHG emissions) and adaptation (resilience to weather variability and the changing climate). While climate-smart agriculture addresses production-side issues, diets must also adapt to allow for more environmentally sustainable food systems. Food system interventions should, therefore, not be considered as isolated fixes but rather as an integrated portfolio designed to meet complex objectives.

The set of interventions included in the economic model (MIRAGRODEP) represents such a portfolio of interventions, designed to leverage synergies and balance trade-offs within food system transformation. In total, there are 11 interventions integrated into the model, categorized into the three axes of the Roadmap. The list of interventions and their breakdown into categories are summarized in Table 1, with further information on the interventions selected provided in the appendix.

Table 1. Mapping Madagascar's Roadmap axes to public policy interventions and policy instruments included in the model

Roadmap axis	Public policy intervention	Modelled policy instrument
Axis n°1: promote access to a diversified, healthy and nutritious diets	Social protection	Food subsidy
	Nutrition education	
	School feeding programmes	
	Input subsidy	Fertilizer subsidy
	Livestock subsidy	Livestock subsidy- agroforestry
		Livestock subsidy- improved forage
	Post-harvest losses	Post-harvest losses - storage
Axis n°2: promote governance for equitable and resilient livelihoods	Vocational training	
	Extension services	
	Rural infrastructure	Irrigation
		Roads
Axis n°3: promote climate-resilient production to ensure the sustainability of natural resources (soil, water)	Production subsidy	Investment subsidy
		Capital endowment
		Production subsidy
	R&D	National agricultural systems (NARS)
		CGIAR

Source: Authors' own. Note: Green shaded interventions are linked to climate adaptation

Interventions in the model support the achievement of Madagascar's climate change adaptation goals through investments in improved planting and crop choices, irrigation and soil management, and access to improved storage and markets (see Table 1). For example, production-related interventions provide direct support to farmers to produce more food, improve production quality, and increase production diversity, which contributes to climate adaptation and resilience building. The model also includes interventions that collectively offer some proxy for interventions to improve the GHG efficiency of animal agriculture, such as R&D, extension services, and livestock subsidies for agroforestry and improved forage. The GHG limits also bias the model against ruminant meat since ruminants are much more GHG intensive per calorie than eggs, poultry, pork, fish, and other non-ruminant animal-source foods.

While the model is not able to integrate institutional reform and capacity building, they are the foundation for the success of any of the policy interventions. Such institutions are also critical to monitor the achievement of the portfolio of interventions, using appropriate indicators for farm-level, individual, household, system-wide, and aggregate outcomes to cover productivity improvements as well as climate change impacts on production and the agricultural sector's resilience, including that of small-scale producers.

3.2 Quantitatively defining sustainable food systems

To project the SDG 2 scenario, the finding from the stakeholder consultations, literature review, and microeconomic analysis are applied to the MIRAGRODEP model hybridised with microeconomic household data.

In the modelled scenario, the PoU is reduced to 25 percent[6], nutritious food targets to achieve healthier diets are reached (e.g., fruits and vegetables and animal-source proteins), the net incomes of small-scale producers doubles on average in 2030 compared to 2015 levels, and agriculture-related GHGs are kept to the countries' NDCs. This scenario requires that all households achieve caloric sufficiency, but it also demands that households achieve healthier diets. In this way, diversification is promoted without compromising on hunger.

To enable the MIRAGRODEP model to allocate costs across the policy interventions, a series of quantitative targets are needed. For the most part, the scenario targets (as above) have clear, widely accepted and modellable quantitative targets (see Appendix). However, there is currently no universally accepted definition of a healthy diet. And yet, in order to estimate costs, there is a need to establish a healthier diet target in the model. The following targets were therefore used:

1. **Overall caloric intake is measured** using the prevalence of undernourishment (PoU) as a metric, with a target of less than 25 percent PoU.

2. **Adequate consumption of non-starchy vegetables and fruits**, based on the WHO guidelines of 400 g of fruits and vegetables per day (WHO, 2020).

3. **Adequate consumption of animal-source foods** (including dairy) through a minimum target of at least 10 percent of households' overall caloric intake to ensure sufficient calcium and B12.
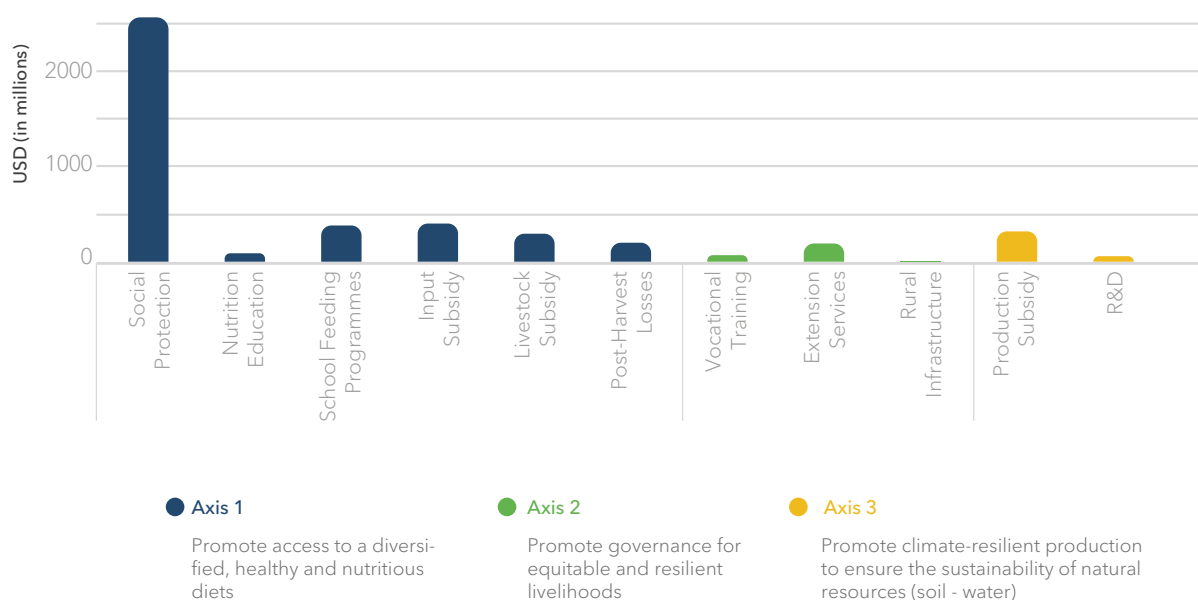
3.3 The financing gap

The results from the modelling show that it will require an additional USD 4.5 billion in annual public investment from now until 2030 to achieve Madagascar's SDG 2 scenario, largely through a scale up of social protection programmes (see Figure 11).

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6 / Participants at the stakeholder consultations noted the target of reducing the prevalence of undernourishment to less than 3% by 2030 from the current rate as overly ambitious and proposed to reduce the current rate to 25%, by 2030

Madagascar needs an additional USD 4.5 billion in public investment to transform its food systems by 2030

Figure 11. Total annual public funding required to achieve SDG 2 by 2030

Axis 1
Promote access to a diversified, healthy and nutritious diets

Axis 2
Promote governance for equitable and resilient livelihoods

Axis 3
Promote climate-resilient production to ensure the sustainability of natural resources (soil - water)

Source: Authors' own based on MIRAGRODEP model simulations

With over USD 2.5 billion (56 percent of the total) directed toward social protection, this allocation reflects the severity of the current food security crisis, where 40 percent of the population is suffering from hunger, and the short timescale of five years remaining until the 2030 deadline. Social protection programmes—such as cash transfers and food assistance—are critical to provide immediate relief for vulnerable households, prevent further deterioration in food security, and address the acute needs of those at risk. This prioritisation is necessary to stabilize the situation and lay the groundwork for other interventions.

However, the allocation of the USD 4.5 billion budget for Madagascar's food systems transformation should balance urgent needs with long-term development priorities, in particular the importance of improving agricultural productivity and resilience. Approximately USD 200 million is dedicated to input subsidies, another USD 200 million to livestock subsidies, and USD 150 million to reducing post-harvest losses. These investments directly support farmers by providing access to essential resources such as seeds, fertilisers, and veterinary care while also ensuring that more of their harvests make it to markets. This approach addresses one of Madagascar's central challenges—low agricultural productivity—by empowering farmers to produce more diverse and nutritious foods, including fruits, vegetables, and animal-source products. These measures also increase incomes and help rural communities build resilience to future shocks.

Further complementing these efforts, USD 150 million is allocated to school feeding pro-grammes, and USD 100 million supports nutrition education. These programmes ensure that children and vulnerable populations have access to healthier diets while fostering broader awareness of the importance of nutrition. School feeding initiatives not only ad-dress immediate dietary needs but also promote school attendance and child develop-ment, thus building human capital for the future.
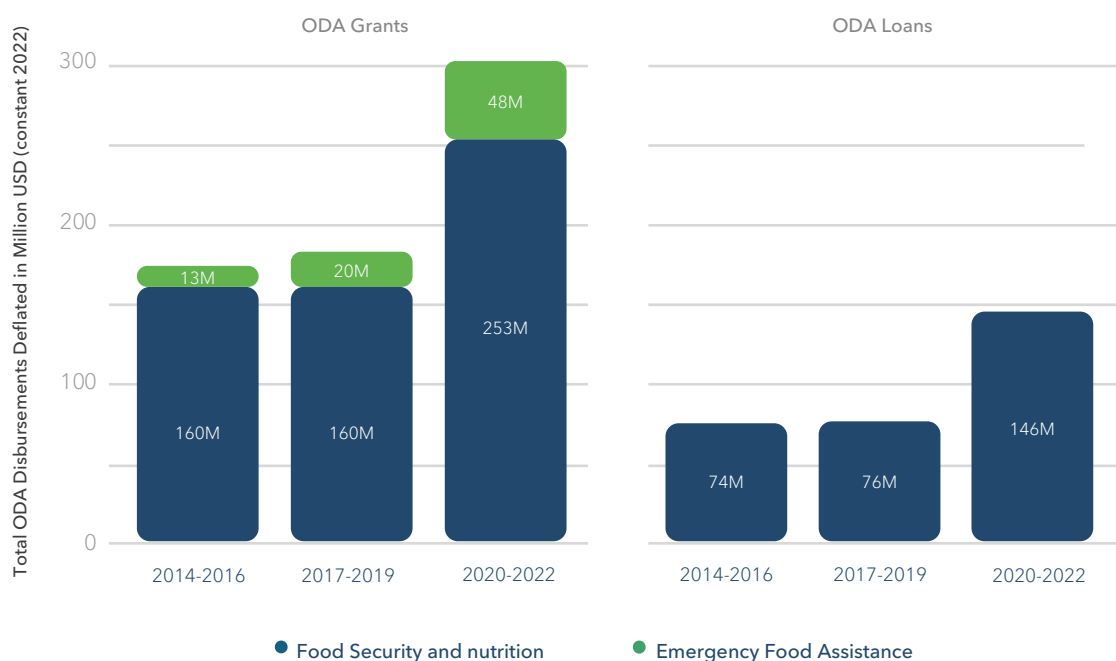
The budget allocation also includes a focus on governance and market infrastructure, ensuring that the benefits of increased production are fully realized. Whilst institutional investments cannot be directly modelled, approximately USD 100 million is allocated to vocational training, which equips farmers with technical skills to improve productivity and diversify income sources. Another USD 100 million is directed toward extension services, helping farmers adopt modern, sustainable practices. These investments are critical for creating equitable and resilient livelihoods, enabling communities to transition from de-pendence on aid to self-reliance.

Finally, although the third axis—promoting climate-resilient production—receives a smaller share of the budget, its inclusion demonstrates a commitment to long-term sustainability. Funding for production subsidies (USD 100 million) and research and development (USD 50 million) supports the adoption of practices that protect Madagascar's natural resourc-es, such as soil and water, while addressing the impacts of climate change. For the most part, this bucket is smaller due to the 2030 timeframe in which the impacts of climate change, and therefore the necessary interventions to address and mitigate its impact, will not be fully realised. Nonetheless, by focusing on sustainability now, these measures ensure that agricultural systems remain productive for future generations.

To contextualise the required increase in public spending in the scenario, it is useful to look at historial donor aid to Madagascar. In response to the worsening hunger and pov-erty crisis, aid from the donor community has already increased significantly in the past few years. Between 2017-2019 and 2020-2022, official development assistance (ODA) grants for food security and nutrition increased from USD 180 million to USD 301 million. This involved more than a doubling of emergency food assistance (from USD 20 million to USD 48 million) - unsurprising given the worsening food security crisis with an estimat-ed 1.64 million people classified to be in crisis or emergency (37 percent of the popula-tion) (ReliefWeb, 2023) - and an increase of over 50 percent in funding for the longer-term food security and nutrition development agenda (from USD 160 million to USD 253 mil-lion). ODA loans have also increased from USD 76 million to USD 146 million, an almost doubling in loan financing for food security and nutrition in Madagascar (see Figure 12).

Financing for food security and nutrition has increased by over 50% since 2014

Figure 12. Financing of long-term investment needs for food security and nutrition, compared to emergency food assistance in Madagascar

ODA Grants

ODA Loans

Total ODA Disbursements Deflated in Million USD (constant 2022)

- **Food Security and nutrition**
- **Emergency Food Assistance**

Source: Authors' analysis of OECD's Creditor Reporting System (OECD, 2024.) Note: For each period, the yearly average is indicated. ODA is Official Development Assistance.

3.4 Beyond ODA: the role of innovative finance

Madagascar is unlikely to attract sufficient ODA grants to meet the future investment gap. Grant funding has already been augmented by concessional loans from multilateral and bilateral development banks, but despite these efforts, development finance alone remains insufficient to fill the additional USD 4.5 billion per year investment gap to achieve SDG 2.

More is needed to make other sources of development finance work, including from private sources. In addition to commercial loans from multilateral and bilateral development banks, blended finance and innovative finance can prove catalytic to achieve food systems transformation. To this end, Madagascar should work closely with large donors and private financiers to better understand how a mix of innovative financing instruments can make better use of donor financing and target the missing middle (i.e., agri-SMEs seeking between USD 50,000 and USD 2 million) to achieve more sustainable and nutritious food systems. More private investment can be catalysed by using donor funding and capital from development finance institutions to enhance de-risking for international and

impact investors (e.g., through higher-risk, longer-term and first-loss financing, insurance schemes and technical assistance programmes, etc.) in addition to providing incentives for domestic lenders to increase lending to the country's agri-SMEs (e.g., through priority lending, results-based financing targeting domestic banks, etc.) (Perera et al., 2023a).

Aceli Africa serves as a prime example of how the flow of financing to the agriculture sector can be increased through donor-supported incentive measures for domestic lenders. Aceli Africa is a market incentive facility backed by donors which provides grant incentives to commercial banks to extend small loans between USD 15,000 and USD 1.75 million to agriculture SMEs in Kenya, Rwanda, Tanzania, and Uganda. To date, these incentives have succeeded in raising commercial banks' net profits on agriculture SME loans from 3.2 percent to 6.5 percent. Moreover, they have improved the financial performance of non-bank financial institutions from a loss of 1.6 percent to a profitable margin of 2.8 percent. Additionally, these incentives have increased the book value of loans directed to agriculture SMEs from 2,411 loans valued at USD 153 million in 2019 to 8,276 loans valued at USD 497 million in 2022 (Aceli Africa, 2024).

Another example of how private sector finance can be leveraged is an impact investment fund, The Livelihoods Fund for Family Farming, that involves multiple stakeholders to support the achievement of food systems transformation in Madagascar. The Livelihoods Fund for Family Farming has invested in a programme in the Analanjirofo region to train 3,000 family farms in sustainable practices to increase vanilla productivity and quality through agroforestry techniques. The implementation partner, the Malagasy non-governmental organization Fanamby, has supported the establishment of producer groups and their integration in the newly created economic interest group, Sahanala. Sahanala brings together producers in the vanilla, spices, and maize sectors involved in organic farming, environmentally conscious private operators involved in fair trade, and civil society organizations involved in conservation. Under the Livelihoods vanilla project, farmers are offered a stable market price and receive a price premium linked to certification. A network of extension workers provides agronomy support and promotes best practices among the farmers. Extension workers use mobile devices to capture information from each farmer and maintain the traceability of vanilla beans (IFC, 2021).

Yet another option is debt-for-nature swaps. A country such as Madagascar that is extremely vulnerable to climate change—and the associated loss of natural biodiversity— is also least able to afford investment to strengthen resilience because of constrained budgets. Making use of debt-for-nature swaps where creditors provide debt relief in return for the government's commitment to protect biodiverse forests, reefs or mangroves, can free up budget that can be allocated to improving resilience without triggering a financial crisis or compromising spending on other development priorities (Georgieva et al., 2022).

Debt-for-nature swaps are not unknown in Madagascar. In 2008 the largest debt-for-nature swap agreement in Madagascar's history was signed between the Government of Madagascar and the Government of France, allocating roughly USD 20 million to preserve Madagascar's rich biodiversity (WWF, 2008).

What remains largely unexplored is the potential for these swaps to fund both conservation and sustainable use – which includes the sustainable farming of crops, livestock, fisheries and aquaculture. This is important, as nature conservation and protected areas include demarcated 'sustainable use' zones in which various forms of nature-integrated agriculture, aquaculture and fisheries are permitted – and even encouraged. Notably, farmers and producers working within these zones are often the first to experiment and practice sustainable designs in agriculture and aquaculture. If proceeds from debt-for-nature swaps increase funding for sustainable farming and food production in earmarked sustainable use areas and buffer zones, replication may spill over and drive the adoption of sustainable practices more widely (Perera et al., 2023b).

CONCLUSION

Madagascar is not on track to achieve the United Nations Sustainable Development Goals (SDGs) by 2030. To get back on track, it is critical to pursue policy pathways that favour synergies and limit the trade-offs between hunger, poverty, nutrition, climate change, and gender equality. This report presents an evidence-based prioritization of effective interventions to operationalize Madagascar's National Roadmap to Support the Transformation of Food Systems to end hunger, make diets healthier and more affordable, improve the productivity and incomes of small-scale producers, and mitigate and adapt to climate change.

Madagascar is at a critical juncture in its journey toward achieving the United Nations Sustainable Development Goals (SDGs), particularly SDG 2, by 2030. The country is grappling with a range of profound challenges, including spiraling hunger, entrenched poverty, poor agricultural productivity, and increasing vulnerability to climate change. Madagascar's food system is facing a stark crisis, with 98 percent of its population unable to afford a healthy diet and 40 percent affected by hunger. The current trajectory is unsustainable without a fundamental transformation of the country's food systems.

Without additional investment, significant levels of hunger, malnutrition, and poverty will persist after 2030. By 2030, economic growth in Madagascar will be insufficient to reduce the number of people affected by hunger and poverty. Without additional investment and effective interventions, the country is set to face persistent levels of hunger and poverty well beyond 2030, with projections indicating that nearly 80 percent of the population will remain in extreme poverty, and food security will continue to be elusive for the majority.

To steer Madagascar toward a sustainable food system transformation, it is essential to mobilise an additional public investment of USD 4.5 billion per year between 2024 and 2030. These resources are needed to operationalize the National Roadmap for Food Systems Transformation, focusing on the most effective interventions for improving agricultural productivity, increasing access to nutritious diets, and building resilience to climate change. The roadmap offers a holistic framework that aligns with Madagascar's commitments under the Paris Climate Agreement and the 2030 Agenda for Sustainable Development.

Moreover, Madagascar should actively seek to mobilise innovative financing mechanisms beyond traditional aid, recognizing that the global funding landscape is constrained. Innovative solutions must be prioritised, including leveraging private sector investments and climate finance. Financial flows should be strategically directed toward long-term, sustainable interventions.

To achieve these objectives, the report calls for a comprehensive, coordinated approach across sectors —agriculture, nutrition, climate change, and gender—that integrates all elements of Madagascar's food systems. The complexity of the interrelationships among these challenges necessitates a balanced, multi-sectoral approach that ensures the sustainable transformation of Madagascar's food systems by 2030.

REFERENCES

Aceli Africa. (2024). Profitability of Agricultural SME Lending in East Africa. Financial Benchmarking Report. https://aceliafrica.ams3.digitaloceanspaces.com/wp-content/uploads/2024/02/01171121/2024-Aceli-Africa-Financial-Benchmarking-Report.pdf

African Development Bank (AfDB), National Institute of Statistics (Madagascar), UNICEF Madagascar, United Nations Population Fund (UNFPA), United Nations Women's Fund (UNIFEM), World Food Programme (WFP). (n.d). Madagascar National Survey on Monitoring the Millennium Development Goals 2012-2013.

African Development Bank (AfDB). (2018). "National Climate Change Profile - Madagascar." https://www.afdb.org/en/documents/madagascar-national-climate-change-profile.

African Development Bank (AfDB). (2021). Country Strategy paper 2022-2026.

African Development Bank (AfDB). (2023). Compact Madagascar for Food. https://www.afdb.org/en/documents/madagascar-pacte-pour-lalimentation-et-lagriculture

Andriamparany, J.N., Heritiana, J.T., Hänke, H., Kunz, S. and Schlecht, E. (2023). Market supply of livestock and animal products in north-eastern Madagascar – the role of the vanilla boom. Scientific African. 19, p.e01526. https://doi.org/10.1016/j.sciaf.2022.e01526

Bellemare, M.F., Lee, Y.N. and Novak, L. (2021). Contract farming as partial insurance. World Development. 140, p.105274. https://doi.org/10.1016/j.worlddev.2020.105274

Bizikova, L. (2020). Ending Hunger Sustainably: The role of gender. International Institute for Sustainable Development, International Food Policy Research Institute, and Cornell University. Available from https://ceres2030.iisd.org/wp-content/uploads/2020/08/ceres2030-en-background-note-ending-hunger-sustainably-the-role-of-gender.pdf

Bizikova, L., De Brauw, A., Murphy, M., Eber Rose, M., Laborde, D., Smaller, C., Parent, M., Picard, F. and Motsumi, K. (2023). Achieving Sustainable Food Systems in a Global Crisis - Summary Report [Online]. International Food Policy Research Institute (IFPRI) and International Institute for Sustainable Development (IISD). https://www.iisd.org/system/files/2023-01/sustainable-food-systems-global-crisis-summary.pdf.

Bockel, L., Tinlot, M., and Gentien, A. (2010). Carbon Balance of Rice Value Chain: Strategies in Madagascar towards 2020. FAO. https://www.fao.org/fileadmin/templates/ex_act/pdf/Climate_Mitigation_Potential_of_Rice_Value_Chain_EN_Mar.pdf

Das, K., Priyabrata Roy, P. and Raj Kumar Singh Tiwari R.K S. (2023). Biofortification of Rice, An Impactful Strategy for Nutritional Security: Current Perspectives and Future Prospect In: B. Hernández-Ledesma, ed. Plant-Based Diet [Online]. Rijeka: IntechOpen. https://doi.org/10.5772/intechopen.110460.

Desbureaux, S. and Damania, R. (2018). Rain, forests and farmers: Evidence of drought induced deforestation in Madagascar and its consequences for biodiversity conservation. Biological Conservation. 221, pp.357–364. https://doi.org/10.1016/j.biocon.2018.03.005

Eka Prasetya, T.A., Devi, R.M., Fitrahanjani, C., Wahyuningtyas, T. and Muna, S. (2022). Systematic assessment of the warming trend in Madagascar's mainland daytime land surface temperature from 2000 to 2019. Journal of African Earth Sciences. 189, p.104502. https://doi.org/10.1016/j.jafrearsci.2022.104502

European Investment Bank (EIB). (2023). Madagascar: Rural electrification progress - EIB confirms support for WeLight project, July.

European Union (EU). (2022). OSRO/MAG/208/GER : Forecast based actions to deal with drought in the districts of Bekily, Betroka and Amboasary Atsimo. Ministry of Agriculture and Livestock's Report.

FAO. (2016). Climate-smart agriculture in Madagascar.

FAO. (2023a). "FAOSTAT - Cost and Affordability of a Healthy Diet (CoAHD)." https://www.fao.org/faostat/en/#data/CAHD.

FAO. (2023b). "FAOSTAT - Suite of Food Security Indicators.".

FAO. (2023c). The status of women in agrifood systems. Rome. https://doi.org/10.4060/cc5343en

FAO, IFAD, UNICEF, WFP and WHO. (2024). The State of Food Security and Nutrition in the World 2024 – Financing to end hunger, food insecurity and malnutrition in all its forms. Rome. https://doi.org/10.4060/cd1254en.

FAO, Union européenne et Cirad. 2021. Profil des systèmes alimentaires – Madagascar. Activer la transformation durable et inclusive de nos systèmes alimentaires. Rome, Bruxelles et Montpellier, France.

FAPBM. (2023). Madagascar: A Diversity to Preserve https://www.fapbm.org/en/madagascar-forests-a-diversity-to-preserve/.

Farris, A. R., Misyak, S., O'Keefe, K., VanSicklin, L., & Porton, I. (2019). Understanding the Drivers of Food Choice and Barriers to Diet Diversity in Madagascar. Journal of Hunger & Environmental Nutrition, 15(3), 388–400. https://doi.org/10.1080/19320248.2019.1566110

Fayad, D. (2023). Food Insecurity and Climate Shocks in Madagascar: Republic of Madagascar. IMF. June 5.

Feldt, T., Neudert, R., Fust, P. and Schlecht, E. (2016). Reproductive and economic performance of local livestock in southwestern Madagascar: Potentials and constraints of a highly extensive system. Agricultural Systems. 149, pp.54–64. https://doi.org/10.1016/j.agsy.2016.08.007

Georgieva, K., Chamon, M., and Thakoor, V. (2022). Swapping Debt for Climate Nature Pledges can Help Climate or Nature Pledges can Help Fund Resilience.: Innovative debt swaps can help governments that have limited access to traditional grants or debt relief, IMF Blog, December 14. https://www.imf.org/en/Blogs/Articles/2022/12/14/swapping-debt-for-climate-or-nature-pledges-can-help-fund-resilience

GIZ. (2022a). PROSAR (Food security, nutrition and resilience building project). Ministry of Agriculture and Livestock report.

GIZ. (2022b). Sustainable Aquaculture in Madagascar GIZ.

Hänke, H., J. Barkmann, C., Kaustky,E. and Marggraf. R. (2017). Social-ecological traps hinder rural development in southwestern Madagascar. Ecology and Society 22(1):42. https://doi.org/10.5751/ES-09130-220142

Hawkes, C., Walton, S., Haddad, L., Fanzo, J. (2020) 42 policies and actions to orient food systems towards healthier diets for all. London: Centre for Food Policy, City, University of London. https://www.foodsystemsdashboard.org/resources/publication-42.pdf.

Innovation Commission: Climate Change, Food Security and Agriculture. (2023a). Priority innovations and investment recommendations for COP28. University of Chicago. https://innovationcommission.uchicago.edu/wp-content/uploads/2023/12/innovation_commission_-_cop28_innovation_cases_compiled.docx.pdf

Innovation Commission: Climate Change, Food Security and Agriculture. (2023b) Investing in Innovation for Climate Change, Food Security, and Agriculture. Draft for discussion. Accessed in August 2023.

International Finance Corporation IFC. (2021). Country private sector diagnostic for inclusive growth: Creating markets in Madagascar.

International Fund for Agricultural Development (IFAD). (2022). DEFIS (Inclusive agricultural sector development program). Ministry of Agriculture and Livestock 's Report.

International Labour Organization (ILO). (2023) "ILO modelled estimates database" ILOSTAT, Accessed January 2023. World Bank national accounts data, and OECD National Accounts data files.

IUCN. (2023). Protecting the Madagascar and the Indian Ocean Islands Biodiversity Hotspots.

Kassouwi, I.K (2023). Madagascar: World Bank approves support for improved access to digital services. April 11. https://www.ecofinagency.com/telecom/1104-44419-madagascar-world-bank-approves-support-for-improved-access-to-digital-services

Konoshima, M., Tonda, T., Kamo, K., Razafindrabe, BHN. (2021) Assessing the Immediate Impact of Surrounding Land Uses on the Extents of Freshwater Body over Time in Madagascar - A Demonstrative Case Study of Itasy Lake. 10.15684/formath.20.003.

Konzack, A. Steinke, J., Rafanomezantsoa, A. S., & Mandaharisoa, S. T. (2020). Expert-based analysis of successful intervention strat-egies for enhancing food and nutrition security in Madagascar. Technical Report. DOI:10.13140/RG.2.2.21778.53445

Laborde, D. and Manun, A. (2024). Food & Fertilizer Export Restrictions Tracker. https://public.tableau.com/app/profile/ifpri.food.security.portal/viz/shared/2CPYTB4G8

Laborde, D., Murphy, S., Parent, M., Porciello, J. and Smaller, C. 2020. Ceres2030: Sustainable Solutions to End Hunger - Summary Report [Online]. International Food Policy Research Institute (IFPRI), International Institute for Sustainable Development (IISD),

and Cornell University. Available from: https://ceres2030.iisd.org/wp-content/uploads/2021/03/ceres2030_en-summary-report.pdf.

Lazaniriana, R., Jules, R., Narindra, R., Andrin'iranto, R. A., Bongo, N., Ngbolua, K.-N., & Baholy, R. (2020). Formulation of Moringa oleifera Lam. based bio-fortified food supplement for pregnant women in Madagascar, Indian ocean. Britain International of Exact Sciences (BIoEx) Journal, 2(2), 533–540.

Liverpool-Tasie, L.S.O., Wineman, A., Young, S. et al. A scoping review of market links between value chain actors and small-scale producers in developing regions. (2020). Nat Sustain 3, 799–808. https://doi.org/10.1038/s41893-020-00621-2

ICF Macro, National Institute of Statistics (Madagascar). Madagascar Demographic and Health Survey 2021. Fairfax, United States of America: ICF International, 2022 https://ghdx.healthdata.org/record/madagascar-demographic-and-health-survey-2021.

Makoni M. (2021). Southern Madagascar faces "shocking" lack of food. Lancet (London, England), 397(10291), 2239. https://doi.org/10.1016/S0140-6736(21)01296-4

Malhi, G. S., Kaur, M., & Kaushik, P. (2021). Impact of Climate Change on Agriculture and Its Mitigation Strategies: A Review. Sustainability, 13(3), 1318. https://doi.org/10.3390/su13031318

Muelle, E. P. (2022). Climate Change and Migration in Madagascar: Investigating the impacts on people, ecosystems, and natural resources. https://digitalcollections.sit.edu/cgi/viewcontent.cgi?article=4394&context=isp_collection

OECD 2024. Creditor Reporting System (CRS). OECD.Stat. [Online]. https://data-explorer.oecd.org/vis?fs[0]=Topic%2C1%7CDevelopment%23DEV%23%7COfficial%20Development%20Assistance%20%28ODA%29%23DEV_ODA%23&pg=0&fc=Topic&bp=true&snb=26&df[ds]=dsDisseminateFinalCloud&df[id]=DSD_CRS%40DF_CRS&df[ag]=OECD.DCD.FSD&df[vs]=1.3&dq=DAC..1000.100._T._T.D.Q._T..&lom=LASTNPERIODS&lo=5&to[TIME_PERIOD]=false

Okoye, B. C., Abass, A., Bachwenkizi, B., Asumugha, G., Alenkhe, B., Ranaivoson, R., … Ralimanana, I. (2016). Effect of transaction costs on market participation among smallholder cassava farmers in Central Madagascar. Cogent Economics & Finance, 4(1). https://doi.org/10.1080/23322039.2016.1143597

Perera, O., Smaller, C., El Harty, K. and Lefebvre, L. 2024. Unleashing the Catalytic Power of Donor Financing to Achieve Sustainable Development Goal 2: Technical note. Global Donor Platform for Rural Development and Shamba Centre for Food & Climate. https://static1.squarespace.com/static/62b1cc763de5423a3166f5e3/t/666a-950cae23361e2e2ab217/1718261016012/2_GDPRD_Shamba_Unleashing-the-Catalytic-Power-of-Donor-Financing-to-Achieve-SDG2.pdf

Perera, O., Elharty, K., and Lefebvre, L. (2023b). Debt-for-Nature Swaps in the Blue Economy. Shamba Centre for Food and Climate. https://static1.squarespace.com/static/62b1cc763de5423a3166f5e3/t/65679ae0c31c8f462387a13a/1701288675662/Shamba-Centre_report_Debt-swaps-for-the-blue-economy_231129_v1.5.pdf

Raholiarimanana, F., Rakotomanana, H., & Ishida, A. (2023). Does Raising Livestock Improve Household Food Security and Child Dietary Diversity in a Rural Region of Madagascar? Children, 10. https://api.semanticscholar.org/CorpusID:258329494.

Rakotovao, N.H., Razafimbelo, T.M., Rakotosamimanana, S., Randrianasolo, Z., Randriamalala, J.R. and Albrecht, A. (2017). Carbon footprint of smallholder farms in Central Madagascar: The integration of agroecological practices. Journal of Cleaner Production. 140, pp.1165–1175. https://doi.org/10.1016/j.jclepro.2016.10.045

Ramaroson Rakotosamimanana, V., Arvisenet, G. and Valentin, D. (2014). Studying the nutritional beliefs and food practices of Malagasy school children parents. A contribution to the understanding of malnutrition in Madagascar. Appetite. 81, pp.67–75. https://doi.org/10.1016/j.appet.2014.05.032

Ramaroson Rakotosamimanana, V., Valentin, D. and Arvisenet, G. (2015). How to use local resources to fight malnutrition in Madagascar? A study combining a survey and a consumer test. Appetite. 95, pp.533–543. https://doi.org/10.1016/j.appet.2015.08.011

Ravaoarisoa, L., Rakotonirina, J., Randriamanantsaina, L., de Dieu Marie Rakotomanga, J., Dramaix, M.W. and Donnen, P. (2019). Food consumption and undernutrition variations among mothers during the post-harvest and lean seasons in Amoron'i Mania Region, Madagascar. BMC Public Health. 19(1), p.1005.

ReliefWeb. (2022). Social Safety Nets Relieve Poverty - and Hunger. Madagascar Needs More of Them. 31 October. World Bank Group. https://reliefweb.int/report/madagascar/social-safety-nets-relieve-poverty-and-hunger-madagascar-needs-more-them

ReliefWeb. (2023). Madagascar to Expand Access to Social Protection for Extremely Poor Households Thanks to $250 Million in World Bank Financing, 6 February. World Bank Group. https://reliefweb.int/report/madagascar/madagascar-expand-access-social-protection-extremely-poor-households-thanks-250-million-world-bank-financing

République de Madagascar (RM). (2000). Stratégie nationale de vulgarisation agricole à Madagascar

République de Madagascar (RM). (2006). Stratégie nationale pour le développement de l'utilisation de l'engrais. https://faolex.fao.org/docs/pdf/mad147395.pdf

République de Madagascar (RM). (2012). Document de stratégie nationale pour la formation agricole & rurale. https://faolex.fao.org/docs/pdf/Mad182120.pdf

République de Madagascar (RM). (2015a). Lettre de Politique BLEUE. https://faolex.fao.org/docs/pdf/mad163970.pdf

République de Madagascar (RM). (2015b). Stratégie nationale de mécanisation de la filière riz à Madagascar. https://faolex.fao.org/docs/pdf/Mad191479.pdf

République de Madagascar (RM). (2015c). Lettre de politique intersectorielle agriculture, élevage et pêche. https://faolex.fao.org/docs/pdf/mad163961.pdf

République de Madagascar (RM). (2016a). Stratégie nationale de développement des semences riz à Madagascar. https://riceforafrica.net/wp-content/uploads/2021/10/SS1_Madagascar-2016-2020.fr_.pdf

République de Madagascar (RM). (2016b). Stratégie Nationale de Gestion des Risques et des Catastrophes 2016-2030. https://www.primature.gov.mg/cpgu/wp-content/uploads/2017/01/SNGRC_finale.pdf

République de Madagascar (RM). (2016c). Programme National Foncier 2016-2020. https://faolex.fao.org/docs/pdf/mad203500.pdf

République de Madagascar (RM). (2016d). Programme sectoriel agriculture, élevage, pêche - Plan national d'investissement agricole (PSAEP/PNIAEP) 2016-2020. https://www.fao.org/faolex/results/details/fr/c/LEX-FAOC169997/

République de Madagascar (RM). (2019). Plan Emergence Madagascar 2019-2023. http://www.mef.gov.mg/assets/vendor/ckeditor/plugins/kcfinder/upload/files/PEM.pdf

République de Madagascar (RM). (2020). Stratégie nationale de promotion de l'agrobusiness à Madagascar.

République de Madagascar (RM). (2021a). Plan National d'Adaptation au Changement Climatique (PNA) Madagascar. https://unfccc.int/sites/default/files/resource/PNA-Madagascar.pdf

République de Madagascar (RM). (2021b). Plan national d'adaptation au changement climatique à Madagascar

République de Madagascar (RM). (2021c). Stratégie nationale de développement de l'agriculture biologique.

République de Madagascar (RM). (2022a). Stratégie nationale de développement de la filière riz.

République de Madagascar (RM). (2022b). Loi n°2022-002 sur l'agrégation agricole.

République de Madagascar (RM). (2022c). Feuille de route nationale pour soutenir la transformation des systèmes alimentaires en vue de la réalisation des Objectifs de développement durable (ODD) de l'Agenda 2030. https://www.unfoodsystemshub.org/docs/unfoodsystemslibraries/national-pathways/madagascar/vf-feuille-de-route-nationale-ssa12--05-2022-vf-new.pdf?sfvrsn=2aee69c8_1

République de Madagascar (RM). (2022d). Politique nationale de nutrition.

République de Madagascar (RM). (2022e). Plan National d'Action Multisectorielle pour la nutrition 2022-2026. https://scalingupnutrition.org/sites/default/files/2023-07/PNA-MN_2022_2026_FINAL_002_070822.pdf

Republic of Madagascar. (2022f) Madagascar's National Intended Determined Contributions. https://unfccc.int/sites/default/files/NDC/2022-06/Madagascar%20INDC%20Eng.pdf

Robotti, C. (2023). Let the light shine. European Union Bank. April, 23. European Investment Bank. https://www.eib.org/en/stories/electricity-rural-madagascar

Sanguen, B. and Bienven, J.M. (2023). Project Information Document - Digital and Energy Connectivity for Inclusion in Madagascar (DECIM) - P178701 (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/099220002162314434/P178701085338e04097500b11a2be225df

Sendramampionona, R. U., Hantanirina, H. I., Rabearimisa, R. N., Zafitody, C., Bola, A, Andriamananjara, A., and Randrianariveloseheno, A.J. (2020). Socio-economic Situation of Poultry Farmer and the Local Chicken Production System of the East-Coast of Madagascar, Universal Journal of Agricultural Research, Vol. 8, No. 6, pp. 185 - 201, DOI: 10.13189/ujar.2020.080601.

Sharma, N., Razafimanantsoa Harivelo, F., Sienaert, A., Islam, A., Geginat, C., Echandi, R., Schmidt, G., Stocker, M.,Keyser, J., Boc, G., Elabed, G., Nyman, S., Drozd, M., Verjee, N., Giraud Kappen, C., Mamitiana, F., Keijser, C.,Randrianarison, H., Crouzel, I., Rajenarison, L., Oolun, M., and Arenas, G. (2020). Madagascar - Country Economic Memorandum : Scaling Success - Building a Resilient Economy (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/699781575279412305

Suzzi-Simmons, A. (2023). Status of deforestation of Madagascar. Global Ecology and Conservation. 42, p.e02389.

The Global Economy. 2022. GDP share of agriculture - Country rankings. https://www.theglobaleconomy.com/rankings/share_of_agriculture/Africa/

UNDESA, Population Division. (2022). World Population Prospects: The 2022 Revision. https://population.un.org/dataportal/home

USAID. (2023). Madagascar Drought and Tropical Cyclone Fact Sheet. September 2023. https://reliefweb.int/report/madagascar/madagascar-drought-tropical-cyclone-response-fact-sheet-3-fiscal-year-fy-2023

Vyawahare, M. (2023). Can land titles save Madagascar's embattled biodiversity and people? 13 August, mongabay.com. https://news.mongabay.com/2023/08/can-land-titles-save-madagascars-embattled-biodiversity-and-people/

Weiskopf, S.R., Cushing, J.A., Morelli, T.L. and Myers, B. (2021). Climate change risks and adaptation options for Madagascar. Ecology and Society. 26(4).

World Bank. (WB) (2020). Madagascar: Balancing Conservation and Exploitation of Fisheries Resources, June 8. https://www.worldbank.org/en/news/feature/2020/06/08/madagascar-balancing-conservation-and-exploitation-of-fisheries-resources

World Bank (WB). (2022a). Madagascar Country Environmental Analysis: Promoting Green, Resilient and Inclusive Development. Washington, D.C.: World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099635010242211316

World Bank (WB) (2022b). Social Safety Nets Relieve Poverty—and Hunger. Madagascar Needs More of Them. October. https://www.worldbank.org/en/news/feature/2022/10/31/social-safety-nets-relieve-poverty-and-hunger-madagascar-needs-more-of-them.

World Bank (WB). (2023a). "Climate Knowledge Portal." https://climateknowledgeportal.worldbank.org.

World Bank (WB). (2023b). "DataBank - World Development Indicators." World Development Indicators. https://data.worldbank.org.

World Bank (WB). (2023c). "Poverty and Inequality Platform (Version 20230328_2017) [Data Set]." . https://pip.worldbank.org/country-profiles/MDG

World Bank (WB). (2023d). Madagascar: $227 million to Increase Productivity and Strengthen the Resilience of Rural Livelihoods, Press Release, 7 April. World Bank Group. https://www.worldbank.org/en/news/press-release/2023/04/07/madagascar-afe-227-million-to-increase-productivity-and-strengthen-the-resilience-of-rural-livelihoods

World Bank (WB). (2024a). Madagascar Overview. October 2024. https://www.worldbank.org/en/country/madagascar/overview#:~:text=As%20of%20September%202024%2C%20the,projects%20and%205%20regional%20operations.

World Bank (WB). (2024b). Madagascar Poverty Assessment: Navigating Two Decades of High Poverty and Charting a Course for Change in Madagascar. Poverty and Equity Assessment. World Bank Group. https://www.worldbank.org/en/country/madagascar/publication/madagascar-afe-poverty-assessment-navigating-two-decades-of-high-poverty-and-charting-a-course-for-change

World Food Programme (WFP). (2019). Madagascar country strategic plan (2019-2024) Madagascar country strategic plan (2019–2024) (wfp.org). https://www.wfp.org/operations/mg02-madagascar-country-strategic-plan-2019-2024#:~:text=The%20country%20strategic%20plan%20has,children%20in%20vulnerable%20communities%20with

World Food Programme (WFP). (2021). WFP Madagascar: Support For An Integrated And Inclusive Social protection System. https://www.jointsdgfund.org/article/wfp-madagascar-support-integrated-and-inclusive-social-protection-system

World Food Programme (WFP). (2023). Madagascar. https://www.wfp.org/countries/madagascar

World Health Organization (WHO) and UNFCCC. (2021). "Health and Climate Change: Country Profile 2021: Madagascar". https://www.who.int/publications/m/item/health-and-climate-change--country-profile-2021--madagascar

World Health Organization (WHO). (2020). Healthy diet. https://www.who.int/news-room/fact-sheets/detail/healthy-diet.

World Health Organization (WHO). (2023). "Non-Communicable Diseases Data Portal." https://ncdportal.org/

World Resources Institute (WRI). (2023). "Climate Watch Historical GHG Emissions (1990-2020)." https://www.climatewatchdata.org/ghg-emissions.

World Wildlife Fund. (2008). "Monumental Debt-for-Nature Swap Provides $20 Million To Protect Biodiversity In Madagascar." ScienceDaily. ScienceDaily, 14 June 14. https://www.sciencedaily.com/releases/2008/06/080612170515.htm

APPENDIX

Methodology

Methods for researching and modelling food system transformation

This section presents the methods and approaches used, including a review of academic and grey literature, policy documents, national plans and programmes, donor-funded projects, several rounds of stakeholder consultations, and microeconomic modelling to map dietary diversity and macroeconomic modelling to estimate the additional public costs of policy interventions in Madagascar.

Methodological approach: literature review and consultations

The literature review focused on peer-reviewed literature, reports and briefing notes developed by major international agencies such as the FAO, the World Bank, major development agencies (GIZ, USAID and others), as well as the country's policy documents. To access peer reviewed literature, we searched the ScienceDirect database (www.science-direct.com) for papers focused on Madagascar and papers outlining regional trends with specific details on Madagascar regarding issues such as climate change adaptation, food security, nutrition, and agriculture.

We covered the period from 2010 to 2023 (papers in pre-publishing). A total of 813 papers were collected. The research team briefly screened the abstracts of the papers, and those papers that were deemed relevant were included in the study. For reports and briefing notes by international and government agencies, we visited the agencies' websites and reviewed their publications for the 2010–2023 time period. A total of 45 documents were collected.

Finally, we reviewed strategies and policy documents published by ministries and government agencies in Madagascar and selected 28 documents. The findings from these sources informed our understanding of current trends and policy-making priorities with respect to agriculture, food security, nutrition, and the environmental and climate change impacts of agricultural production; fed into the consultations; and informed the selection of interventions included in the model.

To inform the development of pathways for food system transformation, the research draws consultations with in-country stakeholders and an inventory of ongoing development projects and policies. The consultations, which targeted EU delegations, GIZ clusters, USAID missions, and national partners, included online and in-person events, as well as surveys. To support the consultations, a non-exhaustive desk review was undertaken to review the current (or recently terminated) projects implemented and/or funded by GIZ, FAO, the EU, and USAID amongst others. Only projects that had a degree of focus on two or more aspects of our nexus were included for review. Overall, 37 projects were reviewed.

The consultations offered stakeholders the opportunity to feed into and provide feedback on the research process, results, and findings at various stages. The consultations also sought to validate the model targets for healthier diets in each country. In addition, a network of experts that formed as a result of their participation in the consultations engaged in disseminating the results of the research, which helped develop joint ownership of the final recommendations and increased the probability of utilization of the research.

Methodological approach: quantitative modelling

The findings of the literature review and consultations were integrated into a hybrid micro and macroeconomic modelling approach to the food system of Madagascar based on the analytical framework developed in the Ceres2030 project (**ceres2030.iisd.org**).

As part of the project's modelling approach, a microeconomic analysis of changing diets, food habits, and nutrition was undertaken.

We present the food and nutrition intake of the people of Madagascar based on the National Survey on the Monitoring of the Millennium Development Goals 2012-2013 conducted by INSTAT, Madagascar's national statistical agency. The 2012-2013 household survey is a nationally representative survey covering both rural and urban households and conducted over 16,912 households.

The raw data provides quantity information of food consumption at a very disaggregated level by each household. We then performed mapping of the food items to standard nomenclature, consistent with the products of FAOSTAT's food balance sheet (FBS). After standardising the food items, we have mapped them to eight food groups:

- cereals and starches

- legumes, nuts, and seeds

- vegetables

- fruits

- dairy

- animal products (excluding dairy)

- vegetable oils

- sweets and alcoholic beverages

We link this "meso-level" data to disaggregated macro-level statistics. To better understand food choices, we performed a cluster analysis to find groups of families with similar diets, complementing the standard analysis of factors like urban versus rural residence.

The microdata was also used to perform a cluster analysis: a data-driven approach that allows households to be classified based on commonalities in observed diets, complementing top-down analysis based on observed household characteristics (such as urban/rural status). The detailed microdata enabled us to estimate a demand system for the country so that our CGE model estimates of how dietary patterns change in response to changes in income are driven by household survey reports.

The nutrition profile analysis maps the calorie, protein, and fat intake of the people (per capita) by eight food groups. All numbers have been weighted by sampling weights of the survey. Appropriate nutrition coefficients for each item available in the survey were derived using FAOSTAT's food balance sheet and the nutritional contents of the food items computed by converting quantity data to various dimensions of nutritions - calorie, protein, and fat.

Our analysis also includes the nutrition profile of Madagascar based on a more recent household survey conducted Madagascar Demographic and Health Survey 2021. As INSTAT was still verifying the data from the 2021 household survey at the time of report writing and was not in a position to release the raw data, we had to rely on the aggregate numbers (quantity) on household food consumption by all available commodities. This limits our ability to compute nutrition profiles by different dimensions such as rural-urban, and high income versus low income earning people. Despite this limitation, we consider this updated nutrition analysis allows us to compare Madagascar's progress in nutrition intakes at aggregate level between 2012-13 and 2021.

Scenario for identifying policy interventions and costs

In order to identify potential interventions for food system transformation, the findings from the stakeholder consultations, literature review, and microeconomic analysis have been used to apply a CGE model hybridized with microeconomic household modelling to project one future scenario until 2030:

- This scenario provides costs for addressing the priorities identified in the Roadmap and that are aligned to the SDGs. In this scenario, the PoU is reduced to 25 percent, nutritious food targets to achieve healthier diets are reached (e.g., fruits and vegetables and animal-source proteins), the net incomes of small-scale producers doubles on average in 2030 compared to 2015 levels, and agriculture-related GHGs are kept to the countries' NDCs. This scenario requires that all households achieve caloric sufficiency, but it also demands that households achieve healthier diets. In this way, diversification is promoted without compromising on hunger.

The scenario was developed based on discussions during the consultation that considered the reality of the situation in Madagascar for the transformation of food systems. Stakeholders discussed that the SDG 2 objective of reducing the prevalence of undernourishment to less than three percent by 2030 from the current rate nearly 40 percent was very ambitious. Experts and national stakeholders proposed an alternative target, halving the current rate of undernourishment to 25 percent by 2030. The other SDG 2 targets and WHO recommendations were considered realistic and achievable by 2030. Specifically, to provide affordable healthy food to more than 60 percent of the population, keep global warming to 1.5°C, double the income of small-scale producers, and ensure the adequate consumption of animal-based foods (including dairy products) through a minimum target of at least 10 percent of total household calorie intake to ensure sufficient calcium and B12.

These four targets are related to SDG targets 2.1, 2.2, 2.3, and 2.4, respectively.

Establishing model targets for food system transformation

To model and provide a costing for sustainable food system transformation, quantitative targets are required. The model seeks the achievement of zero hunger (SDG 2.1), a nutritious food target to achieve healthier diets (SDG 2.2), a doubling of the incomes and productivity of small-scale producers (SDG 2.3), and the constraining of GHG emissions in agriculture (SDG 2.4).

Hunger and poverty

Corresponding to SDG target 2.1, the model simulates the removal of households from the status of hunger, as defined by the FAO's PoU metric. Given the high levels of hunger in Madagascar, stakeholders agreed to an alternative target with a reduction in the level of undernourishment to 25 percent.

Healthier diets

In order to estimate costs for achieving healthier diets, there is a need to establish a quantitative target in the model. Three quantitative targets are used in the model as key in-

dicators of a healthy diet. With a food group-based approach, we model diets that are "healthier" than current diets rather than achieving a "universally healthy" diet. Under current policy scenarios, "universally healthy" diets will not be feasible by 2030 for everyone in Madagascar. Additionally, there is no singular "healthy" diet since multiple healthy diets (diets that differ by the exact food group composition but are each healthy) are possible, and cultural acceptability, preferences, and other aspects of appropriateness can vary within Madagascar. The targets therefore represent progress toward healthier diets, balanced with an assessment of what could feasibly be achieved in the next decade.

Based on national and international guidelines and policy documents, a review of nutrition literature, and expert consultations, we have focused on three targets for achieving healthier diets in Madagascar:

1. Overall caloric intake, measured using the PoU, with a target of less than 25 percent PoU in Madagascar.

2. Adequate consumption of non-starchy vegetables and fruits, based on WHO guidelines of 400 g of fruits and vegetables per day (WHO, 2020).

3. Adequate consumption of animal-source foods (including dairy) through a minimum target of at least 10 percent of households' overall caloric intake to ensure calcium and vitamin B12.

A set of targets for sufficient caloric intake at the household level is based on the modelling of household consumption in comparison to calorie requirements adjusted for the age and sex of household members. For fruits and vegetables, a minimum target of 400 g per person per day is set based on WHO guidelines, adjusting for household demographic characteristics (WHO, 2020). As with caloric intake, the target is adjusted for each household in the sample based on the age and sex of its respective members. Vegetables and fruits are important for meeting a wide variety of micronutrient needs, including vitamin A and iron, which are commonly insufficient in diets. An overall minimum target for animal-source foods, including dairy, is set to at least 10 percent of households' overall caloric intake. The inclusion of animal-source food in the diet is a key means for at-risk populations, especially children, to get sufficient amounts of nutrients, such as zinc, iron, vitamin A, vitamin B12, calcium, and selenium. All targets apply to all households in the population. Full documentation of our dietary targets' selection can be found in Bizikova et al. (2023).

While the dietary targets are relatively general, their achievement would indicate large nutritional progress for Madagascar.

Smallholder income

SDG target 2.3 envisions the net incomes of small-scale producers doubling on average between 2015 and 2030.

Climate change mitigation and adaptation

While it is not possible to integrate climate change adaptation (SDG 2.4) directly into the cost modelling, it is important to achieve resilient agricultural production, and consider-

ation of the impact of—and impacts on—climate change is central to our nexus approach. To reflect this, we follow the approaches of the water–energy–food (WEF) nexus that highlight the critical importance of including climate change impacts and responses. Climate change is integrated into the model by accounting for the gradual impacts of climate change on crop production using FAO crop projections under climate change. This approach suggests that by 2030, climate change will lead to less than a 10 percent drop in production for major crops in sub-Saharan Africa, especially if drought-resistant crops are planted (Malhi et al., 2021). In the model, GHG emissions for agriculture conform to the commitments made in Madagascar's intended NDCs or NDCs (RM, 2022f)). In the model, the country has a carbon budget (permitted GHG emissions) for agriculture, and land-use emissions and emissions from energy and fertilizer use are included in this budget. The model maintains the budget through a domestically determined carbon tax.

Portfolio of interventions

The complex interrelationships among the key food system challenges require a balanced mix of interventions. For example, the necessary changes in consumption patterns to progress toward healthier diet targets will require—and trigger—changes in production patterns. Those changes will have to be compatible with the shift toward a more resilient agriculture and food system, in particular in the context of climate change mitigation (reduction of GHG emissions) and adaptation (resilience to weather variability and the changing climate). While climate-smart agriculture addresses production-side issues, diets must also adapt to allow for more environmentally sustainable food systems. Food system interventions should therefore not be considered as isolated fixes but rather as an integrated portfolio designed to meet complex objectives.

The 11 policy interventions identified by Ceres2030 have been adapted to align with the three axes in the Madagascar National Roadmap for Food Systems Transformation, designed to leverage synergies and balance trade-offs. These interventions are broken down into 16 policy instruments and summarized in Table 1.

Policy intervention included in the model

The interventions were selected based on their relevance for addressing the multi-dimensional challenges of the food system and their potential to deliver on hunger, diet, small-scale food producer income, and climate change mitigation and adaptation targets. At the systemic level—and through the model interactions—all the interventions contribute to improved diets and could lead to stronger resilience to climate change of the food system and its actors.

Nonetheless, how each intervention affects each of the four modelled targets can be complex, particularly because the model accounts for both direct and indirect effects on the economic system. However, there are some rules of thumb for how the modelled interventions affect each target.

- SDG 2.1 (hunger): Generally, any intervention that increases household incomes can contribute to reducing hunger. For example, a social protection programme, like a food subsidy or direct cash transfer, increases the income of a household and their ability to buy more food.

- SDG 2.2 (nutrition): Similarly, anything that increases income allows people to improve their diets. As incomes increase, households tend to increase their consumption of animal-source foods, while increases in the consumption of fruits, vegetables, legumes, nuts, and seeds tend to be relatively small compared to increases in income. Actions that decrease the price of important under-consumed food groups relative to other foods can also play a role in improving diets.

- SDG 2.3 (small-scale producers): Poverty reduction is critical. Thus, anything that increases the incomes of small-scale producers, including income from non-farm sources, or allows those unable to make good livelihoods in agriculture the option to do something else, contributes toward the target of doubling the income of small-scale producers. Examples of this include investment subsidies to help small-scale producer households increase their agricultural income, vocational training to enable employment that is more lucrative than agriculture, or social protection programmes that provide non-farm income.

- SDG 2.4 (sustainable agriculture): Anything that improves the GHG efficiency of agricultural production or other components of the food system helps limit overall GHG emissions from agriculture and land use. While interventions such as agroforestry subsidies have obvious benefits for GHG mitigation, interventions like fertilizer subsidies can also increase the overall GHG efficiency of a crop's production. When used in a context where fertilizer use and yields are very low (as is the case in Madagascar), fertilizer subsidies can lead to land savings outcomes, delivering higher yields on existing cropland, which could reduce deforestation and slash-and-burn practices.

The impacts of climate change on average temperatures and rainfall are included in the model, but due to the 2030 time horizon, they play a minor role in the assessment. However, given the increased frequency and intensity of extreme weather events in all three countries, there is a need to scale up public investment to increase the climate resilience of food systems.

Of the 16 policy instruments included in the model, 10 contribute to building resilience and promote adaptation to climate change (see Table 1). While all the interventions should be designed and implemented in a diet- and climate-sensitive way, these nine interventions are in line with climate change adaptation priorities as stated in national policy documents, peer-reviewed literature, and stakeholder feedback in Madagascar. In addition to contributing to climate change adaptation, these interventions promote the economic resilience of small-scale producers and their households by improving food production and access to diverse agricultural inputs, increasing incomes, and providing access to financial services and social transfers for small-scale food producers with limited capacities. This type of synergistic approach, with interventions simultaneously progressing toward multiple, complex targets, is at the core of the food systems notion and is critical if the targets of SDG 2 are to be met by 2030.

Limitations and challenges of the methodological approach

As with any nexus study, we face a number of challenges due to the complexity of the nexus's elements and its translation to a quantitative model. Limitations include our inability to incorporate gender issues, extreme weather/climate events, regional differences, and

institutional challenges. The constraints we are most concerned about include modelling within-year variation in hunger and diets and modelling at the individual level, especially with respect to gender. This section provides an overview of critical aspects impacting the food system, including climate change, nutrition, and other challenges that we were unable to integrate into the model.

Data limitations

The microdata used in the analysis were intended to give the best possible representation of diets in Madagascar. The primary data source is the National Survey on the Monitoring of the Millennium Development Goals 2012-2013 conducted by INSTAT which forms the basis of our estimation of current and projected dietary trends.

Gender and other individual characteristics

The unit of observation for the Living Standards Measurement Study (LSMS) surveys is the household, and hence food consumption is reported at the household level. This is logical both from an economic perspective, since food resources are typically pooled (i.e., food is purchased for and consumed by the household), and from a practical perspective, since it would be extremely difficult and costly to obtain individual-level food consumption data at a nationally representative level. A key consequence for the analysis is that it is now possible to observe the intra-household allocation of consumption items: while it is possible for a given household to observe what the average household member consumes, it is not possible to attribute individual consumption levels. For a household with male and female members, it is not possible to attribute the amount of a given food item consumed by males versus females, and hence it is not possible to make gender-disaggregated comparisons. This is an important limitation to the analysis that we hope can be addressed in the future through improved resources and methods for gender disaggregated data collection.

Seasonality and its impact on diets

Many of the households in Madagascar experience variation in the availability and price of different food items at different points in the year. This is particularly true of certain categories of perishable items such as fruits, which may only be available in some areas for limited periods. Similarly, where market integration is limited, the price of locally produced staple crops may be low around harvest season and high during planting season. These and other factors contribute to seasonal variation in diets, resulting in differences in the quantity of macro- and micronutrients individuals receive at different points in the year. There is variation in the timing of surveys that allows us to partially observe seasonal variation across households (see Bizikova et al., 2023). However, since each household was not interviewed at all points in the year, we do not observe seasonal variations within households. Our estimates therefore reflect average consumption in a given year. Within-year variation in diets is an important concern that should be considered in the design and implementation of nutritional and other interventions relating to food consumption.

Use of non-standard measurement units

Food items are frequently purchased, exchanged, and consumed in quantities that respondents may not be able to easily estimate in terms of standard units of weight or vol-

ume. For example, a respondent will typically report consuming a bowl of porridge rather than a number in grams or millilitres. Efforts were made during the survey process to get the best possible estimates of these measures through discussion with respondents and the use of standardized visual aids, with auxiliary data also collected from local markets to enable the conversion of non-standard units to metric units. While these procedures reduce measurement error in quantities, some noise in estimates remains, and, for a small group of rarely consumed food items, it is not always possible to convert the reported amount into metric units. For further details on conversion issues see Bizikova et al. (2023).

Impacts of extreme events

While our research approach considers gradual responses to climate change, impacts of extreme events such as droughts, floods, and heavy rainfall pose a serious challenge for our analyzed countries. For example, in Madagascar, natural disasters including droughts, floods, diseases, and pests (specific to some regions) have affected the livelihoods of significant numbers of people (Fayad, 2023). Interventions included in our model indirectly contribute to increasing the resilience of farming households through improved food production, access to healthier food, and access to diverse agricultural inputs. However, analysis of the frequency and intensity of extreme weather events and their impacts that might affect these outcomes was beyond the scope of this project.

Institutional challenges

In practice, agricultural, food security, and nutrition policy interventions can be delivered in a variety of ways that rely on different delivery mechanisms and supporting systems. This study includes information on income, seasonality in rates of undernourishment, gender and family status, and model factors such as access, assets and caloric intake (Bizikova et al., 2023). Other factors that are also important in shaping effective interventions in this context include the use of formal and informal institutions, access to knowledge and physical infrastructure, as well as consideration of social, historical, and cultural conditions when promoting the interventions. In our study, for instance, we consider the impact of food subsidies that can be delivered through universal unconditional cash transfer, depending on the specific country's context. Our model does not currently integrate an appraisal of institutions and delivery mechanisms that would likely speed up implementation or increase effectiveness. Yet, such delivery mechanisms are critical and often include agencies of central or regional governments (or other public or non-governmental entities) to ensure that, for example, a fertilizer subsidy reaches its intended beneficiaries. For more accurate estimates, institutional preparedness and the effectiveness of delivery of interventions should be considered in future work.

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The Zero Hunger Coalition catalyses coordinated action to achieve zero hunger in the world by 2030. An affiliate of HESAT2030, the Coalition unite a diverse range of stakeholders including 11 multilateral organizations, 27 civil society organizations and 30 countries.

www.zerohungercoalition.org/en

HESAT2030 is charting a course for policymakers and donors to make high-impact decisions and investments driven by data. Founding partners are the Food and Agriculture Organization of the United Nations (FAO), Shamba Centre for Food & Climate and CABI.

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